

Best Practice Recommendations For Skin Health And Wound Management 2025

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Best Practice Recommendations For Skin Health And Wound Management 2025 draws on the work of the many experts who contributed their knowledge and experiences to past editions over the years. A total of 112 expert authors have been involved, from the publication of the initial version in 2000 to the current edition in 2025, along with numerous research, editorial and production team members. Wounds Canada would like to thank everyone involved in the production of past and present versions of these articles for their hard work, diligence and rigour in researching, writing and producing these valuable resources.

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Wounds Canada is a non-profit organization dedicated to the advancement of wound prevention and care in Canada. Wounds Canada was established in 1995 as the Canadian Association of Wound Care.

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This document was the immediate predecessor to Skin Health and Wound Management: Best Practice Recommendations 2025 and the contributions of the authors were crucial in informing the current edition.

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1. Foundations of best practice for skin and wound management: a supplement to Wound Care Canada; 2017.

Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 1



Introduction

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Chapter 1
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INTRODUCTION

According to Sackett et al.[1,2] best practice is "the conscientious, explicit and judicious use of current best evidence in making decisions about the care of the individual patient". The WHO defines best practice as, "knowledge about what works in specific situations and contexts, without using inordinate resources to achieve the desired results".[3]

Best practice can also be thought of as an accepted procedure, technique, intervention or method that research has shown will produce positive patient outcomes. But it is not just based on evidence alone.[4] The reality is that the ability to deliver best practice is determined by multiple factors, including patient needs and preferences, the patient's support system, the health system, the health-care providers within the system, available resources and more; hence the WHO's reference to "specific situations and contexts".

While the definitions may vary, a common understanding might be that clinical best practice results from applying the best available evidence to better integrate science and practice, considering risks, resources and patient values.[1,2]

Guidelines versus Recommendations

Both guidelines and recommendations are aimed at enhancing clinician decision making to improve patient care and outcomes. Both are based on rigorous evidence reviews and panel consensus. Guideline development has a strong emphasis on the quality of the evidence. And while the recommendations contained in this document do as well (see below), their development relied on guidelines and other sources where the levels of evidence had already been established. Thus, the recommendations are intended to use the same information as guidelines of the highest standard but present the statements in a context that makes them more clinically applicable. They are appropriate for end users at different levels of expertise and experience, they work with multiple populations and they can be applied in a variety of care settings.

Supporting Patients through a Population Health Model

In alignment with the current global health-care perspective, Wounds Canada is committed to providing support to patients to help them adapt to and self-manage their condition in the face of social, physical and emotional challenges. It is a care model based on the premise that cultural sensitivity in care delivery and self-management is an essential element of high-quality health care. This includes the beliefs, values, traditions and biases on the part of health systems, care providers, patients, families and communities, as all can influence care and outcomes. The recommendations in this document reflect this approach. They emphasize screening, holistic assessments and early interventions to prevent skin breakdown and/or recognize it sooner, as well as sustainable care and self-management strategies to support the mandate of a population health model.

The recommendations also support the Quintuple Aim framework in which the patient experience is enhanced, costs are reduced, population health is improved, the care team experience is improved and equity in health care is available to all. The equity piece is particularly important for patients living with skin issues and wounds.[5] The voices of patients and their care partners have been incorporated in all the chapters, as part of the writing, reviewing, editing and graphic design teams. We thank them for their insights and wisdom.

Terminology

Wounds Canada employs Canadian spelling, referencing the *Oxford Canadian Dictionary of Current English*, and follows APA Style for medical journals. Original names/titles of institutions, programs, etc., using alternate spellings have not been changed. Vancouver Style is utilized exclusively for all referencing and citations.

Wounds Canada is committed to prioritizing the use of inclusive, non-stigmatizing language in published manuscripts. Inclusive language acknowledges diversity, conveys respect to all people, is sensitive to differences and promotes equity. Our intent is to use inclusive and respectful language without bias against any person and to avoid language that negatively or unfairly portrays or describes any person based on factors such as age, gender, race, ethnicity, culture, sexual orientation, disability, neurodiversity, status, class or health condition. Wounds Canada strives to respect gender identity and encourages the use of gender-inclusive terms whenever appropriate.

Individuals who fall into a specific, defined group are generally referred to as *persons* or *individuals with a condition* (e.g., persons with diabetes as opposed to diabetics). However, for purposes of clarity and consistency, and in keeping with accepted journal style, an individual known to be receiving care from a medical practitioner or health-care provider will generally be referred to as a *patient* when discussed within this context. This is, in no way, intended as a reflection on, or judgement of, the individual, but is simply an indication of status within the health-care system at a given point in time. Please note that specific terminology referring to *patient(s)* and/or *person(s*) contained in charts, tables, graphics or similar material reproduced from a third-party source is presented verbatim and has not been altered.

All references to products will use generic terms to avoid product bias.

About this Document

This first chapter gives some background on the history of the project and the methodology used to arrive at the recommendations.

Chapter 2 provides guidance on how to implement the recommendations into practice.

Chapter 3 is an overview of the structures and physiology of skin and the process of skin healing.

Chapter 4 is the foundational chapter for all that follow. It gives readers general recommendations that can apply to all wound types. It should be read before any of the specific wound chapters.

Chapters 5–13 provide the reader with information for specific wound types.

Chapters 4–13 are presented using the Wound Prevention and Management Cycle to guide frontline clinicians and health decision makers through a step-by-step process that addresses the assessments, interventions and outcomes related to factors that may interfere with skin health or affect wound healing.

History of Wounds Canada's Best Practice Recommendations

Wounds Canada Best Practice Recommendation Update 2024 builds on the work of previous authors and editorial teams over the past 24 years.

This initiative began in 2000, when *Ostomy/Wound Management* (OWM) published four articles written by experts from Wounds Canada (at that time known as the Canadian Association of Wound Care). These were: Preparing the wound bed—debridement, bacterial balance, and moisture balance;[6] Best practices for the prevention and treatment of pressure ulcers;[7] Best practices for the prevention, diagnosis, and treatment of diabetic foot ulcers[8] and, the following year, Best practices for the prevention and treatment of venous leg ulcers.[9]

Led by the efforts of Dr. David Keast, Heather Orsted, Sue Rosenthal and Robert Ketchen, and with the publishing rights graciously transferred to Wounds Canada by *Ostomy/Wound Management,* these four articles were updated in 2006 and

published in what came to be known as "the silver book", a special issue of *Wound Care Canada* that contained the four articles in both English and French. They were updated once more beginning in 2017 and published on the Wounds Canada website. More chapters, new topics, updated information and additional authors were added over the years.

Twenty-four years later and with the contribution of a total of 112 expert authors, along with various research, editorial and production team members, who have been involved in the development and updating of these seminal documents over the years, we have the document you see now. This latest version emphasizes that clinicians must recognize and act on the full range of risks and risk-specific—and early—interventions required to support positive patient outcomes. A stronger focus on self-management and sustainability acknowledges the role the patient plays in skin health and the wound prevention, healing and/or palliation process when not under direct care.

Methodology

In this new edition, the editors present best practice recommendations that draw upon the highest-level evidence available and suggested application. The recommendations constitute a synthesis of relevant guidelines that utilize the agreed-upon method (see below), with a strong clinical application process. By leveraging evidence-based guidelines and principles of application, we aim to promote effective and informed decision-making in health-care settings.[10] This methodology used a systematic process for developing clinical best practice recommendations, ensuring they are grounded in clinical expertise and robust evidence.[10] These recommendations have been developed by carefully selected experts with direct experience in each specific topic and have been reviewed by experts in the clinical and knowledge translation fields. Updates will occur on a regular schedule or when it is determined that significant changes are needed due to new research or treatment approaches.[11]

Steps Used to Arrive at the Recommendations

1. Identify the Clinical Topic: The number of topics grew over the years to meet the needs of Canadian health-care providers working in the areas of skin health and wound management. From the original four, the number of chapters relating to specific clinical topics in this edition has grown to 10. Lymphedema is a new chapter in its entirety, and the Nutrition and Wound Healing Appendix of Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview is an essential addition.

2. Utilize an Expert Panel of Authors: The editors assembled a national integrated expert panel consisting of health-care professionals, caregivers and patients from across Canada with expertise and experience related to each clinical topic. It was essential to include a diversity of the authors in terms of clinical settings, geographical locations and professional/lay backgrounds to capture a necessarily broad perspective.

3. Review the Literature: Each author group conducted a review of national and international guidelines chosen on the clinical topic known to them and supplied by the editors and librarian. They gathered and evaluated relevant research studies, systematic reviews, meta-analyses and clinical practice guidelines, knowledge, evidence gaps and areas where best practices are warranted.

4. Define Key Questions: The authors were encouraged to collaboratively develop a set of key clinical questions that the best practices would address. The brief was that these questions be focused, specific and relevant to the clinical topic under consideration and serve as a guide for the subsequent application steps of the methodology, with the goal of integrating the recommendations into the five-step format of the Wound Prevention and Management Cycle.

5. Evaluate the Evidence: The authors conducted a thorough search of relevant research studies, systematic reviews and meta-analyses, evaluated the quality of the guidelines' evidence and identified knowledge gaps using a validated grading system.

6. Develop Best Practice Statements: Based on the evidence evaluation and consensus reached, the authors drafted clear and actionable best practice statements for each key question. They were encouraged to consider using a standardized format, such as PICO (Population, Intervention, Comparison, Outcome), to structure the statements. Statements were integrated into the Wound Prevention and Management Cycle, to move the clinician/reader from assessment strategies to evaluation/reassessment, allowing for a holistic approach to care.

Consensus on the changes was achieved using a modified Delphi method, with all the authors' input compiled in a format to create the updated draft version of the best practice recommendations (BPRs). It was then reviewed by the authors and re-reviewed until consensus was achieved.

It was essential that the author groups were able to collaborate, discuss and deliberate online to reach a consensus on each of the best practice recommendations. This online asynchronous interaction action allowed for team members to work on the online document at their convenience and see other team members' changes in real time. This input incorporated their clinical and personal expertise, perspectives and judgment into the decision-making process. Open dialogue, critical appraisal of the evidence and the consideration of potential benefits, harms and resource implications were encouraged.[11-13]

7. Implement External Review: Once the statements were developed and placed into the chapters with appropriate explanation and additional information and graphic elements, external review from additional experts, patients and care partners (e.g., caregivers in the field) was undertaken to validate the recommendations and ensure their accuracy, clarity and applicability. Feedback was incorporated to refine and improve the recommendations. More than 60 reviewers were involved in this thorough process for the current BPRs. Once these steps had been completed, each chapter went through an additional editing process for clarity, coherence, consistency and readability.

For a more detailed explanation of the methodology used, please see: Kuhnke JL, Burrows C, Evans R, Botros M, Hoover J, Corks I. Best practice recommendations updates 2024: methodology for developing foundations of best practice for skin and wound management. Wound Care Canada. 2023;21(2): 62-65. DOI: 10.56885/ WXVG8173

Distribution and Updates

To ensure these recommendations are widely disseminated, Wounds Canada has made them available for free through its website: woundscanada.ca. This strategy ensures they are easily accessible to health-care professionals, patients and care-partners, supporting partner societies and decision makers at every level, including governments.

But reading the information won't necessarily translate into change activities on the ground. Chapter 2 provides readers with insights into how to apply the information into their practice (as clinicians), lives (as patients) or decision making (as administrators, health leaders or government officials).

Clinical best practices are dynamic and subject to evolving evidence. Wounds Canada has established a process for regular review based on a three-to-five-year cycle and will update specific recommendations if and when significant changes are needed to ensure their continued relevance and alignment with the latest research findings. They will regularly monitor emerging evidence, feedback from users and changes in clinical practice to inform future revisions of the best practice recommendations.

With the help of the best practice recommendations contained in the document, we can all work together to support skin health and excellence in wound prevention management for all Canadians.

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How to Use Wounds Canada's Best Practice Recommendations for Skin Health and Wound Management 2025

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This chapter will assist you in creating a plan to implement the best practice recommendations (BPRs) contained in this document into your clinical setting. This process will involve moving your own new knowledge into practice, knowing where to find and how to use relevant resources to support your practice and creating an environment where you, your colleagues, your patients and their families are adequately supported to achieve the best possible health outcomes.

Learning does not occur until practice changes and measured patient outcomes occur.

Successful integration of the new knowledge will depend on several factors, including:

- organizational supports such as relevant policies, procedures and resources
- education/instruction to support the knowledge and skills of the integrated team members
- the willingness of administrators and other health decision makers to prioritize a 'skin friendly' environment
- the available resources in the care setting and community (post discharge).

The integrated team includes not only health-care professionals, but the patient, their caregivers and other support personnel.

The steps below provide a method for taking the information contained in the subsequent chapters of this document and moving it into practice in an effective, sustainable way that will result in improved outcomes for all patients, cost savings and increased provider and patient satisfaction.

Steps to Implementation of the Best Practice Recommendations

Step 1: Define need for change and establish a baseline

- Before beginning your best practice journey it is essential to start with an assessment of what is currently happening in your care setting through an environmental scan. An environmental scan identifies the current state of the workforce, education, health-care delivery, policies, legislation and availability of resources and technology.[1]
- Determine what skin health and wound care practice changes MAY need to occur. These changes may be identified from the environmental scan, specific quality improvement (CQI) data, critical incident reports and staff and patient surveys.
- Carefully conduct prevalence studies of the common individual wound types in your setting. This will serve as:
  - a measure of how your current approaches compare with those in other, similar settings
  - a baseline for measuring the impact of any changes implemented at the provider and organizational levels including policy and practice changes.

Step 2: Read Chapters 3 and 4

Chapters 3 and 4 provide essential background for the remaining chapters on specific wound types, so it is essential that you read both before proceeding to any of the other chapters on specific wound types. These two chapters provide the fundamentals of promoting skin health and preventing wounds, as well as treating and managing wounds that occur.

Chapter 3: Skin: Anatomy, Physiology and Wound Healing describes and illustrates the layers of skin and discusses how intact skin prevents wounds. The chapter also discusses how these protective layers can be altered by internal and external forces, and the process through which healing takes place.

Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview focuses on the promotion of skin health, prevention of wounds and wound recurrence and management of wounds. In addition, an extensive appendix, Nutrition for Skin Health: Wound Prevention and Wound Healing, discusses the effects of deficits in nutrition and which elements enhance skin health and wound healing. The appendix is divided into two sections—one for generalist health providers and one specifically for registered dietitians—to assist the reader regardless of professional background.

Step 3: Read the chapters on specific wound types (Chapters 5 through 13) as needed

- Choose a best practice recommendation chapter on which you want to focus and read it in its entirety, taking note of new information and creating a comparison chart of your current practice and the best practices outlined in the chapter. Make sure to include whether you have access to the full range of integrated team members indicated in the recommendations and if their knowledge and skill levels meet the requirements.
- Use the hyperlinks in the chapter to become familiar with the relevant resources* that will assist the team in implementing the recommendations and improving outcomes.
- Repeat this process with any of the chapters (wound types) for which you have identified a need and established a baseline, as outlined in Step 1.

*Each of the chapters contains links to many of the tools referred to within the text; patient resources, such as the Care at Home and DIY documents (which cover topics such as changing a dressing at home and managing leg edema); an extensive array of clinician-focused resources such as the BPR Briefs (a condensed version of the chapters); and Product Pickers (information about specific devices such as dressings, offloading devices and surfaces, as well as skin and wound cleansing products). These resources will be invaluable for supporting positive practice change.

Example: Pressure Injuries: If your focus is on pressure injuries, read Chapter 5: Best Practice Recommendations for the Prevention and Management of Pressure Injuries, following the steps above and then move on to Step 4. Ensure you have completed a prevalence study by this point so you understand the true scope of the issue, can make the most effective decisions and can evaluate the progress of any changes made.

Step 4: After you have completed your comparison chart, use it to identify gaps in current practice and policies and discuss possible changes with stakeholders

- Set process and outcome goals for change, based on your identified gaps. To create effective goals, you will need to:
  - -Discuss possible changes with clinical staff and organizational leads, such as educators, professional practice resources and management, as well as patient liaisons/committees
  - -Use data to support the practice, policy and procedure changes you are considering.
- Identify how organizational supports can be leveraged to advance this step, or what other areas of focus need to be considered to ensure greater momentum and uptake.[2]
- Establish priority levels for the changes needed to address the gaps and meet the goals you have set. It can be difficult to implement sweeping changes all at once, and a phased rollout is often an effective and sustainable way to support positive practice and policy change.
- Consider prioritizing policy changes to address the gaps, as new or modified policies are often necessary before practice changes can be implemented to effectively address identified gaps.

Example: Pressure Injuries: Changes needing to be addressed may include improving identification of risk on patient admission, with immediate follow-up for appropriate interventions (such as surface use and/or repositioning schedule), or training staff on proper staging and documentation of existing pressure injuries. Each of these examples may require staff training, practice and policy change and enforcement to result in successful implementation that leads to improved outcomes.

Step 5: Finalize solutions to gaps in best practice and adapt as necessary to the local context

- Create a plan to address the gaps and meet the goals. This process of creating a plan may involve multiple consultations with stakeholders and multiple iterations of the plan to incorporate feedback.
- Ensure the plan is appropriate for your setting, patient population, the level of care provider abilities or potential

abilities and the availability of resources. It is important to recognize what is modifiable and what is not when you create your plan.
- Identify what you want to do, how you envision carrying out or implementing this change based on your plan and measuring outcomes (Plan-Do-Study-Act [PDSA] cycle).[3] The measurement/evaluation components are essential for ensuring your plan is working and for assessing change and driving improvements.
- Identify barriers to implementation of the plan. Include a process for overcoming the barriers within the plan.
- Ensure you have the right team members—with identified roles—to implement and measure any changes (in both process and outcomes). Make sure to assign one or more 'champions' to lead the implementation process.
- Get buy-in from all team members and others within the organization/setting/agency that may influence outcomes (including finance, dietary staff, cleaners and many others who may not traditionally be considered).

Example: Pressure Injuries: Create drafts for training sessions, new practices and policies around proposed changes relating to risk assessment and staging of pressure injuries specific to your organization/setting/agency. Implement a process that allows time for review and feedback. Expand the team as necessary and ensure patients and their families have a voice in the process.

Step 6: Facilitate movement into practice

- Implement the plan.
- Ensure policies are in place to support all practice changes.
- Provide education/instruction, as needed, for stakeholders as required (including health providers, patients and family, administrators, others) to ensure changes are doable and will be effective.
- Create supported time for clinician in-service sessions and patient/family education.
- Keep relevant BPR chapters and other resources readily available in facility libraries, on computers and/or on tablets used at the bedside.
- Ensure relevant resources are available.
- Identify and celebrate implementation successes.[4]

Example: Pressure Injuries: Ensure all staff, patients and families understand the importance and details of pressure injury prevention and effective management, and are equipped to participate (based on adequate knowledge and skills) in best-practice-based and patient-centred care. Hold a 'Pressure Injury Fair' to celebrate and demonstrate successful changes.

Step 7: Monitor and evaluate processes and outcomes and communicate the results

- Ensure you have a process that supports ongoing high-quality documentation to confirm your quality improvement activities are moving in the right direction, are based on best practice and are leading to improved outcomes.[5]
- Revise your plan as needed, particularly if you are not achieving the goals you set out in your plan.
- Consider publishing results as appropriate through posters, articles in journals, panel presentations at conferences, attending conferences and sharing with your peers.
- Continue to celebrate your successes internally through organization/agency/facility publications, posters and newsletters.

Example: Pressure Injuries: Complete chart audits on patients at risk for, or with, pressure injuries to ensure policies and practices have changed. Conduct an annual prevalence study and compare with previous study results to determine if changes have made a difference. Conduct patient and family satisfaction surveys before implementing changes and annually, with specific questions relating to skin health and pressure injuries. Report and discuss findings with the team.

Summary

Evidence demonstrates that use of best practices in health care:

- improves patient care
- reduces variation in care
- transfers research evidence into practice
- promotes clinician, patient and caregiver knowledge base
- increases patient and care provider satisfaction
- assists with clinical decision making
- identifies gaps in research
- stops interventions that have little effect or cause harm
- reduces cost.

To implement best practice, clinicians and organizational leaders in education, quality improvement and management must partner to integrate evidence-based practice, education and policies that consider specific patient risk factors and available resources. The goal of this integration is to implement and sustain high-quality patient-centred skin health, wound prevention and wound management practices in an environment where communication, education, practice and resource-related barriers are minimized. This is an active, continuous improvement process requiring supportive administrators, allocation of appropriate resources and the co-operation of everyone on the integrated team.

Resources to Support Your Success

Choosing Wisely Canada. (2024). Implementation and Research Network
https://choosingwiselycanada.org/about/cwc-irn/

Healthcare Excellence Canada. (2023). Implementation Science.
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Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 3



Skin: Anatomy, Physiology and Wound Healing

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INTRODUCTION

This document is written with the intent to encompass the quintuple aim for health care improvement. This is to enhance the patient care experience, reduce costs, improve population health, improve the clinician experience and enhance equity. This equity piece is particularly important for patients living with skin issues and wounds and specifically venous leg ulcers. Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[1]

Wounds Canada provides support to individuals and family members by providing education on, and promoting, an approach delivered through an integrated team care model to support the social, physical, cultural and emotional challenges faced by each. Screening, assessing, care planning, care delivery and patient self-management are essential elements that need to be considered in order to address the beliefs, values, traditions and biases of health systems, care providers, patients, families and communities, which all influence delivery of high-quality care. For teams, this starts with the promotion of skin health and understanding the role intact skin plays in health.

This chapter presents the anatomy and normal functions of skin and underlying structures and provides the reader with an outline of the normal healing phases of wounded skin.

Skin

Skin is the largest organ of the body and consists of two layers—the epidermis and dermis—that are supported by a number of underlying structures. This organ has multiple functions. It is a barrier between the external environment and the internal organs, protecting against trauma from water, chemicals, micro-organisms, mechanical stress and radiation. It also performs sensory functions related to communication, touch, pressure, temperature and pain and provides an alert for potential tissue damage. Additionally, it has a role in exchanging fluids, salts, gasses and heat.[2-7]

Skin acts as a temperature regulator through a neural feedback mechanism that operates primarily through the hypothalamus. When skin temperature rises above 37°C, sweating helps to cool the body by drawing heat out through the process of evaporation. If skin temperature drops below 37°C, the body acts to conserve heat and increase heat production through the cessation of sweating. At the same time, the skin increases shivering and the secretion of norepinephrine, epinephrine and thyroxine to increase heat production and the erection of hair.[8]

Skin is also a window between the mind and body and the external world. Internal or external stimuli to the neuro-immuno-cutaneous-endocrine network can result in blushing, goose bumps or 'crawling' skin. Skin colouration such as blushing is normally involuntary and triggered by emotional stress that could be associated with embarrassment, anger or romantic stimulation. Patients with skin (dermatological) conditions may experience self-esteem issues, social isolation, and a disrupted body image.[9]

Skin is an endocrine organ and manufactures hormones such as vitamin D, steroids and thyroid hormone for its own use.[10] Skin also makes many of the neurotransmitters and hormones found in the brain.[10] As an organ of the immune system, skin can release powerful signaling chemicals—such as histamine—that activate other components of the immune system, causing the skin to become red and swollen in the presence of foreign material.

Skin health is influenced by various internal and external factors. These factors also influence wound healing. Therefore, to support the health of skin and the healing of wounds, clinicians need to appreciate, recognize and comprehend both the complex nature of skin and what lies beneath.

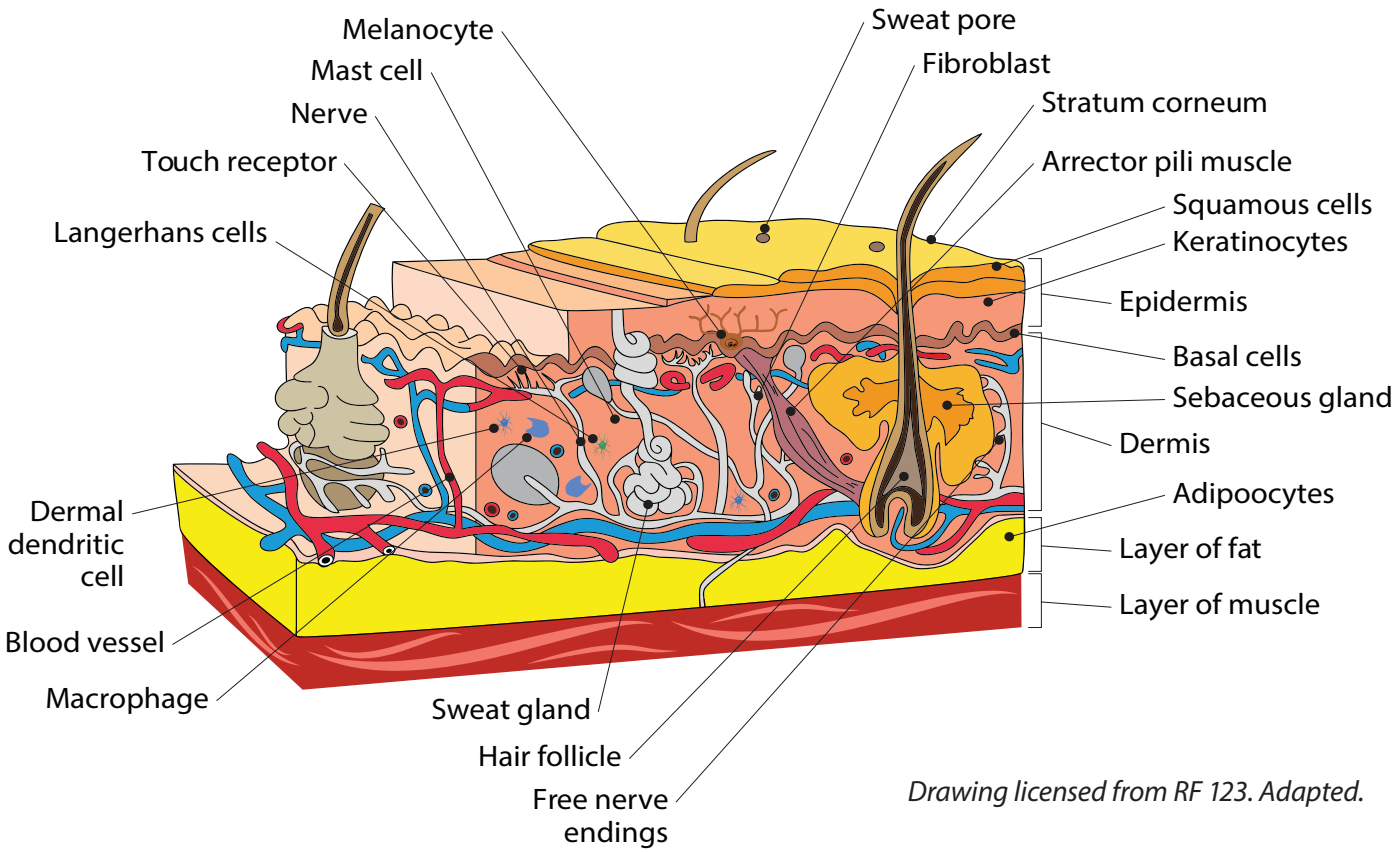
Skin Components

The epidermis is made of tightly woven epidermal, or skin, cells. It is the outermost layer of the skin and forms a waterproof barrier that both holds moisture in and keeps moisture out. Depending on its location, the epidermis ranges from very thin (0.5 mm in the tympanic membrane, or eardrum) to very thick (6 mm on the sole of the foot).[11]

The epidermis has no blood vessels and gets its oxygen and nutrients from the deeper layers of the skin by diffusion from blood capillaries extending to the upper layers of the dermis. The epidermis is made up of several layers:

1. The **stratum corneum** is the outermost layer. It consists of stratified squamous keratinized epithelium. Cells in this layer migrate upward and are shed from the surface every 14 days. These cells require optimal moisture balance, temperature and pH in order to be active. The stratum corneum has an acidic pH, called the acid mantle, that protects the body from some bacteria and fungi.
2. The **stratum lucidum** is the innermost layer of the stratum corneum and is found on the palms of the hands and soles of the feet.
3. In the **granular cell layer** the squamous cells are in transition to becoming the stratum corneum and have lost their inner cell machinery, including the nuclei.
4. The **squamous cell layer** contains the Langerhans cells, which are derived from bone marrow and represent the first line of immune defence.
5. The **basal cell layer** contains keratinocytes, melanocytes and Merkel cells. Skin cells are constantly shedding and regenerating. The keratinocytes, from the lowest layer of the epidermis, are continually pushed to the surface by the production of new cells beneath them. These cells fill with keratin as they migrate to the surface of the epidermis. Keratin gives skin protective qualities and makes it waterproof. When the cells reach the top layer of the skin they are essentially dead flat sacs filled with keratin. Millions of these dead cells are shed daily, resulting in an entirely new epidermis every 35 – 45 days.[3-8,12] Melanocytes are wedged between the basal cells and produce melanin (the pigment that produces the various colours and shades of skin, hair and eyes), which protects the skin from ultraviolet light. Merkel cells are thought to be sensory cells.

Figure 1: Skin components



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The epidermis is separated from the dermis by the basement membrane, a very thin membrane that attaches the epidermis firmly, though not rigidly, to the dermis.

The dermis lies just beneath the epidermis and above the subcutaneous tissue. The dermis is 0.3 to 4.0 mm thick and is divided into the papillary and reticular layers.[13] The junction between the epidermis and the dermis has a series of finger-like structures called rete pegs that project up from the dermis. Similar structures project down from the epidermis. These projections increase the area of contact between the two layers and help to prevent the epidermis from being sheared off. These structures are not present in unborn babies and are almost nonexistent in premature neonates, but develop rapidly after birth. As skin ages they get smaller and flatter.

The dermis contains an extracellular matrix (ECM) made of collagen and elastic fibres that provide structure to the skin and are necessary for wound closure. The dermis also contains a capillary bed that is fed by the arterioles and drained by the venules. Interspersed in the capillary bed are the lymph capillaries. The hair follicles, sweat glands and sebaceous glands are lined with epithelial tissue that leads to the skin's surface and supports the regeneration of the skin at the surface. Sweat (from the sweat glands) helps to regulate body temperature, and sebum (from the sebaceous glands) helps to keep the skin from drying out.

Blood circulates within the capillaries of the dermis to supply nutrients and metabolites to the tissues and to collect waste products produced by the tissues. Without this nourishment and waste removal, tissue health cannot be sustained, and tissue healing cannot occur. This exchange of constituents between the blood and tissues takes place via interstitial fluid (ISF), or tissue fluid.

Blood is mostly water (90% by volume). It contains dissolved proteins, glucose, mineral ions, hormones, carbon dioxide, platelets and blood cells. Blood cells make up 55% of blood plasma and include red blood cells (erythrocytes), white blood cells (leukocytes: neutrophils, eosinophils, basophils, lymphocytes and monocytes) and platelets. The most abundant cells are red blood cells, which contain hemoglobin that enables the transportation of oxygen. Carbon dioxide is almost entirely transported extracellularly in the form of bicarbonate ions dissolved in plasma.[13]

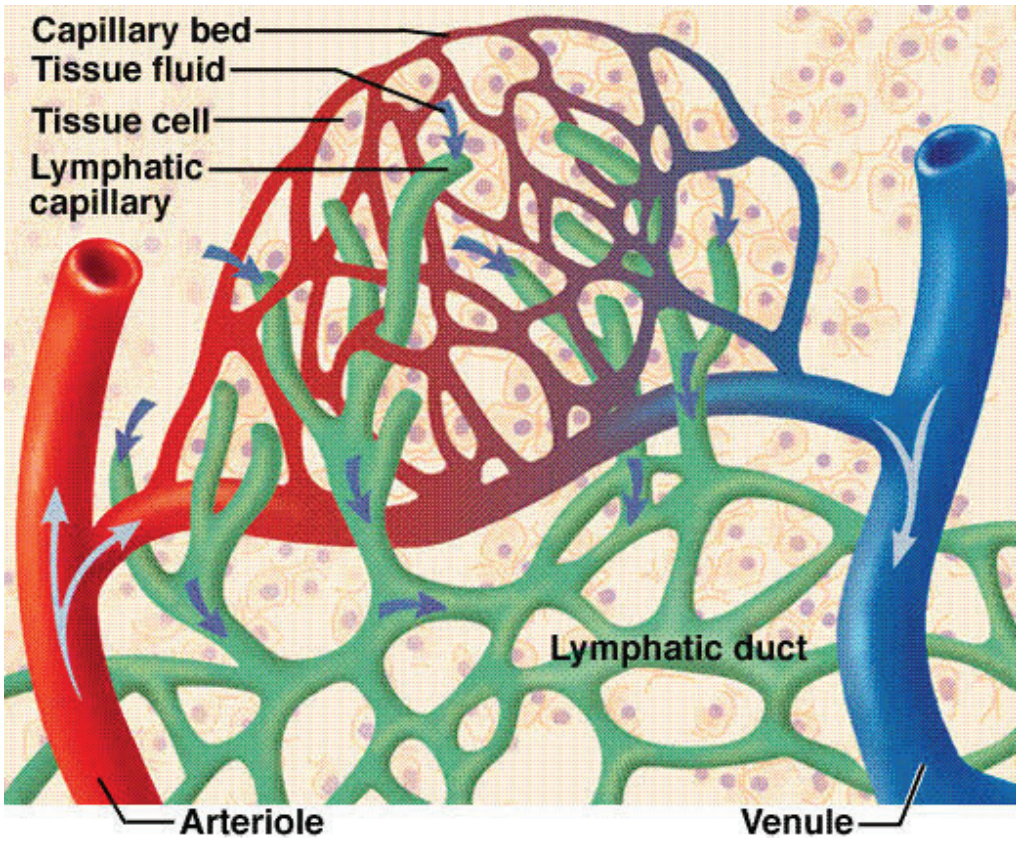
The circulatory system moves arterial and venous blood throughout the body. Arterial blood carries oxygen from inhaled air to the tissues of the body from the aorta, to arteries, to arterioles and to capillaries, through the pumping action of the heart. Venous blood carries deoxygenated blood and carbon dioxide from the lower extremities and abdomen via capillaries to venules to veins to the inferior vena cava for oxygenation, through the pumping action of the calf muscle pump and valve action.[13]

The lymphatic system consists of lymph vessels, lymph nodes, spleen, thymus, tonsils and Peyer's patches in the gut. In addition to its role of transporting lymph, this system has a major role in the functioning of the immune system. The lymphatic capillaries connect to vertical pre-collectors. These drain into a common lymphatic collector that merges into a single lymph vessel (lymphangion). Smooth muscle in the lymphangion contracts once distended to propel lymph through the valves in a peristaltic manner. Normal lymph propulsion is aided by adjacent arterial pulsations, muscle contractions, body movements, respiration and skin distention.

Lymph is a straw-coloured fluid that forms in interstitial spaces. Water, glucose, amino acids and oxygen filter out of the capillaries. Lymph nourishes the cells and supports metabolism, creating waste products that may in part be reabsorbed into the capillaries. Filtration and reabsorption occur throughout the capillary bed but there is no net reabsorption by the capillaries, creating excess fluid and larger molecules which are reabsorbed by the lymphatic capillaries. Large molecules such as proteins do not easily cross the semipermeable membranes of the walls of the capillaries. Newer research demonstrates that filtration and reabsorption by the capillaries are dynamic processes, and proteins may be partially reabsorbed. However, lymphatic capillaries, which are interspersed in the capillary bed, have a unique structure that allows the absorption of these large protein molecules. While the vascular system is a closed loop, the lymphatic system is open ended. The cells of the lymphatic capillaries have anchoring filaments and are able to separate from one another to create an opening through which fluids, proteins and macromolecules can flow into the lymphatic capillary.

Lymphatic fluid primarily consists of water and protein filtrate but also may include lipids (absorbed in the intestine), waste products of metabolism, matrix metalloproteases (MMPs), cytokines, polysaccharides and fibronectin. If there is an imbalance between filtration and absorption, fluid will accumulate in the interstitial space and is seen clinically as edema. While the lymphatics have significant reserve capacity they can be blocked, absent or overwhelmed. If there is significant lymphatic dysfunction, the edema will have high protein content. All chronic edema lasting more than three months is defined as lymphedema. See Figure 2.

Figure 2: Lymphatic transport vessels



Permission granted by Dr D. H. Keast from Penn State University.

Lymph ultimately moves into the thoracic duct, which empties into the subclavian vein, returning the lymph to the circulatory system. One immune function of the lymphatic system is particularly important in the skin. Bacterial antigens are picked up by presenter cells and carried through the lymph vessels to the lymph nodes. Here the antigens are presented to B-cells, which are stimulated to produce antibodies.

Skin as a Barrier: pH and Microbiota

The skin pH scale ranges from 1 to 14 (with seven considered neutral); lower numbers are acidic and higher numbers are alkaline. The normal pH of the stratum corneum is somewhere between 4.1 and 5.8 and varies with age and anatomic location.[14] For example, a newborn has a higher pH of their skin - about seven - while an adult's overall pH is 5.7.[14] This slightly acidic pH, known as the acid mantle, is created from the combined excretion of oil and sweat from the pilosebaceous unit that selects for certain microbial species. This skin microbiota is composed of bacterial, fungal and viral inhabitants that do not cause disease but contribute to proper epithelization of the stratum corneum and provide some defence against pathogenic micro-organisms.[15] This microbiota acts through immune, physical, chemical and microbial actions to create a barrier and protect the host.

Figure 3: Factors that influence the microbial colonization of skin

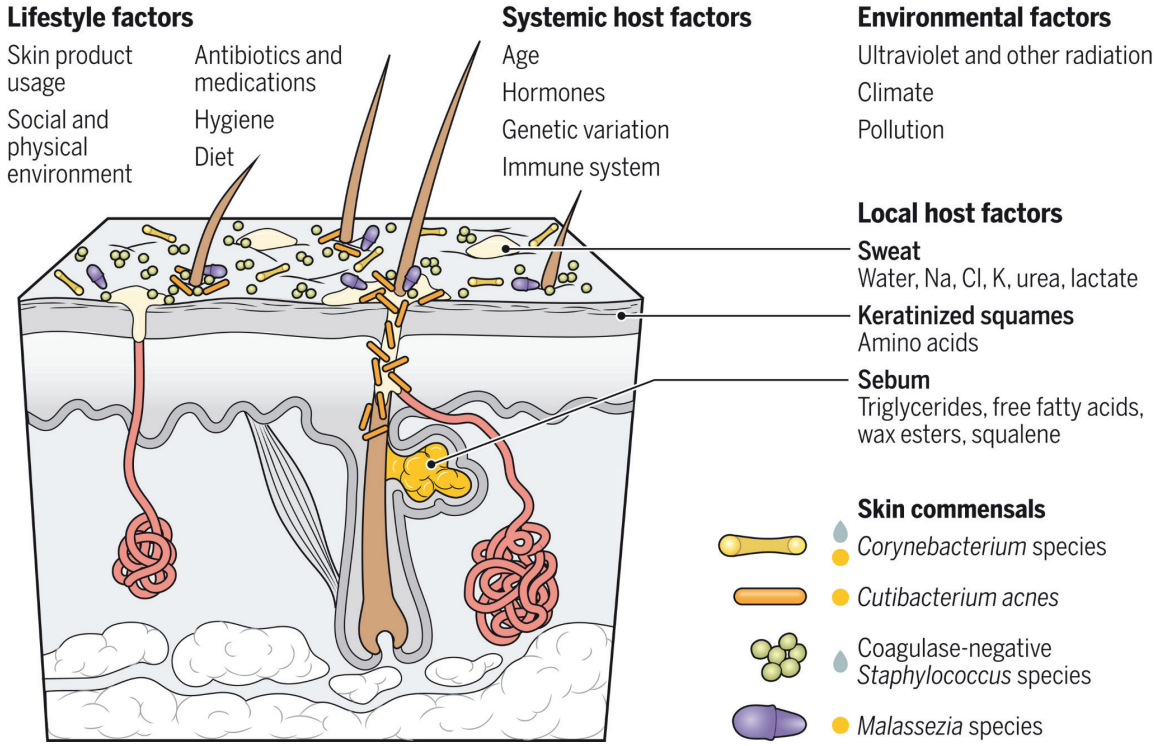


ILLUSTRATION:KELLIE HOLOSKI/SCIENCE. From Tamia A. Harris-Tryon Elizabeth A. Grice, Microbiota and maintenance of skin barrier function. Science 376, 940 -945(2022). DOI:10.1126/science.abo0693. Reprinted with permission from AAAS.

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Unfortunately, altered microbiomes occur in cases with wounds and skin diseases due to alterations in the acid mantle and availability of resources that shift the environment from normal skin inhabitants to opportunistic bacteria (e.g., *Staphylococcus aureus*). These bacteria show optimum growth at a pH of 7.5. Edema is another factor commonly encountered that can affect the acid mantle and moisture barrier of the skin, increasing the risk of infection. These defence mechanisms are not fully developed until puberty, leaving children more vulnerable to infections such as ringworm.

Characteristics of barrier function of the skin is an important concept to consider when treating skin conditions or understanding wound healing, as well as considering topical agents used.

The following are factors that are known to affect skin pH:

- Internal (endogenous) factors: age, anatomic site, genetic predisposition, ethnicity, sebum, skin moisture, sweat,[16] edema[17]
- External (exogenous) factors: detergents, cosmetics, soaps, occlusive dressings, skin irritants, topical antibacterials.[16]

Many factors may influence the microbial colonization of skin such as:[15]

- Lifestyle factors: Skin products, social and physical environment, antibiotics, medications, hygiene, diet
- Systematic host factors: Age, hormones, genetic variations, immune system
- Environmental factors: Ultraviolet and other radiation, climate, pollution
- Host factors: Sweat, sebum, edema.

Skin microbiota have multiple barrier functions. These include:

- Physical: Keratinocytes of the stratum corneum act as the "bricks and mortar" and are mediated by the microbiota
- Microbial: The microbiota protects against invasion, colonization and infection by pathogenic bacteria
- Chemical: The acid environment restricts bacterial colonization. Lipases hydrolyze triglycerides from sebum to produce free fatty acids that inhibit bacteria
- Immune: The microbiota stimulates innate and adaptive immune defenses to develop protective immunity.[15]

Underlying Structures

The following section discusses the underlying structures required for movement, support, protection and production of blood components as well as those that serve as a reservoir for essential minerals.[18]

Subcutaneous tissue, or hypodermis, is under the dermis and is made up of fat-filled cells called adipose cells. The hypodermis also contains connective tissue, larger blood vessels and nerves. One of its functions is to regulate skin and body temperature. The size of this layer varies throughout the body and from person to person. This layer of subcutaneous fat insulates the body, absorbs trauma and is a reserve energy source. It may be divided into two components, the fatty layer, or panniculus adiposus, and a deeper layer of muscle, the panniculus carnosus.[18]

Subcutaneous fat is loosely attached to muscles and bones by connective tissues. If the subcutaneous tissues have too much fat, the areas of attachment become more obvious and the skin cannot move as easily, giving rise to cellulite. Subcutaneous tissue is typically poorly vascularized and wounds that extend to the fatty tissues tend to heal more slowly.

Fascia is an uninterrupted, three-dimensional thin web of fibrous, strong connective tissue primarily consisting of collagen that extends throughout the body. Fascia acts as a shock absorber, maintains the structural integrity of the body and provides support and protection. The superficial fascia is found in the lowermost portion of the skin and surrounds nerves, blood and lymph vessels. The deep fascia is a dense layer that surrounds individual muscles and groups of muscles. The elastin fibres within it allow it to stretch and store kinetic energy. The deep fascia has few blood vessels but is rich in sensory receptors. All organs are covered with a double layer of fascia called the visceral or subserous fascia. Organs are suspended by fascia. After injury, it is the fascia that creates a 'scaffold' for tissue repair.

Muscle is specialized tissue made up of cells that have the ability to contract and conduct electrical impulse, and are well vascularized to support healing. There are three types of muscles: smooth involuntary muscle (such as the muscles in the stomach), striated voluntary muscle (such as the muscles in the arms and legs) and striated involuntary muscle (such as in the heart). Muscle is contractile; it is not easy to grab with tissue forceps and tears easily.[18]

Tendons are tough bands of fibrous connective tissue that connect muscle to bone and are capable of withstanding tension. Tendons and muscles work together and can only exert a pulling force. Tendons have a high concentration of elastin fibres, which allow the stretched tendon to store kinetic energy. Tendons are covered with connective tissue sheaths that produce synovium to reduce friction between the tendon and surrounding structures. Paratenon, which is located between the fascia and tendon, surrounds and nourishes some tendons. When functioning normally, tendons glide easily and smoothly as the muscles contract. If the normal smooth gliding motion of the tendon is impaired, the tendon will become inflamed and movement will become painful. This is called tendinitis. When tendons are damaged they heal slowly because they are poorly vascularized. If they are exposed to the air and are allowed to dry out, the paratenon is destroyed and the tendon may be damaged. Infection tends to spread quickly along the tracts that the sheaths around the tendons create.

Ligaments are short bands of fibrous connective tissue that connect bones to other bones to form a joint. Ligaments often have an overlying vascular layer, the epiligament, covering their surface. This layer is often indistinguishable from the actual ligament and merges into the periosteum of the bone around the attachment sites of the ligament. Some ligaments limit the mobility of articulations or prevent certain movements altogether. Double-jointedness, hyperlaxity and hypermobility refer to individuals with more elastic ligaments that allow joints to stretch and contort further than

normal. Ligaments are most often torn in traumatic joint injuries and can result in either partial or complete ligament discontinuities. As with tendons, ligaments heal slowly and if exposed should not be allowed to dry out.

Table 1: Physiology at a Glance

Structure	Function	Implications for Wounds
Epidermis	provides protection against trauma and harmful environment and organisms	Abrasion occurs if epidermis is damaged
Dermis	provides skin flexibility and strength	Bleeding occurs and the body's first line of defence is breached. Healing is multifactorial
Arterial blood	supplies oxygen to the body	Poor arterial flow leads to ischemia and impaired healing
Venous blood	removes metabolic waste products from the body	Venous hypertension leads to edema and interferes with healing
Lymph fluid	removes waste and supports immune response	Lymphedema often accompanies venous edema. Lymphedema is rarely acknowledged and poorly understood
Subcutaneous tissue	provides protection, cushioning, insulation and energy storage	Poorly vascularized tissue leads to slow healing
Fascia	gives structure, protection, support	Entry into fascial plane leads to infection
Muscles	perform voluntary and involuntary movement	Muscles are very vascular and tear easily
Tendons	attach muscles to bones	Exposed tendons should be kept moist. They are poorly vascularized and therefore slow to heal. Loss of tendon means loss of function
Ligaments	attach bones to bones to form a joint	Exposed ligaments should be kept moist. They are poorly vascularized and therefore slow to heal. Loss of ligament means loss of function
Bones	provide protection, strength and support	Exposed bone usually leads to osteomyelitis. Bone (periosteum) should not be allowed to dry out
Joints	facilitate movement and mechanical support	Joint involvement in wounds usually leads to osteomyelitis
Synovium	lubricates to reduce friction	Appearance of synovium in wounds indicates exposure to joint cavity
Cartilage	connects bones	Exposed cartilage should be kept moist. Exposure leads to osteomyelitis

Bones consist of hard, white, dense connective tissue with a periosteum covering that provides an external blood supply. Bones provide rigid strength and support. Like skin, they are continually turning over and remodeling. Bones can granulate but must be kept moist to preserve the periosteum, which is the nutritional source for bones. If there is no periosteum the bone will die. Exposure of bone can quickly result in infection, which can lead to osteomyelitis.

Joints are the locations at which two or more bones make contact. They are constructed to allow movement and provide mechanical support. Joints are classified based on their structure and function.

- Structure:
    - Fibrous joints are joined by fibrous connective tissue
    - Cartilaginous joints are joined by cartilage
    - Synovial joints are not directly joined

- Function:
    - Synarthrosis joints permit little or no mobility. Most synarthrosis joints are fibrous joints (e.g., those in the skull)
    - Amphiarthrosis joints permit slight mobility. Most amphiarthrosis joints are cartilaginous joints (e.g., vertebrae)
    - Diarthrosis joints permit a variety of movements. All diarthrosis joints are synovial joints (e.g., shoulder, hip, elbow, knee).

Synovium is a thin layer of tissue only a few cells thick that lines the joints and tendon sheaths to control the environment. Synovium acts as a membrane to determine what can pass into the joint space and what must stay outside. As well, synovium produces a thick, viscous, sticky lubricant called synovial fluid that reduces friction in the joint during or with movement. If synovial fluid is noted in a wound bed, joint involvement and osteomyelitis should be suspected.

Cartilage is the dense connective tissue found in many areas in the body, including the articular surface of the bones, rib cage, ears, nose, bronchial tubes and intervertebral discs. Its mechanical properties are an intermediate between bone and dense connective tissue like tendon. Unlike other connective tissues, cartilage does not contain blood vessels. Compared with other connective tissues, cartilage grows and repairs more slowly.

Normal Changes and Differences in Skin

Infant Skin

Infant skin differs from adult skin in several ways. The thickness of infant skin is 40% to 60% that of adult skin. Weak rete ridges provide limited surface attachment to an immature dermis. As well, an infant's ratio of body surface area to weight is up to five times that of an adult. These factors place the infant at greater risk for skin damage.[19]

At birth, the surface layer of the skin is relatively neutral (pH about 6.5) and gradually becomes more acidic over the first few postnatal weeks. The acid mantle forms as a result of changes on the skin surface, such as the presence of sweat, sebum and normal microbiota as well as metabolic processes within the stratum corneum, such as lactic acid and free fatty acid production. Over the first few postnatal weeks the skin's pH falls to about 5.5, a level that is beneficial for antimicrobial defence through the inhibition of the growth of pathogenic bacteria.[20] Acidification also maintains epidermal barrier integrity by stabilizing the double-lamellar structure of intracellular lipids.[20]

Skin Changes in the Adolescent

Adolescence brings about the maturation of the hair follicles, sebaceous (oil-producing) glands and sweat glands in the skin. Stimulation of the sebaceous glands, caused by a surge in the sex hormones estrogen, androgen and progesterone, results in increased production of oil, or sebum. These sex hormones are also responsible for the development of apocrine glands in the pubic region and armpits. The resulting thick sweat mixed with bacteria on the surface of the skin can cause body odour. At the same time hair growth occurs in these areas.

An increase in the lipid content during this time enhances the heat-insulating properties of skin, improving temperature regulation. The higher fat content also helps to retain moisture, making teenage and young adult skin less susceptible to drying out.[21,22]

Skin Changes in the Older Adult

As individuals age, skin goes through many changes based on genetics, environment, lifestyle and any existing chronic disease states.[23] However, despite these individual variations, the normal aging process of all skin causes many predictable changes.

With increasing age there is a 50% decrease in the turnover of the epidermal layer. The pH of the skin becomes more neutral (less acid) and thus more susceptible to bacterial growth and infections. Interestingly, the pH value rises above six when a person actually experiences a skin problem or skin disease.

Thinning of the outer epidermal layer can cause a 1% decrease in collagen per year. Since collagen gives skin tensibility, this loss leads to wrinkling. There is also a decrease in melanocytes, the pigment-producing cells. Langerhan's cells, which serve as macrophage and immune moderators of the epidermis, also decrease. Blood supply is reduced and the dermis becomes increasingly avascular as the body ages.

The skin's aging process also results in biochemical changes in collagen and elastin, the connective tissues underlying the skin, which give the skin its firmness (collagen) and elasticity (elastin). The rate of the loss of skin firmness and elasticity differs from individual to individual depending on genetic makeup, general health, exposure to the sun, skin care regimen and other factors.

Elastin fibers significantly decrease in size and number over time, which leads to decreased elasticity. Elastin maintains the skin's elasticity and recoil, so this loss leads to wrinkling. The skin's ability to perceive sensation to pressure and light touch is also reduced, resulting in an increased threshold for pain. As the skin becomes less elastic, it also becomes drier. The underlying fatty tissue begins to disappear, and skin begins to sag. The skin is less supple and wrinkles begin to form. Atrophy of subcutaneous fat in the hands, face, shins, waist (men) and thighs (women) results in sagging and folds. At this stage, skin is more easily injured, heals more slowly and tends to dry out more quickly.[21,22]

Melanocytes, the pigment-producing cells, decrease in quantity during the aging process. Hair follicles also decrease in number and growth rate, with associated greying due to the decrease and loss of melanin.

Hormones and Skin[24]

Over one's lifespan hormone levels may change because of underlying diseases, medications, hormone therapy, and cancer treatment. Estrogen increases collagen and skin moisture and promotes wound healing, while testosterone stimulates oil production and the growth of facial hair. Of note, men and women have both sex hormones; skin is able to convert testosterone to estrogen and ovaries produce a small amount of testosterone.

Women's skin is generally thinner and less oily than men. Therefore, women are more likely to experience wrinkles because thinner, drier skin is more prone to damage from the sun and cigarette smoke, and from minor trauma. Women also sweat less than men and thus are more likely to suffer heat stroke. During menopause, the loss of sex hormones accentuates wrinkles and estrogen-deprived skin thins, loses collagen and slows down its cell renewal.[23,24]

Wound Healing
Skin's Response to Damage

When skin is damaged or wounded it attempts to regenerate itself so it can continue to protect the larger organism.

Research on acute wounds in animal models shows that wounds heal in four phases. (Note: some authors combine the first two phases.)

- Hemostasis
- Inflammation
- Proliferation (also known as granulation and contraction)
- Remodeling (also known as maturation).

Dean Kane created a wound-repair analogy that compared wound healing to the repair of a damaged house.[25] As with the repair of a house, the process relies on the right materials (cells) being delivered to the site (wound) in the right order and at the correct time (See Table 2). A successful repair also depends on access to the damaged areas with the high-quality materials (adequate blood supply and an active immune system) necessary to get the job done well.[25]

Table 2: Phases of Wound Healing and the Kane Analogy[25]

Healing Time Frame	Phase of Healing and function	Time Post Injury	Cells involved	Analogy to House Repair	Examples of factors that may affect each phase
Wound	1.Hemostasis Clotting, release of growth factors	Immediate	Platelets	Cap off broken utilities	Medications: antiplatelet agents, anticoagulants Clotting disorders
↓	2.Inflammation Phagocytosis	Days 1 - 4	Neutrophils Macrophages Monocytes	Unskilled labourers clean up the site	Co-morbidities: Diabetes Immune related diseases Immunosuppressant medications
Closure	3.Proliferation (granulation and contraction) Fill defect, re-establish skin function, closure	Days 4 - 21	Macrophages Pericytes Lymphocytes Angiocytes Neurocytes Fibroblasts Keratinocytes Epithelial	Contractor or supervisor Specific labourers Framers Plumbers Electricians Roofers and siders	Comorbidities: Diabetes Immune related diseases Immunosuppressant medications Poor perfusion Shear, friction and pressure
↓	4.Remodelling (maturation) Develop tensile strength	Days 21 - 2 years (24 months)	Fibrocytes Fibroblasts	Remodelers	Shear, friction, and pressure, moisture
Healing					

1. **Hemostasis**[25] occurs within minutes of the initial injury unless there are underlying clotting disorders. Once the source of damage (such as fire or flood) to a house has been removed and before work can start, utility workers must come in and cap damaged gas or water lines. Similarly, in wound healing, the source of the damage (e.g., pressure or heat) must first be identified and removed and then blood vessels must be sealed. In wound healing, the platelets are the cells that act as the utility workers, sealing off the damaged blood vessels. The blood vessels themselves constrict in response to injury, but this spasm ultimately relaxes. Although the platelets secrete vasoconstrictive substances to aid in this process, their primary role is to form a stable clot, thereby sealing the damaged vessel. Under the influence of ADP (adenosine diphosphate) leaking from damaged tissues, the platelets adhere to the exposed type I collagen.

   Platelets become activated and secrete adhesive glycoproteins that stimulate further platelet aggregation. They also secrete factors that interact with, and stimulate, the intrinsic clotting cascade through the production of thrombin which, in turn, initiates the formation of fibrin from fibrinogen. The fibrin mesh strengthens the platelet aggregate into a stable hemostatic plug. Finally, platelets secrete growth factors such as platelet-derived growth factor (PDGF), which is recognized as one of the first factors secreted in initiating the subsequent healing steps. The growth factors also recruit neutrophils and monocytes and stimulate epithelial cells to recruit fibroblasts, thereby initiating the next phase of wound healing: inflammation.

The Role of Micronutrients

Each step of the wound-healing process is dependent on circulating amino acids, lipids and carbohydrates. The most important micronutrients known to be associated with wound healing are iron, zinc and vitamins A and C. Deficiencies in the intake of proteins and vitamins are particularly common in the elderly. Infected wounds often require that patients increase their nutritional intake.

2. Inflammation Phase[25]

The vasoconstriction in the hemostasis phase is followed by vasodilation in the inflammation phase to provide an increase in blood flow to the traumatized site. Therefore, clinically, inflammation (the second phase of wound healing) presents as erythema, swelling and warmth often associated with pain; the classic "*rubor et tumor cum calore et dolore*." This stage usually lasts up to four days post injury.

In the wound healing/house repair analogy, the second job to be done once the utilities are capped is to clean up the debris. In a wound, this cleaning is done by the first inflammatory cells on the scene: neutrophils, or PMNs (polymorphonuclear neutrophilic leukocytes). The inflammatory response causes the blood vessels to become leaky and release plasma and PMNs into the surrounding tissue. The neutrophils phagocytize debris and micro-organisms, thus providing the first line of defence against infection. They also enhance the effectiveness of antibiotics through oxidative killing of bacteria. As they digest bacteria and debris, the neutrophils die. Monocytes then become the primary white blood cell in the wounded tissues and release intracellular enzymes in the surrounding matrix, further digesting tissue. Fibrin is broken down as part of this clean-up process, and the degradation products attract the next cells involved: fibroblasts and epithelial cells, which are aided by local mast cells.

The task of repairing a house is complex and requires someone, such as a contractor, to direct activity. Similarly, wound repair requires coordinated activity of the cells and reliable cell-to-cell communication. Cells communicate through soluble proteins called cytokines and growth factors. These cytokines and growth factors are released by one cell and bind to receptors on target cells. Once a cytokine binds to a target cell, it stimulates that cell to move. Growth factors, on the other hand, stimulate the target cell to either divide and produce more cells, or to synthesize and release substances such as the collagen required to form the extracellular matrix. The extracellular matrix also plays an active role in wound healing by interacting with the cells through receptors called integrins. Examples include platelet activation, epithelial migration and fibroblast movement.

Macrophages are also involved in the coordination of cell activity in wound repair. Within two days, circulating monocytes differentiate into macrophages after they exit the blood vessels and come into contact with the extracellular matrix. Macrophages are able to phagocytize bacteria and provide a second line of defence. Macrophages also secrete extracellular enzymes to degrade necrotic tissue and apoptotic cells (including neutrophils), thus paving the way to resolving inflammation. These enzymes belong to a family of substances called matrix metalloproteinases (MMPs). There are approximately 20 different types of MMPs secreted by many different cells, including neutrophils, macrophages, epithelial cells and fibroblasts under the influence of inflammatory cytokines such as tumour necrosis factor alpha (TNF) and the interleukins (IL-1 and IL-6). MMPs require calcium for functional shape and zinc for activation. MMPs act on all components of the extracellular matrix and are responsible for removal of devitalized tissue, repair of lost or damaged tissue and remodeling. MMPs are balanced by tissue inhibitors of metalloproteinases (TIMPs), which are released locally by cells and bind reversibly to the MMPs to deactivate them. Uncontrolled activity of MMPs may result in degradation of newly-formed tissue or destruction of growth factors. An imbalance in protease activity can result in a prolonged inflammatory phase and a delay in wound healing.

Macrophages secrete a variety of cytokines and growth factors such as fibroblast growth factor (FGF), epidermal growth factor (EGF) and transforming growth factor beta that can stimulate keratinocytes, fibroblasts and angiogenesis. As such, macrophages promote the transition to the proliferative phase of healing.[26]

The body's inflammatory response to trauma can be confused with infection. Inflammation is a normal response to trauma and the inflammation subsides as the trauma is resolved. Chronic inflammation is often the result of repetitive trauma, hypoxia, foreign bodies and persistent bacteria, with the presence of persistent bacteria being the most common cause of chronic inflammation that interferes with wound healing.

3. **Proliferation Phase: Granulation and Contraction[25]**
   The proliferation phase starts approximately four days after wounding and usually lasts until day 21 in acute wounds, depending on the size of the wound. It is characterized by angiogenesis, collagen deposition, granulation tissue formation, wound contraction and epithelialization. Clinically, proliferation is observed by the presence of pebbled red tissue, or collagen, in the wound base and involves replacement of dermal tissues (sometimes subdermal tissues in deeper wounds), as well as contraction of the wound. In the wound healing/house repair analogy, once the site has been cleared of debris, under the direction of the contractor, the framers move in to rebuild the framework of the house. Subcontractors can now install new plumbing and wiring on the framework, and siders and roofers can finish the exterior of the house.

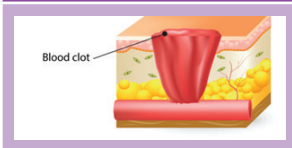
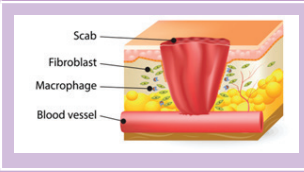
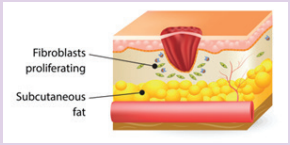
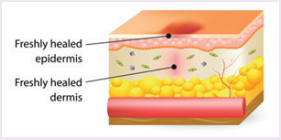
   The "framer" cells are the fibroblasts, which secrete the collagen framework on which further dermal regeneration occurs. Specialized fibroblasts are responsible for wound contraction. Angiogenesis, the process of development of new blood vessels, occurs via pericytes, the "plumber" cells that regenerate the outer layers of capillaries and endothelial cells that produce the lining.[27] The "roofer" and "sider" cells are the keratinocytes. They are responsible for epithelialization. In the final stage of epithelialization, contracture occurs as the keratinocytes differentiate to form the protective outer layer, or stratum corneum. Just as with building a new house, a sound infrastructure must be in place before the finishing components can be added, and the environment must be favourable for the finishing touches to be completed. The wound bed must fill in from the bottom up with collagen and must be maintained in an optimal environment (appropriate moisture balance) before the epithelial cells will begin to proliferate and migrate across the wound's surface to close the wound. Epithelial cells migrate based on contact inhibition, meaning they spread in only one layer and only where they are in contact with each other and the collagen framework of the granulating wound bed.

   In a healing wound, growth factors cause cells to divide to produce new cells, and cytokines cause these cells to migrate to where they are needed. A balance between the MMPs and TIMPs results in a net production of new tissue. In contrast, in chronic wounds that are stalled with suppressed cell division and migration, high levels of inflammatory cytokines and MMPs and low levels of TIMPs and growth factors inhibit new cell development. In this environment cells are often senescent and unresponsive to the growth factors. This chronic inflammatory state may be caused by increased bacterial burden, presence of devitalized tissue, chronic ischemia or repetitive trauma, which must be addressed in order for the wound to progress to healing.

4. **Remodeling Phase: Maturation[25]**
   Once the basic structure of the house is completed, interior finishing may begin. Similarly, in wound repair, the healing process involves the remodeling and realignment of collagen. Collagen type III is initially produced by the fibroblasts. This is later replaced by type I collagen. With time, the fibres cross-link and align along tension lines to increase the tensile strength of the wound. A subgroup of fibroblasts called myofibroblasts also assists in wound shrinkage.[28] Tensile strength will not be more than 70 – 80% of what it was before the injury occurred.[29] In addition, cell and capillary density decreases following the presence of a wound. In the acute epithelialization phase, thin layers of scar tissue form and thicken over time. Initially scar tissue is deep pink in colour. This changes to bright pink, regardless of normal skin pigmentation. In the chronic epithelialization phase, scar tissue may be hypertrophic, keloid or hyperkeratotic. In the absence of epithelialization, weak scar tissue may be friable, break or wash out. The main cells involved in remodeling are the fibroblasts. The process of remodeling can take up to two years after wounding. This is why closed wounds can break down so dramatically and quickly if attention is not paid to the initial causative factors.

Normal wound healing is depicted in Figure 4. The process flows through the above stages with overlap between.

Figure 4: Phases of Normal Wound Healing

Day 0	Day 1-4 Inflammation Hemostasis	Day 5-21 Closure	Up to 2 years Healed
			
Example: Community based patient with basal cell left arm (95-year-old female)			
Pre-op	Day# 4	Day# 15	Week 3
			

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Defining the Wound Repair Process

Not all wounds heal in a timely fashion and clinicians need to determine why.

Acute wounds heal in a normal, orderly sequence of repair as described above. This usually occurs because the cause and co-factors that affect healing have been removed and an optimum environment for healing has been created. Time to closure and wound healing also depends the size and depth of the wound Chronic wounds are wounds that have failed to progress through a normal, orderly and timely sequence of repair due to incomplete resolution of factors and co-factors that interfere with healing. These wounds may eventually pass through the repair process without restoring sustained anatomical and functional results.

Chronic wounds can further be identified as non-healing or non-healable:

- Non-healing wounds are wounds that have failed to heal due to factors and co-factors that have not been resolved and interfere with healing. These wounds MAY never heal
- Non-healable wounds are wounds that have failed to heal due to factors and co-factors that cannot be resolved and interfere with healing. These wounds WILL never heal.

Summary

For health-care professionals, knowledge of the anatomy and physiology of skin and the healing process is essential to prevent, assess, treat and manage acute and chronic wounds effectively.

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Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 4

Prevention and Management of Wounds: An Overview

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INTRODUCTION

Skin health can be challenging, particularly when the individual is living with complicating factors that may increase their risk of skin breakdown or the development of wounds. However, by using the following three guiding principles, health-care professionals can support optimal skin health and the prevention and management of skin breakdown:

1. the use of a logical and systematic approach to prevent and manage skin breakdown
2. the application of a constant, accurate and multidirectional flow of meaningful information within the team and across care settings, and
3. the affirmation of the patient as the core of all decision making.

Wounds Canada uses an integrated team care model of care. Assessing, screening, care planning, care delivery and self-management are essential elements that need to be considered to address the beliefs, values, traditions and biases of health systems, care providers, patients, families and communities, all of which influence delivery of high-quality care.

This document is written with the intent to encompass the quintuple aim for health care improvement. This is to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity. This equity piece is particularly important for patients living with skin health and wounds (See Table 1). Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[1]

Table 1: Quintuple Aim

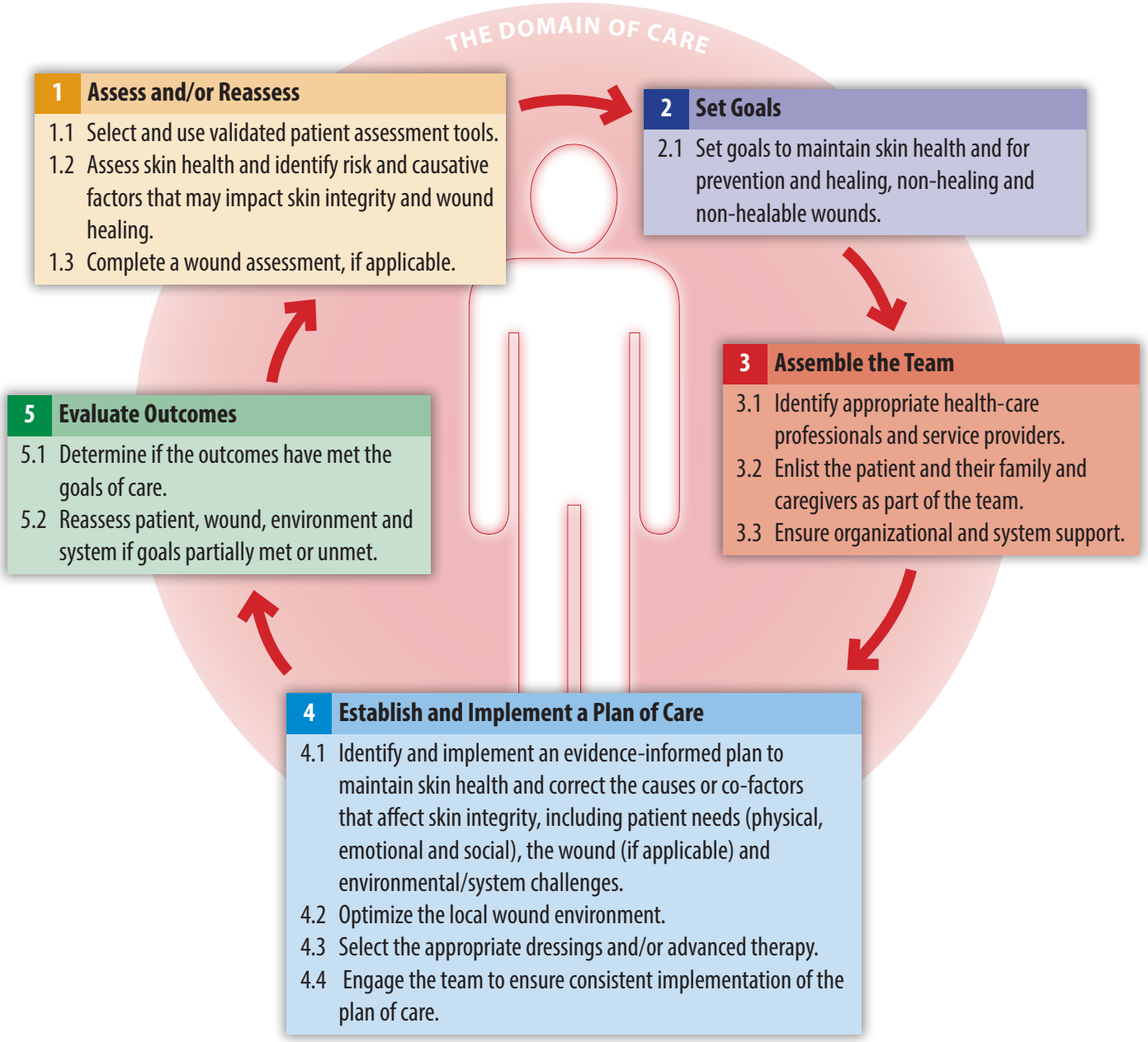
5 components	Applied to Skin Health and Wound Prevention and Management
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practice to ensure most effective treatment. Appropriate use of resources-examples skin health products, dressings, pressure redistribution surfaces, devices
Advancing health equity	Application of principles to all those at risk for or affected by skin changes and wounds
Care team wellbeing	Providing clinically usable information for frontline clinicians
Enhancing the patient experience	Providing a supportive process of care for all those with skin and wound issues

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter outlines a process—or series of consecutive steps—that supports the individual as part of the integrated team. These steps are organized into a methodical framework called the Wound Prevention and Management Cycle (See Figure 1), which aims to guide the clinician through a logical and systematic method for developing a customized plan for skin health and the prevention and management of wounds. This cycle enables the team to move from the initial screening and assessment, to goal setting, to developing and implementing a sustainable management plan and, finally, to identifying successes and areas for improvement.

In the event the plan of care fails to meet the needs of the individual, the team returns to step one and reassesses and modifies the plan as required.

Figure 1: The Wound Prevention and Management Cycle



Health-care professionals must recognize that many internal and external stressors can affect the promotion of skin health and the prevention and healing of wounds. Effective use of the Wound Prevention and Management Cycle will take all factors into account and will result in a more complete, person-focused, sustainable process. Personal health, the environment and the context in which individuals live all impact skin integrity and wound healing. Available local and regional resources also contribute to skin health and wound healing. Ultimately, the body must heal itself, so the purpose of the health-care team is to optimize the body's ability to prevent or heal a wound.

Screening and assessments must identify risk and all relevant factors, while interventions must acknowledge and align with a person's culture, beliefs and values. This approach, which treats people as experts in their own lives, assists in the development of attainable goals of care and supports self-management across the person's continuum of care.

This chapter outlines general principles that apply to all types of wounds. The chapters that follow contain best practice recommendations for specific wound-related etiologies, with details relevant to each of those wound types.

The recommendations are based on the best available evidence and are intended to support the health team in planning and delivering the best clinical practices. They are organized using the same format as this chapter, which is based on the steps from the Wound Prevention and Management Cycle, allowing readers to become familiar with the process regardless of wound type.

Step 1: Assess and/or Reassess

Assessment is an in-depth evaluation of the individual's health issue(s) and current presentation. Assessment occurs, in part, to determine any risks, causes or co-factors that may impact skin integrity and wound healing. Patient assessment includes history and current health status (physical, emotional); skin status (and wound, if applicable); environmental factors, such as socio-economic status, culture, lifestyle, spirituality, family status; care setting; access to services and system factors, such as government policies, supports and programs. Screening for risk, though often grouped together with assessment, includes specific processes. For example, clinicians screen for risk of pressure injuries, or risk of diabetic foot ulceration.

Reassessment can take place at any time, but *must* take place once all the steps in the Wound Prevention and Management Cycle have been completed. This may occur many times up to and including the individual's discharge from care.

Discussion: Assessment is the foundation for care planning and is most effective when:

- cultural and ethnic considerations, which may impact assessment and planning of care, are assessed, acknowledged and incorporated[2,3]
- standardized admission protocols and comprehensive screening and assessment tools are used by clinicians, patients and their care partners
- patients are encouraged not only to be the object of these screens or assessments, but also to become active participants in the process.

Maintenance of healthy skin in health-care settings has become an Accreditation Canada quality-of-care indicator.[4] A standard for early screening and identification of those at risk for skin breakdown to support prevention is now required for most health-care settings. Clinicians must be aware of the individualized risk factors (physical, psychosocial, spiritual, environmental, cultural and systemic) that can lead to skin breakdown or interfere with healing should breakdown occur.[5,6]

The term *care partner* in this document refers to a person who supports an individual in their direct care or any aspect of their life. The care partner may be a family member, community member, or a person from the patient's spiritual care/faith-based community, a neighbour or close friend.[7]

NOTE: All skin and wound assessments must be documented based on institutional/agency policies and procedures. If it is not documented, the assessment is not considered delivered.

A Holistic Assessment

'Listen, look, then touch' provides a holistic assessment approach that is used by health-care providers. A contextual interpretation of the assessment that is grounded in communication principles is important to establish a relationship of trust and inclusivity.

Listen

Health-care providers must **listen** and give the patient and/or their care partner time to tell their story. This helps to identify what promotes their skin health or puts them at risk of skin breakdown and for wounds. They can describe what works to maintain healthy skin, what they feel may put them at risk for skin injury, how their wound started, evolved and what has made it better and worse.

Providers should always listen to the patient's perception of what is happening and how it is affecting their quality of life. Trauma-informed approaches, including realizing the impact of trauma and paths for healing and recognizing signs and symptoms, are useful and should become part of every care provider's skill set. Leaders need to develop policy and procedures and educational opportunities to support knowledge integration into practice. Together, these principles, when applied, improve patient engagement, build trust and, thereby, potentially improve patient health outcomes.[8]

Important information the clinician needs to gather in the assessment includes:

- Overall health: changes in height or weight, new or existing comorbidities (short or long-term), as well as family history
- Medication and drug history and known allergies and sensitivities
- Lifestyle factors such as smoking, use of substances, level of physical activity, high-risk activities and choices, topical medications and skin care products
- Level of physical function: mobility, gait, fatigue, eyesight, hearing, activities of daily living, use of assistive devices (and funding support, if applicable)
- Housing security and income to meet needs
- Nutritional factors: appetite, hydration, food security, cultural preferences, functional barriers to eating and swallowing (See Appendix A: Nutrition for Skin Health, Wound Prevention and Wound Healing)
- Spiritual factors, including supports such as a community group, faith-leader, spiritual leader and related activities[9]
- Psychological factors such as stress, anxiety and depression, diabetes-distress and pain—which are all associated with delayed wound healing[10]
- Experience with racism, sexism, agism or other types of discrimination (systemic, individual)
- Psychosocial factors, including motivation of the patient/family/care partners; social supports and coping mechanisms; culture and traditions; past adherence to treatment modalities; behavioural conditions affecting ability to participate in self-care
- Ability to participate in decision-making, understand, retain and utilize health information and instructions.

Look

What should a health-care provider **see** when looking at a patient and their environment? Observation begins as soon as you see the patient and/or family members in order to identify any visual cues of concern. An overall impression of a patient can reveal a lot about them; body language (posture, gait), facial affect (eye contact, or lack of eye contact), style of interaction with family members or care partners, demeanour and technologies used all contain vital clues about the patient's physical condition, state of mind, social supports and environment in which they live.

Only after interacting with the person, interpreting their non-verbal cues and doing the holistic patient assessment can the clinician move on to complete a full skin assessment. A skin assessment—including appendages—requires observation from head to toe.[11] The clinician should:

- Assess skin, skin folds and mucous membranes for colour, moisture, temperature, texture, mobility, turgor, lesions and potential yeast or bacterial infection[12]
- Inspect for bruising and altered or broken skin, which could indicate bleeding disorders, trauma, injury, pressure injuries
- Check for red, shiny skin on the lower legs that blanches with elevation, which could indicate insufficient peripheral arterial flow (PAD) and/or hypo-perfusion
- Assess for lower leg edema as it can impair healing and may be signs of a venous and/or lymphatic disorder
- Check nails for thickness, splitting, discolouration, breaking, separation (fungus)
- Assess hair for distribution and condition and the scalp for lesions and infestation
- Check for perineal/perianal inflammation, rash, redness, pain, itching that could be indicative of incontinence (urine/ fecal, both)
- Assess for signs of pressure, friction, shear that could be damaging to skin integrity
- Assess feet for redness that could be signs of rubbing or irritation.

Once observed, skin trauma findings should be discussed with the patient to identify reasons for the injury. Particular care should be taken in patients with, or suspected of, impaired sensation related to either central or peripheral nerve function or that induced by medication, disease or underlying illness. Extreme sensitivity should be exercised if physical abuse is suspected.

Touch

Not everything can be seen or heard with the patient, so strategies that involve clinician contact or blood work may need to be considered. Ask permission and maintain the patient's privacy to promote comfort and minimize embarrassment.

Note: A fear of being touched during a health assessment could indicate anything from the presence of pain, previous negative health-care experiences, traumatic events and/or adverse childhood events (ACEs) or historical and cultural trauma.[13] These are important for the clinician to understand in order to optimize care.[14,15]

The clinician should be aware that:

- Limbs that are cool to touch or pulses that are difficult to feel may be indicators of vascular compromise and require a more complete arterial assessment
- Lower leg pitting or non-pitting edema may require a duplex ultrasound to assess for venous reflux and lymphatic compromise. Note: Edema can be multifactorial and other health-related causes may need to be considered, such as congestive heart failure.[16]

Nutritional status may include lab investigations, for example:

- Albumin levels below 30 g/L put skin at risk for trauma, and albumin below 20 g/L puts wound healing at risk. Both require a screen for nutritional status to determine albumin levels[17]
- Hemoglobin levels below 100g/L (anemia) can cause delayed wound healing. Levels below 70 to 80g/L may lead to very hard-to-heal or non-healing wounds.[17]

Recommendations

1.1 Select and use validated patient screening and/or assessment tools

Discussion: The use of validated* tools provides a standardized process for the screening and assessment of patients and supports effective communication within the team, ensuring all factors and co-factors are addressed. **Screening tools** discriminate between individuals on the basis of parameters that are designed to screen the person to predict the likelihood or risk of future development of an outcome (such as a pressure injury or diabetic foot ulcer). **Assessment tools** are designed to measure the amount of change that occurs over time (such as assessment of skin health or wound healing).[6]

The validated tools used in each facility/agency should become policy, part of staff orientation/education and be used in all subsequent screenings or assessments for ongoing comparison. The use of validated and standardized patient screening and risk assessment tools is essential for not only identifying risk for altered skin integrity and providing common communication terms but also for providing a template for preventative screening, care or management. Greatex-White and Moxey, in their investigation of 14 wound assessment tools, stated that even though a tool has benefit(s), it cannot be a substitute for clinical knowledge and expertise, and outcomes must be considered based on the clinical situation and contents of care.[18]

*For more on the definition of *validated* in relationship to assessment tools, please read "Clinimetrics and Wound Science" (Flahr et al., in Wound Care Canada starting on page 18) at:
https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/2005-vol-3-no-2/612-vol3no2full/file.

1.2 Identify risk and causative factors that may impact skin integrity and wound healing

Discussion: The multifactorial nature of physical, psychosocial and environmental factors that affect skin integrity and wound healing requires health-care providers to build trust-filled relationships and focus on communication (written,

verbal, in person, through technology,) with strong interpersonal skills in order to identify various elements that may impact their patients. Ideally, clinicians need to recognize the key risk factors that may either lead to or cause skin breakdown so that prevention strategies become the priority, rather than waiting until skin breakdown has occurred and wound management strategies are required.

Examples of tools to screen and identify the risk for skin breakdown include:

- Braden Scale for Predicting Pressure Sore Risk has undergone rigorous evaluation and meets the standards outlined above.[19] Braden Scale: www.bradenscale.com/
- Inlow's 60-second Diabetic Foot Screen has undergone rigorous evaluation and meets the standards outlined above.[20,21,23] Inlow's Screen: https://www.woundscanada.ca/docman/public/2642-2022-wc-inlow-foot-ulcer-screen-tool-1101r6e-copy-nov4/file (pdf fillable)
- Waterlow Scale has demonstrated poor inter-rater reliability, high sensitivity and low-specificity levels.[20]
- Waterlow Scale: https://scireproject.com/wp-content/uploads/2022/04/worksheet_waterlow_pressure_risk_assessment_scale.pdf

Examples of tools to screen for risk of pediatric and neonatal skin breakdown include:

- Braden Q:[24] http://www.marthaaqcurley.com/uploads/8/9/8/6/8986925/braden_q_scale.pdf
- Glamorgan Scale:[25] https://media.starship.org.nz/glamorgan-scoring/Glamorgan_Scoring.pdf
- Neonatal Skin Risk Assessment tool (NSRA):[26] https://media.starship.org.nz/nsra-neonatal-skin-risk-assessment-tool/NSRA_Neonatal_Skin_Risk_Assessment_Tool.pdf

1.2.1 Patient: Physical, emotional and lifestyle

Discussion: As discussed above, assessments begin with a systematic and detailed history of the patient's general health and specific issues related to the skin condition from the patient, care partner and/or previous medical records. Patient co-morbidities that increase the risk for skin breakdown, interfere with healing and/or impair immunity should be identified.[27] These include, among others, diabetes mellitus, advanced age, peripheral arterial disease (PAD), obesity, collagen vascular diseases (lupus, scleroderma, dermatomyositis), organ transplants, cancer, hormone therapy, chemotherapy and therapeutic radiation.[28]

Pain

A systematic approach is required to assess the factors that are causing or exacerbating pain.[29] A standard pain assessment should be considered before and after physical activities and other aspects of patient care, medication or treatment.[30] There are two types of pain: **nociceptive** (an appropriate physiological response to painful stimuli, either acute or chronic) and **neuropathic** (an inappropriate response caused by a primary lesion or dysfunction in the nervous system). Pain is often associated with local wound-related factors such as dressing changes, debridement, infection and lack of moisture balance. At dressing changes, pain can be caused by the dressing material or sticking to the wound base.[31,32]



Psychosocial factors such as age, sex, culture and traditions, anxiety and depression, as well as environmental factors such as availability of resources and the setting and timing of a procedure can all affect the patient's unique pain experience. Describing pain and monitoring the impact of management strategies for pain control begins by listening to how the patient describes the pain. When wounds are present, pain is consistently reported by patients as one of the worst aspects, and it often has a significant impact on their quality of life.[33] Chronic, persistent pain between dressing changes, even

at rest, also occurs. This type of pain can be precipitated by periwound,[34] contact-irritant skin damage from enzyme-rich wound exudates or infection/inflammation. Pain may also be termed *ischemic pain* and be related to poor perfusion.[35]As well, the impact of pain and related stress delays the wound healing.[17,36]

Some older adults live with numerous complicating factors such as sensory deficits and cognitive impairments, so when assessing pain in the older adult population, simply worded questions and visual tools that can be easily understood may be the best approach. The use of open-ended questions will provide a clearer understanding of the person's pain experience. Instead of asking, "Do you have pain?" a better approach might be, "Can you please describe your pain." Subjective tools such as the Visual Analogue Scales (VAS) and the Faces Scale are highly effective for this population and for those with language and cultural barriers.

Young children benefit from the use of the Faces, Legs, Activity, Cry and Consolability (FLACC*)* pain scale, which is completed through visual and behavioural assessment by the clinician.

For First Nations Elders, youth, children and parents (n=188), pain and hurt experiences were explored in a community based study. "Participants describe experiencing pain and hurt in all four dimensions of health and from a historical, cultural, and spiritual identity, as well as from a community, family, and individual perspective. The FIRST approach captures Indigenous knowledge relating to Family, Information, Relationship, Safe-Space, and Two-Eyed treatment in the health-care encounter."[37]

Examples of pain assessment tools include:

- The Visual Analogue Scale (VAS): https://www.physio-pedia.com/Numeric_Pain_Rating_Scale
- Numeric Rating Scale (NRS): https://www.sralab.org/sites/default/files/2017-07/Numeric%20Pain%20Rating%20Scale%20Instructions.pdf
- Verbal Rating Scale (VRS): www.jpsmjournal.com/article/S0885-3924(11)000145/abstract
- McGill Pain Questionnaire (PRQ): https://www.physio-pedia.com/McGill_Pain_Questionnaire
- Faces, Legs, Activity, Cry and Consolability (FLACC): https://www.dshs.wa.gov/sites/default/files/ALTSA/stakeholders/documents/duals/toolkit/forms/Pain%20Scale%20FLACC.pdf
- Faces Pain Scale-Revised (FPS-R): https://www.ncbi.nlm.nih.gov/books/NBK269606/figure/practicesheets.f17/
- NOPPAIN: http://prc.coh.org/PainNOA/NOPPAIN_Tool.pdf
- Pain diary (e.g., Toronto Academic Pain Medicine Institute): https://tapmipain.ca/TAB%203-%20Reflective%20Practices.pdf
- Wong-Baker FACES Scale: https://wongbakerfaces.org/wp-content/uploads/2016/05/FACES_English_Blue_w-instructions.pdf

A pain scale tool is also available for neonates: https://www.uwhealth.org/healthfacts/parenting/7711.pdf.

Changes in pain levels may indicate a need to reassess the choice and timing of analgesics and/or other interventions used in pain management.[38] Pain can also be anticipatory and can lead to anxiety, especially in children.[38]

Quality of Life

Quality of life (QoL) refers to all aspects of patients' lives, including where they live, how they live, how they work and how they play. It encompasses life factors such as family circumstances, food security, culture, finances, spiritual/religious activities, housing, job and employment opportunities and satisfaction. Health-related quality of life (HRQoL) usually refers to aspects of patients' lives that are dominated or significantly influenced by mental or physical wellbeing.[39] Examples of tools to assess quality of life (QoL) and health-related quality of life (HRQoL) include:

- The Cardiff Wound Impact Schedule[40] is a validated questionnaire that measures the impact of chronic wounds (leg ulcers and diabetic foot ulcers) on patient HRQoL and identifies areas of patient concern. Cardiff Schedule: www.ncbi.nlm.nih.gov/pubmed/16722893
- The Wound-QoL is a tool to assess quality of life in those with chronic wounds.[41] Wound-QoL: www.ncbi.nlm.nih.gov/pubmed/24899053

- The Freiburg Life Quality Assessment is a wound module to measure disease-specific, health-related quality of life parameters in patients with chronic wounds.[42] Freiburg Assessment: www.ncbi.nlm.nih.gov/pubmed/15197001
- Würzburg Wound Score (WWS).[43]

Nutrition

Nutritional support plays a vital role in the prevention and management of wounds. Without adequate nutritional intake, the body is unable to maintain tissue integrity, repair damaged tissue or mount an offence against microbial invasion and infection.[44,45,46]

Please see Appendix A: Nutrition for Skin Health, Wound Prevention and Wound Healing for more detailed information on nutrition in skin health and wound healing.

Examples of nutritional screening tools include:

- The Canadian Nutrition Screening Tool is a simple two-question screen with good sensitivity and specificity to predict adverse outcomes.[47,48] https://nutritioncareincanada.ca/resources-and-tools/hospital-care-inpac/screening
- Link to Professional Guide for nutritional screening tools that are population specific. *Wounds Canada: Nutrition:* https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/nutrition

1.2.2 Environmental: Socio-economic, care setting, potential for self-management

Discussion: An environmental assessment is imperative to determine if the patient and/or family has socio-economic support to meet any goals of care that will be set. Determinants that should be assessed include:[50]

- Income and social status
- Employment and working conditions
- Education and literacy
- Childhood experiences (Adverse Childhood Events-ACEs)
- Physical environments
- Social supports and coping skills
- Healthy behaviours
- Access to health services
- Biology and genetic endowment
- Gender
- Culture
- Race/Racism.

Persons or families with very low total incomes often lack resources and consistent access to nutritious food, adequate housing and safe physical environments such as accessible walking paths with adequate lighting. Any of these factors can negatively impact skin health and wound healing. Financial and life stress can have health consequences such as high blood pressure and immune and circulatory complications.

In general, those with adequate incomes and employment are likely to have better health outcomes, particularly if they feel they have control and influence over decision-making in the home, at work and in social settings and when intersecting with the health-care system. Increased exposure to stress (experiencing distress), as well as a lack of resources, coping strategies, skills, social support and trust-filled connection to the community can contribute to poor health and potentially harmful coping skills, such as smoking, over-consumption of alcohol and unhealthy eating habits.

1.2.3 Systems: Health care support and communication

Discussion: The collective health of Canadians has a significant impact on economic performance and the health-care system. Systems assessment considers access to funding, availability of services and skin and wound-related products, diagnostic services, service delivery personnel and co-ordination of care, all of which vary considerably from one province/territory to another and from region to region, or even one service delivery site to another (for example, from acute care to home care). Therefore, standards relating to assessment and care need to be based on available regional resources. For example, negative pressure wound therapy or government-provided special dietary allowances might not be available in all regions or all sectors of care.

1.3 Complete a wound assessment, if applicable

Discussion: The occurrence of a skin condition or wound is considered an incident and should be reported and recorded in compliance with institutional/agency policy.

There are many components of wound assessment and many validated and standardized assessment tools available. Using the tools sanctioned by your facility/agency, assess the wound to determine the impact of trauma, wound size (length, width, depth), presence of any foreign bodies and quality of the wound bed. A complete wound assessment should also include: edges, undermining, tunnelling, induration, exudate (amount, type, colour), peripheral edema, periwound skin, odour, wound pain and tissue type: granular, slough, necrotic. The degree of skin trauma or injury is usually described by the depth of the injury, however, bruising, induration, bogginess and changes to skin turgor can indicate deep tissue damage without a break in the skin.[51,52]

Examples of wound assessment tools include:

- Bates-Jensen Wound Assessment Tool (BWAT) formerly known as the Pressure Sore Status Tool (PSST).[53,54] https://www.woundscanada.ca/docman/public/health-care-professional/1428-bwat/file
- The Leg Ulcer Measurement Tool (LUMT):[55] http://pda.rnao.ca/sites/pda/files/images/legulcrmesr.pdf
- Pressure Ulcer Scale for Healing (PUSH) tool has been validated for use in all wound types:[56] https://bpgmobile.rnao.ca/sites/default/files/Pressure%20Ulcer%20Scale%20for%20Healing%20%28PUSH%29%20Tool%203.0.pdf
- The Photographic Wound Assessment Tool (PWAT) has been found to be very responsive to change and can be used as a bedside tool as well as to assign a score to a photograph of a wound.[57] www.southwesthealthline.ca/healthlibrary_docs/B.9.3c.PWATResources.pdf

Assessments may be quantified and qualified based on the tool used. It is important to ensure that it is the wound being assessed and not the dressing debris.[58,59]

The Applied Wound Management tool categorizes most wounds healing by secondary intention using three different continuums[60]

- Wound Healing Continuum (WHC): is represented by the tissues in the wound and is a colour-based continuum
- Wound Infection Continuum (WIC): is subdivided into named stages representing varying host responses to bioburden, each identified by clinical clues
- Wound Exudate Continuum (WEC): is represented by volume and consistency parameters, and each can be graded according to a 'matrix' continuum.

The National Wound Assessment Form[61] is designed to be used with digital pen technology with tick boxes. It includes a body map for quick visual location of the wound and easy numerical identification if more than one wound is present. Wound assessment data categories include:

- Date of assessment
- Wound number (if more than one wound present)
- Has the wound been traced?

- Type of wound
- Duration of the wound
- Tissue type and percentage
- Clinical signs of infection, eight indicators of infection
- Swab sent and result
- Wound moisture levels
- Surrounding skin condition
- Wound pain (level and frequency)
- Wound odour
- Current status of the wound (deteriorating, static, improving, healed)
- Treatment objectives.

The MEASURE[53] mnemonic (See box) may be useful, but it is important to note that not all mnemonics translate well in a multilingual environment and that MEASURE is not a standardized tool. Completing a wound assessment using a common, validated tool such as one of the examples below, creates a visual indication for clinicians and patients of wound healing, stalling or deterioration that can prompt a change in the plan of care.

The **MEASURE** mnemonic provides a trigger to assist the clinician when completing a wound assessment. It addresses:

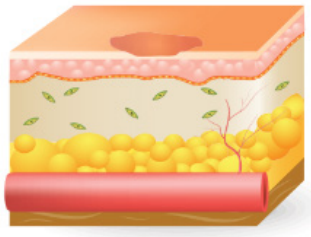
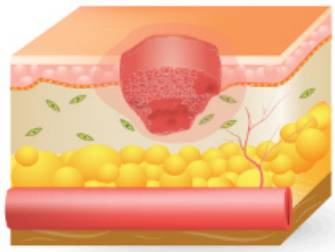
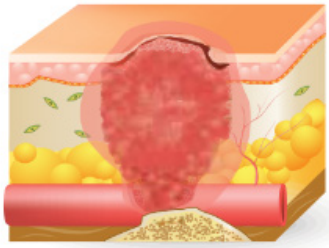
Measure (length, width, depth and area)
Exudate (quantity and quality)
Appearance (wound bed, including tissue type and amount)
Suffering (pain type and level)
Undermining (presence or absence)
Re-evaluate (monitoring of all parameters regularly)
Edge (condition of edge and surrounding skin).

A healing wound typically has granular tissue that is pale pink to beefy red, is glistening and has a rough surface due to blood vessels and collagen deposits. Often there is yellow tissue in the wound, which can be confusing to the clinician and can impact intervention decisions. Yellow tissue that is stringy and non-adherent to the wound bed may be slough (non-viable tissue), while firmly attached yellow tissue may be fibrinous tissue and a precursor to granular tissue, which indicates normal healing.[54] Eschar is the hardened or soft black crust of necrotic tissue that may form over the wound and may interfere with healing and may be a source for bacterial growth. Chapter 3: Skin: Anatomy, Physiology and Wound Healing discusses the phases of normal wound healing in detail.

Note: Pressure injuries, diabetic foot ulcers, surgical wounds, burns and skin tears employ specific wound staging, categorization or classification systems to describe injury. See the specific chapters on these subjects for discussions on these systems.

Once a comprehensive assessment has been completed the wound depth can be determined. Tissue depth will have an impact on care planning (See Table 2).

Table 2: Depth of Injury

Superficial thickness	 Superficial thickness	Superficial-thickness skin loss involves only the epidermis and may present as an abrasion or blister
Partial thickness	 Partial thickness	Partial-thickness skin loss involves the epidermis or dermis (or both) and may present as a shallow crater
Full thickness	 Full thickness	Full-thickness skin loss is the result of extensive destruction, tissue necrosis or damage to deep underlying structures such as muscle, tendon or bone. It may present as a deep crater and may tunnel into surrounding subcutaneous tissue

Assessing Bacterial Balance[60]

The International Wound Infection Institute (IWII)[60] is a group of international wound leaders, including Canadians, who have developed tools that enable clinicians to assess and treat infection in both acute and wounds of long duration. The IWII details categories of bacterial burden and their activities in a continuum of bacterial invasion, from contamination to systemic infection (See Table 3). Since bacteria are normally found on skin and in wounds they may or may not cause problems for the patient, depending on a number of factors and conditions.[61,62] The IWII provides tools to assess for risk of wound infection and wound infection assessment.

Examples of tools to assess *risk* of wound infection include:

- International Wound Infection Institute (2022). Eight tools are listed for consideration depending on wound type, risk variables, and predictive power: https://woundinfection-institute.com/wp-content/uploads/IWII-CD-2022-web-1.pdf

Examples of wound infection assessment tools:

- International Wound Infection Institute (2022). Eight tools are listed for consideration depending on wound type, description, and psychometric testing: https://woundinfection-institute.com/wp-content/uploads/IWII-CD-2022-web-1.pdf

Table 3: Categories of Bacterial Burden[60]

Contamination	*Contamination* is used to refer to a stage in which there is presence within the wound of micro-organisms that are presumed not to be proliferating. No significant host reaction is evoked and no delay in wound healing is clinically observed. In a contaminated wound, the host defences destroy micro-organisms through a process called phagocytosis
Colonization	• *Colonization* is used to refer to a stage in which the presence of micro-organisms within the wound that are presumed to be undergoing limited proliferation. In a colonized wound, no significant host reaction is evoked, and no delay in wound healing is clinically observed. • Due to the protective function of the skin microbiome, all open wounds are colonized with micro-organisms at the time of skin breakdown, but at this stage the virulence appears to be low • Micro-organisms that colonize a wound may also arise from exogenous sources or as a result of environmental exposure
Local Infection (Covert and Overt)	*Local infection* is used to refer to a stage of infection in which there is presence and proliferation of micro-organisms within the wound that evoke a response from the host, often including a delay in wound healing. Local infection is contained within the wound and the immediate periwound region (less than 2cm) • Local infection is divided into covert (subtle) that may progress to overt, or classic, signs and symptoms that are more recognizable. (See Table 3 for signs and symptoms)
Spreading infection	• *Spreading infection* (also referred to as cellulitis) describes the stage of infection in which there is invasion of the surrounding tissue by infective micro-organisms that have spread from a wound • Micro-organisms proliferate and spread to a degree that signs and symptoms extend beyond the wound border. Spreading infection may involve deep tissue, muscle, fascia, organs or body cavities. (See Table 4 for signs and symptoms)
Systemic infection	*Systemic infection* refers to the stage of infection in which micro-organisms spread throughout the body via the vascular or lymphatic systems, evoking a host response that affects the body as a whole. In the context of wound infection, micro-organisms spread from a locally infected wound. Systemic inflammatory response can also be triggered by a local wound infection through other pathways, for example release of toxins or a dysregulated immune system. (See Table 4 for signs and symptoms)

Used with permission of the International Wound Infection Institute (2022).

The bacterial burden of a wound can be assessed and a diagnosis of infection can be made using a variety of methods: clinical observations, laboratory testing (wound culture and susceptibility and/or blood cultures) and, occasionally, radiological assessment.[60] The classic signs of wound infection are often absent (covert) in wounds of long duration, so it is up to the clinician to evaluate other clinical signs (See Table 4) along with risk factors specific to the patient to fully evaluate for infection. Wound deterioration or failure to progress toward healing can also be indicators of potential wound infection and should always be considered clear signs that further investigation is warranted.[60]

Table 4: Stages of the Wound Infection Continuum[60]

Note: Microbial burden increases from contamination to systemic infection[60]

Contamination	Colonization	Local Infection		Spreading Infection	Systemic Infection
		Covert (subtle) signs of local infection:	Overt (classic) signs of local infection:		
All wounds may acquire micro-organisms. If suitable nutritive and physical conditions are not available for each microbial species, or if they are not able to successfully evade host defences, they will not multiply or persist; their presence is therefore only transient and wound healing is not delayed	Microbial species successfully grow and divide but do not cause damage to the host or initiate wound infection No delay in wound healing is clinically observed	Hypergranulation (excessive vascular tissue) Bleeding, friable granulation Epithelial bridging and pocketing in granulation tissue Increasing exudate Delayed wound healing beyond expectations	Erythema Local warmth Swelling Purulent discharge Wound breakdown and engagement New or increasing pain Increasing malodour	Extending induration Spreading erythema Inflammation or erythema (greater than 2 cm) from wound edge Crepitus Wound breakdown/ dehiscence with or without satellite lesions Lymphangitis (swelling of lymph glands)	Malaise, lethargy or non-specific general deterioration Loss of appetite Fever/pyrexia Severe sepsis Septic shock Organ failure Death

Used with permission of the International Wound Infection Institute.[60]

The host's resistance to the bacteria is the single most important determinant of a wound moving from the states of contaminated, colonized to local, spreading and systemic infection. Pain should be assessed regularly in conjunction with infection since an increase and or change in pain can be a warning sign of wound deterioration and may indicate the presence of infection.[60] Wounds of long duration are often polymicrobial (more than one infective agent), especially in patients with diabetes, making management challenging.[63,64] The unique health status of each patient is also a factor for infection risk and impact (See Table 5). Patients with serious compromises or multiple factors will be at higher risk for the presence and higher levels of infection.

Factors Associated with Increased Risk of Wound Infection

Characteristics of an individual with increased risk of wound infection include poorly controlled diabetes, prior surgery, radiation therapy or chemotherapy, conditions associated with hypoxia and/or poor tissue perfusion such as anemia, cardiac or respiratory disease, arterial or vascular disease, renal impairment, immune system disorders (e.g., rheumatoid arthritis, acquired immune deficiency syndrome), malignancy, shock, inappropriate antibiotic prophylaxis, particularly in acute wounding protein-energy malnutrition, alcohol, smoking and substance use.[60] Finally, Upton (2020) states the mechanism of malnutrition may be attributed to complex factors such as physiological, psychological, social, educational and economics (See Table 5).[65]

Table 5: Factors Associated with Increased Risk of Wound Infection[60]

Characteristics of the Individual (host)
• Poorly controlled diabetes mellitus (DM) (hyperglycemia) • Peripheral neuropathy (sensory, motor, and autonomic) • Neuroarthropathy • Prior surgery • Radiation therapy or chemotherapy • Conditions associated with hypoxia and/or poor tissue perfusion (e.g., anemia, cardiac or respiratory disease, peripheral arterial disease (PAD), renal impairment, shock) • Immune system disorders (e.g., rheumatoid arthritis, acquired immune deficiency syndrome) • Malignancy • Connective tissue disorders (e.g., Ehlers-Danlos syndrome) • Corticosteroid use • Inappropriate antibiotic prophylaxis, particularly in acute wounding • Malnutrition and obesity • Alcohol, smoking and substance (illicit) drug use • Poor engagement or participation in the treatment plan
Wound Risk Factors
• Contaminated or dirty wounds • Traumatic injuries with delayed treatment • Operation is classified as contaminated or dirty • Inappropriate hair removal • Operative factors (e.g., prolonged surgery, blood transfusion or hypothermia) • Duration of wound (degree of chronicity) • Large wounds • Anatomically located near a site of potential contamination (e.g., perineum or sacrum) • Foreign body (e.g., drains, sutures or wound dressing fragments) • Hematoma • Necrotic and sloughy wound tissue • Impaired tissue perfusion • Increased exudate or edema that is not adequately managed • Wounds over bony prominences or probing to bone • Involvement of tissue deeper than skin and subcutaneous tissues (e.g., tendon, muscle, joint or bone)
Environmental Factors
• Unhygienic environment (e.g., dust, unclean surfaces, or presence of mould/ mildew) • Hospitalization (due to increased risk of exposure to antibiotic resistant micro-organisms) • Inadequate hand hygiene and aseptic technique • Inadequate management of moisture (e.g., due to exudate, incontinence [fecal/urine or both, drooling] or perspiration) • Interface pressure that is inadequately offloaded

Used with permission of the International Wound Infection Institute.[60]

Practice tool: The Bioburden checklist was developed by Keast and Lindholm to determine the level of bioburden and assist in selecting the correct intervention. It can be found at:
https://www.swrwoundcareprogram.ca/Uploads/ContentDocuments/BioburdenChecklist.pdf

NOTE: Inflammation versus Infection

Clinicians sometimes confuse normal inflammation with infection, and it is essential to understand the difference between the two to support clinical decision-making (See Table 6).

- Inflammation is an important immune response of the body that supports wound healing and removes harmful stimuli, including damaged cells, irritants or pathogens. In cases where there is continued tissue trauma, prolonged inflammation and delayed healing can result.
- Infection, on the other hand, is the invasion of tissues by disease-causing agents, their multiplication and the reaction of host tissues to these organisms and the toxins they produce. An untreated infection impedes healing.

Persistent inflammation may also indicate the presence of increased levels of metalloproteinases (MMPs), elastase and other inflammatory substances that impair or delay wound healing. Point-of-care diagnostic testing has been developed to identify increased MMPs. Topical dressings exist to reduce MMPs and can be used in combination with topical antimicrobials or systemic anti-inflammatories/antimicrobials.

Table 6: Differences between Inflammation and Infection

	Signs and Symptoms
Inflammation	Redness, warmth, swelling and pain (the four classical signs of inflammation) and decreased function are seen in injured, infected or irritated tissues. Inflammation is also the first mechanism used as a type of nonspecific immune response
Infection	Multiplication and invasion of an infectious agent within the body tissues causing signs and symptoms of disease. In wounds the most common are Gram-positive cocci such as staphylococci and streptococci. In long-duration wounds and where co-morbid conditions exist, gram negative bacteria and anaerobes may be more of a concern

In Wound Infection in Clinical Practice: Principles of Best Practice the IWII identified the types of wound specimens that can be used to support microbiological analysis including: tissue biopsy or curettage, wound fluid aspirate (pus collection), debrided viable tissue from the ulcer base via sharp debridement, and wound swab. The Levine method is the preferred method of wound culture (See Table 7).[60]

Table 7: Levine Method of Wound Culturing[60]

Step	Taking a swab for culture	Further Information Begin and end the procedure with hand hygiene
1	Cleanse and debride wound prior to wound culture	• Inform and seek permission from the patient to obtain specimen • Cleanse wound using warm normal saline • Debride non-viable tissue as required • Cleanse wound again
2	Moisten the swab tip	• Moisten tip with sterile normal saline, especially with dry wounds
3	Obtain the sample specimen	• Obtain the specimen from the cleanest area of the wound • Do not obtain the sample from pus, slough or necrotic tissue
4	Apply correct technique	• Inform the patient that procedure may cause discomfort • Firmly press swab into wound and rotate • Using a sterile technique, place the swab into the culture container

5	Label the sample appropriately	• Place the patient label on the culture container and pathology slip • Provide site location (e.g., left medial malleolus), time and initials of the person who obtained the specimen • Provide as much relevant history as appropriate: - current antibiotic or medication(s) (steroid) - co-morbidity (e.g., DM) - specific microbe suspected (Pseudomonas) - provisional diagnosis of wound - duration of wound
6	Apply dressing as appropriate	• Use local wound-care principles to select an appropriate dressing • Use medicated dressings if appropriate • Document wound assessment, measurements, and procedure performed

Used with permission of the International Wound Infection Institute.[60]

The IWII also outlines potential diagnostic investigations and the purpose of each to support wound assessment (See Table 8).

Table 8: Potential Diagnostic Investigations and Purpose[60]

Diagnostic Investigations	Purpose
Hematological (blood) markers	
White blood cell (WBC) counts (e.g., granulocytes, lymphocytes, monocytes)	• Detect presence of infection in the body • WBC's indicate an immune response
C-reactive protein (CRP)	• Detect inflammation related to infection
Erythrocyte sedimentation rate (ESR)	• Detect inflammation related to infection
Blood cultures	• Detect an infection in the blood and identify the causative organism(s) • A positive blood culture indicates bacteremia
Microbiology	
Wound culture	• Identify causative organism(s) of infection • Construct an antibiogram based on sensitivity testing
Radiological investigations	
Plain x-rays	• Identify presence of osteomyelitis of abscess
White cell /bone scan	
Magnetic resonance imaging (MRI)	
Computerized tomography (CT)	
Fluorodeoxyglucose positron emission tomography (PET)	
Leukocyte scintigraphy (with or without CT)	
Ultrasound	
Ultrasound	• Identify extent of abscess, fluid collection or hematoma

Used with permission of the International Wound Infection Institute.[60]

Tip: Only after a complete assessment has been completed can a working diagnosis be formulated, after which focused lab investigations can confirm and guide treatment if necessary.

Biofilms

A biofilm consists of a complex network of bacteria and fungi embedded in a thick, slimy barrier of sugars and proteins that begin to form within minutes to hours of skin breakdown. The biofilm barrier protects the micro-organisms from external threats, making them resistant to standard treatment. Biofilms are present in the majority of wounds of long duration (60–90%) and have the potential to delay healing.[66-69] The organisms within the biofilm cannot be detected using a normal wound culture method. The only definitive techniques available to detect biofilm involve advanced microscopy or specialized culture. See Table 9 for criteria indicative of potential biofilm in a wound.

Table 9: Criteria Indicative of Potential Biofilm in a Wound[60]

- failure of appropriate antibiotic treatment
- recalcitrance to appropriate antimicrobial treatment
- recurrence of delayed healing on cessation of antibiotic treatment
- delayed healing in spite of optimal wound management and health support
- increased exudate/moisture
- low-level chronic inflammation
- low-level erythema
- poor granulation/friable hypergranulation
- secondary signs of infection

Used with permission of the International Wound Infection Institute.[60]

Moisture Balance

A moist wound environment is necessary for wound healing[70]; however, too much or too little moisture (or exudate) in the wound environment can adversely affect wound healing.[71,72] Identifying the optimal moisture balance for the wound and periwound skin is a necessary part of wound assessment.

Assessing Exudate

The quality of the exudate is also an important aspect of assessment:[73]

- Serous drainage is clear, thin and watery plasma and is considered normal during the inflammatory stage of wound healing. Small amounts are considered normal throughout healing. However, a moderate to heavy amount may indicate repetitive trauma or a high bioburden.
- Sanguineous exudate is fresh bleeding. A small amount may be normal early in the injury and during the inflammatory stage. It may indicate trauma to the wound bed.
- Serosanguineous exudate is thin, watery and pale red to pink in colour that indicates damage to the capillaries, usually with dressing changes.
- Seropurulent exudate is thin, watery, cloudy and yellow to tan in colour. It is considered abnormal and may indicate infection.
- Purulent exudate is thick, opaque and tan, yellow, green or brown, is considered abnormal and almost always indicates infection.

Discuss Assessment/Screening Findings with Patient

At the end of the skin and wound assessment it is important to discuss and summarize the findings with the patient and/or care partner. This may include current skin status, wound type and status, and if the wound is improving or deteriorating based on assessment or reassessment. The clinician needs to assess how aware the patient is of his/her health status and ensure that there has been a meaningful exchange with the patient and or care partner during this assessment.

Step 2: Set Goals

Discussion: Goals of care need to be developed with the patient and/or their care partner. Achieving goals will depend on the interplay of each patient's health status and lifestyle, the availability of resources and the knowledge and ability of care providers and care partners to provide optimal interventions.[74-76] If these factors are not taken into consideration the goals of care may be unrealistic and unrealizable.

Tip: Prevention: Even if the patient has a wound, there should always be a plan of care focused on skin health in place to prevent further skin breakdown in other areas.

Recommendations
2.1 Set goals for healthy skin, prevention of trauma and management of healing, non-healing and non-healable wounds

Discussion: Goals are not static and can often transition with various co-morbidities and conditions over time. Goals must be reviewed regularly and adjusted accordingly. The team should aim to set goals according to the SMART principle:[77]

Specific: The goals must be specific and clearly state what needs to be accomplished, how, when and where
Measurable: The results should be able to demonstrate quantifiable results—how much, how many, and how often—to help measure progress
Attainable: All goals must be realistically achievable
Relevant: Goals must be relevant to overall outcome goals
Time bound: A clear and realistic timeframe should be set for each goal

Table 10 provides some samples of goals of care.

2.1.1 Identify goals based on skin health, prevention or healability of wounds

Discussion: Determine skin- and wound-related goals based on prior assessment and team discussion. For example, goals related to skin management might be:

- For healthy skin: Goals should be developed based on patient preferences and consideration of what has been working and what can be improved. See Wounds Canada - Care At Home Series. https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series
- For intact skin at risk: Preventative goals should be developed based on identified risk and implemented to avoid skin breakdown
- For a healing wound: Plan of care goals should be developed to support the patient who has the physical capacity to heal. Choices should be made based on optimal wound healing principles and where the system can support optimal wound healing
- For a non-healing wound: If the patient **does have** the physical capacity to heal, but due to patient or health-care system factors optimal healing is not happening at this time, the plan of care goals should address the factors inhibiting the healing process and prevention of deterioration

For a non-healable wound: If the patient **does not have** the physical capacity to heal, the plan of care goals should be centred around supportive care, prevention of deterioration and enhancement of quality of life.

2.1.2 Identify quality-of-life (QoL) and symptom-control goals

Discussion: Anything that impacts a patient's daily life, such as the ability to engage in normal activities and maintain an adequate level of emotional well-being, need to be addressed (See Table 10). Regular screening and assessment using validated, responsive and standardized tools allow the clinician to access essential information at a glance and set realistic goals with the team.[78-80] These may include QoL and symptom control goals that:

- support healthy lifestyle choices (e.g, smoking cessation, alcohol consumption, nutrition and hydration, activity, mental health),
- promote skin health,
- decrease numbers of dressing changes,
- support symptom control (e.g., pain, odour, infection, exudate) and
- support a return to and/or maintenance of a specified quality of life.[81]

Table 10: Examples of Goals of Care

Status	Example	Examples: Goal of care
Healthy skin	No skin-related risk factors present	• Maintain existing healthy skin routine • Schedule regular health status screenings as per protocols
Intact at-risk skin: Screen for risk of skin breakdown	Diabetes with peripheral neuropathy that includes loss of protective sensation to feet	• Maintain existing healthy skin • Perform daily skin assessment • Modify skin protocol as necessary • Provide instruction to the patient on daily foot care practices they can perform themselves or with the care partner within 48 hours • Access funding for foot care and footwear (if necessary) • Schedule an appointment for fitted footwear by trained professional within 2 days
Healing wound: Wound is healing in a predictable fashion	Pressure injury where pressure and other factors such as incontinence are being managed	• Maintain existing healthy skin • Wound closure within 3 weeks • Prevent recurrence or new pressure injury • Continence status is assessed regularly and issues of concern are addressed within 24 hours
Non-healing wound: Wound has healing potential, but causes and co-factors that can interfere with healing have not yet been removed	Neuropathic diabetic foot ulcer where patient-does not wear plantar pressure redistributing footwear	• Maintain existing healthy skin • Source funding for offloading footwear within one week • Prevent infection • Reassess wound progress on a regular basis and address issues of concern within 24 hours • Prevent new skin breakdown • Arrange for the patient to engage in a support group within 2 weeks
Non-healable wound: Causes and co-factors that can interfere with healing cannot be removed, e.g., in cases of terminal disease or end-of-life care	Fungating breast cancer	• Maintain existing healthy skin • Prevent infection • Reduce odour by 50% within 3 days and by 90% within one week • Provide emotional support at each visit • Prevent worsening of existing wounds • Link to new Professional Guide - Malignant Wounds https://www.woundscanada.ca/dhfy-doc-man/public/2957-professional-guide-malignant-wounds/file

Step 3: Assemble the Team

An integrated team is necessary to meet the goals that have been set. The team should include the relevant health-care professionals and other service providers as required as well as the patient, family, and their support system.[82] Because patients, their care partners and other service providers in the community are part of the team, the term *integrated team* is preferred over *interprofessional team* or *multidisciplinary team*.[83-85]

Discussion: Teams complete screening/assessing, goal setting, treatment plans, assessing outcomes and sustainability to maintain and manage skin integrity and to optimize wound healing. This is especially true in cases for persons at risk for or with skin breakdown, where interventions by multiple disciplines and of varying levels of care are required. Also, teams support patients to achieve goals that may be directly or indirectly related (co-factors) to skin and wound issues (e.g., lifestyle factors, housing, food security, mental health and wellness).

Given that the patient, their care partners and many other team members may be outside the clinical setting, the 'team without walls' approach is often the only way to achieve optimal patient outcomes. This is especially true because some of the team members work together in a clinical setting while other members of the team work across a variety of service delivery sites or use web-based platforms. In all cases, the effectiveness of any team depends on having a well-functioning communication strategy in place with common goals between ALL team members.

Ongoing professional development is necessary to maintain a best-practice approach to patient care. Wounds Canada offers educational programs through the Wounds Canada Institute and conferences to support team member knowledge and skills development.

Recommendations
3.1 Identify appropriate health-care professionals and service providers

Discussion: Best practice care for skin health and for persons at risk for the development of wounds, or for those who have wounds, demands a systematic, team approach from knowledgeable health professionals and other providers with expertise not only in skin health and wound management but also in any of the factors that may be impacting or have the potential to impact skin health and wound management.

The selection of team members will be based on thoughtful analysis of the results of the patient's screening, assessments, individual needs and goals and the plan of care. All team members must support the plan of care and be an active part of revisions to the plan as necessary. Members of the team will contribute to patient care in their specific area of expertise, but in a co-ordinated way.[84]

Potential Team Members

Health-care professionals on the team may include: nurses, physiotherapists, occupational therapists, language translators, orthotists, dietitians, podiatrists/chiropodists, social workers, traditional compounders, recreational therapists, pharmacists, diabetes educators, nurse practitioners, nurses specialized in wound, ostomy and continence care providers, psychologists, and physicians—both generalists and specialists, including dermatologists, plastic surgeons, physiatrists and vascular surgeons–depending on patient need.

Unregulated health care providers such as health-care aides and personal support workers can play a vital role as the 'eyes' of the team, as they often have daily contact with the patient and assist with bathing and skin-care activities. Spiritual care providers and traditional healers offer emotional and spiritual care. Laboratory and radiology teams may be part of diagnostic investigations and reporting.

Other important community-based service providers in the integrated team may include shoe fitters, meal delivery personnel, homemakers, garment fitters, medical aid specialists, financial aid workers and transportation providers.

3.2 Enlist the patient and their family and care partners as part of the team

Discussion: The patient, family and any formal or informal care partners need to be at the core of the integrated team.[85] This approach may be a new concept to the patient, so the first step is to ensure they recognize the role of individual team members and responsibilities in their care, as successes in health care can be dependent on early, trust-filled, effective and shared communication between health-care providers and patients.[86]

While all patients want to be seen, heard, supported and connected, truly effective communication must be individualized to accommodate the person's needs and environment. Some strategies and techniques to optimize the provider-patient relationship and communication require the clinician to:

- Create a safe environment and allocate adequate time
- Identify language needs, the need for an interpreter, cultural sensitivity, hearing ability and literacy needs
- Identify the need for care partners, parents, and/or legal guardians to be present
- Consider access to and use of technology (phone, computer, devices, e-platforms)
- Avoid medical terminology and jargon
- Listen, and indicate that you have allowed time for questions through frequent pauses and check-ins where you might ask questions such as, "What do you want to know about?" or, "What worries you the most?"
- Use open-ended questions such as, "Can you please describe your pain" or, "Can you tell me about your pain"; rather than, "Do you have pain?" Use visual analogue scales, when appropriate
- Allow for pauses for reflection, on both sides, between questions
- Encourage engagement and maintain good non-verbal communication
- Avoid cultural stereotyping while respecting potential differences
- Confirm information received from the patient by saying, "In other words what you are telling me is…"
- Verify information given to the person by having them provide feedback such as, "What you are asking me to do is . . ."
- Follow up to ensure the care plan is successful and adapt as required.

3.3 Ensure organizational and system support

Discussion: Organizational and system support is required to ensure that patients receive a co-ordinated transition of care through community and health-care agencies as well as the development of specialized, knowledgeable, integrated teams. Ongoing knowledge mobilization of the latest evidence through education, policy and procedure development, evaluation of outcomes and availability of appropriate resources requires system support.[87,88]

The development and implementation of a successful wound prevention and management program involves collaboration with practice leaders, educators, policy makers, researchers and administrators at a local, regional, and national level.[89] See Chapter 2: How to Use Wounds Canada's Best Practice Recommendations for Skin Health and Wound Management 2025 for more on implementation of these recommendations.

Supporting an individual successfully requires proactive, risk-based interventions at a variety of levels: individual, organizational and cultural. To secure successful outcomes:

- Decision makers must establish, train and support an integrated team composed of interested, skilled and knowledgeable persons to address and monitor all elements related to skin health, prevention and management of wounds.
- Frontline clinicians must communicate with decision makers through appropriate channels about the needs and concerns of their patients, as well as about workplace issues that may impact their ability to deliver best practice-based care.

Step 4: Establish and Implement a Plan of Care

Ensure that care addresses the goals that have been set and considers individual needs (physical, emotional, spiritual, cultural and lifestyle), factors and co-factors related to skin health and the prevention and management of wounds, if applicable.

Discussion: Best practice-based skin health, wound prevention and wound management are both a science and an art because of the individual circumstances of each person. Therefore, the plan of care required needs to be guided not only by the evidence, but also through documented clinical decision-making involving patient input regarding preferences, circumstances, values and rights.

The Care at Home series: https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series developed by Wounds Canada provides easy-to-use resources for patients and their families who need to provide skin health and wound care activities in their own homes.

Recommendations

4.1 Identify and implement an evidence-informed plan to maintain skin health and correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional and social), the wound (if applicable) and environmental/system challenges

Discussion: Promotion of skin health to prevent breakdown is always a priority. Daily skin care generally involves:

- Ensuring the individual's skin is kept clean and dry and appropriately moisturized
- Skin is protected against injury due to incontinence or other types of excessive or corrosive moisture, pressure, thermal assault, skin tears, inappropriate clothing and poor-fitting footwear
- Lubricant is used when shaving
- Nails are kept well cared for, with no ragged edges (to protect against skin tears)
- Hair is clean and well-kept.

For more on basic skin health, please see Skin Health and Hygiene: Keeping Skin Healthy https://www.woundscanada.ca/doclink/professional-guide-skin-hygiene/eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9.eyJzdWIiOiJwcm9mZXNzaW9uYWwtZ3VpZGUtc2tpbi1oeWdpZW5lIiwiaWF0IjoxNjg3MTkyODMwLCJleHAiOjE2ODcyNzkyMzB9.fBOnkzHo_dJtNyzSdsyysTw3wVJj4ecT6QRNsOGnCAM

Individuals at risk for or with wounds may have multiple co-morbidities that can interfere with skin integrity or that can lead to prolonged or stalled healing of existing wounds. Addressing the co-morbid conditions that affect the health of skin and/or its ability to heal is paramount in the development of a plan of care that will effectively meet goals relating to maintenance of skin integrity and or the prevention and management of wounds.

Physical Activity

Appropriate levels and types of exercise have beneficial effects, both physically and mentally. Exercise can improve weight control, cardiorespiratory function, blood pressure, cholesterol levels as well as mood, sleep and mental function.[90,91] Chronic illnesses have strong links with inactivity. While there is limited evidence linking improved physical fitness to better wound healing, there is strong research associating exercise with a reduction of the effects of chronic diseases, which could impact skin health. Exercise also positively affects impairments such as pain, stress, circulation, neuropathy, blood glucose levels and well-being, which can be directly linked to issues of skin integrity.[92-96]

Given the potential risks of ill effects associated with unsupervised exercise in certain patient populations, it is imperative that high-risk patients be closely supervised by a skilled health professional. With guidance, exercise can be an empowering and safe intervention to enable patients to improve their overall well-being.

Nutrition

If a nutritional deficiency is thought to be significant enough to impact the health of skin or impair wound healing, a registered dietitian should be consulted[45,46,97] to develop an individualized nutrition plan as part of the plan of care, with the goal of optimizing the person's nutritional status. Management of deficiencies may make the difference between a healing and non-healing wound even in the presence of best clinical practice. The nutritional component of the plan of care must account for the patient's needs, beliefs, preferences, health status, ability to secure and eat food and fluids, along with socioeconomic, cultural and psychosocial status. As well, the availability of care partners, community and system support (e.g., community food banks, meals-on-wheels, meal plans) must be considered.

For more on nutrition and skin health and wound healing please see Appendix A and the Nutrition page on the Wounds Canada website:
https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/nutrition

Moisture Control

As mentioned above, skin should be kept clean and dry, but hydrated appropriately.

Intertrigo, which occurs when there is too much moisture, is a common condition that leads to skin erosions, primarily in skin folds. It is caused by the combined impact of moisture, friction and shear. Researchers recommend the following prevention and management strategies:[98]

- Implement a skin-fold-hygiene program to keep skin dry and minimize skin-on-skin contact and friction
- Avoid the use of or contact with any skin irritants
- Wick moisture away from affected and at-risk skin; consider silver impregnated textiles (not to be confused with silver dressings)
- Control or divert the moisture source
- Prevent or treat secondary fungal or bacterial infection.

Incontinence-associated dermatitis (IAD), caused by feces, urine or both, can create a type of irritant contact dermatitis that requires reduction and management of incontinence. According to the Global IAD Expert Panel, two key interventions are critical for the prevention and management of IAD.[99]

Management of incontinence requires that the clinician identify and treat reversible causes (e.g., urinary tract infection, constipation, dehydration, diarrhea, use of diuretics) to reduce or eliminate skin contact with urine and/or feces. A structured skin care regimen should be implemented to protect the skin exposed to urine and/or feces and help restore an effective skin barrier function. Skin care regimens must be supported with education, policy and measurement of improvements.

For more on moisture and the skin, please see Chapter 5: Best Practice Recommendations for the Prevention and Management of Moisture-Associated Skin Damage

For more information please see: Assessment and Management of Persons Living with Continence Issues

Pain Management

The intensity and impact of pain on the patient's quality of life of all assessed pain must be taken into consideration when creating a personalized plan of care.[12,21,63] Table 11 summarizes some of the causes of pain and strategies for person-centred management.

Table 11: Causes and Management of Pain[17,30,31,85,100-102]

Causes of Pain	Characteristics	Management Strategies
Background pain	Pain at rest (related to wound etiology, infection, ischemia)	Treat the underlying etiology of the wound and associated pathologies Utilize pharmaceutical and non-pharmaceutical approaches considering integrative therapies
Incident pain	Pain during day-to-day activities (walking, coughing, friction, dressing slippage, device wear)	
Procedural pain	Pain from routine procedures (e.g., anticipatory pain, dressing removal and application, debridement)	Preparation and planning of the procedure are key to preventing pain Analgesics should be administered before a procedure and may be required post procedure Dressing selection is key to pain management related to dressing removal and application
Operative pain	Pain associated with an intervention, such as cutting of tissue or prolonged manipulation, that would require an anesthetic	

Additional Strategies to Promote Patient Health

The plan of care may require referrals to programs relating to mental health, social support, spiritual care, smoking cessation, weight management and stress management, among others, to optimize patient health to prevent skin breakdown or support wound healing. Table 12 outlines several examples. Check local and regional links to programs.

Table 12: Examples of Lifestyle Strategies for Optimizing Patient Health

Strategy	Impact and Benefits
Smoking cessation programs	Smoking cessation benefits a patient's long-term health by reducing the risk of disease development. There is also evidence that quitting smoking may reduce wound complications, such as infection, and increase rates of bone healing[103]
Weight management programs	Obesity and associated co-morbidities increase the likelihood of impaired skin integrity and slow-to-heal wounds due to poor blood supply to adipose tissue.[104-106] Patients diagnosed with obesity may have protein malnutrition, which further impedes the healing Effective weight management can decrease a patient's risk of developing pressure injuries, irritant dermatitis due to urinary and/or fecal incontinence, candidal intertrigo, cellulitis or more serious skin infections such as necrotizing fasciitis, venous ulcers, diabetic foot ulcerations and surgical site infections
Stress management programs	Stress can have a negative impact on the development of wounds and wound healing[33] The most prominent impact is on cellular immunity. Stress management programs have demonstrated reduced distress and improved quality of life
Mental health and other programs	Programs that support the management of anxiety, addiction, chronic illness, pain, palliative care, healthy living and sleep disorders can improve skin integrity, wound healing and quality of life[107]
Spiritual health programs	Programs that spiritual health care can improve their well-being, hope, outlook on life and optimism, and help manage spiritual distress[108-110]
Alcohol consumption/ use	Patients should be informed about the risks of alcohol use. The Government of Canada has guidelines[111] to support patients in making informed decisions about alcohol and substance use

4.2 Optimize the local wound environment (if applicable)

Discussion: Local wound management strategies should fit within the context of the overall goals of care. For a wound to heal, it is first essential to determine the reason(s) the wound developed and to identify any factors that are impairing or might impair healing. The first step is to protect the area from further trauma. Following that, the wound environment needs to be optimized, which involves the four basic components in wound hygiene: cleansing, debridement of necrotic or indolent tissue, managing bacterial balance and managing (controlling) moisture through the selection and application of appropriate dressings.[112]

4.2.1. Wound Cleansing

Discussion: Wound cleansing solutions vary and should be used at body temperature. Cleansing solutions should be nontoxic, hypoallergenic, readily available, cost-effective and easy to use.[21,60,63]

Wound cleansing solutions commonly used in wound management include: sterile normal saline, sterile water, potable tap water[113] and antiseptics (See Table 13). A therapeutic irrigation with a force of 4–15 psi has been demonstrated to be effective and generally safe.[60,114-121]
When wound infection is suspected, a solution with a surfactant, antiseptic or antimicrobial agent may be recommended. Antiseptics should be used short term and with caution since they are non-selective and may damage healthy tissue. Some commonly used antiseptic solutions are polyhexanide (PHMB), betaine/PHMB (a surfactant), povidone-iodine and octenidine with ethylhexyl glycerine (a surfactant). Clinicians should be aware of the cytotoxicity of each solution, appropriate concentrations and the individual wound requirements when choosing the most appropriate solution.[60]

Wound cleansing may cause pain during the dressing change. The routine practice of using abrasive materials and gauze to scrub the wound surface is discouraged. It is important that clinicians use the most appropriate solution and technique to minimize harm to the wound bed and periwound skin.

Table 13: Cleansing Solutions[60]

Solution	Type	Cytotoxicity	Effect on biofilm	Comments
Potable tap water	Varies in content	• unknown/ variable	• none	• not sterile • once opened product is no longer sterile
Sterile normal saline (0.9%)	Isotonic	• none	• none	• sterile, non-antiseptic solution • once opened product is no longer sterile
Sterile water	Hypotonic	• none	• none	• sterile, non-antiseptic solution • once opened product is no longer sterile
Polyhexamethylene biguanide (PHMB)	Surfactant anti-micro-bial	• low to none	• surfactant qualities disrupt biofilm attachments	• lowers liquid surface tension, allowing greater spread and facilitating separation of non-viable tissue • does not promote bacterial resistance

Octenidine dihydrochloride (OCT)	Surfactant anti-micro-bial	• *in-vitro* tests show high toxicity • lack of absorp-tion suggests no systemic effects • not shown to disrupt healing	• prevents formation of new biofilm for at least 3 hours • inhibits planktonic and bacterial biofilm growth for up to 72 hours	• comes in a gel, irrigation and surfactant preparations and irrigation preparation that can be used together or separately • lowers liquid surface tension, allowing greater spread and facilitating separation of non-viable tissue
Super oxidized solutions (Sodium hypochlo-rite [NaOCL] antimi-crobial preservative) (Hypochlorous acid [HOCl] antimicrobial preservative)	Antiseptic	• may vary depending on concentrations	• penetrates biofilm rapidly, killing forma-tions from within • does not promote resistant bacteria strains	• purported to provide desloughing and antimicrobial activity • comes in a gel and irrigation preparation that can be used together or separately
Povidone-iodine	Antiseptic Iodophor	• varies depending on concentration	• inhibits development of new biofilm • eradicates young biofilm colonies • significantly reduces mature biofilm colonies	• modulates redox potentials and enhances angiogenesis, thereby promoting healing • may inhibit excess protease levels in chronic wounds

For more on cleansing agents, see Wounds Canada Product Picker: Skin and Wound Clean-up

4.2.2 Debriding

Discussion: The European Wound Management Association defines debridement as the, "act of removing necrotic material, eschar, devitalized tissue, serocrusts, infected tissue, hyperkeratosis, slough, pus, hematomas, foreign bodies, debris, bone fragments or any other type of bioburden from a wound with the objective to promote wound healing."[122]

In some wounds debridement is required to eliminate moist necrotic tissue, which provides a medium for bacterial growth, initiates an inflammatory response, places a phagocytic demand on the wound and retards wound healing. The ensuing infection and biofilm formation limit the effectiveness of topical and systemic antibiotics.

It is important to note that debridement of a wound that does not have adequate vascular supply is not recommended. **Therefore, a thorough assessment of vascular supply to the wounded area is imperative prior to debriding.** If there are concerns regarding vasculitis or pyoderma gangrenosum, debridement should not be done.

In the case of diabetic foot plantar ulcers or calluses, debridement is part of offloading, unless there is evidence of PAD. See Chapter 10: Best Practice Recommendations for the Prevention and Management of Peripheral Arterial Ulcers for more on arterial disease.

Caution: Sharp debridement should never be performed by unskilled clinicians. Clinicians require proven training, documentation and agency support through policy and procedure prior to performing conservative sharp wound debridement.

Debridement may be selective (removing only non-viable tissue) or non-selective (potentially harmful to healthy tissue). More than one debridement approach may be used. See Table 14 for the common types of debridement.

Table 14: Types of Debridement[60]

Biological Debridement (Biosurgical) Or Maggot debridement therapy (MDT)	Maggots possess enzymes that liquefy necrotic tissue and secrete substances that destroy bacteria[123] • First described by Pare in the 1500s • During World War I, successful treatment of leg ulcers and osteomyelitis • The development of antibiotics and improvements in surgical techniques reduced MDT to a treatment of last resort • MRSA has renewed interest in MDT, being beneficial and cost-effective There is substantial literature available on larval therapy; however, large-scale clinical trials supporting the evidence are lacking. The largest deterrent to the use of larval therapy appears to be the 'yuck' factor[124]
Mechanical Debridement	• Uses mechanical forces to remove bacteria and non-viable tissue • One of the most common forms of debridement, usually performed by removing 'wet-to-dry dressing' along with adherent debris - As it may cause unnecessary trauma and added pain, **it is strongly discouraged** • Spray wound cleansers or non-traumatic irrigation systems deliver irrigation pressure with a force of 4 – 15 (psi), demonstrated to be effective and safe at the wound surface to dislodge bacteria and debris - Pressure greater than 15 psi must be used with great care - In the case of fragile elderly or newborn skin, a psi of 8 or less is recommended[60] - Syringe irrigation (30 – 35 cc) and needle (18 – 19 gauge) can also be used for wound irrigation[60] • **Polyacrylic microfibre pads** have recently been employed[125,126] but most wound professionals today prefer more selective methods of debridement • **Low-frequency ultrasound,** a noncontact mechanical debridement method using sound waves transmitted through a constant flow of saline that removes necrotic tissue, fibrosis, exudate and bacteria with minimum bleeding and pain. It is performed at a distance between 5 mm and 15 mm from the wound surface[127,128]
Hydrosurgical Debridement	• Specialized, powered surgical tool that enables a surgeon to precisely select, excise and evacuate nonviable tissue, bacteria and contaminants from wounds, burns and soft tissue injuries using pulsed lavage irrigation[129,130]
Chemical Debridement	• Use of a chemical agent, such as sodium hypochlorite, to remove necrotic tissue • Non-selective and can be harmful to healthy cells and granulating tissue • More selective debridement methods are preferred[131]
Autolytic Debridement	• Autolysis allows natural physiologic processes to occur where the body uses neutrophils aided by macrophages and enzymes (proteases and collagenase) to self-digest dead tissue • Scoring or crosshatching of the eschar with a scalpel is necessary to assist in the autolytic process • Some dressing promote autolytic debridement and also support the rehydration and softening of the devitalized tissue[132,133] **Note:** Must be used with care in wounds that are actively infected

Enzymatic Debridement	• Uses the topical application of proteolytic substances (enzymes such as collagenase) to break down devitalized tissue • Can be used to remove necrotic tissue from the wound through its ability to digest the collagen fibres that anchor necrotic tissue to the base of the wound. In the process, necrotic tissue is separated from the wound, leaving behind a clean base to support an increased rate of healing • The activity level of enzymatic agents decreases in a dry environment; therefore, dry eschar should be scored (cross-hatching) and kept moist • Can be used alone or in combination with sharp debridement and autolytic debridement when combined with a foam dressing topper[134] **Note**: Collagenase-based products are available only in Canada
Surgical Debridement	• Fastest way to remove devitalized, contaminated or infected tissue. It may also be used to convert a non-healing wound environment into a healing wound[132] • Must be performed by a properly trained health professional (e.g., a surgeon), usually in the controlled conditions of an operating room or properly equipped clinic (i.e., with sterilized equipment and coagulation equipment) • Costly because it requires an operating room or specialized clinic • May be contraindicated for individuals who are medically unfit or who have uncontrolled blood clotting disorders **Note:** Delays in wound healing can arise when wait times for operating rooms are long
Conservative Sharp Wound Debridement (CSWD)	• CSWD involves the removal of only devitalized tissue, usually with a scalpel or scissors. Blood is not an expectation of CSWD • **Sharp debridement should never be performed by unskilled clinicians. Clinicians require proven training, documentation and agency support through policy and procedure prior to performing conservative sharp wound debridement** • Clinicians must verify within their health-care institution or agency that sharp debridement is within their scope of practice and whether there is a policy indicating who may perform CSWD [135-137] • The patient must provide informed consent (written or verbal) based on information that includes why the procedure is being conducted, the benefits and risks

Table 15 reviews key factors in determining which type of debridement would be best suited to which patient situation and whether the type of debridement is selective or non-selective. For clinicians not skilled in sharp debridement, autolytic or enzymatic debridement may be the preferred option. In all cases, the method used needs to suit the clinical situation based on patient and wound assessment.

Table 15: Key Factors in Deciding Method of Debridement[60,135,137]

	Surgical/sharp	Enzymatic	Autolytic	Biologic	Mechanical
Speed	1	3	5	2	4
Tissue selectivity	3	1	4	2	5
Painful wound	5	2	1	3	4
Exudate	1	4	3	5	2
Infection	1	4	5	2	3
Cost	5	2	1	3	4
1 is most desirable and 5 is least desirable					

For more on debriding agents, see Product Picker: Skin and Wound Clean-up

4.2.3 Managing Bacterial Balance

Discussion: Bacterial balance is essential for wound healing. Management of a wound needs to address the interaction between the individual and the infecting pathogen by:

- optimizing the host response optimizing the wound environment
- reducing the number or virulence of micro-organisms in the wound.[60]

Terminology related to bacterial management can be confusing. For clarification:

- Antibiotics are agents that kill selectively and require metabolic activity for action
- Antibiotics can be bacteriostatic (suppress) or bactericidal (kill)
- Antiseptics are non-selective agents that may affect normal human cells and do not require metabolic action for efficacy
- Antiseptics are always bactericidal and usually act on the surface
- *Antimicrobial* is an umbrella term often used to group antibiotics and antiseptics.

Tip: To prevent the development of resistance it is important when selecting topical antimicrobials to avoid those that may be used systemically[60]

Figure 2: Managing Wound Infection

Effective wound infection management

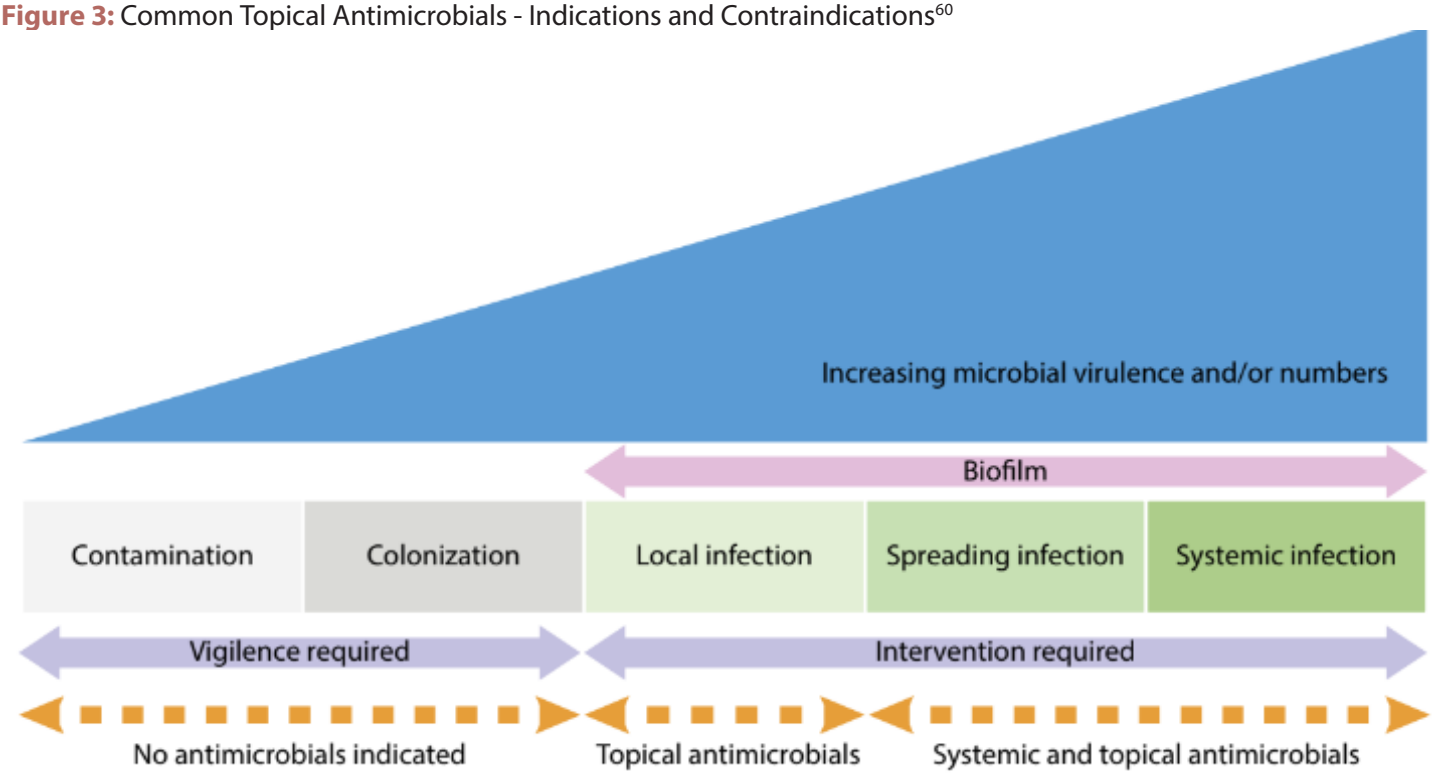
↓ **Optimize individual host response**	↔	↓ **Reduce wound microbial burden**	↔	↓ **Promote environmental and general measures**
1. Optimize management of co-morbidities (e.g., diabetes, tissue perfusion /oxygenation) 2. Minimize or eliminate risk factors that increase infection risk where feasible 3. Optimize nutritional status and hydration 4. Assess and manage other anatomical sites of infection (e.g., urinary tract, respiratory infections) 5. Treat systemic symptoms (e.g., pain, pyrexia) 6. Promote psychosocial support 7. Provide appropriate systemic antimicrobial therapy, where indicated 8. Ensure the individual is engaged in development of an individualized management plan 9. Provide information to the patient and their care partners outlining the importance of the interdisciplinary wound-management team		1. Prevent cross infection by implementing universal precautions and aseptic technique 2. Facilitate wound drainage 3. Ensure periwound hygiene and protection 4. Manage wound exudate 5. Optimize the wound bed: • Remove necrotic tissue, debris, foreign bodies, wound dressing remnants and slough • Disrupt biofilm by debriding • Cleanse the wound with each dressing change • Use appropriate antimicrobial dressings • Use an appropriate topical antiseptic therapy • (e.g., perform a 2-week challenge before assessing effectiveness)		• Perform wound care in a clean environment • Determine the appropriate aseptic technique based on the risk assessment of the patient, the wound and the environment • Store equipment and supplies appropriately • Provide education for the individual and their care partners • Regularly review local policies, procedures and services

Regular reassessment

- Diagnostic interpretation requires holistic knowledge of the individual and their wound
- Evaluate interventions based on efficacy in resolving signs and symptoms of wound infection and the overall condition of the individual. Consider:
  - Has the individual's pain decreased?
  - Has exudate decreased?
  - Has malodour resolved?
  - Has erythema and edema decreased?
  - Is there a reduction in non-viable tissue?
  - Is the wound reducing in size and/or depth?
- Monitor condition of the periwound, particularly in heavily exuding wounds
- If there is limited or no improvement in signs and symptoms of wound infection, reassess the individual and their wound and adjust the management plan
- Consider referring the individual to specialized services (e.g., a wound clinic)
- Consider if further investigations are required
- Document wound assessments (e.g., serial digital photography)

Used with permission of the International Wound Infection Institute.[60]

Figure 3: Common Topical Antimicrobials - Indications and Contraindications[60]



Used with permission of the International Wound Infection Institute.[60]

Note: The characteristics of topical antimicrobials will change depending on the use and type of dressing used. Dressings that absorb wound exudate and wick infectious material away from the wound bed can provide additional benefit due to the reduced number of endotoxins that often impede healing. Drainage absorption by dressings may have synergistic effects by disrupting the bacteria's ability to attach and form a biofilm.[60]

Topical Antimicrobial Therapies[60]

See International Wound Infection Institute (IWII) Wound Infection in Clinical Practice. Wounds International. 2022. https://woundinfection-institute.com/wp-content/uploads/IWII-CD-2022-web-1.pdf for the current list of antiseptics (medicated and non-medicated) commonly used in wound treatment.

Use the following link https://woundinfection-institute.com/wp-content/uploads/IWII-CD-2022-web-1.pdf to view the solution, in vitro/bench activity, how it is used in wound treatment (cleansing/ irrigation, topically, or in biofilm-based wound care (BBWC).[60]

For a current list of Canadian products see the series of Wounds Canada Product Pickers:
www.woundscanada.ca/Product-Pickers

For a list of international products visit the International Wound Infection Institute website (2022)
www.woundinfection-institute.com/

In addition to topical antimicrobials and commercially available topical antimicrobial/antibiotic dressings, the management of wound and skin infections may also require oral and systemic antibiotics. The choice of antibiotic will depend on current antibiotic stewardship principles: using the correct antibiotic, for the correct length of time. Consideration should be made for:

- patient factors such as allergies, hepatic and renal function,
- patient goals (e.g., whether the wound is a healable or non-healable wound) and co-morbidities; pregnancy and breastfeeding status are also considerations,
- infection factors such as severity of the infection, involvement of bone, risk for drug-resistant bacteria (e.g., MRSA) and recent antibiotic use and
- drug factors such as drug interactions, cost, safety profile and frequency of dosing, system factors such as drug coverage, available route of administration (e.g., oral versus intravenous) and available resources required for IV administration and management.

Figure 4 outlines some options for empiric management of cutaneous and cellulitis infections.

Figure 4: Empiric Management of Cutaneous and Cellulitis Infections[138]

Drug	Dosage
Cutaneous infections – Uncomplicated (adults)	
Folliculitis and Furuncles (boils)	
Hot compresses and antiseptic cleanser	
Mupirocin 2% oint/cream or Fusidic acid 2% oint/cream	tid topically until resolved (max 7 days) tid – qid topically until resolved (max 7 days)
Carbuncles (moderate to severe)	
Hot compresses and antiseptic cleanser	
• Cephalexin • Cloxacillin If penicillin/cephalosporin allergy: • Clindamycin • Trimethoprim/Sulfamethoxazole • Doxycycline If MRSA suspected: • Trimethoprim/Sulfamethoxazole • Doxycycline	500 mg PO qid for 7 days 500 mg PO qid for 7 days 300–450 mg PO qid for 7 days 1 DS tab PO bid for 7 days 100 mg PO bid for 7 days or 100 mg PO bid day 1, then 100 mg PO once daily 1-2 DS tab PO bid for 7 days 100 mg PO bid for 7 days

Cutaneous infections – Complicated (adults)		
First Line	ONE of: Trimethoprim/Sulfamethoxazole Ciprofloxacin +/- ONE of: Metronidazole Clindamycin	1-2 DS tab PO bid 500–750 mg PO bid 500 mg PO bid 300–450 mg PO qid
Second Line	Amoxicillin/Clavulanate	500 mg po tid or 875 mg po bid
	Ceftriaxone +/- ONE of: Metronidazole Clindamycin	1 g IM/IV q24h 500 mg PO bid 300-450 mg PO qid
Third Line	Cefazolin PLUS ONE of: Metronidazole Clindamycin	1–2 g IV q8h 500 mg IV/PO q12h 300–450 mg PO qid or 600 mg IV q8h

Caution: Antimicrobial dressings should never be mixed!
A wide variety of active chemical agents (or biocides) are found in antimicrobials, many of which have been used for hundreds of years for antisepsis, disinfection and preservation. They kill micro-organisms and may be bactericidal, fungicidal, virucidal or sporicidal. The antiseptic interacts with the cell surface followed by penetration into the cell and action at the target sites, but some are cytotoxic and can be harmful to healthy tissue. Others are non-cytotoxic in dilute preparations but can be cytotoxic in higher strengths. Mixing two or more of these products in the dressing can change the chemical formula of each, which may be cytotoxic to the healthy tissue or inactivate the antimicrobial effect. Studies on the efficacy and safety of antimicrobial dressings do not include using them with another antimicrobial dressing or antiseptic product. If one product appears to be ineffective, with lack of response or deterioration, it is time to reassess for reasons, which may be other than infection. It may also indicate the need for a different product or systemic antibiotics.[73]

4.2.4 Managing Moisture Balance

Discussion: The seminal work by Winter in 1962 first described the advantages of moist wound healing that are now recognized in clinical practice.[70] Dressings should retain enough moisture to stimulate good healing yet not cause maceration or irritation to the surrounding tissues.[139,140] Some advantages of moist wound healing include:

- Decreased dehydration and cell death. Wound repair requires the activity of a host of cells, from neutrophils and macrophages to fibroblasts and pericytes. These cells cannot function in a dry environment
- Increased angiogenesis. The cells required for angiogenesis require a moist environment. As well, angiogenesis occurs toward regions of low oxygen tension, meaning that occlusive dressings may act as a stimulus in the process[40, 141,142]
- Enhanced autolytic debridement. In a moist environment, neutrophil cell life is enhanced and proteolytic enzymes are carried to the wound bed, allowing for painless debridement.[85] The resulting fibrin degradation products are a factor in stimulating macrophages to release growth factors into the wound bed
- Increased re-epithelialization. In larger, deeper wounds, epidermal cells must spread over the wound surface from the edges and have a supply of blood and nutrients. Dry, crusted wounds reduce this supply and provide a barrier to migration, slowing epithelialization[85]
- Decreased pain. A moist wound bed insulates and protects the nerve endings, reducing pain

The use of occlusive dressings, or ones that isolate the wound from the outside environment, is one of the most effective ways to maintain moisture in a wound[17,85,143] (See Table 16). The potential results are:

- Improved bacterial barrier and decreased infection rates. Occlusive dressings with good edge seals can provide a barrier to the migration of micro-organisms into the wound. It has been demonstrated that bacteria can pass through layers of moist gauze. Wounds covered with occlusive dressings have been shown to have lower rates of infection than those with conventional gauze dressings
- Decreased pain. Occlusive dressings often require fewer dressing changes, which may be uncomfortable for patients
- Decreased costs. While occlusive dressings have a higher per-unit cost than conventional gauze, increased healing rates and the reduced frequency of dressing changes and related costs of nursing care may be cost-effective in the long term
- Moisture-retentive dressings may be used in combination with other products to support healing such as antimicrobials or pain control dressings.

Table 16: Moisture Management in the Wound

How much moisture is there in the wound?		
Too little… dry	**Just right… moist**	**Too much… wet**
Use a hydrating dressing such as a gel	Use a moisture-retentive dressing such as a wafer	Use an absorber such as a hydrocolloid fibre or foam
Caution Frequent assessment of the wound is required because the wound's moisture level can change, potentially making the dressing an impediment to healing		

4.3 Select the appropriate dressings and/or advanced therapy

Discussion: Over the past 40 years an ever-expanding list of dressing products has come onto the market. There remains, however, no magic 'one-size-fits-all' dressing.[144] The selection of the most appropriate dressing takes into consideration:

- the goal of treatment (based on whether the wound is healing, non-healing or non-healable),
- wound characteristics (including infection) indications and contraindications for the different classes of dressings and advanced therapies,[60]
- phase of healing,
- the needs (and risk factors) of the patient, patient choice, lifestyle and comfort (during change and with use) and cost-effectiveness,
- product availability and the availability and skill of the patient or care partner and
- safety and effectiveness, ease of use and cost-effectiveness of the dressing available.[85,145-149]

Health Canada states that wound dressings and surgical barriers containing an antimicrobial agent and wound dressings whose primary purpose is to act as a barrier to pathogens are considered **devices.** Wound dressings whose primary purpose is to deliver a drug are considered **drugs.**[150]

Studies have consistently shown that appropriate dressing selection and models of care can improve patient outcomes, decrease pain with dressing changes and demonstrate cost-effectiveness when both the dressing product and human resource costs are factored into the equation.[151-155] The patient's response to the dressing requires documented monitoring within a reasonable trial to determine effectiveness before changing to another product.

Dressing selection can be challenging even for the most seasoned clinicians and cannot be made in isolation of the clinical situation. At times, dressings may be used in combination with other products or topical preparations to adequately address patient needs and preferences. Care needs to be taken to ensure that products do not interact with, interfere with or counteract one another.

Wounds Canada has created a series of Product Pickers that address, among other things, (1) product categories, characteristics and contraindications and (2) the clinical situation, local wound care and other care considerations. This tool for clinicians can be posted in the clinical area to assist with decision-making at the point of care.

Dressing Tips: Remember to:

- Change dressing based on patient, wound and dressing assessment, not on standardized routines
- Practise with dressing materials to learn their performance parameters and related 'tricks'
- Check the product information/manufacturer's recommended usage documentation before using any dressing or advanced therapy to ensure it is an appropriate product based on need, costs and availability.

For more on dressings that help with moisture management, please see Product Picker: Wound Dressing Selection Guide & Product Picker: Wound Dressing Formulary: https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/library/183-resources-industry-partner/288-product-picker
Wounds Canada Care at Home Series: Preventing and Caring for your Wounds at Home
https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series

Wounds Canada Product Pickers use generic names to avoid product bias. Most are pdf fillable and free to download

Advanced Therapies

Some wounds may require advanced therapies such as negative pressure wound therapy, electrical stimulation, ultrasound, electromagnetic therapy, ultraviolet light C, hyperbaric oxygen therapy (HBOT), topical oxygen therapy, warming therapy and biologically active dressings. Though each of these modalities has evidence to support their use in limited situations, cost or the lack of good therapeutic evidence in some may limit their usefulness. Not all advanced therapies are available in every region.

Consultation with local experts familiar with these therapies should be sought before using one as a therapeutic course of action.

Table 17 provides an overview of some of the most common advanced wound therapies.

Table 17: Overview of Common Advanced Wound Therapies

Category	Description	Consideration/ Indications/ Contraindications
Negative pressure wound therapy (NPWT)[156,157]	Applies controlled subatmospheric pressure to remove exudate, reduce periwound edema • increases local microvascular blood flow/test vascularity, promotes formation of granulation tissue • reduces complexity/size of the wound • optimizes the wound bed prior to and following surgery and reduces complexity and length of surgical wound closure procedures.	Debridement, including bone if osteomyelitis is present, is necessary prior to the application of NPWT The wound must be free of active, untreated infection (e.g., cellulitis) The wound bed should not involve fistulas to internal organs or body cavities over a blood vessel Caution required in patients receiving anticoagulants Contraindicated with the presence of intracutaneous fistulae, necrotic tissue, untreated osteomyelitis and malignancy
Electrical stimulation (ES)[158-160]	Delivery of a low-voltage electrical current to the wound bed to stimulate healing. Provides benefits in three of the four phases of wound healing **Inflammatory**: increases circulation affecting phagocytosis and tissue oxygenation, reduces microvascular leakage, stimulates fibroblasts and epithelial cells, stimulates DNA synthesis and may have bactericidal effects **Proliferative:** stimulates fibroblasts and epithelial cells, stimulates DNA and protein synthesis, increases ATP generation and membrane transport, improves the organization of the collagen matrix and stimulates wound contraction **Epithelialization**: stimulates epidermal cell reproduction/ migration Electrical stimulation may also address other impairments such as inactive muscles, impaired perfusion, edema and pain to enhance conditions necessary for wound healing	ES should not be applied to areas where it could cause malfunction of electronic devices including cardiac pacemakers, low back or abdomen of pregnant women, acupuncture points of pregnant women, regions of known or suspected malignancy, active DVT or thrombophlebitis, untreated infection or osteomyelitis, recently radiated tissues, to the chest of persons with cardiac disease, arrhythmias or active heart failure, the neck or head region of persons known to have seizures, transcranially without specialized training, areas near reproductive organs or genitalia without specialized training, areas near or over eyes, anterior neck or carotid sinus.
Electromagnetic therapy (EMT)[160,161]	Does not involve the use of a current, as electrical stimulation therapy does. EMT works with generators that create an electromagnetic field to stimulate wound healing	Similar indications and contraindications to ES

Ultrasound (US)[160]	Delivers high-frequency mechanical vibration to facilitate healing at a cellular level in all phases of healing **Inflammatory:** facilitates the release of histamine to attract fibroblasts and endothelial cells and accelerates this phase **Proliferative:** stimulates fibroblast migration and proliferation, promotes angiogenesis **Epithelialization:** releases growth factors **Remodeling:** improves tensile strength of healing tissue	US should not be applied over eyes, genital areas, exposed neural tissue; avoid in thromboembolic diseases Should be distinguished from low frequency ultrasound debridement
Ultraviolet light C[162,163,164]	There are three forms of ultraviolet light: UVA, UVB and UVC. UVC is the most frequently used for chronic wounds and its bactericidal effect has been demonstrated	Can be used for a short period when traditional therapies have failed Contraindications include active cancer in the area
Hyperbaric oxygen therapy (HBOT)[165-168]	In HBOT the patient breathes 100% oxygen intermittently while the pressure in the chamber is increased to greater than one atmosphere absolute (atm abs) Reverses hypoxia by increasing the oxygen diffusion in blood plasma and local tissues The benefits include angiogenesis, collagen synthesis, osteoclastic activity and the release of vascular endothelial growth factor Current information indicates that pressurization should be at least 1.4 atm abs. This may occur in a monoplace (single-person) or multiplace (two or more people) chamber	Indications for use include 'air or gas embolism, carbon monoxide/cyanide poisoning, clostridial myositis and myonecrosis, crush injury, compartment syndrome and other acute traumatic ischemias, decompression sickness, enhancement of healing in selected problem wounds, exceptional blood loss, intracranial abscess, necrotizing soft tissue injuries, refractory osteomyelitis, soft tissue/bone radiation necrosis, compromised skin grafts and flaps and thermal burns.' Should be closely managed by certified hyperbaric physicians/clinicians Considerations include patient selection, monitoring of wounds, contraindications and risks of HBOT use and indications for discontinuation
Topical pressurized oxygen therapy1[60,169]	Differs from HBOT in that topical pressurized oxygen therapy delivers a regulated, pressurized oxygen flow directly to a specific wound area using a portable device (e.g., a soft plastic sleeve or hard plastic chamber) that can be secured to a body surface or around an extremity to create an airtight seal	Controversy exists as to the therapeutic value of topical pressurized oxygen delivery to local tissues/wounds

Warming Therapy[170]	Application of a heating element in the dressing that increases heat in the wound bed, inducing vasodilatation of the original blood vessels	Contraindications: • very large areas or at sufficient intensity to raise core temperature in pregnant women, persons with severe cardiac disease or cardiac failure • regions of known or suspected malignancy • infected tissues or persons with TB • persons with active DVT or thrombophlebitis (in the area) • areas of impaired sensation that prevent the patient from giving accurate and timely feedback • areas of active bleeding or persons with untreated hemorrhagic disorders • recently radiated tissues • persons with cognition or communication impairments that prevent the patient from giving accurate and timely feedback
		• areas with significantly impaired circulation • tissues inflamed as a result of recent injury or exacerbation of chronic inflammatory condition • areas affected by heat-sensitive skin diseases (e.g., eczema) • areas of severe edema • reproductive organs (e.g., testes) Precautions: • areas near or over eyes • anterior neck and carotid sinus • pregnant women • people with cardiac failures • areas of skin breakdown or damage that produce uneven heat conduction across the skin

Biologically active dressings [143,171-174]	Developed to find adjunctive exogenous factors to induce and stimulate healing or to produce a skin substitute for use in acute and chronic wounds Living skin equivalents (LSE), or tissue-engineered skin is a bilaminar structure of epithelium cultured on a dermal equivalent. It has characteristics that closely resemble a skin graft and is used in that capacity (This is not currently available in Canada.) Protease modulating dressings: Rebalance high protease activity levels in a stalled, healable wound. Isolated growth factors: Platelet-derived growth factor (PDGF), available as recombinant human PDGF-BB, reduces healing time and improves the incidence of complete wound healing in stage 3 and 4 pressure injuries	Used alone, these dressings will not effectively produce results if proper wound bed preparation does not first occur Contraindications: • wounds with infection, sinus tracts or excessive exudate • patients known to have hypersensitivity to any of the product components Cultural issues related to the source of the biologically active dressing may be of concern to some patients

4.4 Engage the team to ensure consistent implementation of the plan of care

Discussion: Ensure that all team members have well-defined roles and responsibilities, are making contributions, documenting care, and communicating effectively with the larger team, including discussing outcomes. The team needs to show continuous progress toward the goal(s) of the plan of care and provide regular feedback to all team members.[21,85]

To ensure optimum care, health-care professionals need to recognize the need for their own continuing education to keep abreast of changes in the skin and wound management community. Researchers and industry partners are key ancillary team members that support clinicians in providing innovations for wound management. Because of ongoing developments in the areas of treatment and medication, all professional members of the team have a responsibility to remain up-to-date and share information on the latest evidence, practice and self-management strategies.

Knowledgeable and effective advocates can influence policies that support best practice in all areas of wound prevention and management. This can be accomplished by:

- working within individual institutions and agencies to influence decision making regarding policies, procedures, culture and resource allocation
- presenting a unified voice to governments and actively leveraging collaborative relationships to develop and implement public health policy related to prevention, assessment, prevention, assessment and management of wounds
- raising the profile of wounds in Canada with the public and decision makers.

Step 5: Evaluate Outcomes

Evaluation of the plan of care should be routine and ongoing to identify whether the plan is effective in meeting the goal(s).[1]

Discussion: Routine reassessment and potential modifications of the plan of care need to be built into the plan to ensure it continues to meet the patient's needs and is sustainable. Changes to the plan of care should be documented and shared with the team. Promotion of skin health and prevention of skin complications and wounds is a priority. Since wound healing is only one outcome parameter and wound closure is not always realistic, other outcomes outlined in the goals of care, such as symptom control (pain, odour, depression, anxiety) should also be routinely measured with standardized tools.

Recommendations

5.1 Determine if the outcomes have met the goals of care

Discussion: The use of validated and responsive tools as well as patient feedback can assist in determining if the goals of care have been met. These tools provide benchmark assessments to determine the improvement or deterioration of a condition or wound and if outcomes have been met.[21,63]

Documentation determines whether the goals of the plan of care have been met because it verifies progress from admission to discharge.[11,175] Documentation must address the patient's needs, track clinical performance and support a defence in the event of a lawsuit. Therefore, chart entries need to be thorough, accurate, factual, objective and follow agency policy and procedures.

If goals of care have been met, discharge planning may proceed and must include a discussion of new goals and relevant self-management strategies (See 5.3).

5.2 Reassess patient, wound, environment and system if goals partially met or unmet

Discussion: When goals of care are not being met, go back to Step 1 of the Wound Prevention and Management Cycle. Reassessment needs to consider the level of adherence to the plan of care by anyone involved in either the planning or implementation of interventions, and the appropriateness of the goals of care. Careful exploration may reveal modifiable factors that can be addressed. These issues should be discussed utilizing trust-filled communication strategies, and in a non-confrontational and sensitive manner, otherwise the patient or health-care colleagues may not be able to support progress to the desired outcome.

Key documentation areas to address include the following:

- patient and or family engagement and support, as this may change over time,
- all communication with the patient and care partners,
- completed assessment tools,
- consistently followed protocols,
- all communication with health-care professionals and service providers,
- patient response to care and
- changes in the delivery of care, access to products, providers, costs.

5.3 Ensure sustainability to support skin health, wound prevention and reduce risk of recurrence

Transitions in care are when transfer of responsibility and accountability for some or all aspects of patient care occurs among providers, institutions, and/or sectors (e.g., federal and provincial jurisdictions, or education, judicial and other environments). Canadian health systems are organized in a way that requires individuals to receive health services from a number of care providers, in a number of locations, leading to multiple transitions in care over time. This is especially true for individuals with long-term health complications, those experiencing changes to their health status or a change in care need and/or a change in their location of care.[176]

Discussion: Discharge planning begins at admission and should include collection of comprehensive data to ensure transitions of care are communicated and smooth for the patient and/or care partner. For patients with skin and wound care issues, transitions of care must be communicated clearly between team members. Team membership may change, but communication must be organized, continuous and documented and include the patient and family. This is especially important when patients transition to and from emergency, acute care, rehabilitation units, assisted living and long-term care locations. Those living unhoused, in shelters or in challenging housing scenarios may require additional interventions for care and safety.

Information collected from any patient encounter contributes to successful transitions in care. Discharge teaching information for patients and care partners should be written in plain language and made available in relevant languages. Pamphlets with discharge instructions should be reviewed with the patient, and they should be given an

opportunity to ask questions and provide feedback to ensure that the instructions are understood. Education may include web-based resources, videos and peer support groups. Patients should also receive clear instructions about whom to call should complications arise.

To ensure sustainability, consideration needs to be given to the patient's ability to manage their own care, comfort and cosmetic appearance, patient preference, product availability and the presence and ability of the care partner to provide care and/or assist in the patient's care.

Summary

Best practice includes the patient voice, evidence, clinician expertise and resources and does not occur innately; it requires substantial work as well as a framework for implementation. Sustainable best practice requires even more work and involves the patient at every step. Collaboration is required not only in the short and intermediate terms with all members of the team, but also in the longer term with stakeholders such as researchers, educators, researchers, practitioners and policymakers at individual, organisational and systems levels. By using the Wound Prevention and Management Cycle the integrated team will have a systematic process to provide individualized best practice-based care to support skin health and wound healing.

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Appendix A

Nutrition for Wound Prevention and Healing
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Introduction

Maintaining healthy, intact skin and promoting wound healing is a complex and energy-demanding process; therefore, understanding and supporting the nutritional status of the patient is essential.[1]

Although often overlooked, nutrition is a key component of care.[2] Eating well and staying hydrated will help patients at risk for skin breakdown, support wound healing and prevent complications such as slow healing, prolonged inflammation, infection and reduced tensile strength of the scar.[3] Nutrition support is a low-risk, cost-effective strategy that not only helps improve overall health but also has the potential to reduce length of stay in hospitals and reduce rates of hospital readmission.[4]

Nutrition deficiencies may lead to dermatological changes (dryness, itching, cracking, inflammation, infection, bleeding, pain).[5,6] In a recent review, researchers highlight the links between protein-energy and micronutrient-related malnutrition (vitamin and mineral deficiencies) and skin changes.[5] Early Nutritional screening, including identification of any skin changes, may decrease or reverse the risk of further skin breakdown and reduce risk of complications (infection). As such, its importance should not be underestimated. Individualized nutritional care plans are crucial to promote skin health and to promote wound healing.[7-9]

For patients that develop wounds, the process of wound healing includes timely assessment and development of an individualized care plan. This includes educating the patient, care partner and family.

Wound healing phases included coagulation, inflammation, proliferation of new cells and remodeling.[2] Nutrients are required at all stages of the wound healing cascade and are vital for all wound types, regardless of the cause. Nutrient requirements are increased when a wound is present or the skin is at risk for breakdown. Macronutrients (protein, energy [calories] and fat), micronutrients (e.g., iron, zinc, vitamins A, C, and D) and fluids are needed to support skin integrity and wound healing.[10-13] As the wound healing cascade may take up to a year to complete, enhanced nutrition support needs to be sustained in patients who have had wounds.

Patients living with overweight or obesity need special nutrition consideration as their risk for wounds may be increased; they may have a greater incidence of pressure injuries, venous ulcers, wound dehiscence and skin infections.[14,15] Due to the increased nutritional demands of wound healing, a patient's effort at weight loss should be discouraged at this time. Weight maintenance or gain, where indicated, may be appropriate.

Malnutrition

Approximately 2.5% of Canadians are malnourished16 and 20% to 50% of individuals are malnourished on admission to the hospital, with additional decline expected during hospitalization.[4,17] Therefore, nutritional screening and appropriate interventions, such as referrals to the registered dietitian (RD), nutrition support, monitoring and evaluation of the patient and healing outcomes are required for patients at risk for skin alterations or living with skin breakdown or a wound.[18]

The Canadian Malnutrition Task Force states:

Malnutrition includes both the deficiency and excess (or imbalance) of energy, protein and other nutrients. In clinical practice, undernutrition, and inadequate intake of energy, protein and nutrients is the focus. Undernutrition affects body tissues, functional ability and overall health. In hospitalized patients, undernutrition is often complicated by acute conditions (e.g. a trauma), infections and diseases that cause inflammation. Such complications worsen undernutrition and make it more challenging to correct due to extensive physiological changes and increased nutritional needs when appetite is decreased.[4]

Malnutrition, or undernutrition, is a common risk factor that contributes to the development of wounds and prolonged healing of wounds, in addition to other health concerns.[19] Patients at risk for malnutrition include those hospitalized and extremes of age (infants, children, youth, elderly).[20] As well, patients living with changes to their ability to ingest (e.g., poor appetite, swallowing or chewing concerns), digest, and/or absorb (e.g., crohn's, colitis) food and fluid are at a high risk of malnutrition.[9] In a recent review focused on older adults/geriatrics, researchers emphasized the complexity of malnutrition and the need for multi-factorial assessment to address the challenges.[21]

Diabetes

Hyperglycemia impairs wound healing and may increase risk for infection, malnutrition and other vascular complications. Diabetes Canada suggests an A1C target of equal to or less than 7% for most individuals with diabetes. Individualized targets need to be considered for those at risk for severe hypoglycemia, hypoglycemia unawareness, frail elderly or those who are functionally dependent (A1C target 7.1-8.5%).

Clients may need support adjusting diabetes medications, assessing blood glucose levels (capillary blood glucose or continuous glucose monitoring), learning the sources of carbohydrate in the diet, choosing lower glycemic food options and spreading carbohydrate through the day.

Malnutrition Screening

All patients with, or at risk for, a wound should be screened using a validated nutritional screening tool (See Table 1). Screening can be completed by any member of the health-care team.[11,12] Due to the relationship between malnutrition and poor patient health outcomes and health care costs, leaders and policy makers should have nutrition screening, and subsequent RD assessment of patients at nutritional risk, imbedded into standard interdisciplinary practice, policy and outcome measurements for persons across the lifespan.[3] Leaders should establish interprofessional education and training, alongside RDs, for health-care team members to maintain their understanding on the importance of screening for nutrition risk, referring to RDs and involving the patient and care partners.

Registered Dietitians and Wound Care

The role of the Registered Dietitian (RD) on the wound care team is essential.[22,23] RDs assess patient nutritional status and use evidence-based guidelines to co-create patient-centred interventions and monitor and evaluate skin and wound healing outcomes.[11,12]

The Team

The integrated health-care team includes the patient, care partner(s), family, RD, health-care personnel, primary care providers, speech-language pathologists and occupational therapist (for swallowing assessment), as well as staff that prepare and serve food in institutional settings and home settings.

Barriers to skin health and wound healing include a range of modifiable and nonmodifiable factors that must be assessed and addressed by an interprofessional health-care team alongside the patients and care partners.[2]

The Role of the Patient and Care Partners

In the community setting, key to nutritional success is to engage the patient and care partners and community services available. In the home environment, families and regular caregivers can promote optimal intake, provide meals and snacks and document food and fluid intake records to share with the RD. This includes supporting patient positioning while eating/feeding.[24] Care partners and family members benefit from education to help them understand their role in food and fluid intake, especially to support skin health and wound healing.

Section A of this Appendix uses the Wound Prevention and Management Cycle as a framework for providing best practice as it relates to nutrition for the prevention and management of wounds.
Section B contains information aimed specifically at registered dietitians.

Section A

Step 1: Screen for malnutrition risk and conduct a comprehensive patient nutrition assessment as part of an overall patient assessment

Screening for risk of malnutrition is part of baseline data collection and should be conducted using validated tools. Choice of screening tool will vary depending on the patient. See Table 1 for Nutrition Screening Tools. Positive screens for malnutrition should trigger a referral to the registered dietitian (RD) for individual nutrition assessment and intervention.[25,26]

For care partners and families, this may include having them complete a basic nutritional data collection form. This information can then be used by the health-care professional to support baseline data collection alongside their completion of a validated tool. For more information Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.

Table 1: Nutrition Screening Tools

Screening Tool	Population
Mini Nutrition Assessment SF (MNA®-SF)	Identifies adults 65 years or older, living in long-term care or community dwelling, who are malnourished or at risk of malnutrition
Self-Mini Nutritional Assessment (Self-MNA)	Identifies adults over 65 years of age who are at risk of nutritional compromise
Malnutrition Universal Screening Tool (MUST)	Identifies adults who are underweight and at risk of malnutrition (acute, long-term care or community)
Malnutrition Screening Tool (MST)	Identifies adult patients in acute or ambulatory care who are at risk of malnutrition
Canadian Nutrition Screening Tool (CNST)	Identifies adult patients in acute care at risk of malnutrition
Short Nutritional Assessment Questionnaire (SNAQ)	Identifies adults who are underweight and at risk of malnutrition (acute)
Short Nutritional Assessment Questionnaire 65+ (SNAQ 65+)	Identifies adults over 65+ in the community who may be at risk of malnutrition
Short Nutritional Assessment Questionnaire for Residential Care (SNAQ-RC)	Identifies adults over 65+ in residential care who may be at risk of malnutrition
Nutri-eSCREEN (online)	Used for self-screening eating habits for adults aged 50 and over

Assess the patient's body weight and height, as able, to help assess nutrition risk and aid the RD in estimating nutrient requirements for skin health and/or wound healing.

While the RD will provide individual assessment, health-care team members support the patient and care providers. This includes:

- Discussing food choices, medication(s) that may affect their desire to eat or drink, access to food and fluid, finances and meal planning and preparation with the patient and family. This includes access to a kitchen, meal services available in the community (e.g., with a fee or not) and social activities where food is included
- Determining if the patient has been referred to RD services in the past or present. Re-refer as appropriate
- Assessing the patient's appetite and food preferences based on personal and cultural preferences
- Assessing for food allergies, sensitivities and intolerances (e.g., Celiac disease)
- Determining if the patient is following any potentially restrictive diet (e.g., a weight-loss diet, low-carbohydrate diet, periods of fasting)
- Assessing for barriers to food intake, such as chewing or swallowing difficulties, nausea, pain, taste changes or shortness of breath
- Assessing for additional fluid and nutrient losses through diarrhea, vomiting, fever, heavily draining wounds (e.g., document losses with negative pressure wound therapy) or high output ostomies
- Determining use of nutritional supplements such as oral nutrition supplement drinks, modular/powdered protein supplements, or vitamins or minerals tablets
- Assessing glucose management (e.g., capillary blood glucose, continuous glucose monitoring data or A1C) and use of insulin and/or other diabetes medications
- For persons with cognitive changes and/or disabilities, reviewing medications and their side effects. As well, consider how their medications may be impacting their cognitive function and appetite (e.g., anti-seizure medications may affect one's desire to eat or drink)
- Documenting findings as per policy
- Discussing any concerns with the RD and the team (including the patient, care partner and family).

Step 2: Set goals for skin health or wound healing

The importance of nutrition and fluid intake cannot be understated to promote wound healing.[18] Nutritional interventions should be specific, timely and provided in a culturally sensitive manner. For example, Clark et al., reported that patients with wounds who received daily wound-specific oral nutritional supplementation had wounds that closed sooner.[27]

Ensure the patient and their care partners are actively involved in the goal-setting process[28] by:

- Providing education to the patient, care partners and family members on the importance of food and fluid for skin health and wound healing
- Outlining the importance of additional nutritional needs while healing
- Discouraging efforts at weight loss while a wound is healing.

Once the patient and care partners have the information they need, the team can begin the goal-setting process following SMART principles.

- In consultation with the RD, set goals for desired outcomes such as regular meals and snacks, fluid intake in 24 hours or intake of nutrient-dense foods. The RD may suggest liberalizing restrictive diet patterns or plans
- Review strategies to address food intake barriers and set specific goals to address them
- Review glucose management targets. Refer to a diabetes educator, most responsible clinician or visit Individualizing Your Patient's A1c Target: https://www.diabetes.ca/managing-my-diabetes/tools---resources/individualizing-your-patient%E2%80%99s-a1c-target] from Diabetes Canada website for more information
- In consultation with the RD, determine if the patient qualifies for nutritional products to support wound healing and, if so, set goals with specific targets
- If appropriate, consider goals related to collaboration with community-based food programs to support food access.

Step 3: Assemble the team

Effectively addressing issues of malnutrition or appropriate nutrition management for at-risk individuals or those healing a wound requires a knowledgeable team working together to help patients and their care partners meet nutritional needs and overcome any barriers to meeting those needs. For some individuals, these barriers can be significant. Based on the results of the assessments and goal-setting process, assemble a team that will have the ability to address the challenges presented by the patient's individual situation. For many individuals, the members of the team will need to be outside the health-care system and involve community-based professionals or personnel from other government agencies.

To improve the team's knowledge about skin and wound-relevant nutrition, useful resources may include:

Nutrition and Malnutrition Resources for Health-care Providers

Wounds Canada. Nutrition
https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/nutrition

- Eating well for wound healing https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/wcc-2022-v20-n1/2576-wcc-summer-2022-v20n1-final-p-46-51-eating-well/file
- Feeding the foot: nutrition and diabetic foot ulcers https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/2020-v19-n3/1857-wcc-fall-2020-v18n3-final-p-40-47-nutrition/file
- Nutrition and pressure injury healing: updated recommendations https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/2020-vol-18-no-1/1656-wcc-spring-2020-v18n1-final-p-20-27-nutrition/file
- Malnutrition and wound healing https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/2019-v17-no3/1591-wcc-fall-2019-v17n3-final-p-33-37-malnutrition/file
- Healing with hydration https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/2018-vol-16-no-2/1343-healing-with-hydration/file
- The power of protein in wound healing https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/wcc-2019-v17-no1/1407-wcc-spring-2019-v17n1-final-p-34-37-protein-pdf/file
- Nutrition and negative pressure wound therapy: improving outcomes https://www.woundscanada.ca/doclink/wcc-summer-2023-v21n1-final-p-15-19-nutrition-and-negative-pressure-wound-therapy-improving-outcomes/

Wounds Canada. Professional guide focused on Indigenous health. Nutrition for wound prevention and healing. 2022.

Nutrition Resources for the Patient, Care Partners and Family

- Wounds Canada. Eating well for wound healing: a patient resource. https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/wcc-2022-v20-n1/2576-wcc-summer-2022-v20n1-final-p-46-51-eating-well/file
- Alberta Government. High-protein foods for wound healing. https://myhealth.alberta.ca/Health/pages/conditions.aspx?hwid=abs1199
- Canadian Digestive Health Foundation. Diet and nutrition - tips for seniors and their caregivers. https://cdhf.ca/en/diet-nutrition-tips-for-seniors-and-their-caregivers/
- Sinai Health and University Health Network (Healthy Ageing and Geriatrics). Why is nutrition important to consider as you age? https://sinaigeriatrics.ca/patient-resources/improving-nutrition-as-you-age/
- Government of Canada. Healthy eating for seniors. https://food-guide.canada.ca/en/tips-for-healthy-eating/seniors/
- Canadian Nutrition Society. Protein foods for older adults. https://cns-scn.ca/sites/default/uploads/files/Protein%20Resources%202020/Protein%20Foods%20Handouts%20older%20adults%20EN.pdf

Step 4: Establish and implement a plan of care

Consider interdisciplinary, collaborative and patient-centred treatment, utilizing an evidence-informed approach that is aligned with the overall goals of care to maintain skin health and/or promote wound healing.
Some elements of a care plan might include:

- Meal planning: Encourage meal plans that include preferred foods, are culturally appropriate and address identified nutritional deficits to support skin health or wound healing
- Communication: Discuss how the support person(s) can be of assistance in achieving the goals, such as offering the patient smaller, more frequent meals, snacks or fluids more often, or adding specific types or quantities of food to address nutritional deficits
- Blood glucose management: Engage diabetes educators, physicians, nurse practitioners for glucose management, as needed
- Navigation: Support the patient in attending web-based appointments related to nutrition and skin health/wound healing
- Toileting: Promoting toileting routines and management of bowel and bladder routines
- Connections: Partner with community-based food services for additional nutritional foods/fluids
- Contact government agencies regarding food assistance eligibility if needed
- Referrals: Refer to a speech language pathologist for swallowing difficulties, and occupational therapy for positioning/seating while eating, and other professionals as appropriate
- Education: Provide nutrition information that is appropriate for the patient and family using credible resources (see Nutrition Resources for the Patient, Care Partners and Family above).

Step 5: Evaluate Outcomes

On a regular basis and in discussion with the patient, care partner, family and RD/health-care team determine if the goals set are being achieved or require adjustment. For example:

- Has skin health been maintained?
- Is the wound healing?
- Is the patient achieving and maintaining their food-related goals?
- Is the patient hydrated?
- Is the patient maintaining or gaining weight, as appropriate?
- Are nutrition supplements recommended by the RD being used and/or tolerated?
- Have the barriers to eating being successfully addressed? (e.g., swallowing safety, access to food, cost, feeding support and meal preparation?)
- Is there an established toileting routine to promote bowel and bladder hygiene?
- Are the blood glucose targets being met?

Regular communication (in person, web-based, email, phone) with the family and/or support persons will aid in determining if any suggested changes they implemented have been beneficial and/or successful for the patient.

If, after the steps above have been completed, and the nutrition goals have not been fully met, go back to the assessment step. It is then necessary to reassess causative factors, barriers to promoting nutrition support and revise the care plan. Ask the patient, family or the support person(s) for feedback. Discuss reassessment with the RD, patient, family and health-care team.

Revising the care plan may highlight a single hygiene product, food access or behaviour that was not identified in earlier care plans, or may identify several areas where new goals need to be set and a revised plan implemented.

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Section B

Nutrition for Wound Prevention and Management for Dietitians (Adults)
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This section is specific to registered dietitians. The British Columbia Provincial Interprofessional Skin and Wound Committee - Registered Dietitians sub-committee has developed guidance for the nutrition and wound prevention and management for adults.

Introduction

This section will review the key nutrition requirements common to all wounds. Note: burns greater than 10% total body surface area are beyond the scope of this document. For more information please refer to specialized burn nutrition, such as discussed in Chapter 8: Best Practice Recommendations for the Prevention and Management of Burns.

Wound healing is an anabolic process requiring a steady supply of nutrients and fluid to the wound bed. Nutrients are required at all stages of the wound healing cascade and are vital to preserve skin integrity. Nutrition is an important part of the care plan for prevention and treatment of all wounds. While a wound may result from a variety of different etiologies (e.g., venous stasis, diabetes mellitus, arterial insufficiency, post-surgical, pressure injury, burns, skin tears, trauma, moisture associated skin damage, lymphedema, etc.), the nutrition considerations for prevention and treatment remain consistent. Cultural considerations and understandings should guide assessment and care planning to support patient (client, resident) preferences, cultural safety and relevance.

Malnutrition

Poor nutrition and malnutrition can increase the risk of wound development, interrupt the healing process, reduce the tensile strength of a wound, contribute to wound chronicity and severity and can increase the risk of infection.

Malnutrition is usually diagnosed when two or more of the following nutrition characteristics are identified: unintentional weight loss, loss of muscle mass, loss of subcutaneous fat, fluid accumulation (that may mask weight loss) and diminished functional status (as measured by hand-grip strength). See validated malnutrition screening tools in Table 1. Risk factors contributing to malnutrition include poor appetite, the inability to eat or cook independently, pain, dehydration, dementia, disordered eating, dysphagia, gastrointestinal disorders and food insecurity, among others.

When a patient/client/resident is identified with malnutrition and at risk of developing a wound, the nutritional focus is to optimize energy, protein and fluid intake in order to maintain overall health and skin integrity. The nutritional approach includes promoting a balanced diet where intake meets the dietary reference intakes (DRIs) for macro- and micronutrients, including energy dense foods, liberalizing diet restrictions and correcting suspected or confirmed nutritional deficiencies through the diet or vitamin-mineral supplementation. Recommendations should be adapted for cultural and personal preferences. Nutrient needs are best met through a 'food first' approach, meaning offering nutrient-rich foods before offering fortified foods or oral nutrition supplements (ONS).

Management

Early identification and diagnosis of malnutrition followed by nutritional intervention by an RD has the potential to reduce the prevalence of wounds, improve a person's quality of life, support wound healing and reduce health-care costs and hospital admission/readmission rates. See Dietitians of Canada for more information: https://www.dietitians.ca/

When a wound is present, nutritional requirements are increased. Individual energy needs are based on the number and severity of the wound(s), body weight, degree of weight loss (if applicable) and other comorbidities. Energy from carbohydrates and fat is needed to 'spare' protein, thereby allowing protein to be used for wound healing and preserving skin integrity. Hydration status impacts wound healing, as dehydration can reduce blood volume and

circulation, resulting in reduced delivery of nutrients to the wound bed and elimination of wastes, thereby impairing wound healing and increasing risk of further skin breakdown. Protein and fluid requirements may be further increased with heavily exudative wounds and/or use of negative pressure wound therapy (NPWT). Assessment of fluid status through a review of laboratory markers and/or clinical signs is recommended. As protein and fluid needs are impacted by renal and hepatic disorders and other comorbidities, caution is advised when recommending protein and fluid to people with these diseases/disorders. To enhance communication and collaboration, consider consulting the most responsible physician/nurse practitioner to review recommendations and to ensure consistent messaging for the patient.

While all micronutrients are essential for health, there are several key vitamins and minerals associated with wound healing, including vitamin A, vitamin C and zinc. Vitamin D intake can also be low in the Canadian population and warrants attention, particularly for those living with diabetes. As anemia can lead to delayed or non-healing wounds, intake of iron, vitamin B12 and folate should be assessed. When interpreting laboratory data, it is important to note that micronutrient levels and certain biomarkers are sensitive to the presence of inflammation (particularly if C-reactive protein [CRP] levels are greater than 20 mg/L). For example, ferritin levels could be falsely elevated in the presence of inflammation, while zinc, vitamin D and vitamin A levels may be falsely decreased. While correcting known deficiencies is essential, single vitamin or mineral supplementation above the DRIs has not shown benefit. If an individual cannot meet the DRIs through a balanced diet, supplementation can be considered. Of note, not all physicians can order vitamin or mineral assays, and results may take several weeks to complete. Clinical judgement and other nutrition assessment data may prove more useful in the near-term when recommending vitamin and mineral supplementation.

Recent evidence supports use of ONS that include arginine, zinc and antioxidants in adults when a pressure injury is present (Category/Stage II or greater), as these have been shown to improve healing. However, these arginine-enhanced or other ONS specifically formulated for wound healing are not currently available in Canada.

Optimal glycemic control for people living with diabetes and wounds is strongly recommended, as hyperglycemia can impair wound healing. Ensure a balanced diet with adequate fluid intake and modify carbohydrate intake. Include lower glycemic carbohydrate choices, whenever possible, while optimizing the diet.

People with larger bodies need special nutrition consideration as their risk for wounds may be increased and they may have a greater incidence of pressure injuries, venous ulcers, wound dehiscence and skin infections.

In addition, malnutrition risk may be higher in those individuals who undertake long-term efforts at weight loss or have unbalanced diets. Weight maintenance or gain, where indicated, is recommended during wound healing.

Guidelines

Screening

1. Screen all clients with a wound, or at risk for a wound, for malnutrition. Choice of screening tools will vary depending on the population screened: inpatient, living in a residential facility or community dwelling (See Table 1).
2. Subscales of the Braden Risk and Skin Assessment and the Pressure Injury Prevention Points (NPIAP) can also be helpful in delineating those at risk for wounds as a result of nutrition complications. These scales, however, do not specifically screen for malnutrition.
    a. Braden score of 3 or less: recommend high protein/high calorie diet
    b. Braden score of 2 or less: requires a RD referral.

Assessment

3. Perform Subjective Global Assessment (SGA) or Nutrition Focused Physical Exam (NFPE).
4. Review recent bloodwork, focusing on the following values:
    a. Complete blood count (CBC)
    b. Electrolyte panel, blood urea nitrogen (BUN) and creatinine
    c. Fasting blood glucose and hemoglobin A1c

d. Vitamins/minerals such as vitamin D, zinc, and iron panel, with or without ferritin, as available

e. Monitor for signs and symptoms of dehydration (thirst, dizziness, dry lips and mouth, fainting, flushed skin, low blood pressure, tiredness, increased heart rate, irritability, headache, dark strong-smelling urine, decreased urine output).

Note: albumin and prealbumin levels are not reflective of protein stores and may be altered by inflammatory conditions.

5. Review weight history. Watch for significant weight loss indicated by more than 5% weight loss in one month, 7.5% in three months or 10% in six months.
6. Review number and staging of wounds.
7. Nutrition Requirements:

a. Energy. Recommend 30–35 kcal/kg to meet energy requirements and maintain/regain body weight.

i. If BMI is greater than 30:

1. The Mifflin-St. Jeor equation may be more appropriate for predicting resting metabolic rate, **OR**

2. Use adjusted body weight to calculate energy needs, **OR**

3. Use 11–14 kcal/kg actual weight

ii. Consider high energy/high protein ONS between meals if nutrition requirements cannot be met through food alone.

iii. Calculate energy requirements using indirect calorimetry if available.

Note: Adjusted body weight for BMI >30 = IBW + 0.25 x (actual body weight - IBW)
Ideal Body Weight (IBW) = weight at BMI of 24.9.
Consider use of Diabetes Canada – Calculate your Body Mass Index https://www.diabetes.ca/managing-my-diabetes/tools---resources/body-mass-index-(bmi)-calculator

b. Protein. Recommend 1.25-1.5 g/kg protein depending on the number and severity of wounds. Caution is advised when determining protein needs in renal or hepatic disorders. Use adjusted body weight when assessing protein requirements for individuals with BMI greater than 30.

i. Consider fortifying food with modular protein supplements (e.g., whey, soy, collagen) when protein needs cannot be met through food.

ii. Higher protein requirements may be seen with high output NPWT and larger wounds. Closely monitor nutrition status.

c. Hydration. Recommend 30–35 ml/kg fluid or 1.0 ml/kcal to meet fluid needs. Fluid needs will be increased with heavily exudating wounds, use of NPWT, fever or gastrointestinal losses (e.g., diarrhea, vomiting). Caution is advised when recommending fluid requirements in renal, cardiac or hepatic disorders.

d. Micronutrients. Correct known or suspected deficiencies. Refer to the DRI for specific nutrients.

i. Minerals

1. Assess iron deficiency anemia by reviewing CBC, iron profile and ferritin. Caution is advised in patients with chronic kidney disease or those with active infection/sepsis.

a. Recommend adequate dietary sources of iron or suggest iron supplementation if deficient.

b. Consider potential gastrointestinal side effects of oral iron supplementation (e.g., constipation, diarrhea).

c. Avoid concurrent oral calcium supplements or calcium-rich foods with oral iron or zinc supplementation.

2. Assess zinc status if available. Recommend adequate dietary sources of zinc or suggest zinc replacement if deficient.

ii. Vitamins

1. Assess Vitamin C status if available. Recommend adequate dietary sources of Vitamin C or suggest Vitamin C supplement if deficient. Vitamin C requirements may be increased with commercial tobacco use.

2. Assess Vitamin D status if available. Recommend adequate dietary sources of Vitamin D or suggest Vitamin D supplement if deficient.

3. Assess Vitamin A status if available. Recommend adequate dietary sources of Vitamin A or suggest Vitamin A supplement if deficient. Consider Vitamin A supplementation with prolonged corticosteroid use.

4. Assess B12 and/or folate level(s) if available. Screen for macrocytic anemia by reviewing CBC (elevated MCV). Recommend adequate dietary sources of B12 and/or folate or suggest supplementation if deficient. Consider a potential for low B12 status for clients over 60 years of age, long-term adherence to a vegan/vegetarian diet, diagnosis of gastrointestinal disorders, or prolonged use of some medications (e.g., proton pump inhibitors, metformin, methotrexate).
iii. Recommend a general multivitamin-mineral supplement if intake is poor (e.g., less than 50% usual food consumed). Consider all sources of vitamin and minerals before recommending (e.g., ONS, fortified foods, single nutrient supplements, tube feeding formula, parenteral multi vitamin preparation).

e. Consider enteral nutrition support for those who cannot meet nutritional requirements orally. Parenteral nutrition must be considered for patients with non-functional GI tract when feeding via oral and enteral routes is not possible. Initiation of enteral and parenteral support must be consistent with the patient/client/resident's goals, priorities, context and resources.

8. Recommend optimal glycemic control for people living with diabetes. For most people, target:
   a. Capillary blood glucose of 4.0–7.0 mmol/L preprandial and 5.0–10 mmol/L 2 hour postprandial (5.0–8.0 mmol/L if A1c not at target).
   b. Hemoglobin A1c ≤ 7.0%.
   c. Glycemic targets may need to be individualized with frailty, functional dependence or those living with hypoglycemic unawareness or recurrent severe hypoglycemia. Refer to the client-specific targets as determined by the diabetes team and/or physician.
9. Consider mental, spiritual and emotional wellness factors that are influencing health and healing.
10. For many Indigenous, First Nations, Metis, Inuit peoples, food is considered a medicine. Create space in the conversation to inquire about traditional food(s), fluid(s) and/or traditional medicine use.

Nutrition Care Process

11a. Determine the most appropriate nutrition diagnosis(es) (See Table 2).

Table 2: Nutrition Diagnosis Examples

Inadequate oral intake (NI-2.1)
Inadequate fluid intake (NI-3.1)
Increased nutrient needs. Specify the nutrient(s), (e.g., energy and/or protein) (NI-5.1)
Malnutrition (NI-5.2)
Inadequate protein-energy intake (NI-5.3)
Inadequate protein intake (NI-5.7.1)
Inadequate vitamin intake (specify) (NI-5.9.1)
Inadequate mineral intake (specify) (NI-5.10.1)
Unintended weight loss (NC-3.2)
Acute disease or injury related malnutrition (undernutrition) (NC-4.1.3)
Food- and nutrition-related knowledge deficit (or accepted synonym), limited food and nutrition related knowledge (NB-1.1)

11b. Identify the Problem, Etiology, Signs and Symptom (PES) statement (See Table 3).

Table 3: Problem, Etiology, Signs and Symptom (PES) Statement Examples

Inadequate protein intake related to inability to meet elevated protein requirements secondary to a stage III pressure injury as evidenced by client's estimated protein needs and diet history
Food and nutrition-related knowledge deficit related to previous lack of education around nutrition for wound healing as evidenced by recent dietary intake and food choices

Inadequate oral intake related to decreased appetite and ability to meet macro- and micronutrient needs as evidenced by a 5% weight loss in one month and non-healing diabetic foot wound
Increased protein and hydration requirements related to stage IV wound treated with wound VAC as evidenced by 300 ml exudate accumulating in 24 hours, and prolonged wound healing time
Malnutrition may be related to dysphagia as evidenced by the patient eating less than 50% of minced and moist foods (IDDSI L5) with mildly thick (IDDSI L2) fluids due to the client's report of low appetite for the same
Predicted inadequate vitamin intake (vitamin C) related to reduced intake of fruits/vegetables and increased vitamin C needs with commercial tobacco use, as evidenced by bleeding gums and impaired wound healing
Inadequate mineral intake (zinc) related to malnutrition/inadequate oral intake as evidenced by serum zinc 0.4 mcg/mL, weight loss of 20% in six months, and client report of low intake of zinc-rich foods (e.g., meats, eggs, legumes, etc.)
Unintended weight loss related to increased difficulty purchasing food and preparing meals due to mobility impairment with foot ulcer as evidenced by weight loss of 5% of body weight in the last sixweeks
Inadequate oral intake related to limited access to sufficient, appropriate, safe food as evidenced by recent dietary intake
Acute disease- or injury-related malnutrition (coccyx wound) related to poor appetite and cognitive changes/reduced ability to prepare foods as evidenced by moderate loss of subcutaneous fat, moderate muscle loss and total weight loss of 20% of body weight over 12 months

Nutrition Intervention

12. Determine the appropriate nutrition intervention and implement the nutrition care plan. Examples of potential nutrition interventions include: high protein/high energy diet, nutrient-dense diet, texture modified diet, nutrition support, vitamin/mineral supplements, ONS, protein supplements, feeding assistance adaptive feeding aids.
13. Provide nutrition education as needed.
14. Provide nutrition counseling and collaborative goal setting.
15. Co-ordinate nutrition care to support individuals and family to access supports and resources as needed. Consider:
    a. Referral to community dietitian or other nutrition support upon discharge, such as registered dietitian services through HealthLink as per your province/territory. For example: HealthLink BC. High-protein foods for wound healing. Available from: https://www.healthlinkbc.ca/health-topics/high-protein-foods-wound-healing
    b. Meal-based programs, assisted shopping or cooking services.
    c. Financial subsidies and assistance. Assess eligibility for the Monthly Nutrition Supplement. Available from: https://www2.gov.bc.ca/gov/content/governments/policies-for-government/bcea-policy-and-procedure-manual/health-supplements-and-programs/monthly-nutritional-supplement
    d. Day programs, respite care, or home support agencies.
    e. Community organizations, Indigenous and First Nations Friendship Centres or other wellness services, as appropriate. For First Nations individuals living on reserve, co-ordinate care with the nursing team in comunities (home care nurse/community health nurse, care support workers) for continuity of nutritional care.

Nutrition Monitoring/Evaluation

16. Rescreen for malnutrition at each encounter or readmission.
17. Ensure nutrition care plan is co-created with the patient/client/resident and/or care provider and reflects their preferences, goals, priorities, context and resources.
18. Monitor intake (energy, protein, fluids, micronutrients), weight, available laboratory data and wound healing.
19. Slow-to-heal wounds require enhanced monitoring and possible adjustments to nutrition requirements, glycemic control and supplementation.
20. Refer to other care providers as needed (e.g., home care nursing, wound care team, social worker, financial personnel, occupational therapist [positioning/equipment], speech language pathologist [dysphagia/communication], dental care professional, mental health care providers, elders or spiritual assistance providers).
21. Refer to the dietitian team.
22. Refer to diabetes education team/clinicians if optimal glycemic control is required for wound healing.

Patient/Client/Resident-Centred Education Resources

Patient resources are listed in Section 1 (above). In addition, consider the following:

- Health Canada. Getting enough vitamin C. https://www.canada.ca/en/health-canada/services/nutrients/vitamin-c.html#c2
- Health Canada. Health promotion – facts on fluids: how to stay hydrated. https://www.canada.ca/en/department-national-defence/corporate/news/regional-news/western-sentinel/2021/08/facts-on-fluids-how-to-stay-hydrated.html
- Indigenous Diabetes Health Circle. Iron and protein handout. https://idhc.life/wp-content/uploads/2020/08/2019-10-11-Iron-Protein.pdf
- First Nations Health Authority. Traditional foods fact sheets. https://www.fnha.ca/Documents/Traditional_Food_Fact_Sheets.pdf
- Fraser Health. Eating to help wounds heal. https://patienteduc.fraserhealth.ca/file/eating-to-help-wounds-heal-595294.pdf
- Primary Care Dietitians' Association. Nutrition and hydration tips on your road to recovery. https://nutritioncareincanada.ca/sites/default/uploads/files/Malnutrition%20Toolkit/Tips_for_Nutrition_and_Hydration.pdf
- University of Waterloo. Older Adult Nutrition Screening. Consider a high protein, high energy diet order for inpatients/residents. Healthy Eating Factsheet for Older Adults
- Vancouver Coastal Health & Providence Health Care Nutrition for wound healing. https://vch.eduhealth.ca/PDFs/BB/BB.200.N959.pdf

Resource Literature (Section B)

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Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 5



Prevention and Management of Moisture-associated Skin Damage

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INTRODUCTION

This best practice recommendation chapter is intended to aid teams in their ability to identify and differentiate the types of Moisture-associated skin damage (MASD), to identify those at risk for the various types of MASD and to become familiar with strategies to prevent and manage all forms of MASD. As well, it is intended to guide researchers to plan future projects.

Moisture-associated skin damage (MASD) occurs when the patient's skin is exposed to various sources of moisture.[1] MASD is an often overlooked and under-researched health concern.

MASD is often confused with pressure injury as a diagnosis. As well, the reporting of incontinence-associated dermatitis (IAD) is often inconsistent, as clinicians mistakenly document IAD as Stage 1 or 2 pressure injuries (PIs), this may account for variances in reported MASD prevalence.[2] As IAD often coexists with PIs and is suggested to increase the risk of damage associated with pressure, it is imperative that clinicians are able to differentiate between the two conditions. Friction, shear and pressure are contributing elements, often increasing the complexity of being able to accurately assess the etiology of the presenting MASD.[3]

MASD occurs when skin is exposed to moisture for prolonged periods of time, resulting in over-hydrated, inflamed skin (dermatitis) or eroded skin.[4] This leads to transepidermal water loss (TEWL) and an elevated skin pH that reduces the skin's ability to maintain its barrier function.[5] The result is separation of the skin layers, also known as maceration. Overhydration results in swelling to the stratum corneum, increasing the risk of irritants entering and further exacerbating inflammation.[6] The overhydrated stratum corneum is then at further risk of damage caused by friction or shear forces from objects such as bedsheets or incontinence pads.[7,8]

For more details on skin, please refer to Chapter 3: Skin: Anatomy, Physiology and Wound Healing.[48]

Prolonged exposure to any type of moisture, such as water, perspiration, urine and/or feces (both), wound exudate, mucous, and saliva (i.e., irritant contact dermatitis due to saliva or irritant contact eczema due to saliva) may contribute to MASD.[2,9-11] The length of time moisture is in contact with the skin, combined with previous skin injury and mechanical and/or chemical factors such as friction, shear and composition of fluid, are key factors contributing to MASD development.[2,12] In addition, some patients with MASD may be suffering from underlying medical conditions (e.g., hypothalamus disorders, cancers, hypoalbuminemia, neurological disorders, edema/lymphedema, or hyperhidrosis [abnormally excessive sweating]) that affect the body's moisture production.[13,14]

Over-hydrated skin is more prone to mechanical damage caused by friction and shearing forces from skin rubbing against clothes, bedsheets or incontinence pads. The skin is more likely to break down and there is an increased risk of infection. Inflammation can also occur because normal skin flora is able to penetrate the skin barrier and activate the skin's immune defenses.[12,15]

In addition, known skin irritants are found in the various types of fluid, including inflammatory substances, digestive enzymes such as proteases and lipases, and micro-organisms. MASD is further linked with increased skin flora—such as coagulase-negative staphylococci and *Candida albicans*—that create an opportunistic environment for secondary infection.[2]

As the onset of MASD often goes undetected, it may first present as basic inflammation of the skin with or without skin breakdown.[1,2] It is often only when significant inflammation, maceration and/or skin breakdown emerge that clinicians take notice and intervene.[2]

Although the term *MASD* can be applied to any of the etiologies provided, five specific types of MASD are reported in the literature. Throughout this document MASD may refer to any one of the following:

- Incontinence-associated dermatitis (IAD)
- Intertriginous dermatitis (intertrigo or ITD)
- Periwound (e.g., peri-tube/drain and peri-fistula) MASD
- Peristomal MASD (e.g., colostomy, ileostomy/ ileal conduit, urostomy, suprapubic catheter, or tracheostomy, gastrostomy, nephrostomy)[16]
- Immersion foot, or trench foot (IF).

Moisture-associated skin damage can have a negative effect on patient wellbeing and quality of life.[16] Individuals with MASD experience persistent symptoms that affect quality of life, including pain, burning and pruritus.[11,16,17]

In the acute care setting, a recent prevalence study conducted in the United States found 34% of admitted patients had MASD incontinence-associated dermatitis {1.54%}, intertriginous dermatitis {2.66%}, peristomal MASD {0.14%}.[18] Another large-scale study addressing IAD, conducted in 448 nursing homes across 28 states in the United States, demonstrated an MASD incidence of 5.4%.[2] Of these individuals, 89% went on to develop IAD within 14 days of their first episode of onset of incontinence.[19] These studies highlight a need for further research of this issue.

Note: The reporting of skin that has been damaged by moisture is often inconsistent, as many clinicians mistakenly document it as Stage 1 or 2 pressure injuries (PIs).[2] This may account for variances in reported prevalence. As moisture damage often coexists with PIs and is suggested to increase the risk of damage associated with pressure, it is imperative that clinicians are able to differentiate between the two conditions. Friction, shear and pressure are contributing elements, often increasing the complexity of being able to accurately assess the etiology of the presenting MASD.[3]

Many risk and etiological factors for MASD overlap with those related to skin tears and pressure injuries. This best practice recommendation chapter does not address prevention and management strategies for skin tears or pressure injuries, but information can be found in Chapter 6: Best Practice Recommendations for the Prevention and Management of Skin Tears and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[49]

It is assumed that the number of patients affected by MASD increases with age and comorbidities.[20] Yet, patient groups at high risk for MASD have complex health problems or multiple comorbid conditions, including older adults and those who are critically ill, with limited mobility, or receiving cancer treatment.[21]

Types of MASD

Incontinence-associated dermatitis (IAD): Incontinence-associated dermatitis is a type of irritant contact dermatitis (inflammation of the skin) found in patients with urinary and /or fecal urinary incontinence.[2] The urea present in urine is transformed into ammonia by urease present on human skin. This reaction results in an elevation of pH that compromises the skin's protective acid mantle, thus reducing the chemical barrier effect of the skin.[22] Feces contain more water, proteolytic and lipolytic enzymes and is highly corrosive to the epidermis, with liquid feces having a higher concentration of water and these enzymes than formed feces.[21] These cofactors, in combination with excessive exposure to moisture, increase the risk of epidermal injury.[23] Literature supports a prevalence range of 5.6–50%, with the higher being related to fecal or dual incontinence (both fecal and urinary).[24] Despite high prevalence rates, incontinence and IAD rates are believed to be underreported due in part to lack of screening.[25,26] A key feature of IAD is erythema, the dilation of cutaneous blood vessels and pain, which is often described as burning, a common feature of ICD. Pain level increases with level of epidermal damage.[27]

Intertriginous dermatitis (intertrigo or ITD): Intertrigo is the result of friction in the presence of moisture. ITD can be very painful.[28] Areas of the body most susceptible are those where the skin is warm, trapped and where the skin is prone to friction.[2] Commonly areas affected include the axillary, inframammary, abdominal and inguinal folds.[24,29] The trapped moisture, normally caused by perspiration in the skin folds causes the skin surfaces to 'stick' together. This increases friction, leading to skin damage and inflammation, setting up a cycle that often becomes complicated by secondary infection.[30] Damage is typically mirrored on both sides of the fold.[31,32]

For patients with incontinence-related issues, the presence of lower body folds in the lower pelvic region may also contribute significantly to morbidity.[24] Obesity and diabetes are two conditions considered to be related to an increased risk for ITD as they are both prone to physiological skin changes, including higher rates of TEWL, increased sweat gland activity[2] and a higher surface pH in prone areas.[24] Although ITD has no race or gender predilection, it does tend to be more prevalent in geographic regions with hot and humid climates. ITD may be seen as a moisture-related issue independent of complicating factors; however, it is more commonly seen in combination with overgrowth of micro-organisms such as *Candida* species[24] or, less commonly, pathogenic bacteria.[33] In one acute care setting, ITD was prevalent in 2.66% of all reported cases of MASD.[18] The prevalence of ITD falls across a variety of sectors, with 20% of patients living in community dwellings, 17% in long-term care homes and only 6% in acute care settings.[17]

Periwound MASD: Periwound skin damage is multifactorial and often associated with irritant or allergenic contact dermatitis of the surrounding wound skin secondary to moisture. The presence of bacteria, specific proteins or proteolytic enzymes, as well as the volume of wound exudate greatly reduces the barrier function of the skin and can lead to maceration.[15] As well, the volume of wound exudate contributes to its presence.[31] Literature pertaining to the prevalence of periwound MASD is scarce, and the exact burden remains elusive. More research is needed.

Wound exudate is created during the natural process of the inflammatory phase of wound healing due to infection, inflammation or systemic edema.[34] When a wound is stalled, the concentration of metalloproteinases (a proteolytic enzyme) present in wound exudate increases, resulting in periwound skin damage and increasing the opportunity for maceration to occur.[34] When factors such as inadequate compression or inappropriate selection of wound dressings are present, wound exudate may not be well contained and can accumulate on the surface of the skin. When moisture becomes trapped under a dressing there are two factors to consider: the length of time between cleansing the periwound skin and applying the dressing may not be sufficient, or the dressing selected may not have adequate capacity to handle the amount of exudate present. Inadequate cover dressings may cause the wound exudate to seep back out of the dressing, especially as the level of compression over the dressing increases. The resultant dermatitis may exhibit mild damage in the form of erythema or may escalate to denudation of the epidermis with erosions, skin necrosis and blisters.[3]

Peristomal MASD: The major determinant of skin damage around a stoma is the enzymatic-containing effluent, although other contributory factors can also play a major role. These include mechanical trauma or medical-adhesive-related skin injury (MARSI) from appliances, bacteria, underlying skin disorders, such as psoriasis or eczema, and the possibility of allergies to chemicals or fabrics.[35] A multifactorial etiology is common, with mechanical trauma, moisture and stoma effluent all working in tandem to break down the epidermal barrier.[36] This may occur post-operatively, and may reduce patients' ability to engage in self-management of the stoma. Alternatively, it may develop later if body shape changes because of weight loss or gain.[31,32]

Peristomal MASD affects approximately 50% of individuals with ostomies experiencing leakage.[17] A further study identified that approximately one-third of patients with a stoma who were followed up over a five-year study period had evidence of skin complications within 90 days of surgery.[37] Patients living with an ileostomy are more likely to experience peristomal MASD than were patients living with a colostomy.[16,38]

Immersion Foot (IF): Immersion foot, or trench foot as it is also known, is a syndrome secondary to prolonged foot exposure to moisture[39] and was first described in soldiers participating in trench warfare in the early part of the 20th century.[40] More recently, a rise in incidence has been noted among individuals who are experiencing homelessness and those living with untreated serious mental health issues.[41,42] Excessive sweating of the feet (hyperhidrosis), travelers, persons struggling to find a safe home, may also lead to IF.[43,44]

In IF, moisture damage to the stratum corneum, the outermost layer of skin, compromises barrier function. Prolonged exposure to wet conditions at temperatures above freezing results in peripheral neuropathy and microvascular damage.[43,44] IF may be further subdivided into that occurring only with prolonged exposure to water or in conjunction with severe cold injury. When occurring as a result of prolonged exposure to water alone, this pattern of damage is known as non-freezing cold injury (NFCI), as any prolonged exposure to water lower than normal body temperature can lead to localized hypothermia. Where temperatures are low enough to induce ice crystal formation in affected

tissues, the term freezing injury (FI) is used.[45] Frostbite is FI in the absence of prolonged exposure to water. Early symptoms of both types of IF are burning or stinging of the distal extremities. Progression to severe pain is most often associated with tissue ischemia. In more severe injury, cyanosis with significant swelling of the extremities has been well documented in published literature.[46]

Frostbite injury will not be discussed in this chapter (See Chapter 8: Best Practice Recommendations for the Prevention and Management of Burns).

This best practice recommendation is intended to aid interprofessional teams in their ability to identify and differentiate the types of MASD, to identify those at risk for the various types of MASD and to become familiar with strategies to prevent and manage all forms of MASD. As well, it is intended to guide researchers to plan future projects.

The recommendations that are included in this chapter are based on the best available evidence and are intended to support the clinician and integrated team in planning and developing best practices in the prevention and management of MASD. For more information see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[49]

This chapter is written with the intent to encompass the quintuple aim for health care improvement. This is to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity (see Table 1). This equity component is particularly important for patients living at risk for, or with, skin issues, wounds and specifically MASD. Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[47]

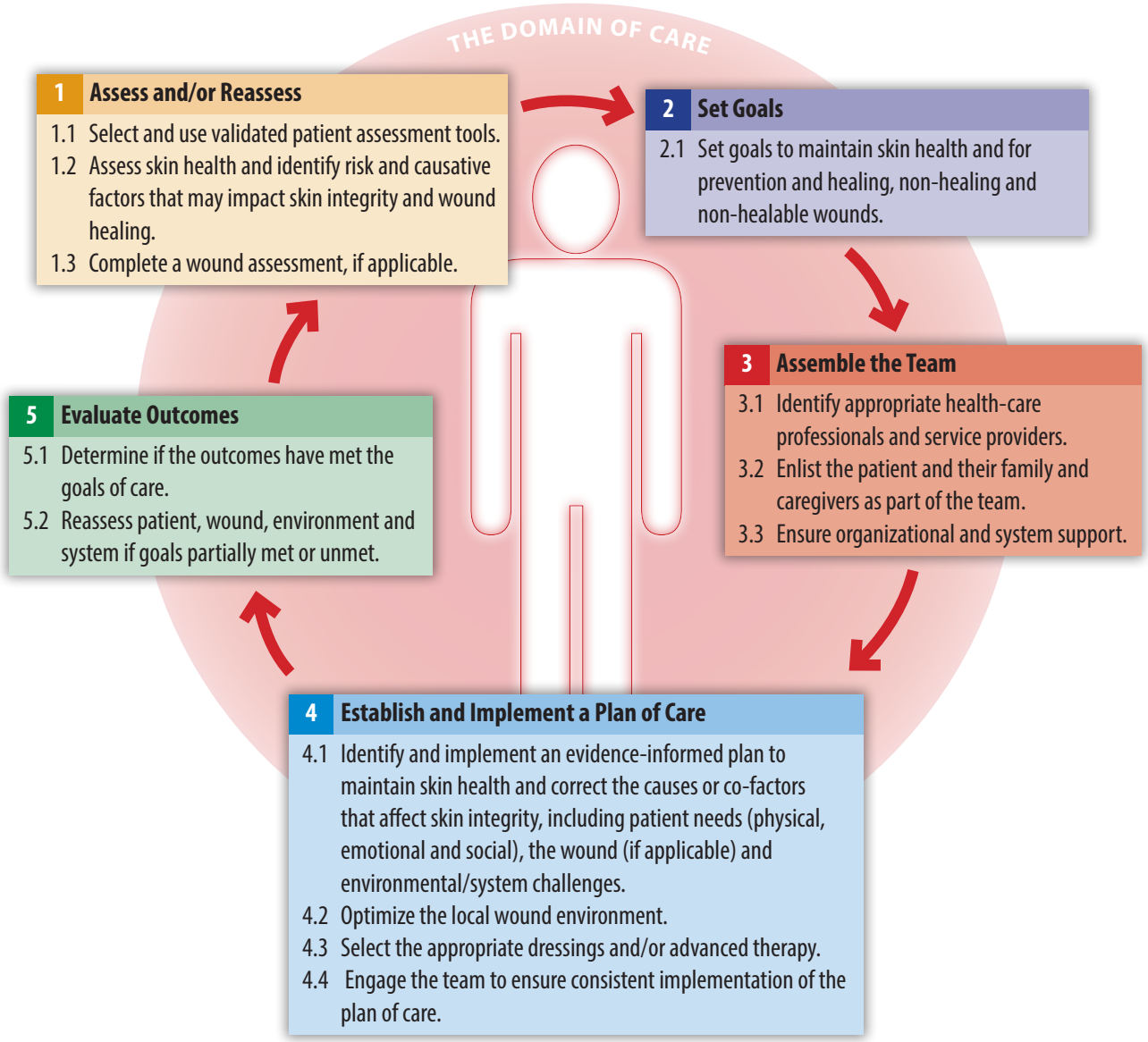
Table 1: Quintuple Aim and Management of Moisture-Associated Skin Damage

5 components	Applied to Moisture-Associated Skin Damage
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practice to ensure most effective treatment Appropriate use of resources-examples products, dressings, devices
Advancing health equity	Application of principles to all those at risk or affected by moisture-associated skin damage
Care team well-being	Providing clinically usable information for front line clinicians
Enhancing the patient experience	Providing a supportive process of care for all those with moisture-associated skin issues

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide that incorporates the best available evidence. It outlines a process, or series of consecutive steps, that supports patient-centred care using a process called the Wound Prevention and Management Cycle (See Figure 1), which guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of wounds, from the initial assessment to a sustainable plan targeting self-management for the patient.[48]

Figure 1: The Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence and are intended to support the clinician, the patient, care partners, their family, and the health-care team in planning and delivering the best clinical practice.

Two foundational chapters supplement this chapter with additional evidence-informed information and recommendations that are general to all wound types. These are: Chapter 3: Skin: Anatomy, Physiology and Wound Healing[48] and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[49]

Three guiding principles, within the best practice recommendation papers, support effective prevention and management strategies for skin breakdown:

1. Utilization of the Wound Prevention and Management Cycle regardless of the specifics to prevent and manage skin breakdown,
2. Consistent, accurate and multidirectional flow of pertinent information within the health-care team and across settings, and
3. Ensuring the patient remains the core of all decision making.

Step 1: Assess and/or Reassess

The following section provides information for each of the five types of MASD: IAD, ITD, peristomal MASD, periwound MASD and immersion foot (IF). Each type of MASD will be treated separately according to the best available evidence for each type.

Recommendations
1.1 Select and use validated patient assessment tools

Keeping a patient's skin intact is a priority in delivery of care.[50] This occurs through regular skin assessments and assessment of *direct risk factors* (body fluids, skin cleansing procedures and products) and mechanical factors, and *indirect risk factors* such as age, dependency, mobility, nutritional status, body mass index, medical conditions, pain, sensory changes and immunosuppression.[20] Skin assessments are completed by conducting routine head-to-toe skin checks (documenting skin tone) and assessing pain, risk of infection at regular intervals.

The literature has identified validated assessment tools pertaining to MASD. Pain, nutrition and quality of life (QoL) assessments should be performed with each type of MASD.[49] See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[49] Researchers suggest pain is present in 25% of those with periwound MASD, likely as a direct result of periwound skin damage and consequent local inflammatory reactions.[17] Increased pain can drastically reduce QoL and overall patient and clinician experience, negatively impacting participation in the plan of care.[51] Given the strong link between malnutrition and delayed wound healing, and the fact that MASD is a form of altered skin integrity, clinicians should assess the nutritional status of individuals with MASD[52] especially older adults.[53]

See Appendix: Nutrition for Skin Health, Wound Prevention and Wound Healing in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[49]

Staging and categorization tools are as important as validated assessment tools, as each stage or categorization works to standardize the language used when documenting, defines the state of a wound and may help to guide interventions. Where available, both staging or categorization and assessment tools should be used. Table 2 provides a list of evidence-based validated tools.

Table 2: Categorization and Assessment Tools for the Different Types of MASD

	Categorization Tool	Assessment Tool	Tool validation
Incontinence Associated Dermatitis (IAD)	Ghent Global IAD Monitoring Tool Perineal Assessment Tool (PAT)	Ghent Global IAD Monitoring Tool	Yes Yes (valid, reliable)
Intertriginous dermatitis (ITD)	None available	None available	
Periwound Moisture-Associated Dermatitis (MASD)	None available	None available	
Peristomal MASD	The SACS™ Instrument DET Score AIM (Ostomy Skin Tool)	The SACS™ Instrument DET Score AIM (Ostomy Skin Tool)	Yes Yes Yes
Immersion Foot (IF)	None available	None available	

Incontinence-associated dermatitis (IAD): A variety of tools are available to aid the clinician in identifying IAD or risk factors for the prevention of IAD. Implementing a validated assessment tool into practice may prevent unnecessary delays in identifying the risk or correct etiology of existing damaged skin. This is important, as IAD is often misdiagnosed as a PI and/or skin tear.[54]

The Perineal Assessment Tool (PAT) was developed to assess the risk of IAD using four main criteria: 1) type and severity of irritant, 2) length of exposure, 3) existing condition of the skin and 4) other factors such as the use of antibiotics, presence of *Clostridium difficile* diarrhea, low serum albumin and tube feeding.[2,54] The PAT demonstrated content validity and adequate interrater reliability; however, opinions differed on the frequency of use, and information was not reported to support the tool's predictive validity.[56,57]

The Perineal Dermatitis Grading Scale is a descriptive tool used to evaluate four parameters of IAD: erythema, skin integrity, measurement (cm) of the affected area(s) and symptoms experienced by the patient.[11] Another description tool reported in the literature is the IAD Skin Condition Assessment Tool.[11] Designed to measure the severity of IAD, this tool includes three of the four parameters included in the Perineal Dermatitis Grading Scale: erythema, affected area(s) and presence of skin damage. There do not appear to be validation studies for either of these tools.[11]

The validated Ghent Global IAD Categorisation Tool (GLOBIAD), currently available in 19 languages, suggests any patient with any form of incontinence and intact skin should be considered Category 0, placing them automatically at risk of IAD.[22] Category 1 and 2 are based on the duration of erythema and damaged skin, respectively, with both categories further subdivided based on the presence of clinical signs of infection. Using this tool to differentiate between categories demonstrated a sensitivity and specificity of 90% and 84%, respectively.[58] Overall, interrater reliability was 0.41, intrarater reliability 0.61 and agreement was 0.86 for the tool.[58]

The Skin Integrity Research Group (SKINT) based out of Ghent University took the GLOBIAD, combined it with a core outcome set, and developed the GLOBIAD-M, an outcome assessment tool to measure change,[59] providing clinicians with a standardized way to monitor their interventions when treating IAD. The GLOBIAD-M demonstrated good interrater agreement and reliability when photographs were assessed by experts[59] providing an innovative assessment tool that can be used virtually in regions without immediate access to expert clinicians.

The Incontinence Associated Dermatitis and its Severity tool is used to generate a score between 0 and 52 using 13 locations on the body and assessing for redness, skin loss and presence of rash.[17] Face validity and content validity were determined.[60] Inter-rater reliability was also tested; however, the method used for statistical analysis was not provided. Criterion validity was determined using four case scenarios; agreement was 0.98.[60]

Intertriginous Dermatitis (ITD): To date, there are no validated risk assessment tools for ITD, but common risk factors include hyperhidrosis, large skin folds, obesity, diabetes mellitus, poor hygiene and malnutrition. Hot, humid environments also increase the chances of developing ITD and increase the risk for those with the above-mentioned conditions.[61]

Periwound MASD: There are various valid and reliable wound documentation tools that include parameters such as the periwound skin, wound edges and exudate characteristics. Tools such as the revised Photographic Wound Assessment Tool (PWAT),[62] Bates-Jensen Wound Assessment Tool (BWAT),[63] and the Pressure Ulcer Scale for Healing (PUSH)[64] are available. However, none of these have been validated for outcome measures for MASD.

Peristomal MASD: The DET Score Tool[65] measures: 1) a discolouration, erosion and tissue overgrowth (DET). The DET Score is intended to measure the extent and severity of peristomal skin damage as a real-time assessment and was developed by an international group of 12 stoma care specialty nurses.[66] Martins et al. recently reported new statistical analysis of the OST version 2.0.[67]

The Peristomal Skin Assessment Guide (PSAG) for clinicians is available on the WOCN website https://psag.wocn.org/index.html#home. This guide has been developed to help standardize assessment, identify probable reasons for the complications and provide simple management options. Another validated classification system is the studio

alterazioni, cutanee, peristomali (SACS) study on peristomal skin lesions.[68] Criterion validity was determined, and its ability to accurately categorize was measured and evaluated to be very good.[69] This tool enables clinicians to assess and classify peristomal skin lesions from urine or fecal sources.

To date, there are no validated assessment or categorization tools available for gastrostomies, tracheostomies, drains, tubes or fistulas.

Immersion foot (IF): Currently there are no risk assessment tools for immersion foot. Certain populations are known to be at higher risk, such as persons experiencing homelessness (living unsheltered, emergency shelters, provisionally accommodated, or being at risk of homelessness), and those with poorly managed mental illness such as schizophrenia, depression, and complicated by substance use.[42] For frostbite injuries, a classification system is available to identify grades of injury.

1.2 Assess skin health and identify risk and causative factors that may impact skin integrity and wound healing

Obtaining a detailed history in all areas of the biopsychosocial spectrum, in combination with a comprehensive physical examination, is essential in discovering all intrinsic and extrinsic causative factors. Only when these underlying factors are identified can a plan of care geared toward evidence-based prevention and treatment be developed for risk and causative factors associated with the healing process.

1.2.1. Patient: Physical, emotional and lifestyle

Physical Assessment

Begin by assessing skin health status by conducting a head-to-toe assessment. Discuss skin issues with the patient, care partner and family. This includes a focused patient history including cognition, medications, continence status to identify any risk factors for MASD.[50] A physical assessment should include a skin assessment that takes into consideration the level of hydration (e.g., dryness, flaking, maceration), baseline skin tone, redness, areas of denudement, number of lesions, symmetry, location of changes, odour, periwound skin and skin colour changes, and the patient's ability to perform head-to-toe skin care.[48] Assess and identify the source or potential source of moisture to determine the level of risk for any type of MASD, as a plan of care to treat and prevent MASD depends on the moisture's origin. For those experiencing peristomal or periwound MASD, removal of any dressings or appliance and thorough cleansing of the area is required before inspecting the skin. Once the origin has been identified, implement steps to reduce the presence of moisture to protect skin integrity and support the wound healing process.[70]

A comprehensive assessment must differentiate MASD from other underlying etiologies, such as PIs. MASD is a major contributing factor known to increase the effects of pressure, and many expert clinicians report the average bedside clinician is not able to differentiate between the two.[71,72]

Incontinence-associated dermatitis (IAD)

According to Beeckman et al., any individual with urinary and or fecal incontinence is considered Category 0 (at risk for IAD)[70] therefore, performing a regular, focused genitourinary assessment may be warranted to identify any variation in skin condition and avoid ensuing skin damage. Common locations for skin damage secondary to IAD are the sacrum, perineum, thighs and buttocks. Broken skin is at higher risk for secondary bacterial infection.[2] During the physical assessment, the category of breakdown should be documented according to the GLOBIAD Categorization Tool.

Physical assessment should also include mobility and range of motion to determine the level of functional incontinence.[2,70] Obtain any previous urodynamic testing and imaging, and conduct a pelvic floor assessment to determine any factors contributing to incontinence.[72] Refer the patient to a nurse continence advisor.

Intertriginous Dermatitis (ITD)

The assessment of risk and/or diagnosis of ITD begins with a review of the patient's medical history and a thorough physical examination with a focused skin assessment. During the skin assessment it is essential to include careful visual examination of axillae, groin, gluteal cleft, inframammary and abdominal folds, as well as labiocrural folds (where the labia majora and the inner thighs meet).[71] Ruling out other various skin disorders is important, as many mimic the appearance of intertrigo but may require urgent intervention. Misdiagnosis can result in a significant adverse event.

A comprehensive skin assessment and the ability to differentiate between IAD and ITD is imperative, especially as these conditions may overlap. Friction, the force of two surfaces moving across one another (such as the mechanical force exerted when the body is dragged across another surface), can place a patient at increased risk of MASD secondary to ITD.[72] Friction in the presence of moisture creates an optimal environment for *Candida albicans* to grow (See Table 2: Categorization and Assessment Tools for the Different Types of MASD).

Clinically, a cutaneous superficial *Candida* infection would appear as an erythematous patch, often shiny, with satellite vesicopustules prone to easy rupture.[33] In contrast, IAD spares creases and folds, except when superimposed with a *Candida* infection. Although clinical assessment is typically sufficient to provide a diagnosis, a scraping for microscopic examination may be required to confirm the organism as *Candida albicans*.[33] During assessment for ITD the patient should lie in supine position to allow for all skin folds to be visualized.[2] For patients with a larger body size inspect the skin folds (e.g., neck, arms, abdomen, groin, legs, toes). It is always safer to enlist the help of another clinician, where feasible, to help lift any folds and avoid further friction-related trauma.[2]

Periwound MASD

A comprehensive skin assessment should include inspection and documentation of the periwound skin and wound edges. Skin breakdown and excess moisture can lead to periwound inflammation and erythema, as wound exudate contains proteolytic enzymes that can break down intact skin.[34] Include in the focused wound assessment the amount and type of drainage and attempt to identify the causative factor(s) so you can create a plan to reduce them.

Periwound skin changes may also occur from using dressings that do not support the level of drainage or when clinicians do not allow the skin adequate drying time prior to the application of an adhesive or silicone-bordered dressing.

Macerated skin is more permeable to micro-organisms and prone to damage from friction and irritants than intact skin.[34]

Periwound skin damage from moisture leads to inflammation and denudation of the skin adjacent to the wound edge (within 10 cm of the wound edge) and secondary to exposure of wound exudate. Periwound skin damage is evident from the varying degree of skin maceration, erythema, edema, inflammation, denudation and destruction.[73] Currently there is no standardized tool to measure or assess periwound skin damage; however, such an assessment is similar to a wound assessment.

For instance, non-advancing wound edges are a common sign indicating excessive moisture. Erythema will present differently in those with darker skin pigmentation, so it may be more useful to consider hyper- or hypo-pigmentation when performing a periwound skin assessment.[34] Assessment characteristics in the PWAT and BWAT both include those directly related to edge effect and appearance.[62,63] The BWAT also includes assessment of wound exudate including exudate type and amount.[63] Although the BWAT is a great descriptive tool, the PWAT score provides the clinician with an objective score indicating whether the wound is improving or deteriorating.

Peristomal MASD

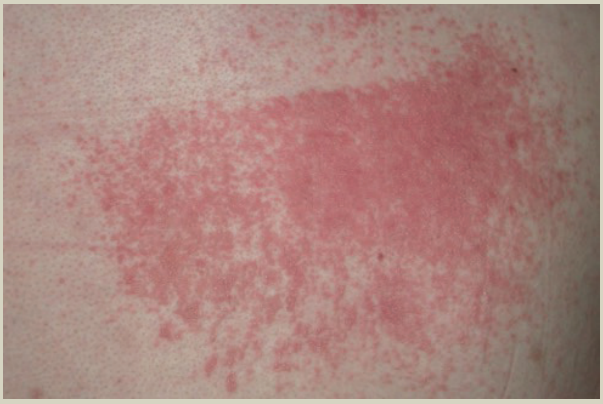
Peristomal skin must be regularly assessed (either by the patient during self management, care partner or clinician) by performing a physical assessment. Peristomal skin damage is routinely assessed as part of ostomy (colostomy,

ileostomy, urostomy, gastrostomy or tracheostomy), tube, drain and fistula care. MASD in a peristomal location incorporates the skin surface area that may extend out from the base of the stoma, in a circumferential manner.[65] Assessment of the peristomal skin includes inspection and palpation. Complications can be related to several etiological factors. Maceration is secondary to prolonged exposure to moisture, which is secondary to effluent from the stoma.[74] This can be related to inadequate application of the containment product or medical device. Caustic changes can occur to the peristomal skin when in contact with urine or feces, since the effluent contains chemicals and a high volume of enzymes and bacteria.[74]

In addition to stomal effluent, perspiration is a source of moisture contributing to peristomal MASD. Begin the assessment with visual inspection of the skin and stoma, including skin colour and integrity and stoma location, size, protrusion and shape.[34] A primary factor to assess is the ability of the chosen appliance to contain the effluent and ensure the peristomal skin remains dry and intact.[75]

Note also if there is evidence of a fungal infection. Table 3 presents examples of peristomal fungal infections.

Table 3: Examples of Peristomal Fungal Infections *(Used with permission from Louise Forest-Lalande.)*

Fungal infection	**Peristomal skin erosion and fungal infection occurring under the skin barrier**
	
Fungal infection around a tracheostomy	**Peristomal skin erosion/inflammation and extended skin fungal infection under the skin barrier**
	

Used with permission from Louise Forest-Lalande.

Immersion Foot (IF)

An important part of the overall assessment of patients with this type of complication is to identify additional potential life-threatening injury prior to focusing on the extremities.[39] Begin with a comprehensive physical, mental status and social assessment. Signs of neglect such as poor hygiene, broken nails and poor skin quality should trigger an assessment for malnutrition and other risk factors for IF.[76] Other identified factors for IF are tight and poor-quality

clothing and wearing footwear (boots, shoes, sandals, wet socks) inappropriate for ambient weather conditions, obesity, urine and/or feces accumulating in footwear, inability to provide good foot inspection and hygiene, excessive foot sweating (extrinsic and intrinsic), living alone, poor mental health status and low socioeconomic status.[39,40-42]

Clinicians should follow this with assessment for skin quality, pain and vascular status of the affected limb.[77] Reduced pulse quality or capillary refill should prompt referrals for vascular assessment. Evaluate severe injury with angiography, ultrasound and bone scan.[77]

Emotional and Lifestyle Assessment

All forms of MASD are linked to diminished quality of life, so clinicians should assess for this as well: IAD can result in significant discomfort or pain, increasing the reliance on health-care providers and facilities.[78] ITD, with its associated itching, can lead to high rates of secondary fungal infections.[79]

The psychosocial effects on an individual with MASD, regardless of type or etiology, need to be sensitively explored as early as possible.[80] Perform a psychological assessment to assess the level of impact of MASD on QoL of the patient, the family and the care partners.[80,81] MASD can result in severe limitations on the activities of daily living as well as various other social activities, such as dining out, traveling or engaging in intimate and/or sexual activity.[81] Barrow points out that detrimental psychological effects are far less common in people who feel like they have an influence on their situation and can participate in planning the next steps.[82] Modifiable risk factors can be defined as those within an individual's ability to change by making lifestyle adjustments. These may include weight, activities deemed harmful, such as smoking, and diet. Non-modifiable risk factors would include those that cannot be controlled through lifestyle changes such as congenital conditions and non-reversible physiological impairments. See Table 4 for a summary of risk and causative factors for MASD.

1.2.2. Environmental: Socio-economic, care setting, potential for self-management

Patients with predisposing dermatological issues, previous pressure injuries, dermatitis (contact with urine and/or feces), cutaneous fungal and/or bacterial infections may be more prone to developing some forms of MASD.[20] Populations at higher risk are those who have limited access to the health-care system (e.g., accessing home care in remote and rural regions, those experiencing homelessness). Fortunately, there is an increasing recognition related to diversity in health care and culturally sensitive care has become the standard in many regions and health-care facilities throughout the world.[83] Those new to Canada, undocumented immigrants, individuals with low income, those who are uninsured or underinsured and those with low literacy are associated with poor health outcomes and the ability to provide self-managed care.[84] These factors compound for those considered to be of low socioeconomic status and directly impact the ability to fund the required items to aid in preventing MASD. See Table 4 for modifiable, non-modifiable and causative factors for MASD.

Table 4: Modifiable, Non-modifiable and Causative Factors for MASD

Type of Moisture-Associated Dermatitis (MASD)	Modifiable Risk/ Causative Factors
IAD	• Urine and or feces are the two primary sources of moisture • Urinary and/or fecal incontinence combined with friction between the skin and an absorbent product • Urinary incontinence • Fecal incontinence provides greater risk of exposure to digestive enzymes present in feces that accelerates skin breakdown • Aged skin, altered skin oxygenation, fever, air flow restriction, decreased mobility • Prolonged use of steroids, antibiotics or promotility agents • Impaired functional, emotional or cognitive status and/or mobility[19]

ITD	• Perspiration is the most associated source of moisture[11] • Often the result of moisture combined with areas of high friction • Risk factors include high body mass index, lymphedema, multiple skin folds, pendulous breasts • Those who are malnourished, immobile, have poor hygiene or diabetes mellitus[61,85] • Hyperhidrosis, or profuse perspiration[85] • Hot and humid climates[85]
Periwound MASD	• Wound exudate is the most common source[11] • Chronic wounds contain higher amounts of proteolytic enzymes[3] • Occlusive wound care dressings or products that increase the level of moisture to an excessive amount • Individuals at higher risk include the elderly, the immunocompromised, or those with previous environmental skin damage (radiation, sun exposure), skin disorders (eczema, psoriasis), underlying pathology and congenital disorders (epidermolysis bullosa)[34]
Peristomal MASD	• Primary source of moisture is stoma effluent: urine, feces or mucus[6] • Saliva and respiratory secretions in those with tracheostomies[24] • Ill-fitting or leaking appliance • Stoma placement embedded within skin folds, flat or retracted stomas[6] • Fluctuation in weight, change in abdominal circumference[6] • Untrained clinicians and new ostomates applying appliances[11] • Gastric leakage from gastrostomies[35] • Peri-drain/tube drainage[11]
Immersion Foot (IF)[86]	• Wearing wet footwear and or socks for prolonged periods of time • Leg edema, skin folds, higher body mass index (obesity) • Urine and/or feces (both) accumulating on legs and in footwear • Reduced mobility • Lack of support to perform foot hygiene • Excessive foot perspiration • Insecure housing and experiencing homelessness • Plaster casts • Long wear time of combat, construction, fishing, or rubber boots[41]

With health care shifting into the community sector, an aging population and a consistent lack of qualified clinicians in the community sector, it is increasingly necessary for patients to participate in self-managed care.[87] For those with MASD, a precipitating factor is the ability to perform self-managed personal hygiene and bowel and bladder routines.[50]

1.2.3. Systems: Health-care support and communication

Support from all levels of a health-care system is imperative for effective prevention and management strategies related to all forms of MASD. Currently provincial/territorial legislation mandates that organizations report on the incidence and prevalence of PIs but not for other nosocomial injuries such as skin tears or MASD. Although guidelines exist in some provinces/territories, it is not mandated that organizations report metrics. Standardized language is a critical component of effective communication between clinicians and organizational leaders.[88]

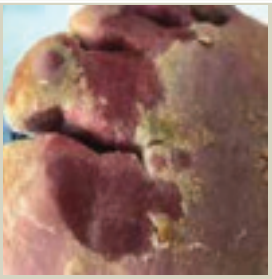
Clinicians require education and tools to be able to differentiate not only among PIs, skin tears and MASD, but also among the types of MASD. Standardized language and descriptions result in more accurate and consistent documentation, increasing the opportunity to perform more accurate data collection and, where a clear description of a problem is reported, for a clinician to provide evidence-based interventions.[89] Tay and colleagues reported the Knowledge, Attitudes, and Practices of IAD Questionnaire (KAP-IAD-Q) to have good psychometric properties when measuring nurse knowledge, attitudes and practice.[90] Such tools support teams to measure KAP among nurses working with patients at risk of developing IAD; more research is needed utilizing this tool.

1.3 Complete a skin/wound assessment, if applicable

Complete a comprehensive and focused skin assessment to determine the specific subtype of MASD and etiology (See Table 5). This should include, but may not be limited to, maceration, pain, erythema and level of erosion including dermatitis.[91] Where validated staging or categorization tools exist (GLOBIAD for IAD, or OST (2.0), or SACS for ostomies), documenting the stage or category is essential to accurately collect data and to enhance communication through standardized language. Thorough cleansing of the area prior to a focused wound assessment will improve accuracy in identifying the level of tissue involvement and drainage type. Note the wound edges and appearance or breakdown of surrounding skin. These areas of breakdown are difficult to measure, as they often have no depth and are quite large and irregular in shape, spanning both sides of an area. Location of the affected area(s) will enable identification of the type of MASD present. A skin biopsy can be an important diagnostic tool in the diagnosis of a wide array of inflammatory skin conditions and irritant dermatitis such as IAD and ITD; however, it cannot reliably discriminate between the two. Diagnosis should be based on clinical features with judicious use of percutaneous skin testing for contact dermatitis related to irritants and allergies.[92]

Table 5: Comparison of MASD Clinical Subtypes *(Used with permission from Kimberly LeBlanc and Laurie Parsons.)*

MASD Type	Appearance	Clinical Features
IAD[70] *		• Location: perineum, labial folds in women, scrotum in men, buttocks, gluteal fold, medial and posterior aspects of upper thigh, lower back[1,2,50] • Erythema and inflammation of the affected area(s) with or without skin breakdown[1] • Discomfort, pain, itching, burning.[19] Prone to secondary infections[19] • Extreme cases: swelling and blister formation may occur[3]
ITD[61] *		• Location: axilla, inframammary, abdominal and inguinal folds, pubic panniculus, gluteal cleft and areas prone to harbour moisture • Less common locations include interdigital, eyelids, antecubital, retro auricular[33] • Starts as mild erythema and can progress to severe swelling with maceration, denudation, weeping and crusting with potential secondary infection[3] • Centralized erythema with satellite lesions often associated with candida albicans • Itching, burning, pain and odour • Chronic subtle onset of pruritus, burning, tingling and pain in the skin folds[93]
Periwound MASD[94] **		• Erythema and inflammation of the skin surrounding the wound up to 4 cm from the wound edge[95] • Maceration appears as reversible pallor secondary to excessive moisture and wrinkled skin[1] • Edge migration may be diminished • Hypergranulation tissue may be present within the wound edges • Hyper- or hypo-pigmentation of the surrounding intact skin[34]

Peristomal MASD[34] **		• Location begins at the stoma-skin junction and may extend outward by up to 10 cm around the stoma[34] • Includes urinary and fecal diversions, tracheostomies and other stomas • Erythema and inflammation of the peristomal skin with or without skin breakdown[11,21]
Immersion Foot (IF)[96] **		• Begins as tingling, itching and/or numbing feeling[40] • Erythema or cyanosis with appearance[40] • Feet may appear doubled in size as a result of edema • Burning, pain • Mild to moderate to severe blistering • Petechiae • Numbness[42]

**Used with permission from Kimberly LeBlanc.*
***Used with permission from Laurie Parsons.*

Severity of MASD

MASD may be categorized as mild, moderate or severe and can occur across the lifespan, though it is more common in the extremes of age.[97] Mild MASD presents with red, irritated and inflamed intact skin. Moderate and severe MASD are more complex and present with blistering and erosion and/or denudation of the epidermal to dermal layers of skin.[55] Once the damage has compromised the protective barrier function of the skin, secondary fungal or bacterial infection can occur. The challenge with classifying MASD as mild, moderate or severe is that this is based on a subjective assessment by the clinician; one clinician may interpret the signs as mild while another may interpret them as moderate. The negative impact MASD has on human life includes mild pain to severe discomfort, loss of dignity and reduced quality of life. The economic burden associated with the care and management of MASD is considered by many to be high; yet, to date, the full complexity and scope of this problem is not fully understood.[16]

Step 2: Set Goals

2.1 Set goals to maintain skin health and for prevention and healing, non-healing and non-healable wounds

Please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[49] for the definition of healable, non-healing and non-healable wounds.

Primary goals should focus on prevention and include a distinct skin care routine and nutrition (food/fluid) strategy in conjunction with methods of reducing friction and moisture within the affected areas.[2,72] Bliss and colleagues were able to demonstrate this for IAD in a nursing home population, where results showed that participants following regular skin care regimens as a method of prevention were 46% less likely to develop IAD.[19] In cases complicated by opposing skin surfaces and increased friction, such as ITD, donning products designed to reduce friction and wick away moisture may reduce the risk of developing complications.[3] Outcomes on the use of moisture-wicking fabrics, however, have not been reported in the literature.[17] Voegeli also supports the adoption of a regular skin care protocol, controlling the cause of moisture and treating and preventing any secondary infection.[3] For IAD, continence control is the key to successful management and prevention. Referral to a pelvic floor physiotherapist may allow for strengthening of the pelvic floor muscles. In some instances, a urinary or fecal diversion may be necessary.[72]

See Table 6 for a breakdown of examples of goals to be considered for each type of MASD.

Table 6: SMART* Goals for MASD

Type of MASD	Goals
IAD	• Prevent skin breakdown related to IAD • Manage incontinence within 1 week • Restore skin integrity within 2 weeks
ITD	• Prevent skin breakdown related to ITD • Keep skin folds dry within 1 day • Reduce the amount of friction in intertriginous areas within 1 day • Resolve secondary infection if appropriate within 5 days
Periwound	• Prevent periwound skin maceration • Manage periwound skin maceration • Resolve secondary infection if appropriate within 5 days
Peristomal	• Prevent peristomal skin maceration • Restore healthy peristomal skin • Resolve secondary infection if appropriate within 5 days
Immersion Foot (IF)	• Prevent further damage related to IF • Restore skin barrier function • Ensure wearing of appropriate footwear and socks within 2 days

***SMART** stands for Specific, Measurable, Achievable, Realistic and Timely

2.1.1 Identify goals based on prevention or healability of wounds

All MASD types should be considered healable, as the underlying factor is moisture secondary to a variety of mainly controllable factors, and the primary goal should be the prevention of future episodes of skin breakdown through methods of moisture control. When determining healability and establishing goals it is important to determine if patients and caregivers will be able to manage moisture on their own if they are provided relevant education and resources[61,98] as this will directly impact the goal setting activity and expected outcomes.[50]

In settings where licensed health-care professionals are present, all new cases of MASD should be given independent consideration and be considered a nosocomial injury to the patient. Most institutions are mandated to audit for PIs on an annual basis; however, clinicians generally do not use this opportunity to document other prevalent skin injuries such as MASD or skin tears. Prevention of all categories of incontinence-associated dermatitis begins with a continence assessment including a functional assessment of the patients' ability to toilet and to regain or maintain their ability to toilet.[73,99]

2.1.2 Identify quality-of-life and symptom-control goals

Clinicians must work with the patient and develop an individualized plan of care, always considering the patient's quality of life, values and wishes for treatment. Organizations investing in evidence-based skin care protocols are more likely to improve patient experience, increase the number of positive clinical outcomes and drastically increase the quality of life for those living with MASD.[27,100]

Step 3: Assemble the Team

3.1 Identify appropriate health-care professionals and service providers

In constructing a team, clinicians need to consider all available team members when developing an individualized plan of care. Table 7 summarizes the role of each team member as it pertains specifically to MASD. Respectful and trusting partnerships among patients and health-care professionals is crucial in obtaining patient buy-in and agreement to engage in self-care strategies.[101] All team members including the patient and care partners should be provided with

education and support to ensure their knowledge and understanding of MASD is current and in alignment with best practice.[72,102]

Clinicians must know their community and the resources available within their catchment area to better facilitate seamless transition across sectors (e.g., from hospital to home, or home to respite). Establishing a culture of respect is the responsibility of all stakeholders, including every member of the interprofessional team, the patient and the patient's support network, which may include the family or caregiver/care partner.[103]

3.2 Enlist the patient and their family and caregivers as part of the team

Patient participation is shown to increase positive patient outcomes and experience within health-care systems.[103] As well, including the patient in their own plan of care can empower them, resulting in better overall health and building relationships with the health-care providers.[82,104,105] Clinicians must therefore initiate the conversation about self-managed MASD care at the initial interaction to promote independence and encourage patients to actively participate in their care. The team must then define roles for each member (see Table 7). Next, the team should collaboratively establish expectations from each member to ensure engagement and co-ordination of all activities related to MASD prevention or management. To be a contributing member and to optimize outcomes, the patient and their care partners must fully understand their health-related conditions and all components of the plan of care. A well-functioning team with the patient at the centre increases the likelihood of successful engagement. This can result in higher patient satisfaction and QoL, greater comprehension of personal requirements, more informed decision-making ability, reduced anxiety and emotional turmoil, a stronger bond among members of the team and higher rates of healing.[104,105]

Table 7: Professional Members of the Team

Discipline	Roles and Responsibilities for Wound Healing (these may vary depending on health-care setting
Wound care clinician (nurse with advanced wound, ostomy education)	• Performs comprehensive assessment to determine the source of moisture and optimize care planning to manage and prevent complications[50] • Advocates for publicly funded sources, when required • Facilitates knowledge transfer to patients, care partners, families and health-care providers (care coordination, case management) • Provides leadership by promoting best practice[50,106,107]
Physician or nurse practitioner (NP)	• Coordinates care, including management of existing health conditions • Provides necessary prescriptions to alleviate symptoms of MASD, such as fungal infections, restoration of skin barrier function and inflammation • Treats coexisting skin conditions such as eczema or psoriasis
Registered dietitian (RD) **See Appendix: Nutrition for Skin Health, Wound Prevention and Wound Healing in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[49]**	• Provides a nutrition assessment to ensure patients are consuming adequate amounts of micro/macro nutrients to support skin integrity and synthesis of healthy tissue[50] • Supports optimal nutrition for those at risk of dehydration and malnutrition, such as high output ileostomies and those losing excess fluid (e.g., diarrhea, vomiting)[50] • Maximizes nutrient intake for those with poor appetite or intake to meet increased nutrient needs required for wound healing • Provides nutritional counselling to people with obesity, malnutrition, diabetes and other chronic diseases that impact skin integrity

Personal support worker/care aid workers	• Provides day-to-day care of the patient • Identifies and reports MASD at onset[108]
Occupational therapist (OT)	• Performs cognitive and psychosocial assessment and provides interventions • Ensures assessment and management of appropriate equipment to support functional continence[50] • Performs a surface assessment as certain mattresses increase moisture (e.g., low air loss when a fitted sheet is used). This example can also increase the risk of dehydration, demonstrating the importance of having the whole team assess and plan together • Assesses ability to self-care and provide tools to help maintain autonomy and activities of daily living within the home
Physiotherapist (PT)	• Assesses the strength and ability to contract and relax the pelvic floor muscles. This is performed by physiotherapists with additional education in pelvic floor management[50] • Teaches strength-building exercises to avoid muscle wasting, as patients may limit their mobility to avoid episodes of leakage or incontinence; validates if pelvic floor exercises are correctly executed to determine effectiveness[50]
Pharmacist	• Reviews all medications to avoid possible interactions with any topical products being used, identifies any medications that may impact the ability to heal and/or provides alternative medication choices to increase adherence[109] • Provides recommendations on a variety of continence-related medications such as diuretics, stool softeners and laxatives • Collaborates with dietitian, as needed, when recommending vitamins, minerals and/or supplements
Social worker (SW)	• Reviews and/or performs cognitive and psychosocial assessment and provides interventions • Ensures care coordination and transitions of care • Determines any financial or social supports needed (e.g., devices, funding for products)
Psychologist	• Provides a psychosocial assessment • Offers interventions

3.3 Ensure organizational and system support

Individuals with MASD experience a significant decrease in QoL and are more prone to PIs and secondary skin infections, which may in turn be associated with increased financial costs to the health-care system.[11,110]

Organizational acknowledgement of risk factors and implementation of prevention strategies for the various types of MASD are crucial to prevent occurrence. Awareness, access and appropriate evidence-based implementation of products among all members of the team are necessary to control the various sources of moisture for any type of MASD and reduce negative outcomes in any health organization, public or private.

The World Health Organization recognizes MASD as a significant cause of skin injury and has included types of MASD in the latest version of the International Classification of Diseases.[111] This global attention can ultimately foster increased recognition among clinicians at a systems level regarding accurate identification and reporting, treatment goals, management and prevention strategies for MASD.[21]

Additionally, Kayser et al. examined the prevalence and risk factors of IAD within adult patients in LTC, acute care and rehabilitation facilities in both Canada and the US. They noted nearly 1 in 5 incontinent patients had documented IAD. Of the incontinent patients, prevalence of IAD ranged from 8.4% in LTC facilities to 19% in acute care facilities. This study demonstrates the significant burden of IAD on both the patient population and the health-care system.[26]

Organizations, in collaboration with the health-care team, can include a toileting schedule for those admitted with mobility issues to reduce the likelihood of complications associated with incontinence. Costs associated with prevention strategies are likely to be far less than those associated with managing the resulting skin damage. With the increasing complexity of patients combined with ongoing staff shortages, it is no wonder the proportion of nurses reporting that they miss skin care in their regular routine of patient care is as high as 39.5%.[112] System support requires organizations to provide adequate staffing to ensure such vital prevention strategies are not missed.

Step 4: Establish and Implement a Plan of Care

4.1 Identify and implement an evidence-informed plan to maintain skin health and correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional and social), the wound (if applicable) and environmental/system challenges

Once the origin of risk or actual MASD has been identified, implement steps to reduce the presence of moisture to protect skin integrity, and support the wound healing process. Preventing and correcting the cause for all types of MASD includes removing the moisture source or, at a minimum, reducing the length of exposure time of the epidermis to the moisture source. Repairing the epidermal barrier with emollients and humectants and using appropriate products such as skin barriers and dressings to manage the moisture source are essential evidence-based strategies to include in each plan of care.[23,34,113]

In cases of recalcitrant MASD, percutaneous testing may be necessary to look for potential allergic contact dermatitis.[114] Sources of contact allergens include topical antibiotics, preservatives, antioxidants and fragrances in skin cleansers, emollients and barrier creams. Components of the dressings themselves may act as allergens.[115,116] Testing for contact allergy may require a referral to a specialized clinic/service (i.e., dermatologist).[117]

Clinicians should always assess and manage emotional, social and psychological factors associated with MASD.[80,81]

MASD necessitates continuing commitment from the clinician to recognize and care for patients.[110] Disciplines and facilities must engage in best practice interventions for both prevention and treatment of MASD which also extends to standardized documentation.[110]

Peristomal skin complications are very specific and require the advice of experts. Consultation by a stoma care nurse or nurse specialized in Wound, Ostomy and Continence (NSWOC) is often required to reduce the risk of complications. See Table 8 for prevention and management strategies for MASD.

Table 8: Prevention and Management Strategies

Type of MASD	Prevention and Treatment Strategies
IAD	• Assess and treat reversible causes of incontinence[50] • Put in place a skin care regimen and ensure all team members are diligent with the plan • Optimize nutrition/fluid management[50] • Provide appropriate containment devices/products and ensure they are applied correctly • Check containment products on a regular basis • Ensure prompt and frequent changes of soiled products and cleanse and protect the skin adequately • Facilitate purchase of highly breathable and absorbent product, ensuring correct fit[118] • Introduce toileting techniques as able, including appropriate equipment, devices and education

ITD	• Apply moisture-wicking product impregnated with silver[61] or PHMB-impregnated gauze between the folds to wick away or absorb moisture (follow manufacturers product supply information) • Select clothing that is loose-fitting and breathable, such as cotton • Make sure antifungal cream or oral antifungal treatment is continued for 7 days after the disappearance of clinical signs to prevent recurrence. • Administer pain and antihistamine medication according to pain and discomfort assessment • Reduce or eliminate skin-on-skin contact[61] • Encourage, where able, weight reduction in case of obesity. • Instruct patient and care partners on the importance of bathing, showering (especially after exercise) and carefully drying skin folds
Periwound MASD	• Use appropriate dressing types to manage moisture balance (See Wounds Canada's Wound Dressing Selection Guide) • Apply a skin protectant (no-sting film barrier, petrolatum-based or zinc-based skin protectant) to the periwound skin to reduce the risk of periwound skin maceration[119]
Peristomal MASD	GI/GU Ostomy: • Maintaining skin integrity relies on proper selection, application and function of ostomy products and skin barrier appliances, for adequate protection • Use appropriate technique and ostomy devices to provide a good seal Tracheostomy: • Keep peristomal skin dry, and apply absorbent products that will keep the humidity away from the skin and absorb any leakage[120] • Apply a moisture-wicking product impregnated with silver[61] or PHMB-impregnated gauze • Consider referral to a respiratory therapist and consider non-product-based treatment such as increasing frequency of upper airway suction Gastrostomy: • Identify and correct the cause of leakage • Keep peristomal skin dry and apply absorbent products that will keep the humidity away from the skin and to absorb any leakage[120] • Consider referral to NSWOC, stoma or gastroenterology nurse[121]
Immersion Foot (IF) **Frostbite***	• Address physical and mental status and consider social assessment during acute events • Provide first aid to severely affected individuals by following the same treatment protocols for frostbite[39-41] • Educate patients to prevent repeat injury[39-41]

* For frostbite see Chapter 8: Best Practice Recommendations for the Prevention and Management of Burns.

Canadian health-care professionals and individuals can contact Nurses Specialized in Wound, Ostomy and Continence Canada (NSWOCC) to find a stoma, wound, continence care specialist in their area.

4.2 Optimize the local wound environment

The first step in treating any form of MASD is to control the moisture on the affected skin and prevent the moisture from accumulating and lingering. Management strategies for MASD are outlined in Table 9.

Table 9: Skin and Wound Management for MASD

	IAD	ITD	Periwound MASD	Peristomal MASD	IF
4.2.1 Cleansing [17, 21,22,122,123]	Wash with a gentle cleanser* (avoid soap or alkaline products) Cleanse the surrounding intact skin well Pat dry; do not rub Single-use wash cloths are preferred Use no-rinse skin cleansers	Use a noncytotoxic agent* (typically potable water, normal saline irrigating solution or an appropriate wound-cleaning agent) Cleanse the surrounding intact skin well Pat dry; do not rub	Use a noncytotoxic agent* (typically potable water, normal saline irrigating solution or an appropriate wound- cleaning agent, neutral pH between 6.5 to 7.5) Cleanse the surrounding intact skin well, 10-20 cm outward from the damaged skin edge Pat dry; do not rub	Wash with potable water. Use a soft or disposable cloth. Gently but thoroughly pat dry Avoid soaps (especially oily soaps) and other alkaline products	Use a noncytotoxic agent* (typically potable water, normal saline irrigating solution or an appropriate wound-cleaning agent) Cleanse the surrounding intact skin Pat dry, do not rub
4.2.2 Debriding	No	No	No	No	Yes, if indicated by the presence of necrotic tissue and adequate blood flow
4.2.3 Managing bacterial balance[17,21, 22,122-123]	Category 1B where fungal (link to note below) infection is evident, apply a miconazole-containing paste 1-2 times daily Category 2B, where signs for increased bioburden is evident, a swab should be done	Place silver-impregnated fabric between the folds to wick away moisture Use PHMB-impregnated gauze Antiperspirant, loose clothing, good air flow	Ensure periwound hygiene and protection	Apply antifungal cream or powder in case of fungal infection. Apply for 7 days after the disappearance of the clinical signs of fungal infection When applying cream, ensure the cream is well penetrated before applying the ostomy pouching system	Prophylactic antibiotics have no benefit; however, if infection is suspected, target streptococcal, staphylococcal and *Pseudomonas aeruginosa*

Note: Fungal infections: When a fungal infection is diagnosed, apply an antifungal cream/product as prescribed (usually 2-3 times a day). However, in the case of IAD, it is important to apply a skin barrier cream over the antifungal product to protect the skin from stools and urine. The skin barrier should be applied as many times as needed.

4.2.4 Managing moisture balance[17,21 22, 122,123]	Use polymer-based incontinence products or under pads instead of non-polymer In the case of extensive diarrhea, it is preferable to apply pads instead of briefs When applied, briefs should not be closed tightly Use containment devices when appropriate[4]	Place silver-impregnated fabric between the folds to wick away moisture Apply PHMB impregnated gauze	Use a cover dressing** designed to absorb the exudate vertically to protect the periwound skin or absorbent enough to avoid any leaking on intact skin Use absorbent dressings such as alginate, gelling fibre, polymers and foam Protect the skin with no-sting barrier film or ointment-based skin protectant. Explore the form and function of various products to ensure maximal absorption and skin protection (e.g., not all foam dressings will absorb and lock exudate away from periwound skin)	Ensure the ostomy skin barrier is protecting the peristomal skin[121] Assess pouching device to ensure proper fit and prevention of leakage	N/A

4.3 Select appropriate care or therapy[17, 21, 22, 122-123]	Hydrophillic paste dressings Petrolatum, zinc or dimethicone-based barrier ointments or creams No-sting film barrier or ointment In the case of fungal infection, avoid use of no-sting film barrier until the infection is resolved Implement a personalized toileting schedule If using containment products, ensure that barrier products are compatible with the containment device	Moisture-reduction products (4.2.3) Treat infection by lightly dusting skin with antifungal powder Use of anti-inflammatory topical steroids when needed (in case of major inflammation), for a limited period Consider referral to a dermatologist for recalcitrant dermatitis	Apply a non-alcohol-based (or no sting) liquid skin protectant to the periwound skin Apply barrier creams Control moisture with appropriate absorptive dressings, ideally providing vertical absorption In some cases, excessive moisture may be due to edema, which must be controlled (such as using compression in venous leg ulcers and lymphedema)	Refer to a wound care clinician or a stoma care nurse Consider referral to a dermatologist for recalcitrant dermatitis	Provide adequate oral analgesia (e.g., amitriptyline; however, this is still not well supported) Elevate affected extremity Hypothermic cooling Slow rewarming Pain relief

**See Product Picker for Skin and Wound Clean-up https://www.woundscanada.ca/dhfy-doc-man/public/health-care-professional/1307-product-picker-skin-and-wound-clean-ip*
***See Product Picker for Dressing Selection https://www.woundscanada.ca/docman/public/health-care-professional/1114-product-picker-2017-selection-guide-1/file*

4.3 Select the appropriate dressings and/or advanced therapy

IAD: Liquid film-forming acrylate sprays or wipes can provide an adequate barrier in instances with occasional incontinence. Ointments with a petrolatum, zinc oxide or dimethicone based are commonly reported to be effective and inexpensive barriers; cream-based products, however, are more likely to promote hydration in addition to providing a barrier. Containment devices may be required when severe incontinence is not well-managed using barrier films. Ensure that any barrier products used are compatible with the selected containment device. Successful prevention and treatment of IAD are dependent upon three strategies: the removal of feces and/or urine from the affected skin; the application of a moisturizer to repair skin barrier function; and the use of a barrier, usually in the form of cream, to prevent further damage to the epidermis from feces and urine.[70]

Utilize the ACT mnemonic (Assess, Cleanse, Treat). Steps to preventing and treating the cause of IAD includes, as a method of prevention, assessing those not yet experiencing skin breakdown:

Step 1: Assess the skin after each episode of incontinence to determine the irritant and note the condition of skin.
Step 2: Cleanse using pH-balanced solution, protect the skin and contain the effluent.
Step 3: Treat vulnerable, damaged, traumatized skin[123]

There is a role for using topical corticosteroids to reduce inflammation until moisture balance is achieved. Plan use with the primary care provider and pharmacist and monitor for skin improvement. Care is required, however, to avoid epidermal atrophy from inappropriate topical corticosteroid use, especially if the steroid is used under occlusive products such as dressings and barriers.[124]

ITD: Initial treatment must always include managing underlying factors. It is crucial to rule out any secondary infection prior to proceeding with a plan of care. It is also imperative that other skin conditions be ruled out.[21,24] Methods of preventing moisture build-up include the use of antiperspirants, wearing loose clothing to avoid overheating, and trying to remain in air-conditioned places.[21,24]

Treatment of intertrigo is dependent on reducing or removing the predisposing cofactors of heat, humidity and infection where present. Dressing choice is often difficult, as affected areas are frequently compounded by hard-to-dress locations and, in ambulatory patients, physical movement. Barrier creams, zinc or talc solutions and powders are of limited value; however, these products may be considered for recalcitrant cases.[33] Other successful management strategies include placing a piece of textile with embedded wicking fabrics in the skin fold to draw moisture away from the apex of the fold, thereby reducing the amount of moisture within the area; however, the effectiveness of this intervention remains unknown.[24]

There is often a role for targeting the overgrowth of yeast organisms with topical antifungal therapy. A variety of topical antifungal agents are used to combat fungal infections of the skin, including polyene antifungals, such as nystatin; azole-type antifungals, such as clotrimazole, econazole and ketoconazole, and allylamine antifungals, such as terbinafine, most of which can be applied twice daily for 10 to 14 days. Low-dose topical corticosteroids may also be used in combination with an antifungal to reduce epidermal inflammation and speed restoration of normal skin barrier function.[24]

Periwound MASD: This occurs when wound exudate (mild to copious) comes into contact with skin (short or longer durations). The proteolytic enzymes erode the skin's ability to remain intact. Chronic wounds have increased enzyme levels and when in contact with the skin, are more likey to cause periwound MASD.[125] Irritation and pruritus may cause the patient to scratch their skin, leading to secondary infections and further skin irritation/injury.

Signs of periwound MASD include erythema, maceration and skin loss. Macerated skin is soggy and soft, and it may be whiter than usual. Among darker-skinned patients, maceration presents as gray-white and wrinkled skin. Effective treatment uses a two-pronged approach aimed at reducing the moisture on the skin and repairing skin barrier function.[119]

Peristomal MASD: Treatment and management of peristomal MASD can be difficult, because any investigation of dermatitis under an appliance must first consider etiologic factors. Treatment should always involve a wound care clinician/stoma nurse with advanced knowledge.[121] Film skin protectants may not be appropriate for application under an ostomy appliance, because many of the barriers are intended to adhere to dry intact skin.[126] Therefore, it is essential to determine the source of moisture, most often leakage, and find a method to control it. For extreme inflammation, a dermatologist should be consulted for additional steroid therapy. Overuse of a corticosteroid, however, can be damaging to the skin long-term, and follow-up skin assessment by a specialist in this area is recommended.

The selection of a barrier (e.g., an antimicrobial containing fabric) to be applied around a tracheostomy site should be based on the ability of the barrier to keep the surrounding skin dry and intact. This includes ease of application and removal, but any barrier should be used with caution to prevent obstruction.[127]

Immersion Foot (IF): Less severe forms of IF (uncomplicated by ischemic injury or infection) should be managed with the conservative measures of drying feet, applying a barrier cream and the use of appropriate analgesics.[128] Evidence suggests, however, that some patients may experience a persistent vaso-neuropathy, even after resolution of the cutaneous findings, resulting in pain and/or persistent sensory abnormalities as demonstrated on Semmes-Weinstein and thermal testing.[129] Prevention of reinjury can be accomplished by keeping the feet warm and dry with daily application of a barrier cream, ensuring the wearing of adequate footwear/dry socks and use of appropriate analgesics if required. [40,41] Treatment of severe injury is best achieved by slow rewarming of the affected limb(s) to prevent reperfusion injury.

This is of importance for persons experiencing homelessness. Those, without adequate shelter or housing need support to obtain and maintain adequate foot hygiene practices, as well as properly fitting shoes for various weather conditions.[130]

Products *not* recommended for MASD are those that donate moisture to the area such as hydrogels or dressings promoting an occlusive environment, thereby restricting moisture evaporation.

4.4 Engage the team to ensure consistent implementation of the plan of care

To optimize the outcome, it is essential to engage all members of the integrated team in care planning and implementation. For nursing staff, education and awareness campaigns that report the outcomes of MASD prevention strategies help change practice. Keeping the patient and family members engaged is crucial, as the patient will ultimately control many of the underlying factors that caused the MASD.

Step 5: Evaluate Outcomes

5.1 Determine if the outcomes have met the goals of care

Reassessment of MASD helps clinicians determine if prevention and treatment plans have achieved the established goals. If a clinician implements a routine skin care regimen, an improvement should be noted within a two-week period.[131] If subtypes of MASD are not resolving and skin integrity is not maintained, it is necessary to reassess causative factors and barriers to healing and revise the care plan.

5.2 Reassess patient, wound, environment and system if goals partially met or unmet

If the goals are only partially met or unmet, complete a systematic assessment to re-evaluate the goals and determine the reasons for unsuccessful prevention and management of MASD. Including team members is important in reassessing and exploring modifiable factors, patient involvement and patient ability to support the care plan. Erythema, maceration, erosion, related pain and patient satisfaction are crucial factors in considering outcomes for MASD secondary to IAD.[17] Additional important outcomes for consideration are colonization and infection of MASD and the impact of MASD on the patient's quality of life. Less-experienced clinicians should discuss with the appropriate team members or other mentors to confirm the subtype of MASD. Other skin conditions, such as cutaneous fungal infections, dermatitis, bacterial infection and PI, should be ruled out in the assessment process.[21]

Timely referral and continued use of categorization and assessment tools can provide a foundation for development of validated assessment tools able to reliably detect change.

Patient Reassessment

The literature indicates that individuals with bladder and bowel incontinence are more likely to develop a PI than those who are not incontinent. Pressure injury should be assessed in unresolved MASD, by appropriate clinicians, and prevention strategies implemented. Frequent skin assessments are required, and a bundled approach to care should be implemented if it is deemed that an individual is at risk of MASD and PIs.[70,132] Clinicians should also reassess mobility, overall nutrition, continence status and possible allergies.[31]

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Identifying and managing the cause of the MASD, type of MASD and patient barriers to healing are vital in reducing risk of recurrence. Incorporating prevention strategies into the plan of care can promote preventative behaviour throughout the management process.

Routine and Structured Skin Care Regimen

Implementation of a consistent and structured skin care regimen is essential for preventing and managing MASD. Education for patients, families and care partners regarding the skin care regimen is important for sustaining and reducing recurrence rates.

Social Isolation and Depression

The impact of MASD on the patient's psychological and social functioning is also an important consideration. Social isolation and loss of independence can lead to depression, something clinicians should be prepared to assess and manage. This includes ongoing evaluation and education of patients and families, including care partner education.[59, 70]

Environment

Assessment of an individual's environment is crucial to determine whether there is appropriate equipment, capacity to participate in self-care, and if the home is conducive to good hygiene practices. Knowledge of community resources (e.g., pharmacies within close proximity, access to food and medical supply stores, community supports) is helpful in supporting the patient to remain at home.

Cost Effectiveness

If risk factors for MASD are not well managed, individuals, care partners and health-care systems will experience increased costs. Health-care professionals and individuals need to be aware of the various products available.[21] Guides, such as the Wound, Ostomy and Continence Nurses' (WOCN) *Body Worn Absorbent Product Guide*, are valuable in assisting health-care professionals with such decision-making. Wounds Canada's Do-It-Yourself Series: *Incontinence-associated dermatitis (IAD)* and ***Intertrigo*** are valuable resources for patients, care partners, and clinicians. https://www.woundscanada.ca/patient-or-caregiver/resources/diy-series

The greater health-care system should consider the entire cost of care and clinical outcomes when making decisions about publicly funded formularies and compendiums. Often the focus is on the hard cost of products versus the larger picture. For nosocomial-related MASD, organizations should not hold the patient accountable for funding their own products to manage situations caused by inadequate health-care resources. This is often the case post discharge, when the patient returns home.

Conclusion

The Wound Prevention and Management Cycle ensures the patient remains the focus of care and helps the clinician navigate through a comprehensive assessment and plan of care. It is critical to promptly recognize any emerging clinical signs of MASD and understand the differences among these types in order to make the right diagnosis. Taking the time to complete a holistic head-to-toe patient assessment will help to unveil underlying factors and aid in determining the type of MASD. This, in turn, enables the clinician to develop an appropriate health-care team and put in place an effective plan for prevention or care.

In all patients, supported self-care should be encouraged wherever possible, with the individual encouraged to engage with their treatment and be educated about the importance of skin integrity and protection. Individual capacity will need to be considered so that the appropriate level of ability and willingness to be involved can be ascertained. All self-care should be encouraged within a support system and the patient must know how to obtain

further advice when needed.[16] It is crucial for all team members to adhere to a standardized approach to ensure the continuity of care that is the key to obtaining positive outcomes. Regular, ongoing education about MASD is strongly recommended. Nundy et al. recommend teams focus on the quintuple aim, including data collection and research initiatives that support and seek health care improvement. This includes focusing on understanding the patient and care partner experiences, exploring ways to reduce costs, improving population health, improving the clinician experience and enhancing equity.[47]

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Best Practice Recommendations For Skin Health and Wound Management 2025



Prevention and Management of Skin Tears

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Chapter 6
Prevention and Management of Skin Tears

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INTRODUCTION

This best practice recommendation chapter is intended to aid teams in their ability to identify risk for, and differentiate, the types of skin tears and to become and to become familiar with strategies to prevent and manage skin tears. As well, it is intended to guide researchers in planning future projects.

What are Skin Tears?

The International Skin Tear Advisory Panel (ISTAP) defines a skin tear as, "a traumatic wound caused by mechanical forces, including removal of adhesives." [1] Severity may vary by depth (not extending through the subcutaneous layer).[1] "A skin tear can be partial-thickness (separation of the epidermis from the dermis) or full-thickness (separation of both the epidermis and dermis from underlying structures)."[2] Skin tears have been reported to occur in the extremes of age (neonates and the elderly), as well as critically and chronically ill persons.[2,3] Skin tears can be found on all areas of the body but are particularly common on the extremities, such as the upper and lower limbs[4] or the dorsal aspects of the hands.[5] While some skin tears are unavoidable, most are preventable.[1]

Impact of Skin Tears

Individuals with hard-to-heal or stalled skin tears are vulnerable to prolonged pain, emotional distress, embarrassment, infection and decreased quality of life.[1,5] Qualitative studies to examine the patient experiences and human burden from the impact of skin tears on physical, psychological and social functioning are recommended. Skin tears can result in extensive health-care costs related to material and labour, increased workload and increased length of stay in health-care facilities.[1,6]

For adults, skin is at greater risk of skin tears as ageing occurs. When comparing normal outer epidermis and aged outer epidermis one can identify multiple factors that affect promotion of skin health and prevention of skin tears. ISTAP identifies the following changes in ageing skin:

- "Thinning of the epidermis and flattening of the epidermal junction
- Loss of collagen, elastin and glycosaminglycans
- Atrophy and contraction of the dermis (causing appearance of wrinkles and folds)
- Decreased activity of sweat glands and sebaceous glands, causing the skin to dry out
- Thinning of blood vessel walls and a reduction of blood supply to the extremities
- Increased dermal LEP (low-echogenic pixels), including solar elastosis, may represent a risk factor for skin tears; this indicates that skin tear risk factors might not only represent chronological ageing but also photoageing."[1]

ISTAP discusses changes experienced by patients' skin integrity, from infant to fully developed adult skin and aging skin.[1] Multiple factors contribute to increased risk of skin tears. Although skin tears may occur in all populations, the highest risk of skin tears is common in older adults with particularly fragile and aged skin.[7]

Prevalence of Skin Tears

Skin tears are found in various clinical settings and are highly prevalent yet preventable.[7–9] Skin tears have a wide prevalence range that varies in care settings. The prevalence of skin tears has been reported to be 4.1-12.2% in hospital;[7,10,11] 10.5%-20-8% in long-term care centres;[12,13] 14.5% in intensive care units[14] and 6.5% in patients living with cancer.[15]

It is important for clinicians to recognize that skin tears are adverse and reportable events that require reporting through patient safety systems.[16] Consistent documentation is required to aid in tracking and monitoring the prevalence of these wounds. Skin tears are frequently compared to pressure injuries in the literature because:

- they are both found in the frail elderly and the very young, as well as in those who are critically or chronically ill[17] and
- pressure injury burdens have long been used to benchmark quality of care, a function that could be applied to skin tears as well.[18–20]

Despite their impact, skin tears are often unrecognized and under-reported in clinical practice, resulting in suboptimal prevention and delayed or inappropriate treatment.[21] The paucity of published studies and the lack of standardized assessment makes the benchmarking of skin tears difficult. This is especially important for care of patients with dark skin tones.[22] Skin tears are generally more common among the long-term care (LTC) population, with prevalence

rates ranging from 10 to 54% across different countries.[20,23–27] The high prevalence of skin tears highlights the need for standardized tools to assess risk and prevent skin tears and to educate clinicians on classifying and treating skin tears effectively.[28]

In recent years, researchers have begun to monitor the prevalence and incidence of skin tears and have established a common definition and universally acceptable classification system to identify risk factors and examine prevention strategies. While health-care professionals and care partners should place a primary focus on risk assessment and implementation of prevention strategies to limit the prevalence of skin tears, they must also be equipped to manage these wounds when they do occur.

Best practice includes early and accurate identification, classification, documentation and the application of an evidence-based treatment protocol.[21,29] By recognizing which patients are at risk for skin tears, preventing skin injuries and using the appropriate skin tear treatment protocols, health-care professionals can ensure that patient outcomes are improved, unnecessary pain is avoided, system efficiencies are enhanced and costs are reduced.[20] A systematic review highlights the connection between skin care bundles and the reduction of the number of skin tears.[30] Current treatment of skin tears may vary based on available—but not always appropriate—options. In fact, skin tears are often left untreated without any dressing.[26] There continues to be a need for increased awareness and common terminology. The current version of the World Health Organization's International Classification of Diseases does not include separate coding for skin tears.[31] There is a suggestion that this current lack of coding contributes to skin tears being perceived as insignificant injuries[8] and that separate coding is needed.[1]

The interprofessional team of authors of this chapter engaged in synchronous and asynchronous collaboration using a variety of online tools. This collaborative process fostered rich discussion of the literature and its applicability to practice at the bedside. The depth of these discussions is reflected throughout this paper. This document is written with the intent to encompass the quintuple aim for health-care improvement. This is to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity. This equity piece is particularly important for patients living with skin issues, wounds and, specifically, skin tears (See Table 1). Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[32]

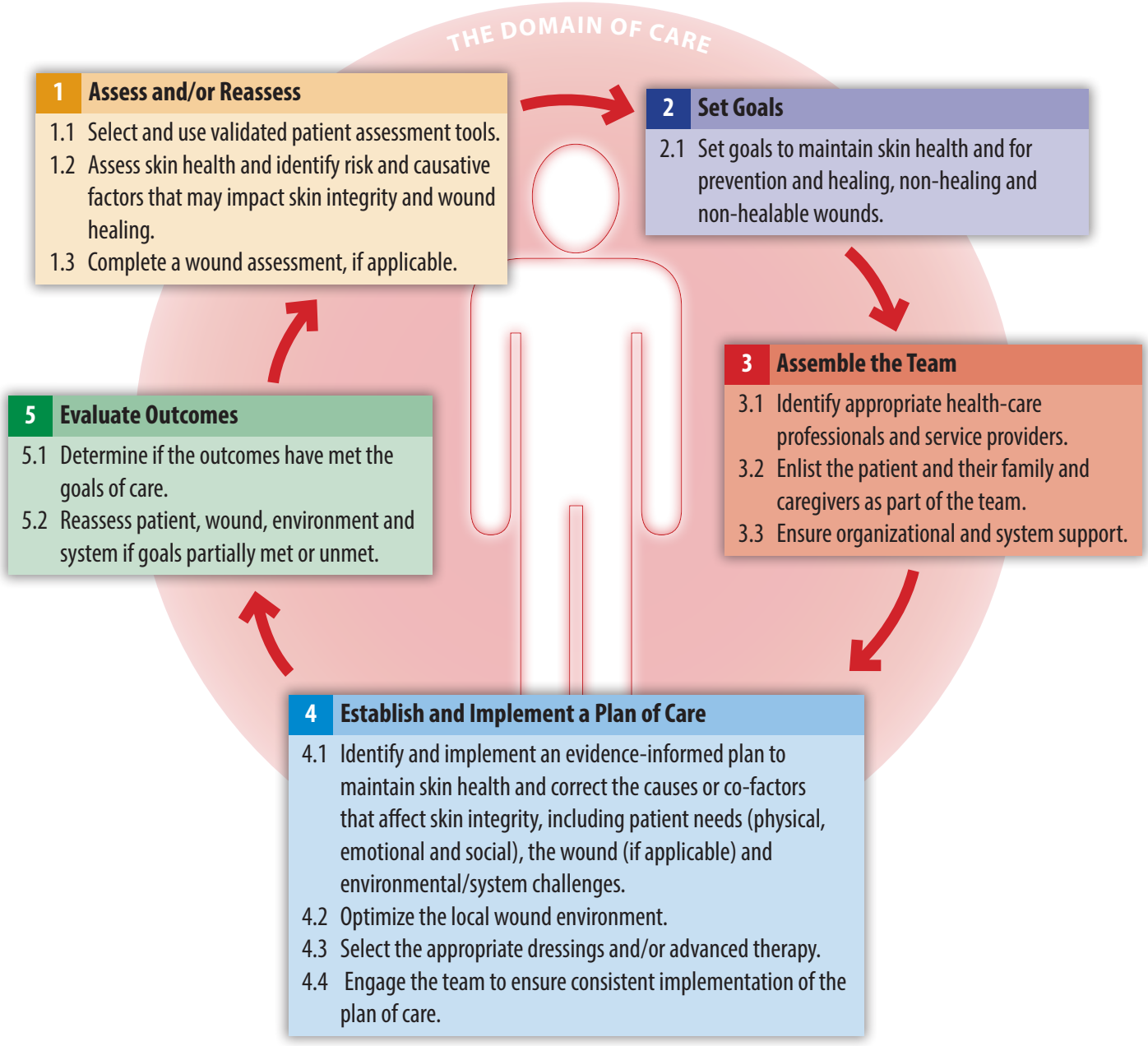
Table 1: Quintuple Aim and Management of Skin Tears

5 Components	Applied to Skin Tears
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practice to ensure most effective treatment and appropriate use of resources – examples: risk screening, skin tear prevention, lotions, dressings
Advancing health equity	Application of principles to all those at risk for, and affected by, skin tears
Care team well-being	Providing clinically usable information for front line clinicians
Enhancing the patient experience	Providing a supportive process of care for all those with a skin tear

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide that incorporates the best available evidence. It outlines a process, or series of consecutive steps, that supports patient-centred care using the Wound Prevention and Management Cycle (See Figure 1), which guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of wounds, from the initial assessment to a sustainable plan targeting self-management for the patient.

Figure 1: Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence and are intended to support the clinician, the patient, care partners, their family and the health-care team in planning and delivering the best clinical practice. Two foundational chapters supplement this chapter with additional evidence-informed information and recommendations that are general to all wound types: Chapter 3: Skin: Anatomy, Physiology and Wound Healing,[33] and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds An Overview.[34]

There are three guiding principles within the best practice recommendation papers (BPRs) that support effective prevention and management of skin breakdown:

1. the use of the Wound Prevention and Management Cycle, regardless of the specifics, to prevent and manage skin breakdown,
2. the constant, accurate and multidirectional flow of meaningful information within the team and across all care settings, and
3. the patient as the core of all decision making.

Step 1: Assess and/or reassess

Recommendations

1.1 Select and use validated patient screening and risk assessment tools

Discussion: Health-care professionals have developed and validated risk assessment tools for various wound types but, unfortunately, a validated risk assessment tool for skin tears does not yet exist. This lack of a tool complicates identifying who is most at risk and why. Few studies address skin tear risk factors in general, and the majority of the skin tear prevention literature is based on expert opinion only.[20]

The International Skin Tear Advisory Panel (ISTAP) conducted a review of skin tear risk factors and expanded on search criteria.[35] Using a Delphi process, the panel subsequently developed a risk assessment pathway. The ISTAP risk assessment pathway is composed of three categories:

1. General health (chronic and critical disease, polypharmacy, cognitive, sensory, visual and auditory impairment and nutritional status),
2. Mobility (history of falls, impaired mobility, dependence for activities of daily living [ADLs] and mechanical trauma) and
3. Skin (extremes of age – neonates, children, older adults – fragile skin and previous skin tears).[36–38]

The pathway aids in identifying both modifiable and non-modifiable risk factors and predicts an increased risk among those with deficits in any of the categories.[1,21]

In addition to the risk factors identified by ISTAP, new evidence suggests that aggressive behaviour[35] and an increased risk of pressure injuries[26,39] may also be relevant to skin tear risk. Given these more recent findings, additional studies are required to include these factors in the ISTAP risk assessment pathway and to test its validity and predictive ability.[39] It is recognized that the ISTAP risk assessment tool is limited in that it focuses primarily on elderly populations and does not address the chronically ill or pediatric populations.[40] More research is needed to focus on persons living with dementia.[41] See ISTAP risk assessment pathway for more details.[1]

1.2 Identify risk and causative factors that may impact skin integrity and wound healing

1.2.1 Patient: Physical, emotional and lifestyle

Discussion: Skin tears can occur anywhere on the body so prevention strategies and screening should include the entire body.[9]

An early, complete and holistic assessment of patients should be performed and documented, including baseline information pertaining to their knowledge, beliefs, health status and perceived learning needs, to address the risk factors as identified below (See Table 2).[1,35] Cultural and psychological variables must also be considered.[1,2,36,42]

This is important as skin tear causes are poorly documented.[20,43] Documentation may be improved by using electronic incident records at the bedside, on admission or first visit and whenever the patient's health status changes.[42] Document the patient's baseline skin tone. The Skin Tone Tool helps clinicians identify the patient's baseline skin tone by assessing the patient's inner arm.[44] Skin changes associated with ageing, such as ecchymosis and senile purpura, are risk factors for skin tear development.[12] In patients with dark skin tones, identification of these factors is challenging. It is important that clinicians assess for other indicators of injury in patients with dark skin tones by using both visual and tactile cues (e.g., purple/blue/grey discolouration and change in temperature). Use of the senses, especially touch and hearing (listening to the patient story), is valuable in the assessment regardless of the tone of their skin. Ask the patient about their skin and listen to their perspectives about what they consider to be an issue (e.g, tightness, changes

in feeling/sensation and pain, discomfort or numbness over the affected area).[22] Ongoing daily inspection, documentation and communication of assessment and preventative education with the team should be performed to identify any changes in health status or skin.[1,45]

Table 2: Skin Tear Risk Factors

Skin Tear Risk	Causative Factors
Altered sensory, auditory and visual status	Decreased sensory, auditory and visual status that often occurs as an individual ages
Cognitive impairment	An increased risk of skin tear development including: • Displaying reactive and or aggressive behaviour • Being cognitively impaired • Having dementia, altered cognition or delirium
Nutritional concerns	Inadequate nutrition and hydration may affect tissue viability[46,47] and increase the risk of falls, leading to injury thereby increasing the risk of skin tears Side effects and causes of dehydration including vomiting, diarrhea, impaired kidney function, diuretic use, or input problems, such as not drinking enough water or fluids[5,48]
Polypharmacy	Polypharmacy has been indicated to be an independent risk factor for falls; individuals receiving four or more medications are at a greater risk for falls[49] Increased risk for falls coupled with the increased risk of confusion reported with persistent polypharmacy in the elderly population[50] links polypharmacy to a potentially heightened skin tear risk The chronic use of topical and systemic corticosteroids has been linked to skin tear development.[16] Corticosteroids are known to regulate the expression of genes encoding collagens, elastin, matrix metalloproteinases (MMPs) and tissue inhibitors of MMPs, among others Medications that may affect skin integrity include:[5,51–53] • anti-bacterial agents • anti-hypertensives • analgesics • tricyclic antidepressants • antihistamines • antineoplastic agents • neuroleptics • diuretics • hypoglycemic agents • nonsteroidal anti-inflammatory agents • oral contraceptives • steroids • anti-coagulants
Mobility	Factors that increase risk of skin tear development include:[54,55] • Having an altered level of mobility • Being unable to reposition independently • Having spasticity

cont'd. . . .

Assistance with activities of daily living (ADLs)	Skin tears are frequently linked to: • wheelchair injuries • transfers • blunt trauma from bumping into objects[2,56] and/or impaired activity • use of assistive devices • dependence on others for care and activities of daily living • lower levels of functional ability
History or risk of falls **(See Appendix for additional falls resources)**	Falls and associated blunt trauma have been linked to heightened skin tear risk[2,58,59,60,61] Predisposing factors for falls include: **Environmental issues** • Limited or no lighting • Sun exposure • Loose throw rugs, torn carpeting, or flooring materials, stairs • Slippery tubs and showers • Poorly fitted shoes, slippers, boots • Floor clutter (electrical cords, oxygen tubing) • Beds, chairs, or toilets without handrails/grips • Broken medical equipment **General Health** • Depression and mental health issues • Changes to vision • Unsteady gait, strength and balance (multiple causes) • Chronic diseases, including, kidney disease, heart disease, diabetes mellitus, stroke, chronic obstructive lung disease (COPD) • Urinary / fecal (both) urgency • Pain (anticipatory, procedural) • Cardiovascular changes – stroke, orthostatic hypotension • Lower leg edema (dressings, devices) • Parkinson's disease (posture, gait) • Osteoporosis, arthritis / Rheumatoid arthritis • Ménière's disease (balance) • Neurological disorders: epilepsy, brain disorders, seizure activity • Nutrition: dehydration, malnutrition (low vitamin D levels) • Thyroid problems[62]
Mechanical trauma (not related to mobility aids)	Medical adhesives are common contributors to skin tear development in all at-risk groups. Skin tears that result from adhesives occur when adhesive attachment is stronger than the skin's tensile strength or when the product is removed. A Medical Adhesive Related Skin Injury (MARSI) is suspected where erythema or other form of skin injury persists for longer than half an hour after skin removal of an adhesive[63] Handling premature neonates may result in skin breakdown due to the extreme fragility of their skin. Close monitoring of premature neonates requires the use of medical devices that must be frequently removed. Removal of any layers of the neonatal stratum corneum during the process of adhesive removal can further reduce the skin's barrier function, which significantly compromises fluid balance and homeostasis and increases skin permeability; these disruptions can lead to toxicity and irritation from topically applied substances as well as an increased risk of infection[64]

cont'd. . . .

Skin, age and critical illness	The underlying mechanism of injury differs between younger and older individuals. The longevity of skin collagen and elastin and the cumulative effects of ageing and UV radiation have shown to progressively degrade the physical architecture of the skin, which alters the biomechanical behaviour and gross clinical appearance of skin with an associated increase in the risk for skin tears[53,65] Age-related skin conditions are increasingly prevalent. Ageing is associated with anatomical and physiological skin changes, such as flattening of the dermo-epidermal junction, loss of cutaneous collagen, drying and reduction in subcutaneous tissue, rendering the skin more fragile and less elastic[36] Dermatoporosis (chronic skin frailty), insufficiency fragility syndrome[66,67] Presence of senile purpura (when small blood vessels leak under the skin) and elastosis (a degenerative change in the dermis layer with increased deposition of elastin material)[48,68] Skin related risk factors include: • Extremes of age (very young and very old) or critically ill • Presenting with skin exhibiting signs and symptoms of aging and/or sun damage • Darker skin tone[22] • Having been identified with an increased pressure injury risk[20,26,35] • Having presence of: · ecchymosis (bruises) · senile purpura (benign condition with recurring bruising) · hematoma (a bad bruise where blood pools under the skin) · stellate pseudoscar (Colomb, whitish, slightly depressed area, a condition of senile skin often on the back of hands and arms[69] · skin atrophy[8,70] • Having any evidence of previously healed skin tears • Presenting with edema of the extremities • Chronically ill individuals (greater risk for skin breakdown in general and skin tears in particular)[2,20,40]

Table 3 outlines an overview of modifiable and non-modifiable factors to consider when promoting patient skin health and prevention of skin tears with the patient and care partners.

Table 3: Modifiable and Non-modifiable Risk Factors[120]

Non-modifiable Risk Factors	• Skin changes associated with advanced age • Edema and ecchymosis • Spasticity • Hematoma • Impaired mobility, bedridden • Dependence on others for activities of daily living, such as dressing, feeding and transfers (e.g., operating room, care settings) • Previous skin tears • Increased pressure injury risk, history of falls • Sensory deficits, cognitive impairment, and aggressive behaviour
Modifiable Risk Factors	• Hydration (oral) • Protection of skin (e.g., cream and lotions) • Dressing choices: use of adhesives, tape • Assistive devices: orthoses/prostheses, wheelchairs, walkers • Tubes related to care (e.g., urinary, nutrition): type and positoining • Limited or poor nutritional intake • Polypharmacy

Considerations specific to the pediatric population

DIscussion: In Canada, pediatrics includes neonates, infants, children, adolescents and young adults.[71] Skin tears occur in greatest numbers in the pediatric population. Unfortunately, limited literature addresses skin tear risk factors in these populations.[72] Premature neonates are known to have minimal stratum corneum and attenuated rete ridges, giving their skin a red, wrinkled, translucent and gelatinous appearance. They also have less subcutaneous tissue than other populations, meaning that the dermis lies directly over muscle. With less subcutaneous tissue, pediatric patients are at a much higher risk of skin tears caused by medical adhesive removal.[72]

Researchers have demonstrated that functional maturity of skin is not completed until the second year of life, when increased collagen is found in the tissues. Skin immaturity is considered a risk factor for skin tears in the very young.[73] Baharestani reports that all children are at heightened risk of skin tears until the age of three, when the stratum corneum is fully matured, and that all children with acute and chronic illnesses, like their adult counterparts, are at heightened risk for skin tear development.[72]

Newborns have significantly fewer layers of stratum corneum, fewer collagen and elastic fibres, increased transepidermal water loss (TEWL) and less cohesion between the epidermis and dermis.[74,75] Because neonatal skin is not fully mature, it is more sensitive and less resistant to mechanical stress, such as friction and shear forces,[29] especially for preterm neonates and children under the age of three.[72]

Pre-term and newborn infants are particularly susceptible to skin tears. In fact, neonates have under-developed skin, and their decreased epidermal-to-dermal cohesion, deficient stratum corneum, impaired thermoregulation, body surface/weight ratio that is nearly five times greater than an adult and immature immune system place them at an increased risk for skin tears.[5,72] As well, characteristics of neonatal/infant skin may affect the skin's ability to resist shear, friction and/or blunt force.[2]

However, while rates are higher in older patients, skin tears affect many different patient groups and are not limited to older patients. Further research around skin tears in neonates and children is required.[1,53]

1.2.2 Environmental: Socio-economic, care setting, potential for self-management

Discussion: Health-care professionals must have knowledge about the environmental factors that can impact a persons' skin integrity. These factors include socio-economic status, health-care setting and ability to self-manage skin care.[76] Socio-economic and environmental factors not only affect patients' access to prevention, wound-healing products and technology, but also their ability to adhere to a recommended prevention or wound management protocol. Regional differences in access to supplies, equipment and care may also affect the individual's self-management potential. Even within similar regions, access to supplies, equipment and care may fluctuate depending on the type of environment in which the care is being delivered.

For example, skin tear prevention for a pediatric patient in a critical/intensive care unit may be different from that of an ill child in the home setting, and skin tear prevention for an older person living independently in their home may be different from that of an individual with dementia living in a long-term care facility, yet the underlying preventative, assessment and treatment principles must be adhered to.

With the current trend of individuals with cognitive changes and other co-morbidities remaining longer in a home setting, self-management and prevention will present challenges and more resources will be required to prevent skin tears from occurring. As discussed above, resources such as skin tear checklists and falls prevention programs will be required to enable individuals to safely reside in their homes.

Environments should be assessed to identify factors such as sharp-edged objects like coffee tables, dishwasher doors and loose rugs that may lead to injury and put patients at risk for a skin tear. There may also be ethnic or cultural biases toward or against certain wound care products or practices.[77–79] As well, there are inconsistent findings between studies in Japan and those in Western countries, suggesting that different conditions such as ethnicity, environment and medical situation affect skin tear likelihood.[80]

1.2.3 Systems: Health-care support and communication

Discussion: Organizations and health-care professionals are concerned with the prevalence of skin tears and their ultimate burden on the health-care system. To improve care, screening and assessment are required to understand current skin tear prevention practices at a population, health-care professional and organizational level. This assessment is challenging due to the absence of existing skin tear evidence that might inform quality indicators.

Health-care professionals require regular and consistent education about skin tear risk assessment, prevention and treatment.[81] A skin tear knowledge assessment instrument is supported by acceptable psychometric properties and can be applied in nursing education, research and practice to assess knowledge of health-care professionals about skin tears.[21]

Education on risk factors should be provided to patients, care partners and others within their circle of care.[35,36]

Each health-care setting and agency needs to develop policies and protocols for health professionals to follow to ensure consistency in the assessment of risk and treatment of skin tears.[45]

1.3 Complete a wound assessment, if applicable

Discussion: Wounds should be classified in a systematic and universally accepted manner.[82,83] To accurately assess, document and treat skin tears, it is important that a common language be used to describe these challenging wounds. Proper documentation is vital to understanding the extent of the problem. Skin tears should not be grouped into pressure injury categories.[83]

Prior to the initial assessment of the skin tear, the wound should be cleansed, removing all residual hematoma or debris, and the flap re-approximated (See section 4.1). Skin tears should be assessed and documented as per facility protocol. Refer to the ISTAP Skin Tear Classification system for skin tear classification.[36,57]

Skin Tear Classification

Health-care professionals can more effectively communicate with other health-care professionals, policy makers, researchers, educators and patients/care partners by using common and appropriate descriptors for various types of wounds, including skin tears.[83]

Step 2: Set goals

"A flap in skin tears is defined as a portion of the skin (epidermis/dermis) that is unintentionally separated (partially or fully) from its original place due to shear, friction, and/or blunt force. This concept is not to be confused with tissue that is intentionally detached from its place of origin for therapeutic use, e.g., surgical skin grafting."[21]

Table 4: Examples of intact aging skin and skin tears

Descriptor	Examples of skin changes	
Aging skin – intact Note: thinning of skin, sun damage	 	  
	Aging skin, early senile purpura	Aging skin, thinning with sun damage
	Permission: Wounds Canada	
Type 1 No skin loss. This may be linear or there may be a flap that the clinician can reposition over the wound bed		
	Left forearm, linear type	
	Permission: Wounds Canada	

cont'd. . . .

<table>
<tr><td rowspan="3">Type 1:
Flap not approximated: not yet categorized</td><td colspan="2">  </td></tr>
<tr><td rowspan="3">Same wound as above, now categorized as Type 1 Skin Tear Sutured (not recommended)</td><td colspan="2">  </td></tr>
<tr><td colspan="2">Type 1: Sutured</td></tr>
<tr><td colspan="2">Permission: Marlene Varga</td></tr>
<tr><td rowspan="6">Type 2
Partial skin loss, the flap is partially missing and when repositioned does not cover the wound bed</td><td>  </td><td>  </td></tr>
<tr><td>Multiple skin tears on lower leg
Top: Type 3 as no flap present
Bottom: Partial flap present and wound bed exposed</td><td>Bruising, skin flap does not cover wound bed</td></tr>
<tr><td>Permission: Rose Raizman NP (Scarborough Health Network)</td><td>Permission: Mölnlycke</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Top: Wound bed dry, with a devitalized flap
Bottom: No flap present</td><td>Ecchymosis with skin flap irregular and bruising</td></tr>
<tr><td>Permission: Rose Raizman NP (Scarborough Health Network)</td><td>Permission: Mölnlycke</td></tr>
</table>

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Type 2 Skin Tear with Ecchymosis		
	Permission: Marlene Varga	
Type 3 Full skin loss when the flap is missing and the wound bed is exposed	Skin Tear with clear dressing applied – demonstrates progressive healing	
	  	
	Permission: Wounds Canada	

Recommendations

2.1 Set goals for healthy skin, prevention of trauma, management of healing, non-healing and non-healable wounds

Discussion: Even in the presence of skin tears, a primary goal is the promotion of healthy skin and prevention of future skin tears. Goals should be developed using the SMART principle. An example of a multi-part SMART goal may be: within two days the patient and family member will receive educational materials on skin tears, be able to discuss the importance of intact skin and begin to apply lotion to skin twice daily.

2.1.1 Identify goals based on skin health and prevention or healability of wounds

Discussion: It is a priority to promote skin health and prevent skin tears. Protecting intact skin should inform the setting of all goals. Preventative goals could include the implementation of a skin hygiene regimen, hydration of skin with appropriate lotion and promoting oral hydration. Wearing protective clothing, keeping mobile and identifying risk are essential.

If a wound occurs, it is critical that the healability of the skin tear be determined prior to identifying appropriate goals. To prevent situations of misunderstanding due to different assumptions about the healability of the skin tear and the goals of care, it is important that there be discussion, and optimally mutual agreement among health-care professionals, the patient and their family. This discussion allows the health-care team to provide wound care that is directed toward achieving goals that are appropriate for the individual with the wound. For more information, refer to: Chapter 3 Chapter 3: Skin: anatomy, physiology and wound healing[33] and Chapter 4: Best practice recommendations for the prevention and management of wounds: an overview.[34]

Healing: The skin tear has sufficient vascular supply, underlying causes can be corrected and health can be optimized.

Non-healing: The skin tear has healing potential, but various factors are compromising wound healing at this time (e.g., skin tear on a lower limb with uncontrolled edema).

Non-healable: The skin tear has no ability to heal due to untreatable causes such as terminal disease or end-of-life status.[85] If the wound is deemed to be non-healable, goals should be set that reflect management strategies for activities that prevent infection and protect the fragile periwound and other skin to prevent further skin tears from occurring.

2.1.2 Identify quality-of-life and symptom-control goals

Discussion: An important aspect of goal setting includes the customization for each individual. Any plan of care should include the patient's goals of care and cultural considerations, e.g., promotion of healthy skin (nutrition, hydration, lotion use) prevention of future skin tears, pain management and wound healing. Goals should be congruent with the individual's needs, preferences and abilities, risk factors, co-morbidities, pain, quality-of-life issues, support systems and access to care.[85,86]

Step 3: Assemble the Team

Recommendations

3.1 Identify appropriate health-care professionals and service providers

Discussion: Key team members should be identified and included in any promotion of skin health, skin tear prevention and management program. These team members should include (but are not limited to): individuals at risk and their families and interdisciplinary team members such as: nurses, physicians, pharmacists, registered dietitians, paramedics, physiotherapists, occupational therapists, personal support workers, social workers, psychologists, spiritual care providers, policy makers and other allied health professionals as appropriate.[87] All health-care providers involved in the care of the patient with skin tears must be willing and able to work together toward positive patient outcomes. This includes teams that focus on falls prevention, delirium watch and care of older adults (geriatric), as they may be key members in promoting skin health and prevention of skin tears.[88]

To be effective team members, unregulated and lay care providers require education and training to prevent skin tears.[89,90] It is essential that these important members of the integrated team[34,91] have the knowledge and skills necessary to identify and address risk through hands-on interventions or timely alerts to other members of the team, particularly to reduce the risk of infection and wound complexity.

In addition, education for first-responders and paramedics in skin tears can support and optimize skin care. Hickey and Ayers state that prevention of emergency calls related to slips, trips and falls highlight the opportunity for first responders and paramedics to be educated to provide frontline assessment and management of skin tears.[92] Education for these professionals can support their understanding of skin tears (for example) and prevent application of outdated practices such as skin closure strips.[93] In addition, Jansz and colleagues demonstrated that a first responder skin tear pack reduced overall costs and days with a wound over the study period.[94]

Partnership between ambulance services and other disciplines have yielded successful economic, clinical and patient experience outcomes.[92]

3.2 Enlist the patient and their family and caregivers as part of the team

Discussion: Current literature supports the promotion of skin health and prevention, assessment and management of skin tears to promote patient health, reduce numbers of skin tears and associated costs.[1] Patients, care partners and health professionals should be provided with health information regarding the promotion of skin health, risks, prevention and treatment of skin tears. In addition, they must be aware of the proper techniques for providing care without causing skin tears (See section 4.1). Information should include the points discussed in section 1.2.1.

Engagement, Communication and Building Trust

Consistent education relevant to the patient and family is essential for promoting healthy skin strategies and engaging the patient and family with safe self management.[91] Wounds Canada, "encourages patients and families to utilize the skin and wound care resources available on its website to assist in their self-management activities."[4]

Given that skin tears are found across the continuum of age and health-care settings and the associated risk factors have yet to be fully explored, engagement of individuals and family/caregivers is crucial to prevention initiatives. By engaging individuals and family/caregivers to participate in the prevention and appropriate treatment of these wounds, it is hoped that fewer skin tears will be found to transition into complex and costly wounds.[2]

Effective patient and family engagement requires a shift in the role of the health-care team from unidirectional care providers to collaborators. Interactive patient care has emerged as a care-delivery method that effectively engages and

supports patients to manage their health status and improve patient outcomes.[95] Engaging patients, care partners and families to engage actively in preventative strategies can support self-managed care, enhanced patient experience, improved health prevention and well-being, as well as lowered health-care costs.[95] Engagement is not ideal for all situations, however. In some instances patients and their families may choose to be disengaged from their care. Should this occur, health professionals must be prepared to adjust their strategies and reassess patient engagement levels on an ongoing basis to encourage individuals based on their desired level of involvement[91] and interest in shared-decision making activities.[96]

3.3 Ensure organizational and system support

Discussion: Organizations are frequently concerned with the burden of wounds on the health-care system. Individuals at risk are more concerned with quality-of-life issues (pain, physical disability, social, spiritual and mental health) and wound healing. This leads to potentially competing priorities among these groups, so close attention is required to identify any knowledge and awareness gaps and address them appropriately to ensure that implementation of skin tear prevention programs are successful.

Given the prevalence of skin tears and their potential to become complex wounds, skin tears should be included in prevalence and incidence studies and benchmarked in order to track their extent within a facility, agency or system.[1]

To be successful in reducing the burden of skin tears, health professionals and organizations must be encouraged to conceptualize the outcomes of interventions in terms of the processes of care that have a direct impact on the outcomes. Reduction of skin tear prevalence is one important component to be addressed; however, as not all skin tears are preventable, health-care professionals and organizations should also strive to reduce the number of skin tears that transition to complex and chronic wounds. Outcome measures will dictate the success or failure of implementation strategies and, if success is not met, should be used to adjust the strategies.[97]

A desired outcome for skin tear prevention and management programs includes ensuring health-care professionals, patients, care partners and families have the skills necessary to promote and maintain skin health and prevent skin tears, and to reduce the number of skin tears that transition to complex and chronic wounds.

Step 4: Establish and Implement a Plan of Care

Recommendations

4.1 Identify and implement a personalized, evidence-informed plan to correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional and social), the wound (if applicable) and environmental/system challenges

Discussion: ISTAP conducted a Delphi consensus study to establish skin tear prevention strategies. See ISTAP prevention strategies for a detailed plan of care.[1]

Conducting a home safety assessment is a good starting point (Davis & Davis, 2023)*. These assessments are best conducted with the patient and their care partners and usually include occupational therapy and or physiotherapy. Researchers recommend several checklists to assess for physical safety including falls risks and safety of equipment and furnature. These are conducted with a specific focus on the patient and how they mobilize or function within their home setting.[121]

Assess for risk factors and prevention strategies following a systematic approach such as:

- Nutritional status (fluid and nutritional intake, swallowing)
  - Continence status – bladder, bowel status
  - Use of urinary devices (ostomy pouches, urinary catheters, briefs etc)
- Skin conditions (history of issues e.g., eczema, psoriasis, sunburn, pignementation)
  - Location of skin tear
- Cognitive status (e.g., delirium, dementia, depression, anzxiety)
  - Vision, hearing, speech changes and adaptative devices)
- Neurological status (e.g., diseases)
  - Mobility and devices uses
  - Footwear (seasonal)

Skin Tear Prevention Strategies[1,5,35,42,110,120]

Skin tear prevention strategies, for both patients and their care partners, as well as health-care providers and the systems in which they work, are generally categorized within three main risk categories within the risk assessment pathway: general health, skin health and mobility. ISTAP offers a comprehensive resource on the prevention and management of skin tears in aged skin. See: https://woundsinternational.com/wp-content/uploads/2023/02/085aa82de6f9383340ed14a2d2eda3a1.pdf.

General Health Strategies

General health strategies require attention to altered sensory, auditory and visual status of the patient. This includes being cognizant of the environment, participating actively in care and ensuring regular vision and hearing screening.

For partners and care providers, strategies should include ensuring a safe environment (perhaps with an occupational therapist or physiotherapist home assessment) and implementing a falls assessment and reduction program. Patient's footwear and sensation should also be assessed, particularly for patients with a history of diabetes and/or chronic diseases. It is also important to assess for clothing that could injure the patient's skin.

Neonates and children in intensive care units (ICUs) should have an occupational therapy consult for positioning, and education is needed on safe patient handling. Caregivers should be instructed on handling premature neonates with 'gentle' care. Information should be provided to patients and their circle of care regarding individual impairment, safety and the risk of skin tears.

In cases of noted or suspected cognitive impairment, the patient's partner and care providers should be counselled on appropriate strategies. These may include consulting an occupational therapist, physician, nurse practitioner, or geriatrician to assess cognitive status. This could include a confusion assessment if the patient is exhibiting signs of delirium. A pharmacist can review the patient's medications to add/increase or stop/decrease medications related to cognition, as well as address the potential for skin changes with certain medications.

Skin Health Strategies

Patient strategies to support skin health include participating actively in care, being cognizant of the environment, being aware of risks for skin tears and practising behaviour that will reduce the incidence of skin tears.

Care partners and health-care professionals need to be aware if the individual is at risk for skin tears and, importantly, how to reduce the risk. It is important to exercise caution when caring for patients with intravenous lines, nasogastric (NG) and other tubes or devices, with specific attention being applied when anchoring catheter tubes and nasal prongs.

Skin should be treated with hypoallergenic moisturizers after bathing, while the skin is still damp, not wet. Warm water – not hot – should be used for bathing. Soapless, no-rinse and/or pH-neutral skin cleansers should be used. See Wounds Canada Skin and Wound Clean-up: https://www.woundscanada.ca/docman/public/health-care-professional/1307-product-picker-skin-and-wound-clean-ip/file.

Patients at risk should be provided with education regarding the use of protective clothing, such as long-sleeved tops, long pants, knee-high socks and/or shin/elbow guard pads. Adhesive products should be avoided on frail skin. If dressings or tapes are required, non-traumatic paper/silicone tapes, non-adherent contact layers, non-adherent/silicone foam dressings or other topical dressings specifically formulated for fragile skin should be used. This will avoid skin stripping or tearing on removal. Silicone dressings are preferred when appropriate, however, silicone dressings may not provide enough adhesion to ensure that medical devices remain properly in place. For pediatrics, use thin hydrocolloids as a base when adhesives are needed, while leaving adhesives on site for at least 24 hours.

Avoid the use of patient identification armbands with sharp, hard edges, such as those made from metal or hard plastic. The patient's fingernails and toenails should be cut and maintained to a short length and rough edges filed to prevent self-inflicted skin tears. Similarly, staff and caregivers can keep their own fingernails cut short and avoid wearing rings or other jewelry that could damage the skin.

Mobility Health Strategies

Partners and providers can consider supporting mobility with a physiotherapy consult to learn about stability and ensure safe handling techniques and equipment safety. The use of repositioning slings and sliders for position changes, as well as transfer belts to avoid gripping arms during transitional movements, is recommended to avoid trauma to skin.

Daily skin assessment and monitoring and documentation for skin tears caused by mobility devices is vital. Health-care providers should be aware that extremes of weight require handling with extra care to prevent skin tears. Additional strategies include padding devices and hard objects within the environment. In general, an uncluttered environment should be encouraged. Involving Occupational Therapy in home assessments for persons living in their own home and in providing information to the patient and their caregivers on proper transferring and positioning techniques can have a positive impact.

Strategies to support fall prevention for patients include using assistive devices as prescribed by health-care professionals, working with caregivers to follow falls prevention programs and taking vitamin D and calcium supplements, if appropriate and as prescribed by a physician or nurse practitioner. Medications that increase the risk of falls should be used with caution,

Above all, it is essential that all health-care professionals and caregivers are provided with adequate education on the prevention and treatment of skin tears, and respect and communicate the need for 'gentle care', including to transport services, porters and similar institution or facility departments, such as radiology and dialysis.

4.2 Optimize the local wound environment

Discussion: When treating skin tears, the first step is to control bleeding, cleanse the wound and determine if the wound edges can be re-approximated. It is only then that the skin tear classification should be determined using the ISTAP Skin Tear Classification System.[35] See ISTAP prevention strategies for detailed plan of care.[1]

The proceeding example demonstrates the steps needed to manage and reapproximate a skin tear. Figure 2 (below) demonstrates how to re-approximate a skin tear and label a dressing. While skin tears represent a specific type of wound, the same principles used to manage other wounds should be employed when treating skin tears.[35] Once the skin tear has been properly categorized, local conditions within the wound can be assessed. Bacteria and necrotic tissue must be removed and the appropriate dressing selected to maintain moisture balance.[34] Specific to those with and/or those at risk for skin tears, topical dressings should be selected that will not cause additional trauma to the wound bed and any remaining skin flap or cause further skin tear damage to the periwound skin.

If possible, it is best to allow the skin tear to heal without being disturbed; for example, through dressing removal. Therefore, supporting undisturbed wound healing through the use of dressings with an increased wear time should be considered.[98]

Care providers should ideally have access to an appropriate dressing on their formulary and have the confidence to leave it on for an extended period (five days unless there are obvious complications, such as infection).[1,41,93] Communication with the patient and/or family is key, and the rationale for undisturbed wound healing should be explained to ensure that the patient understands and is happy with their treatment.[99]

4.2.1 Cleansing

Discussion: Uncomplicated skin tears (i.e., those without debris) can be gently cleansed with non-cytotoxic solutions such as clean/potable water, normal saline or nonionic surfactant cleansers at a low pressure of less than 8 psi to protect granulating tissue.[35] Congealed and dried blood should be removed gently from the flap.[57] When removing an existing dressing to evaluate the wound, it is important not to disrupt healing or damage the intact skin surrounding the wound. Special care should be taken to NOT cause further trauma to any remaining fragile skin tear flap (Type 1 or 2 skin tears) or the fragile periwound skin. Skin tears with necrotic debris may require wound debridement (See debridement section chapter 4), and a wound specialist should be consulted when necessary.[57] If the layer of skin is torn but still attached, the flap should be repositioned over the wound, covering as much of the original surface as possible. If the skin flap is viable, the area should be gently cleansed and the flap rolled back into place with a dampened cotton tip applicator, gloved finger or tweezers (See Figures 7 & 8).[35,57] If the flap is difficult to align, the clinician should consider the applications of a moistened non-woven gauze compress to the area for five to 10 minutes to rehydrate the flap before repositioning. The

flap should not be disturbed for at least five days to allow for adherence to the cellular structures below.[35,57] A viable flap may not cover the entire wound bed but should be positioned to cover as much area as possible.

Note: Be cautious cleansing the wound bed if the patient is taking anticoagulants. Calcium alginate dressings may be used to help with drainage.

4.2.2 Debriding

Discussion: Non-viable tissue provides a locus for infection, prolongs inflammatory response, inhibits wound contraction and delays wound healing.[87] It is important to note that prior to debridement an assessment of tissue perfusion and blood flow, especially on the lower leg or foot, is required.[35]

Tetanus

Tetanus is an acute, often fatal disease caused by wound contamination with *Clostridium tetani*. Individuals with interruption of skin integrity by a non-surgical mechanism who have not received a tetanus toxoid (Td) inoculation in the past 10 years should be given human tetanus immunoglobulin (TIG) according to institutional policy. TIG neutralizes circulating tetanospasmin and toxin in the wound but not toxin that is already fixed in the nervous system. The TIG should be given before wound debridement because exotoxin may be released during wound manipulation.[100] For pediatric and critically ill populations, determine if TIG is appropriate.

4.2.3 Managing bacterial balance

Discussion: It is important to note that skin tears are acute wounds. Initially these wounds may display increased inflammation to the injured area as the result of the trauma. Prior to treating for infection, it is critical that health-care professionals distinguish between inflammation from trauma and inflammation from wound infection.[101]

All topical dressings selected for the management of infection must be compatible with fragile skin in order to prevent further trauma (See Section 4.3).[35]

4.2.4 Managing moisture balance

Discussion: Ensure that all topical dressings for the management of moisture balance are compatible with fragile skin to prevent further trauma.[57] Dressings should be chosen in accordance with the demands of the wound bed and other patient factors. Generally, skin tears are not heavily exudating wounds; however, in some cases, depending on the location and co-morbidities such as peripheral edema, skin tears may be heavily exudating. Absorbent dressings such as foams, hydrofibres or alginates may be required to manage exudate.[57]

4.3 Select the appropriate dressing and/or advanced therapy

Discussion: The ISTAP established a skin tear product selection guide to identify products currently in the global marketplace that will allow for moist wound healing in accordance with the local wound conditions, while at the same time respecting the fragile nature of the skin of those who have been identified as being at risk for skin tear development.[35]

ISTAP does NOT recommend dressings be used as preventative measures. Adhesives should be avoided on the skin whenever possible. The list is neither all-inclusive nor all-encompassing. Frequency of dressing changes will be based on local wound conditions. The ISTAP recognized that not all of the products discussed are available in all countries. Some dressing categories were excluded for differing reasons: the strong adhesive nature of hydrocolloid and films dressings, the drying effects of iodine-based dressings, the lack of availability in many countries of non-gauze forms of polyhexamethylene biguanide (PHMB) dressings and an increased risk of periwound maceration with the use of medical honey dressings.[35]

Special care should be taken with the pediatric population when selecting topical dressings.[102] Ideally, topical wound dressings used in the pediatric population should be able to maintain moisture balance, protect the wound from bacteria and be atraumatic to the wound bed and periwound skin. Non-interactive dressings such as soft silicone foams and wound contact layers are viable choices.[102]

For persons living homeless or experiencing homelessness, skin health and skin tears can occur in relation to nutrition, hygiene, trauma and poor footwear and sleeping conditions.[103]

Special Considerations for Skin Tears in the Pediatric Populations
• Ensure that all products used have been verified for use in the pediatric populations • Ensure that products do not pose a risk of causing systematic or tissue toxicity when used on immature skin • Ensure that all products are atraumatic on removal

Special Consideration for People with Skin Tears			
Antimicrobial Products	**Indications**	**Skin Tear Type**	**Considerations**
Methylene blue and gentian violet dressings Caution: While the methylene blue primary dressing may be non-traumatic, the secondary topper dressing may cause medical adhesive-related trauma Consider use of products with silicone border The primary dressing requires a moisture retentive topper, and the manufacturer recommends a film dressing	Effective broad-spectrum antimicrobial action, including on antibiotic-resistant organisms	1, 2, 3	• Non-traumatic to wound bed use when local or deep tissue infection is suspected or confirmed • Secondary dressing may be required
Ionic silver dressings	Effective broad-spectrum antimicrobial action including on antibiotic-resistant organisms	1, 2, 3	• Should not be used indefinitely • Contraindicated in patients with silver allergy • Use when local or deep infection is suspected or confirmed • Use non-adherent products whenever possible to minimize risk of further trauma
Note: This product list is not all-inclusive; there may be additional products applicable for the treatment of skin tears.			

Figure 2: This demonstrates the correct way to label a dressing and remove the dressing



Dressings should always be removed in the direction of the skin flap (the pedicle) and not against it, thus maintaining flap viability. Indicate on the dressing the classification, size and shape of the skin tear, as well as the direction for dressing removal. Follow the product monogram instructions for proper dressing removal.

Permission: Mölnlycke

Wound Dressing Resources

Wounds Canada Product Pickers are useful resources on appropriate dressings that can be be used for skin tears: https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/library/183-resources-industry-partner/288-product-picker.

Wound Dressing Formulary: https://www.woundscanada.ca/docman/public/health-care-professional/1113-product-picker-2017-formulary/file.

Change in Practice Related to Skin Closure Strips

Wounds closed by primary intention have been traditionally secured with sutures or staples. With skin tears, closure adhesive strips, sutures and staples are not a recommended option.[1,2,8,29,45] Consideration for the specific components of each medical wound adhesive should be considered, including risk of developing allergic contact dermatitis.[108]

In the pediatric population, Tsai et al. reported that topical skin glue was a faster and less painful method, with increased comfort and better scar management in facial lacerations in children (n=50 children).[109] Tandon et al. reviewed 31 studies of wound cosmesis and incidence of wound complications when comparing tissue adhesives and suturing. They reported no difference in cosmosis and risk of wound infection or dehiscence.[110]

Additionally, in a review study, the cosmetic results using cyanoacrylates to close skin tears have been shown to be superior or equivalent to sutures for type 1 skin tears in elderly patients.[111]

- A cyanoacrylate liquid can be used as a rapid and effective treatment for injury-related Type 1 skin tears on the arms, legs and faces of elderly patients.
- Skin tear wound edges annealed rapidly, thereby promoting faster skin tear closure and wound healing compared to skin closure strips alone.
- The use of a cyanoacrylate liquid skin protectant decreased the time and costs required for skin tear wound care and reduced the time for wound healing.

More research is needed to understand the role of tissue adhesives in Type 1 skin tears.

Advanced Dressing Considerations Specific for Skin Tears

Skin tears are generally acute wounds; however, in cases where the circumstances or co-morbidities delay wound healing, advanced therapies may be considered. A wound clinician should be consulted to work with the integrated health-care team, the organization and the patients and their care partners and families to ensure that the agreed-upon goals of care are established and that the treatment plan is in accordance with these goals.[1]

4.4 Engage the team to ensure consistent implementation of the plan of care

Discussion: Engagement of individuals in their own care occurs when they meaningfully and actively collaborate in the goal setting and management of their care. Skin tear prevention across all age groups and levels of care must include a plan for engaging individuals, families, caregivers, health-care professionals and organizations to ensure that best practices are implemented. All involved must collaborate to ensure that programs are successful and sustainable.

Wounds Canada Resources: Refer the patient to DIY Skin Health Series: Skin Tear
https://www.woundscanada.ca/patient-or-caregiver/resources/diy-series

Implementation of a skin tear prevention program should centre on self-management and ways health-care professionals can aid individuals in modifying behaviours where necessary (See Table 6). As one example of how health-care professionals can assist individuals to choose beneficial behaviours, consider the modifiable risk factor of xerosis. Studies have indicated skin tear incidence can be greatly reduced by twice daily application of moisturizers.[112] Therefore, individuals who are engaged or who can be motivated to modify their behaviours by applying a skin moisturizer twice daily may have a reduction of skin tears. To achieve this reduction, the individual at risk may need physical assistance or support in the form of regular reminders to apply the moisturizer. Family and care partners may also participate in prevention strategies.

Special Consideration: Control of Peripheral Edema

Lower leg edema is well documented to contribute to delayed wound healing, regardless of wound etiology.[107] When skin tears occur on the lower limb, the risk and cause of potential peripheral edema should be assessed.[1,37] It is important to control edema and equally important to rule out any significant degree of peripheral vascular disease. This should be done prior to the application of dressings or compression therapy for edema control and can be established through a clinical history and total leg assessment, including the use of Doppler ultrasound to determine the ankle brachial pressure index.[39]

For additional information on chronic leg edema/lymphedema see Chapter 13: Best Practice Recommendations for the Prevention and Management of Lymphedema.

Table 5: Engagement Strategies for Skin Tear Management[113]

Level	Skin Tear Management Strategies
Direct care	• Integration of individual's (including family and care partners) beliefs around skin health into the plan of care • Introduction of the individual, family and care partners and their health-care providers to strategies for screening, prediction, prevention, assessment and management of skin tears through education and training • Open dialogue between the individual, family/caregivers and health-care providers to discuss and implement plan of care • Provide education related to skin tears to patient, care partners and health-care providers
Organizational	• Integration of the health-care providers and the individual, family/caregivers into the design and governance of an overarching skin tear management program • Including individual, family and care partners in continuous quality improvement teams and strategies to maintain resources over time • Provide education on skin tear prevention and management to health care providers • Partner with stakeholders and researchers to develop quality improvement measures and outcomes
Policy Making	• Engagement focused on developing, implementing and evaluating skin tear management programs • Partnerships between individual, family and care partners, health-care providers and organization to set priorities and make policies required to support skin tear management program • Partner with stakeholders and policy makers to develop policy to support prevention, assessment, treatment and measurement of quality outcomes

Step 5: Evaluate Outcomes

5.1 Determine if the outcomes have met the goals of care

Discussion: Literature supports primary prevention as the best skin tear management strategy.[42,114,115] By controlling modifiable risk factors, skin health can be maintained and injury avoided. If skin tears occur they are traditionally categorized as acute wounds as they are reported to be traumatic wounds and are, therefore, expected to heal in a timely trajectory (7 to 21 days). Yet many reports indicate that skin tears fail to meet the expected wound healing milestones. Skin tears that do not follow an expected healing trajectory may evolve into complex wounds without appropriate care.[17,35,36,52] It is hypothesized that this transition to slow or non-healing status is related to the co-morbidities and complications often associated with the frail elderly, the very young and those who are critically or chronically ill, all of whom are deemed to be at greater risk for skin tear development in the first place.[39]

Skin tears can be further defined as 'uncomplicated' or 'complicated.' An uncomplicated skin tear is a wound that will go on to heal within four weeks. A complicated skin tear is more complex, particularly if it is on on the lower

extremities and/or on a patient with multiple comorbidities.[1] Skin tears can turn into complex or complicated wounds in cases of total flap loss[1], or when not immediately assessed and cared for.[4,116]

Some considerations:

- Monitor wound edge/closure:
  - Skin tears typically proceed to closure within 7–21 days. Re-evaluate if a tear has not closed within this time frame
  - Monitor and address factors that delay wound healing, e.g., diabetes, peripheral edema or nutritional issues
  - Consider compression therapy if the wound is on the lower leg. Perform a full vascular assessment, e.g., ankle brachial pressure index, before applying compression.[1,52]

5.2 Reassess patient, wound, environment and system if goals are partially met or unmet

Discussion: If skin tears do not close in a timely fashion (7–21 days), barriers to wound healing should be assessed. The individual should be assessed for possible repeated trauma to the area and co-morbidities that might be delaying wound healing.[2] The local wound environment, the physical environment and the supports from the organization should be reassessed to ensure that best practice is being followed and all modifiable factors are controlled. If any goals are not met, the barriers should be readdressed and modified if applicable. If necessary, new, more realistic goals should be set.

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Discussion: As with any other wound-related program, implementation and sustainability of a successful skin tear program requires implementation support at both the organizational and clinical level.[117]

The association between skin tear prevalence and rising wound care costs, coupled with governments' political agendas emphasizing primary prevention, provides governments with the incentive to promote population-based skin health.[21] Skin tear prevalence and incidence should be monitored and tracked to allow for benchmarking and program evaluation.[1,45]

The Registered Nurses' Association of Ontario (RNAO) developed a toolkit for implementation of best practice guidelines.[117] While these guidelines were developed for the implementation of guidelines on a more global level, the principles can be distilled to be applicable to the individual as well as an organization (See Table 7). The RNAO guidelines are based on the 'knowledge to action' framework.[118]

Table 6: Implementation and Sustainability of a Skin Tear Management Plan[1,20]

Steps of the knowledge-to-Action Model	Specific Content	Application Specific to Skin Tears
Identify the problem	Identify gaps in practice Use quality indicators to determine the extent of the problem	Identify the knowledge, attitude and practice around skin tear prediction, prevention, assessment and management
Adapt knowledge to local content	Develop an infrastructure for implementing best practices Critically appraise and adapt best practice to the culture	Identify available resources and attitudes surrounding skin tears Adapt knowledge to the environment (long-term care, community, various age groups)
Involve stakeholders	Ensure stakeholder identification, analysis and engagement to lead the implementation process.	As skin tears occur across the age continuum and across health-care settings, multiple stakeholders may be involved
Identify resources	Identify resources (physical and knowledge-based), including available best practices	Valuable resources for skin tear prevention include positive attitudes and practices by individuals, family/caregivers and health-care providers

cont'd. . . .

Assess facilitators and barriers to implementation	Address or manage potential barriers and maximize facilitators (See section 4.2)	A major barrier to skin tear management is the knowledge, attitudes and practices of individuals, family/caregivers and health-care providers (See section 4.2 for strategies)
Tailor implementation strategies to the individual	Assess education needs based on audits and stakeholder feedback Design implementation strategies to meet the identified needs and to align with organizational policies and needs	Adapt skin tear management plan to the setting and age group
Monitor knowledge use and outcomes	Implement ongoing quality improvement processes, indicator monitoring and ongoing data collection and review. Some considerations: • the use of e-health and electronic health records in this process • indicator identification worksheet • structure, process and outcome, evaluation relevant to initial problem and reducing the gaps • evaluation models, logic model	Ensure consistent documentation of skin tears using a validated classification system Conduct ongoing prevalence and incidence studies to benchmark burden of skin tears and success of management programs
Sustain knowledge and implementation	Embed an evidence-informed practice culture through orientation, position descriptions, performance appraisal and mission, vision and values Leverage key organizational structures in ensuring such a culture is adopted throughout the organization at every level	Engage all levels of stakeholders (individual, family/care partners, health-care providers and organization) in ongoing knowledge production and dissemination and implementation of best practices

Conclusion

There is every reason to believe that well-crafted interventions can be highly effective in improving skin health. Skin tears are preventable acute wounds with a high propensity in certain individuals to develop into chronic wounds and impose health burdens on individuals and care agencies. Although often under-reported, skin tears are hypothesized to be highly prevalent and particularly troublesome for the elderly population. Individuals with skin tears often complain of increased pain that, in addition to biopsychosocial factors associated with wounds such as physical disability, social needs and mental anguish, may negatively impact quality-of-life.

Neonatal and pediatric populations can also be affected by skin tears, but the healing process is usually fast if their health condition is stable. Skin growth rates in infants are higher than in adults. The skin of infants is characterized by a greater ability to restore itself as a barrier.[119] It is important to note that skin tears are a source of pain and anxiety for these patients and can create great distress in parents seeing their newborn's skin disrupted.

Prevention of skin tears in all age groups is considered the key to management, so the focus should be on controlling modifiable risk factors so skin health can be maintained and injury avoided.

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Appendix: Skin Tears and Falls

The Registered Nurses' Association of Ontario (RNAO) has published Best Practice Guidelines for Preventing Falls and Reducing Injury from Falls (2017) that may be of value to the clinician. Available at https://rnao.ca/bpg/guidelines/prevention-falls-and-fall-injuries

Clinicians are encouraged to review fall-prevention programs and implement the prevention strategies that are best suited to the individual. Examples of several fall prevention program websites include:

- Registered Nurses' Association of Ontario. (RNAO). Long-term Care Best Practices Toolkit (2nd ed.). Falls Prevention and Management. (Tools and Resources available for download and use by clinicians, patients and families). 2023. Available at: https://ltctoolkit.rnao.ca/clinical-topics/falls-prevention
- Sinai Health. Healthy Aging and Geriatrics. Preventing Falls at Home: What are the dangers of falls. (Patient resources). 2023. Available at: https://sinaigeriatrics.ca/patient-resources/preventing-falls-at-home/
- Centers for Disease Control and Prevention. Clinical resources: STEDI – Stopping Elderly Accidents, Death and Injuries. 2019. Available at: https://www.cdc.gov/steadi/index.html



Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 7

Prevention and Management of Pressure Injuries

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INTRODUCTION

The prevention of pressure injuries (PI) continues to be a concern in Canadian health-care systems. In a 2004 study funded by the then Canadian Association of Wound Care (now Wounds Canada), the overall prevalence of pressure ulcers (PU) across all health-care settings was 26%, with approximately 70% of these wounds considered preventable.[1] According to published literature, clinical practice and expert opinion, nearly all pressure injuries can be prevented.[2] Prevention, based on best practices and use of appropriate equipment and education for interprofessional health-care teams, is of paramount importance and must be the focus of care for all patients, families, care partners and relevant departments across all care settings. RNAO emphasizes "It is good practice for organizations to implement an interprofessional approach for the assessment, prevention and treatment of pressure injuries. This approach includes shared decision making with persons at risk of or living with pressureinjuries and their essential caregivers."[16]

Despite the focus on prevention to date, pressure injury incidence rates have not significantly decreased in Canada[3] when compared with other countries around the world, including the U.S.[4] An integrated approach focused on prevention is required to make a significant difference in incidence rates. For optimal effectiveness, teams need to be interprofessional and integrated to include the person at risk of, or with a, pressure injury (as the first team member), along with their families, care partners and relevant and relevant departments such as purchasing and housekeeping (in the institutional setting).

Pressure injuries affect quality of life, increase mortality and death, are expensive, can take months to heal and not all PIs close.[5] The equipment and interventions required to prevent pressure injuries are less expensive than the cost of treatment.[6,7] The number of pressure injuries in a setting can be multiplied by the appropriate monthly cost per stage to determine the total cost of treatment per month in a setting. Explicitly identifying this cost may help with the advocacy for pressure injury prevention programs and equipment.

In one study in Ontario, the cost of treatment for individuals over 65 who were admitted to hospital with a pressure injury was compared with individuals over 65 who acquired a pressure injury while in the hospital.[8]

- Costs to treat pressure injuries that were present prior to admission ranged from CA $11,000 for a Category/Stage 3 pressure injury to CA $18,500 for a Category/Stage 4 pressure injury.[8]
- Hospital-acquired pressure injury treatment costs ranged from CA $44,000 for Category/Stage 2 to $90,000 for Category/Stage 4.

Researchers studied, "1351 cases of hospital-acquired PUs, and 2523 cases of pre-admission PUs over five years.

- Net cost of hospital-acquired PU ranged between CA$44,000 for a category 2 PU to CA$90,000 for a category 4 PU.
- For pre-admission PU net cost was between CA$11,000 to CA$18,500 for category II and category IV PU, respectively. The net cost of treating hospital-acquired PU is higher than pre-admission PU. Costs increase with increasing PU severity.

In conclusion, the total net adjusted hospitalization cost of a hospital-acquired PU in Ontario was CA$44,000–90,000, compared with CA$11,000–18,500 for a pre-admission PU. Future studies should determine the attributable cost of PU using patient-level data to verify the accuracy of the study results."[8]

Although pressure injury prevention has received increased attention in recent years, Vanderwee et al. found that, "Only 10.8% of the patients at risk received fully adequate prevention in bed and while sitting."[9] At the same time, "More than 70% of the patients not at risk received (some) pressure ulcer prevention while lying or sitting."[9] Overall, the authors suggest, "The biggest improvement can be gained in prevention interventions while sitting (chairs and in bed) and the prevention specific for heels."[9] This study points to the importance of assessing individual patients to ensure pressure management resources are used appropriately to prevent pressure injuries.

"Pressure Ulcer" or "Pressure Injury"?
In May 2016, the National Pressure Ulcer Advisory Panel updated the term pressure ulcer to pressure injury. This update was done to clarify that both Category/Stage 1 and Deep Pressure Injuries refer to intact skin.[10,11] The definitions of the categories of pressure injuries were changed slightly by the revision.[11] In this chapter, the term pressure injury is considered synonymous with pressure ulcer and is used throughout except when directly quoting previously published literature.[12]

This document is written with the intent to encompass the quintuple aim for health-care improvement. This is to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity (See Table 1). This equity piece is particularly important for patients living with skin issues, wounds and, specifically, at risk or having developed a pressure injury. Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[13]

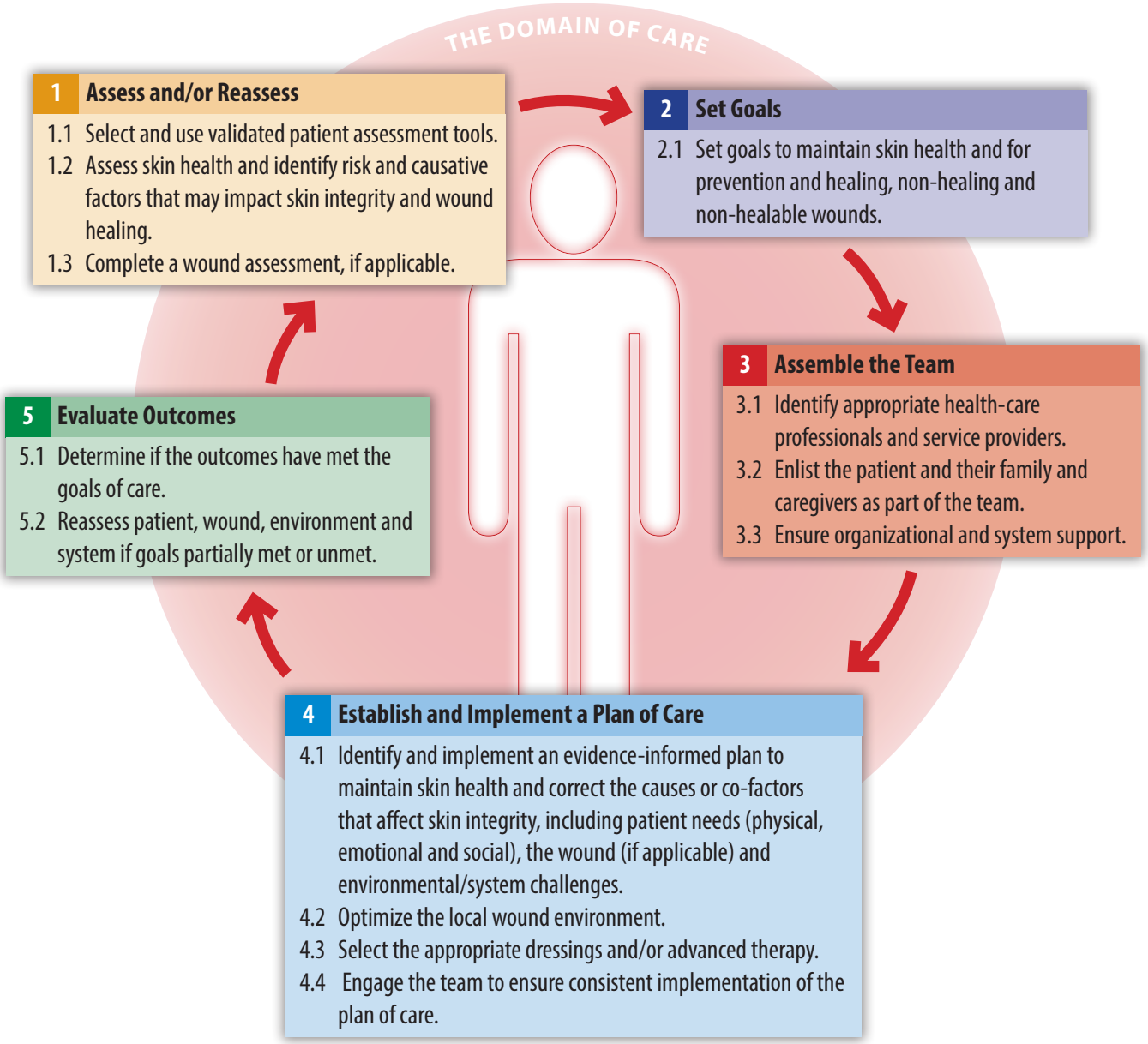
Table 1: Quintuple Aim and Management of Pressure Injury

5 components	Applied to Pressure Injury
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practices to ensure most effective treatment. Appropriate use of resources-examples: products, dressings, pressure redistribution surfaces, devices
Advancing health equity	Application of principles to all those at risk (those with darker skin tones) or affected by pressure injuries
Care team wellbeing	Providing clinically usable information for front line clinicians
Enhancing the patient experience	Providing a supportive process of care for all those with pressure injury issues

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide, called the Wound Prevention and Management Cycle (See Figure 1) as outlined in Chapter 3,[14] that guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of wounds from the initial assessment to a sustainable plan targeting self-management for the patient.

Figure 1: The Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence and are intended to support the clinician, the patient, care partners, their family, the health-care team and decision makers in planning and delivering the best clinical practice. Two foundational chapters supplement this chapter with additional evidence-informed information and recommendations that are general to all wound types: Chapter 3: Skin: Anatomy, Physiology and Wound Healing[14] and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]
There are three guiding principles within all the Best Practice Recommendation (BPR) chapters that support effective prevention and management of skin breakdown:

1. the use of the Wound Prevention and Management Cycle regardless of the specifics to prevent and manage skin breakdown,
2. the constant, accurate and multidirectional flow of information within the team and across care settings, and
3. the patient as the core of all decision making.

Key reference documents include:

- Registered Nurses' Association of Ontario. Pressure Injury Management: Risk Assessment, Prevention and Treatment. Fourth edition. 2024.
- National Pressure Ulcer Advisory Panel/European Association of Pressure Ulcer Panel Pressure Ulcer Prevention Guidelines, 2019.
- National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treatment of Pressure Ulcers: Quick Reference Guide. Emily Haesler (Ed.). Cambridge Media: Osborne Park, Australia; 2019.
- Wound Ostomy and Continence Nurses Society Guidelines for the Prevention and Management of Pressure Ulcers; 2017. Association for the Advancement of Wound Care Pressure Ulcer Guideline; 2017.
- AORN (Association of Peri-operative Registered Nurses Association). Guideline for positioning the patient. In: Guidelines for Perioperative Practice. Denver, CO: AORN, Inc; 2022:705-780.

Step 1: Assess and/or Reassess

Recommendations
1.1 Select and use validated patient screening and assessment tools (Special populations are discussed below)

Discussion: Expert opinion clearly supports the use of validated pressure injury risk assessment tools (e.g., Norton, Braden, Braden Q for pediatric assessment, Waterlow, Gosnell), but controversy exists over which tool is best suited to a particular care setting. In any case, expert opinion recommends the systematic use of a specific validated tool and the development of care plans based on the subscale scores that identify factors that put the person risk for PU development.[16] Wounds Canada has additional best practice resources that provide links to tools that can be used to assess the risk of skin breakdown: https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/28-publications/wound-care-canada/200-library-2.

To support Indigenous communities, Wounds Canada has developed Pressure Injuries: A guide for Alberta with a focus on Indigenous health. Available at: https://www.woundscanada.ca/doclink/bpr-brief-pressure-injuries/eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9.eyJzdWIiOiJicHltYnJpZWYtcHJlc3N1cmUtaW5qdXJpZXMiLCJpYXQiOjE2ODcyMDM4NzEsImV4cCI6MTY4NzI5MDI3MX0.mI_GfJt8uVhZl0b7HhjOHaS91fCQ4tDzuppbltBypSs

As well as the extrinsic risk factors that are addressed by the risk assessment tools, clinical judgment is required to assess for intrinsic risk factors that include the physical, psychosocial and medical conditions.[2] Factors such as neurological disease, advanced age, hydration status, lifestyle, peripheral vascular disease and level of consciousness must also be taken into account.[17] It is important to note that screening tools and visual inspection are critical to prevention due to the under identification of pressure injuries in people with darkly pigmented skin. See the Support surface selection tool for a list of these tools: https://www.woundscanada.ca/dhfy-doc-man/public/2950-wc-product-picker-surfaces-fillable/file.

Assessment Tools: The use of a comprehensive, structured and validated wound assessment tool assists the health-care professional (HCP) to identify the potential etiology of areas of impaired skin integrity, including the ability to determine the depth of trauma by staging pressure injuries.[16,18,79,80] In addition, RNAO states that skin assessment, a visual assessment, looking for redness or skin changes is not sufficient. Using other tools as an adjunct is recommended. This will mean an additional cost for health care systems/facilities, so clinicians need to be equipment to advocate for these devices with a clear rationale). For example, RNAO recommends "...nurses and health providers use thermography as an adjunct to skin assessment for early detection of pressure injuries. Furthermore, RNAO has a conditional recommendation that "...nurses and health providers use subepidermalmoisture detection as an adjunct to skin assessment for early detection of pressure injuries."[16]

Caution should be utilized when selecting a wound assessment tool to ensure that the tool has been validated to be responsive and show changes in the wound status over time. Although there are several wound assessment tools available, none of the tools reviewed by Pillen et al. (2009) were found to be valid in all required criteria (validity, reliability and sensitivity).[19] The Pressure Ulcer Scale for Healing (PUSH) and the revised Photographic Wound Assessment Tool (PWAT) showed strong scores for responsiveness. The revised PWAT is a valid and reliable tool to assess chronic wounds of various etiologies using digital images.[20]

Wounds Canada, Additional Best Practice Resources provides links to Wound Assessment Tools.

Wounds Canada. Wound Healing Phases. Available at:
https://www.woundscanada.ca/health-care-professional/indigenous-health/alberta

Wounds Canada. Wound Types Poster. Available at:
https://www.woundscanada.ca/health-care-professional/indigenous-health/alberta

Although the Pressure Sore Status Tool (PSST) and the BWAT both provide a comprehensive description of wound parameters with good reliability they have not been shown to be sensitive to change. The BWAT demonstrated excellent reliability when used by nurses with special training in wound assessment and has undergone some testing that demonstrated the total BWAT score may be useful in predicting outcomes, although more research is required to determine its predictive validity.[21] If available, serial photography using a standardized technique and/or reliable validated electronic data collection devices can also provide valuable information to assist with wound assessment, although more research is needed.[22]

Stage or Category?
Europeon Pressure Ulcer Advisory Panel (EPUAP) classifies pressure injuries in categories, while the National Pressure Injury Panel (NPIAP) classifies pressure injuries in stages. **It is important to note that whether it be stage or category this classification indicates depth of initial trauma not progression of healing.** It is important that clinicians are not using a system that back stages. The RNAO states "It is good practice for health providers to classify a pressure injury using a validated classification system. This classification system should not be used for monitoring pressure injury healing."[16]

Other validated assessment tools may be required based on patient need. No matter what assessment tool or scale is chosen, the same measurement should be used for subsequent assessments for ongoing comparison. See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

Nutritional screening tools such as the Mini-Nutritional Assessment – Short Form and the Malnutrition Universal Screening Tool or the Malnutrition Screening Tool can be used to assess compromised patients.[23,24] See Appendix 1: Nutrition for Skin Health, Wound Prevention and Wound Healing in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

- Pain scales provide a systematic approach to assess and address the factors that are causing or exacerbating pain.[25] There is no one pain scale deemed universal and useful for all individuals; the selection of a specific pain scale must take into account the person's age, language, educational level, sensory impairment, developmental stage and cognitive status.[16] It also must take into account clinician education.[26]
- Quality-of-life assessment: Maintaining a patient's quality of life is important as it can affect skin health and wound

healing. Use of a validated quality of life (QoL) assessment tool may be beneficial to direct appropriate interventions, monitor effectiveness and to identify barriers to healing and potential options for improvement.[15] For more information on quality-of-life assessment tools please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.

1.2 Identify risk and causative factors that may impact skin integrity and wound healing

Discussion: Assessment is the foundation for providing the most appropriate and timely interventions to prevent wounds and improve the healing potential of existing wounds. Early screening and assessment and collaborating with the patient and family are necessary to identify the risk for pressure injury development and factors that may affect wound healing, enabling the prompt development and implementation of a care plan with appropriate resources and interventions according to the risk factors identified.

The International Pressure Injury Guideline[2] recommends that screening for the risk of pressure injury development occur when a person first enters into any health-care setting and that assessment be repeated according to the level of risks identified, the person's level of acuity and with any changes in their condition (medication use, pain, altered awareness and sensation).[27, 28] For example, in Long Term Care it has been recommended that risk assessment occur whe the client is admitted, weekly for the first 4 weeks and then quarterly. This schedule is recommended as the client's condition often changes within the first 4 weeks of admission to a LTC home, necessitating the increased fequency of assessment.

Reassessment of both risk screening and wound assessment is recommended to evaluate the effectiveness of interventions and identify alterations to the treatment plan that may be beneficial.[2]

1.2.1 Patient: Physical, emotional and lifestyle

Discussion: Clinicians must complete a comprehensive patient history to determine general health status, comorbidities and risk factors that may lead to pressure injury formation or that may affect the healing of existing wounds.[2] To facilitate consistent implementation of strategies for pressure injuries, patient levels of risk and additional risk factors must be communicated with all team members. Strategies to communicate risk include but are not limited to unit huddles/rounds, patient safety boards, identifying patients with an armband, email alerts and having regular check-ins with the patient and family. In community this may include client communication journals. It is important to remember that communication needs to needs to occur in a culturally safe and inclusive manner. RNAO states "It is good practice for organizations and health providers to communicate and collaborate in a culturally safe and inclusive manner with persons and their essential caregivers in the assessment, prevention and treatment of pressure injuries." This is particularly important given the higher rates of severe PI in people with darkly pigmented skin-- and that we are unable to detect pressure injuries through "skin redness" as we have traditionally recommended."[16]

Pressure, Shear and Friction[29, 30]

- **Pressure** is defined as, the force per unit area exerted perpendicular to the plane of interest.
- **Shear** is a general term that encompasses both shear strain and shear stress.
- **Shear strain** is the distortion or deformation of tissue as a result of shear stress.
- **Shear stress** is the force per unit area exerted parallel to the perpendicular plane of interest.
- **Friction:** From a clinical perspective, friction tends to hold the skin in place, enabling the shearing of the bony prominence against the inside of the skin. Although friction doesn't cause pressure injuries, it is clinically important because the friction holds the skin in place, allowing shear to occur.[31,32]

Physical Assessment

Pressure and shear: Clinicians must assess potential sources of pressure and shear by evaluating the patient's posture, activities, mobility, lifestyle, current pressure redistribution surfaces such as sleeping and sitting surfaces and underlying medical conditions (e.g., spinal cord injury).[29,30,33]

Pressure or pressure in combination with shear are recognized as the main factors in the development of PI, with pressure three to five times higher internally near a bony prominence. Although at one time it was thought that individuals could tolerate higher pressure for short periods of time, this curve has been blunted, and the goal now is to redistribute pressure to reduce peak areas of pressure.[2]

Figure 2 demonstrates how pressure alone also contributes to shear strain in the tissue as the tissue deforms around the shape of the bony prominence. Also ideally the blood vessels should curve and move around the bone, be thinner as they reach the bottom of the bony prominence and thicker further away from the bony prominence. For shear see Figure 3: Shear.

Figure 2: Tissue Distortion Due to Pressure

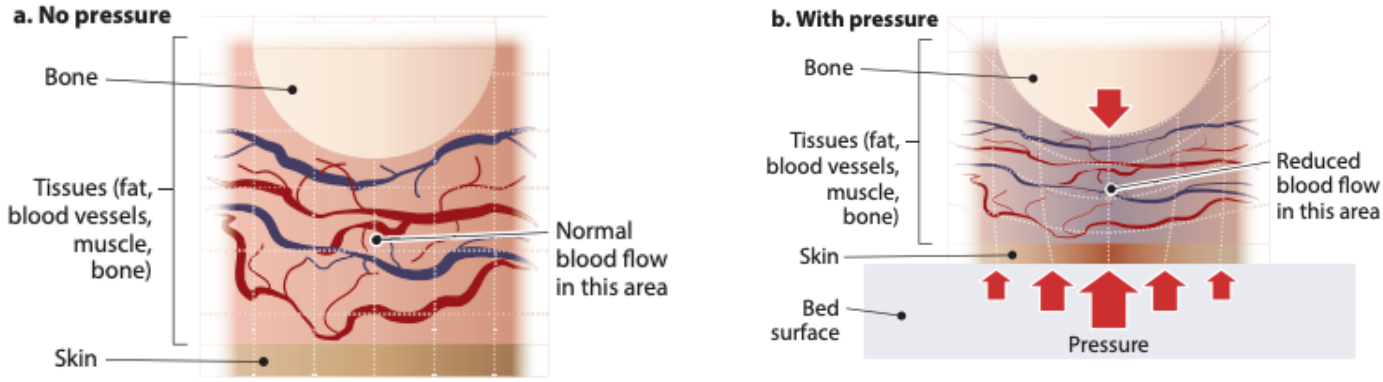
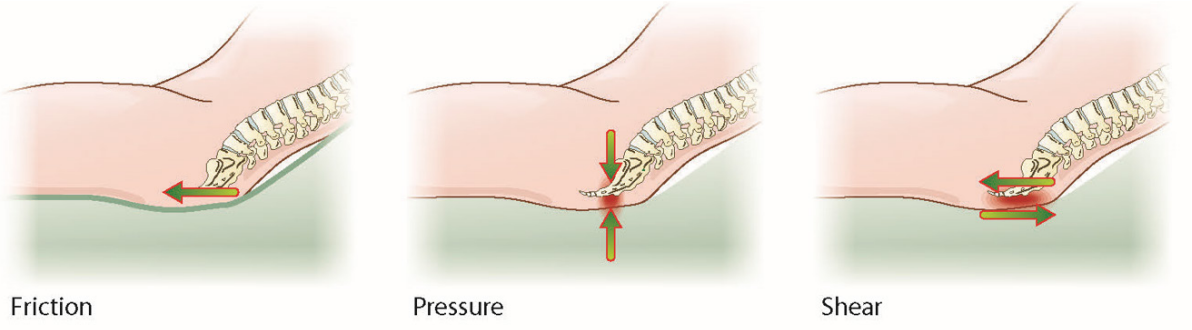


Figure 3: Shear



The role of shear force is equally as important to understand. Shear can be described as the deformation of tissue by two oppositely directed parallel forces, such as what happens with patients slipping down in bed.[31] "The addition of shear forces doubles the impact of pressure."[29] Asymmetrical wound undermining is an indication that shear forces are occuring. The direction of this undermining occurs along the track of movement of the bony prominence during the activity where the shearing is occuring. For example, if there is asymmetrical undermining of a wound over the ischial tuberosity, and the undermining is in a head-to-toe direction, this is likely caused by rocking (the ischial tuberosity moves back and forth) or the patient sliding down in bed or forward in the wheelchair. Knowing the direction of the undermining and the relationship to shear can help the clinician identify the movements and activities where the shear is occurring and develop strategies to minimize shear during these activities.

An assessment to determine the forces occurring on all sleeping and sitting surfaces and during all transitions (e.g., transfers, sitting up in bed), as well as the condition of the surfaces will help identify the priority areas for intervention.[2]

Friction injuries are often misdiagnosed as pressure injuries. An analysis of the literature by Brienza identified that friction contributes to shear strain in deeper tissues, which is identified as a factor in the development of a pressure injury.[32] Clinically this is important because reducing friction may help to reduce shear, as friction holds the skin against the surface allowing the bony structures to slide against the inside of the skin. Tissue damage from friction is related to excessive cell deformation and not ischemic pressure injury in the superficial layers of the skin. Therefore, friction alone is not a direct cause of a pressure injury. Friction is identified as a "risk factor that may contribute to, or exacerbate,

pressure injury development due to the shear it creates."[32] Thus shear has been identified as a "primary causative factor" contributing to pressure injury development, and friction has been eliminated from the current NPIAP definition of pressure injury.[2]

Nutrition screening

Lack of optimal nutrition and hydration may interfere with skin integrity for individuals with elevated pressure injury risk and treatment effectiveness for individuals with pressure injuries (See Table 2).[34,35] For example, placing a patient on a low air-loss mattress may lead to an increase in fluid loss. In addition to using validated nutritional screening tools it is important to review blood work for signs of compromised nutritional status. See Appendix 1: Nutrition for Skin Health, Wound Prevention and Wound Healing in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15] A comprehensive assessment utilized to screen participants with Category/Stage 2, 3 and 4 pressure ulcers in a randomized controlled trial by Houghton et al. identified a decreased healing potential when the number of abnormal blood values increased and a higher rate of non-healing over a six-month period for those with two or more abnormal blood values (even mildly abnormal).[34,36] This study highlighted the value of blood analysis as an effective tool to assist in the identification of nutrition-related barriers that negatively impact pressure injury healing.[36]

Recent research focuses on identification of biomarkers such as hemablogin, albumin, C-reactive protein, pressure injury risk score, age and gender as factors to consider when predicting pressure injury formation.[37] Determining the level of hemoglobin and conducting vascular studies in relevant cases can be beneficial. The presence of low hemoglobin and the presence of more than one wound can be risk factors for delayed wound healing.[38] Having two or more low hematological values is also thought to be indicative of delayed wound healing.[36]

Table 2: Blood Screening Tests to Consider for Nutritional Barriers to Wound Healing

Suggested blood screen to identify nutrition-related barriers to pressure injury healing	Screening for	Normal Values
Complete blood count (CBC)	Hemoglobin (g/L)	123 – 174
Iron status screening: ferritin, serum iron, % saturation, TIBC (total iron building capacity): assess for iron deficiency anemia	Ferritin (ug/L) Serum iron:Fe (µmol) Sat % TIBC (µmol)	41 – 300 11 – 32 0.20 – 0.65 45 – 82
CRP, ESR: (inflammation/ infection – anemia of chronic disease)	CRP (mg/L) ESR (mm/hour)	< 0.8 < 6 ≤ 10
Prealbumin/albumin: severity of illness/injury and risk malnutrition	Prealbumin (mg/L)	180 – 450
BUN, creatinine: assess for dehydration and kidney function	BUN (mmol/L) Creatinine (µmol)	2.5 – 8.0 mmol/L 50 – 100 micromoles/L
Fasting blood glucose (FBG) and glycosylated hemoglobin (HgbA1c): assess for hyperglycemia/ diabetes	FGB (mmol/L) HgbA1C	3.3 – 5.8 4 – 6 %
Thyroid function: assess for hypothyroidism	TSH (mU/L)	0.4 – 5.00

Moisture-Associated Skin Damage (MASD) is a broad term that encompasses several types of skin damage. For more on MASD, please see Chapter 5: Prevention and Management of Moisture-associated Skin Damage.[39] MASD and pressure injuries may co-exist, so a thorough assessment is essential to differentiate the etiology of a pressure injury, MASD lesions, incontinence-associated dermatitis (IAD) and other skin conditions. It is important to know the link between MASD (compromised skin) and risk of developing a pressure injury.[40]

In 2015 the Global Expert IAD Panel used the following descriptor to differentiate IAD from pressure injuries: "IAD is a 'top down' injury, i.e., damage is initiated on the surface of the skin, while pressure ulcers are believed to be 'bottom up' injuries, where damage is initiated by changes within soft tissue."[40,42] It is important that clinicians recognize that incontinence is likely a confounding factor in populations characterized by immobility and poor skin status. It is also likely that, as well as moisture, there is a skin irritant component to many of the factors where moisture is present and the presence of moisture may impact both the mechanical boundary condition (type of load) and the susceptibility and tolerance of the skin (mechanical properties of the tissues). The coefficient of friction is shown to be greater over moist skin.[43]

Skin assessment relies on clinical observation and visual inspection as described in the Table 3.

Table 3: Differential Diagnosis of Pressure Injury and IAD[41]

	Pressure Injuries (Category /Stage1)	Pressure Injuries (Category /Stage 2)	Incontinence-Associated Dermatitis
Location	Over bony prominence or sites exposed to external pressure and shear, or associated with a medical device	Over bony prominence or sites exposed to external pressure and shear, or associated with a medical device	May be localized to the perineum, perigenital areas or generalized to include buttocks; gluteal fold; medial and posterior aspects of upper thighs; lower back; may extend over bony prominence
History	Exposure to pressure, shear, immobility	Exposure to pressure, shear, immobility	Urinary and/or fecal incontinence
Pain (for those with intact sensation)	Burning, itching, warmth	Burning, pain	Burning, itching, tingling, pain
Odour	None	Unlikely	Fecal and/or urine
Characteristics	Localized heat, edema and change in tissue consistency in relation to surrounding tissue (e.g., induration/ hardness) have all been identified as warning signs for pressure injury development.	Shallow open area with distinct edges or margins	Area is diffuse with poorly defined edges with superficial, partial-thickness skin loss or may be intact skin with blanchable or non-blanchable, blotchy erythema Note: This may not be visible in people with darkly pigmented skin.
Periwound skin	Intact	Intact	Irritated, red

	Pressure Injuries (Category /Stage1)	Pressure Injuries (Category /Stage 2)	Incontinence-Associated Dermatitis
Infection	Rare	Rare, although secondary soft tissue infection may be present	Secondary superficial skin infection such as candidiasis may be present
Improvement	Pressure redistribution	Pressure redistribution	Control/containment of incontinence, effective skin protection

Surgical considerations: If surgery is being considered for closure of a pressure injury, a pre-operative interprofessional/multidisciplinary assessment should be conducted, including management of underlying medical conditions, optimizing nutritional and hydration status, smoking cessation, bowel regulation, management of spasticity/contractures and presence of and/or management of infection.[44] The patient's ability and readiness to participate and/or ability to adhere to the post-operative medical requirements and rehabilitation processes must be assessed before surgery is offered. These include, but are not limited to, post-operative protocols for pressure redistribution and progressive seating, as well as readiness for tertiary prevention of pressure injuries. It is important to recognize that any surgical intervention or lengthy procedure increase the risk for PI development in persons at risk for PI.

Emotional Assessment

Prevention assessment needs to identify if the patient has multiple complicating factor such as achieving a balance between the need for pressure redistribution, social-mental wellbeing, physical and psychological needs (e.g., sleep, travel, participating in activities of daily living or meaningful activity such as employment, caregiving or childcare responsibilities).

Pressure injuries negatively affect quality of life (QOL).[45] Effects on QOL differ between partial-thickness and full-thickness tissue injuries.[46] A psychological and QOL assessment should be conducted to assess the impact of the pressure injury on the QOL for the patient and their family/care partners. This assessment will assist in determining their goals, along with their ability and determination to participate in the plan of care.[47] If a pressure injury is deemed healable, commitment of the person with a pressure injury and care partners is crucial in achieving successful outcomes in a timely, resource-efficient manner. As with all parameters of a complete assessment it will ultimately guide the plan of care.

Lifestyle: The importance of the lifestyle choices the person with a pressure injury makes regarding pressure injury prevention and management practices cannot be overstated. Clark et al. summarized the impact of lifestyle choices on pressure ulcer risk: "Every person sculpts a unique existence that reflects an interconnected network of psychological traits, goals, values, preferred activities, environmental opportunities and challenges, habits, routines and personal health practices. Embedded in the context of his or her daily activities and concerns, each individual has a distinctive pattern of pressure ulcer risk."[48]

Lifestyle factors, beyond just smoking history and alcohol or drug use, should be considered when identifying risk for the development of pressure injuries, and when assessing an individual with a pressure injury. An assessment of daily activities, life goals, habits and routines, in addition to the devices and care available, is required to identify the person's pattern of pressure injury risk. This assessment must be done in partnership with the patient and be redone regularly and include decision support systems, where available.[49] A thorough assessment enables the health-care provider to work with the person at risk for or with the pressure injury to identify realistic ways to reduce their risks and implement an achievable and relevant care plan.

General risk factors for the development of a pressure injury may include:[16]

Extrinsic (External) Risk Factors
- Poor hygiene
- Unhealthy living conditions
- Medications (polypharmacy, sedatives)
- Pressure, inability to modify risk factors
- Friction
- Shear
- Use of devices or equipment that press on the body such as some sporting equipment (e.g., sledge hockey and skiing equipment etc)
- Clothing/garments (including footwear) or the ability to acquire
- Presence of moisture
- Transfer type/quality
- Restraint use
- Pressure redistribution surfaces

Intrinsic (Internal) Risk Factors
- Nutritional status (malnutrition and dehydration) anaemia
- Reduced mobility/immobility
- Muscle spasms
- Posture, contractures
- Sensorimotor impairment
- Incontinence (urinary and or fecal)
- Extremes of age
- Level of consciousness
- History of previous pressure damage
- Vascular disease
- Severe, chronic or end-of-life illness
- Pain
- Hypoxia

Risk Assessment for Special Populations

Assessment of individuals with specific risks requires that the clinician be aware of and assess for specific factors that may increase risk for skin breakdown or affect healing of pressure injuries.[2] Screening for risk and assessment of a pressure injury should occur across all care settings. This includes wound care clinics, urgent care, emergency departments, geriatric and rehabilitation units, home-based and community care, convalescence and rehabilitation settings.[2]

The negative impact of not screening for risk can be significant. For example, in emergency care settings, a lack of screening of patients for PI is attributed to increased length of stay and cost of treatment.[50] More research is needed to understand PI prevention in this setting.

Risk for the individual with a spinal cord injury: Due to the lifelong risk of developing a pressure injury, individuals with a spinal cord injury require frequent expert assessment and intervention from an interdisciplinary and integrated team to prevent and manage pressure injuries. This includes providing education on, and engaging the patient in, self-monitoring activities to support prevention of pressure injuries.[51, 52]

Jackson et al. have identified multiple factors that influence the development of pressure injuries in people with spinal cord injuries.[53] These factors include:

- Perpetual danger: the risk of a pressure injury is always present, and a single incident of inattention can cause a pressure injury
- Change/disruption of routine: when a well-established routine is disrupted, such as a change in care partners
- Decay of prevention behaviours: over time, prevention behaviours tend to deteriorate and, for example, the individual may not shift their weight as often
- Lifestyle risk ratio: the unique set of risks and mediating factors for the individual, such as frailty, poor nutrition, inadequate finances, versus lack of a stable support system
- Individualization: the pressure management plan needs to be tailored to the individual's lifestyle and context
- Simultaneous presence of awareness and motivation: the individual must be aware of how to prevent the pressure injury and have the motivation to implement the prevention strategies
- Lifestyle trade-off: individuals may have a desire to participate in meaningful activities and choose these activities over pressure injury prevention
- Access to needed care, services and supports: the equipment, services and resources required for pressure injury prevention may not be available or available in time.

Risk for the elderly and vulnerable: Advanced age has been identified as a predictor of pressure-related injuries due to the gradual decline of general nutritional and mental status, decreased mobility, sensory perception deficits, incontinence and the changing characteristics of the skin, such as decreased elasticity.[54]
In persons living in long-term care homes with non-blanchable erythema, darker skin tones, pressure injury risk is increased for those with hypotension, contractures or a history of cerebral vascular accident; while those with urinary incontinence have a decreased risk of developing a pressure injury, perhaps in relation to the increased movement and positioning while care is being provided.[55] Being aware of the increased risks can assist clinicians in encouraging high-risk individuals and their families to engage in prevention programs.[2]

Risk for the patient in critical care: Pressure injury incidence and prevalence rates remain higher in critical care areas due to the numbers of severely compromised patients and potentially competing short-term goals.[56] The use of risk assessment tools that are specifically designed to assess risk factors related to critical care areas is highly recommended.[2]

Severely compromised patients include those with severe symptoms such as coronavirus disease (COVID-19). Risk factors that potentially increase the risk for pressure ulcer development in critically ill patients are described as:[57-59]
- Length of time in critical care
- Use of mechanical ventilation, intubation, tracheostomy (which may result in medical device-related pressure injuries, or MDRPIs*)
- Prone positioning (which, compared with supine positioning, makes it increasingly difficult to reposition and offload at-risk areas)
- Use of vasopressors (shown to be a significant risk factor in some studies),
- High Acute Physiology Chronic Health Evaluation 11 (APACHE 11) score 60

*In acute care, it has been shown that medical device-related pressure injuries (MDRPIs) account for more than 30% of all hospital-acquired pressure injuries due to long-term prone positioning with mechanical ventilation devices in the mouth and nose, which resulted in compression, shear forces and tissue ischemia to the surrounding tissues. Sedation, edema and increased skin moisture have also been identified as risk factors that contribute to MDRPI development.[57,58,59]

Risk for pediatric populations: Various pediatric risk assessments tools exist, such as the Braden Q. However, due to the variation of pressure injury risk factors within the wide range of the pediatric population—from neonates to infants and children—a valid PI risk assessment tool with validated cut-off points is still not available.[61, 62, 63]

Pediatric populations are at increased risk of developing PIs as their skin is not yet fully developed. Further adding to this risk assessment complexity is the child's communication level, developmental status and ability to properly differentiate pressure from other sensory perceptions of medical devices. According to Schluer et al., "in line with clinical expertise in the field of PU development in children, it is more reliable to focus on different risk populations,

such as children hospitalized in a PICU, and also to assess equipment-related factors contributing to the development of PUs."[61]

While the presence of medical devices is a specific risk factor in all age groups, limited activity, mobility and skin sensitivity are additional risk factors for this patient population. A comprehensive assessment should therefore include a pressure injury risk assessment and a head-to-toe skin assessment, including areas under splints, braces, traction boots, tracheostomy plates and arm boards.[64, 65]

Risk for bariatric populations: Although the precise relationship between obesity and pressure injury development is unclear, maceration, inflammation and tissue/skin necrosis are reported in large and deep skin folds in severely obese patients. Studies show that both increased tissue weight and fragile vascular and lymphatic frameworks subject the skin and tissues to ensuing complications.[28]

It can be challenging to assess skin and visualize all bony prominences. Skin areas under the pannus such as the hips, pubis, trunk and thighs require assessment, as the weight of the pannus can precipitate pressure injuries. Pressure injuries need to be differentiated from intertriginous dermatitis.[50]

Risk for surgical patients: Patients undergoing prolonged surgery have an especially high risk of developing pressure injuries due to the prolonged pressure from immobility during the pre-operative, intra-operative and immediate post-operative periods. Additional risk factors may include: duration of time the patient was immobilized before surgery, length of surgery, hypotensive episodes during surgery, low core temperature during surgery and reduced mobility post-operatively.[2]

Risk for patients at end of life: In many terminally ill patients, multiple factors and comorbid conditions increase their risk for the development of pressure injuries and need to be identified.[2, 66] Ferris et al. state that the prevalence of pressure injuries in patients receiving end of life or palliative care is higher than the general population. Skin failure occurs alongside failure of other systematic organ changes. This should be discussed with the family and care partners so they understand this is evidence of poor care.[67]

Risk for individuals living in community, at home:[2] Pressure injuries can occur in individuals living in the community, and many individuals return to the community from a care setting with a pressure injury. Quality of life must regularly be reassessed during these transitions of care. Regardless of the PI origin, it is essential that care planners and providers assess the risks posed by each individual's environment before developing and implementing a pressure injury prevention and management plan. Some of the challenges individuals face that may pose increased risk include:

- knowledge of available care options: types, location, local referral requirements, caseloads;
- access to health services - these may be difficult to access (including appropriate transportation to a service) and vary widely across geographic regions and access to equipment;
- limitations due to financial cost or availability.

Risk for individuals in the emergency department:[2] Many patients are admitted through the emergency department. Given that pressure injuries can occur quickly, within as little as two hours, the sooner pressure injury prevention strategies can be implemented, the more likely hospital-acquired pressure injuries can be avoided. Unfortunately, PI screening may not routinely happen in this setting, and risk assessment tools for staff in the ER are lacking. Screening for PI in the ER has been associated with decreased length of stay and decreased cost of PI treatment.

1.2.2 Environment: Socio-economic, care setting, potential for self-management

Discussion: Individuals who are at risk for or who have, a pressure injury often have other comorbidities, including disabilities such as mobility impairments. People with disabilities are often underemployed in Canada when compared with Canadians without a disability. Approximately 65% of persons with disabilities (ages 16–64) are employed.[68]

Furthermore, over 12% of people with disabilities have been refused a job because of their disability, with that figure rising to 33% for those with a severe or very severe disability.[69] People with disabilities who are employed tend to earn less than their non-disabled co-workers. The underemployment of people with disabilities has a direct impact on prevention and treatment plans, as they may not have the resources to pay for additional equipment or care.

Care is shifting away from institutions to the community, with over two million Canadians with disabilities receiving care at home. Most people (88%) receive at least some care from care partners, family and friends, while only 12% rely on professional services alone. For those receiving some care from family and friends, 70% have more than one care partner helping them.[70] Given these statistics, assessing the risk for pressure injuries and implementing appropriate care plans present unique challenges. Self-management, sometimes through the ability to direct others, becomes critically important. People at risk for pressure injuries or who have pressure injuries need to be able to identify and manage their own risks related to pressure injuries, as well as implement treatment plans. This works best when trained clinicians 'come alongside' and work collaboratively with care partners to listen, coach and provide education about risk and appropriate prevention and management activities.[71]

1.2.3 Systems: Health-care support and communication

Discussion: Pressure injuries are associated with a longer hospital length of stay,[72] especially for children[73], and those with darkly pigmented skin. Effectively addressing the issues surrounding pressure injury prevention and management at the systemic level (such as offload delays, increased time spent on ambulance or emergency room stretchers waiting for beds, hallway medicine, health-care provider shortages)[74] requires identifying the true scope of the problem and addressing deficits. In addition, a review of the literature by the Registered Nurses' Association of Ontario (RNAO) identified that patient records did not provide valid and reliable data about pressure injuries and often under-predicted prevalence rates. It recommended that more attention be focused on the quality of documentation of the data to enable the reliable use of the electronic patient record for data collection in the future.[6]

To address the issues, a systematic review by Sullivan identified key recommendations for in-facility health-care delivery to prevent hospital-acquired pressure injuries.[75] Findings suggested the following resulted in reduced pressure injury rates in acute and long-term care:

- Multiple components (bundles)
- A focus on accountability with continual performance measurement
- Simplification and standardization of pressure ulcer-specific interventions
- Consistency in staff training related to documentation
- Involvement of multidisciplinary teams and leadership
- Designated skin champions
- Ongoing staff education
- Ongoing audits that provide feedback and recognition of front line staff successes.[75]

The Canadian Patient Safety Institute (2021) recommends measurement of PI occurrences, exploration of contributing factors, and to identify solutions to mitigate risk. This includes solutions and interventions from leaders, clinicians, patient and care partners.[76]

Using these principles, Wounds Canada's Pressure Ulcer Awareness and Prevention Program (PUAP), a continuous quality improvement (CQI) program implemented in Canadian institutions, demonstrated a reduction rate up to 57% (prevalence) and 71% (incidence).[77]

Additional quality indicators such as the 'Required Organizational Practices' identified by national accreditation organizations were also recommended as a method to monitor outcomes.[6] For more information https://accreditation.ca/.

According to Bales et al., sustainability of any program requires assessment to determine if there is support through strong leadership, involvement of staff in decision-making and a desire to foster interdisciplinary relationships.[78]

1.3 Complete a skin and wound assessment, if applicable

Discussion: The early phases of PI development can sometimes be missed if the clinician waits for overt signs, such as complete skin breakdown. The RNAO recommends, "A comprehensive head-to-toe skin assessment be carried out with all clients at admission, and daily thereafter for those identified at risk for skin breakdown. Particular attention should be paid to vulnerable areas, especially over bony prominences and skin adjacent to external devices.[16]

Skin Assessment: A comprehensive skin assessment includes palpation to identify localized areas of edema, changes in tissue consistency and areas of warmth or coolness, which could be indicative of underlying pressure injury development. This is especially important when conducting a skin assessment in persons with darker skin tones where signs of pressure injury may not be easily identified.[2] It is important to document the patient's skin tone as part of the initial assessment. (See discussion of tools below).

Validated and reliable assessment tools that can detect progress toward healing and provide valuable information to direct treatment decisions should be used.[2]

Wound Assessment: In the presence of a wound, the use of a comprehensive, structured and validated wound assessment tool assists the health-care professional in identifying the potential etiology of areas of impaired skin integrity and helps in staging existing pressure injuries.[2] To enable consistent assessment of wound parameters it is recommended that all assessors use the same assessment tool. The frequency of a comprehensive wound assessment after initial assessment depends on the policies of the care setting.

Assessment tools specific to special populations, such as those with spinal cord injuries, have been developed to ensure population-specific information is considered. Thomason et al. introduced the Spinal Cord Impairment Pressure Ulcer Monitoring Tool (SCI-PUMT) which has now been revised to the Spinal Cord Injury Pressure Ulcer Scale (SCIPUS). This tool has been shown to improve outcomes for the assessment and treatment of pressure injuries in patients with spinal cord injuries or similar disorders.[80, 81] One validated tool currently used to measure healing with spinal-cord-injured patients is the Photographic Wound Assessment Tool (PWAT), which shows reliability and validity with other measures of healing.[80,81]

Physical Examination: Visual inspection to identify/classify pressure injuries in darkly pigmented skin is a challenge and is often inaccurate, requiring assessment for differences in skin temperature, colour, consistency and pain.[2] Wounds that are not pressure injuries should not be classified using NPIAP criteria. It is essential to differentiate pressure injuries from various other wound etiologies such as arterial ulcers, neuropathic ulcers, skin tears and moisture-associated skin damage, since management may differ based on cause.[2] Pressure injuries need to be assessed on admission to the care setting and at regular intervals.[2]

Wound Measurement: A wound should be at least 20% to 40% smaller at week four to heal at week 12.[16, 82] Wounds that fail to progress benefit from reassessment by an interprofessional team to ensure accurate diagnosis, to support patients' ability to heal and to optimize patient factors and treatment options. Reclassification of a wound to non-healing or non-healable may be necessary if conditions cannot be optimized.[16,84]

The MEASURE (Measure, Exudate, Appearance, Suffering, Undermining, Re-evaluate, Edge) mnemonic[82] is a communication device that captures many of the key parameters essential for pressure injury assessment.[28, 82] Other parameters that should be assessed include shape, base (tissue type), bacterial balance, wound edge attachment and progression, and periwound skin integrity.

Khoo and Jansen performed a literature search on types of wound measurement techniques.[85] A comparison of measurement techniques (ruler, digital planimetry, acetate tracings/contact planimetry, as well as laser and structured light devices) revealed digital planimetry provided the best precision and reliability over ruler and acetate tracings. The use of laser and structured light requires more study. Institutional resources must be considered when introducing an organizational standard for practice.

A thorough examination of bony prominences, folds, perineal and perigenital area and under medical devices is recommended. Evaluation tools and approaches for skin damage such as high-resolution ultrasound [86] and measuring subepidermal moisture[87] have been developed—and there are studies in progress regarding implementation into clinical practice.[88]

Recent studies now reveal that ultrasound may be useful in detecting deep tissue injury and soft tissue deformation but recommend that further investigations be conducted.

The use of photoplethsmogram (PPQ), Doppler flow meter (LDF) and measures of transcutaneous oxygen levels have also been identified as requiring further study prior to being recommended for practice.[2]

Changes in soft tissue skin temperature can be detected using a handheld infrared thermography device, which has proved valuable in identifying deep tissue injury, especially in persons with darker skin tones.[2] The subepidermal moisture/edema measurement device (SEM) has demonstrated the ability to identify inflammation and tissue damage predictive of stage 1 and greater pressure injuries, especially in the sacral area. NPIAP guidelines recommend that the use of skin temperature and subepidermal moisture measurement (SEM) be included in skin assessments, particularly for persons with darker skin tones.[89]

Staging and Grading Pressure Injuries: Health-care providers should assess and determine the category/stage of the pressure injury according to the NPIAP revised staging definitions.[12] The categories Unclassified/ Unstageable and Deep Tissue Injury should continue to be used. Categorizing pressure injuries from 2 to 4 is preferred to the use of the terms staging or grading, which tend to indicate a hierarchical progression which is not always the case. Accurate categorization of pressure injuries is essential for treatment planning, data collection and financial reimbursement. The NPIAP recommends that pressure injuries be categorized/staged according to the depth of original injury and not be categorized/staged in reverse as healing occurs. For example: A pressure injury that was originally identified as a Category/Stage 4 needs to continue to be classified as a Category/Stage 4 pressure injury as healing progresses.[2] In some provinces of Canada health care providers may be required to complete a version of MDS/RAI that requires back staging. It is recommended that clinicians follow the MDS/RAI requirements, but that their wound documentation in the progress notes not include back staging.

Wound Infection: The clinician must be able to identify when bacterial damage is occurring and differentiate between superficial, spreading and deep infection or abnormal persistent inflammation in order to create a plan of care that will provide the appropriate treatment and prevention of recurrence. Accurate identification of the microbial load and causative organisms within the wound is best achieved by tissue biopsy or by the Levine quantitative swab technique. See International Wound Infection Institute.[90]

For more information visit Wounds Canada. Infection Prevention and Control (IPAC): Focus on Wounds Care. Available at: https://www.woundscanada.ca/health-care-professional/indigenous-health/alberta

A bone biopsy is recommended for diagnosing osteomyelitis if there is clinical suspicion of osteomyelitis. Wound swab is not recommended to diagnose osteomyelitis. Swabs are useful for identifying causative organisms but not for diagnosing infection. For more on swabs, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

Step 2: Set Goals

Recommendations
2.1 Set goals for healthy skin, prevention of skin breakdown and management of healing, non-healing and non-healable wounds

Discussion: Pressure injury prevention should be considered a patient safety goal. Because of the increased acuity of illness of elderly patients admitted and decreased lengths of stay in the hospital, older adults are at greater risk of developing pressure injuries within the first week of hospitalization. For those admitted to long-term care, pressure injuries are most likely to develop within the first four weeks.[91] Older adults with physical-motor limitations, persons with diabetes and those undergoing orthopedic surgery are at increased risk of developing PIs.[92]

Set SMART goals with the patient, caregiver and/or family as appropriate that are specific, measureable, achievable, relevant and timely.[15] To have consistent and quantifiable goals and objectives, the goals should be measurable, repeatable and specific, with interrater reliability.[93] This includes mutually agreed-upon goals that include patient-centered concerns.[94]

2.1.1 Identify goals based on prevention or healability of wounds

Discussion: Once a person has been identified as at risk for a pressure injury or has developed a pressure injury, goals will depend on the client's goals not just related to their PI, but their quality-of-life and the client and team's ability to modify both the intrinsic and extrinsic factors that support prevention or healing. To assist clinicians in setting realistic goals, in collaboration with the patient, family and care partners, risks need to be addressed for prevention goals and wounds need to be classified as healing, non-healing or non-healable.

Clinical judgment is an essential component of risk assessment to facilitate identification of risk factors that are modifiable and those that are not, including physical, psychosocial and medical conditions that may impact the person's level of risk and create potential barriers to healing.[6]

A goal of wound closure may not be realistic when factors that impair wound healing are present and cannot be controlled, such as poor blood flow or perfusion, malnutrition, malignancies, and unmanageable co-morbidities. Client choices around the PI prevention and management plan may cause the wound to be classified as non-healing. It is important to regularly check in with the client to see if their goals and choices have changed, such that the classification of the would would change to healable.[2] When preventing or healing a pressure injury is not possible, these wounds may be classified as non-healable and the goals of care should be centred on supporting optimum quality of life.[84]

Wound closure may also be an unrealistic goal for patients who are terminally ill. Therefore, setting goals that focus on quality-of-life, pain management, managing dressing changes, reducing odour and managing exudate may be most appropriate. It is essential that the care provider explain this approach to the care partners and family members so they are aware that wound closure is not a realistic option due to skin failure, and or systematic organ changes.[95] The use of the Skin Changes at Life's End (SCALE) may assist in care plan development in such circumstances.[96]

Goal Examples:
- For prevention: Daily skin assessment starting now!
- For all wounds: Adequate positioning and pressure redistribution surfaces within two days
- For a healable pressure injury: Wound closure within three weeks
- For a non-healing pressure injury: Wound infection controlled within two weeks
- For a non-healable pressure injury: Alleviation of smell and pain within four days.

Table 4: Team Members and their Roles[2,16]

Team Members	Roles
Patient, family and care partners	Communicate patient abilities, history and needs (goals) to rest of team, advocate for patient and identify any changes and progress they notice
Clinician with intermediate and advanced wound care training	Develop and implement optimized care planning for prevention and management of pressure injuries
Chiropodist/podiatrist	For pressure injuries on the foot: deliver specialized care, pressure offloading, some surgical procedures to eliminate or minimize pressure points on the foot
Diabetes educator	Provide ongoing education for the management of diabetes to optimize glucose control and enhance healing potential
Wound care educator	Deliver advanced education regarding risk assessment and management of pressure injuries
Infectious disease specialist	Address unresponsive, recalcitrant or recurrent infection such as osteomyelitis
Primary care provider (e.g., nurse practitioner, family physician, hospitalist)	Assessment and referral Prescribe medications, order tests/laboratory
Occupational therapist	Provide pressure redistribution; activities of daily living assessments; cognitive assessments and interventions; psychosocial and quality-of-life assessment; support; support/counseling; expertise in assessment of pressure redistribution surfaces, including wheelchair seating prescription, shear prevention and management
Pedorthist/orthotist	Provide pressure offloading for foot and lower extremity pressure injuries as well as bracing for other areas of the body
Personal support worker/ attendant/ care worker/ continuing care assistant	Deliver day-to-day personal care; provide early recognition of Category/ Stage 1 pressure injury, including changes in activity level, nutrition and hydration, bladder/bowel changes and/or mental wellness
Pharmacist	Assess and optimize medication(s) for management of comorbidities, pain, infection; provide information, education, monitoring for interactions, especially with polypharmacy
Physiatrist	Deliver care to persons with SCI and with other musculoskeletal injuries or other conditions; work with rehabilitation personnel
Physical therapist	Provide pressure redistribution, mobility, safe exercise and reconditioning, adjunctive therapies, wheelchair seating and positioning, shear prevention and management
Psychologist	Assess and treat mental health issues; provide coping strategies; address quality-of-life issues impacting adherence to the plan of care
Registered dietitian	Assess and manage nutritional status to ensure optimal nutrition to maintain skin integrity and facilitate healing
RN/RPN	Assess, manage and monitor patient and wound, perform dressing changes, administer medication, provide health-related education
Social worker	Provide psychosocial assessment and support/social supports (e.g., housing, devices, financial resources, food security) and transition in care planning

Team Members	Roles
Speech and language pathologist	Assess swallowing and communication ability and make recommendations to optimize nutritional intake and quality of life
Spiritual care	Provide support and counseling and connect patient/family to spiritual care communities
Surgeon	Perform surgical intervention, debridement, flap closure for deep or slow-healing pressure injuries; vascular interventions to improve perfusion to lower limb pressure injuries

2.1.2 Identify quality of life and symptom-control goals

Discussion: Goals need to be established to enhance the patient's quality of life regardless of the healability of pressure injuries.[84] Comfort is the principal consideration in supportive care and, therefore, may supersede prevention protocols and wound treatments for actively dying patients and for those who have conditions that cause them to have a single position of comfort.

Goal setting should centre on ways to prevent or minimize tissue trauma while engaging in meaningful activity, minimize dressing changes as able, prevent complications, such as infection and minimize pain. The importance of these types of goals in a patient's life cannot be overstated.

Step 3: Assemble the Team

Recommendations
3.1 Identify appropriate health-care professionals and service providers

Discussion: The etiology of pressure injuries is complex and multifactorial, and as a result requires an integrated, interprofessional team to address the many underlying impairments and contributing factors. Each team member brings a unique body of knowledge, but also needs to have a foundational understanding of pressure injuries, as well as the patient and their family. Team member knowledge can be assessed through tools such as the Pieper-Zulkowski Pressure Ulcer Knowledge Test (PZ-PUKT).[97]

The team process requires that all team members work together, not independently of one another, to create a customized plan of care to prevent or manage pressure injuries. The comprehensive patient assessment and goal-setting stages will help identify who should be part of the team. Table 4 lists some of the potential members and what they bring to the team.

3.2 Enlist the patient and their family and care partners as part of the team

Discussion: The success of a plan of care for the prevention and treatment of pressure injuries hinges on the collaboration of the person with a pressure injury, their care partners, family and their support system along with communication among the team of professionals involved in the development of the plan of care.[98] Consider engaging families virtually when they are not available in person. To be effective, all team members must have the motivation, capacity, ability and commitment to act on behalf of the patient, who may be unable to act for themselves.[2, 16]

3.3 Ensure organizational and system support

Discussion: Health-care organizations need to be accountable for any pressure injury development under their purview. To ensure prevention is a focus and is adequately supported, they need to:

- Set appropriate policies and procedures and ensure they are being followed; this must include policies and procedures related to:
    - o screening/assessment
    - o communication
    - o education*
    - o interventions
    - o documentation
    - o analysis of data
    - o continuous quality improvement**
- Make available relevant and adequate financial, human and material resources
- Create a culture of prevention that involves all staff (clinical and non-clinical), patients, family members and caregivers.[99]
- Ensure there is appropriate and equitable access to supplies and medical equipment such as moisturizers, skin barriers, therapeutic pressure redistribution surfaces and other devices.[6]

**It is essential that organizations support appropriate staffing and education so team members obtain adequate skills and knowledge to effectively manage the multiple complex issues related to pressure injuries. A needs assessment should be undertaken to identify knowledge gaps and ensure that educational sessions are tailored to meet those needs. Educational sessions need to utilize principles of adult learning, relate to clinical practice and reinforce strategies to sustain knowledge.[99] Patients and their families can also benefit from education about pressure injury prevention.*

*** Organizations should engage in assessment of Required Organizational Practices focused on prevention of pressure injuries as this process engages the team and provides opportunity for improvement.[100]*

The Patient Safety Institute states organizations are responsible for utilizing an interdisciplinary approach to support all levels of the organization in the prevention of pressure injuries. A standardized approach to prevention should be established across all units and care sectors, including patient transitions in care from one unit/setting to another (urgent care, emergency, medicine, surgery, rehabilitation, long-term care and home settings), where pressure injury prevention may be inconsistent and/or not a priority.[99]

Step 4: Establish and Implement a Plan of Care

Recommendations
4.1 Identify and implement an evidence-informed plan to support healthy skin, correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional and social), the wound (if applicable) and environmental/system challenges

Discussion: It is important to establish an establish an integrated, interprofessional, collaborative, patient-centred plan utilizing an evidence-informed approach that is aligned with with the patient care goals have been set during Step 2.

Pressure injury prevention interventions that are based on a comprehensive patient assessment and the risks identified by sub-scale scores of a structured and validated risk assessment tool have demonstrated effectiveness in reducing the incidence of pressure injuries.[101]

A systematic review by Reddy et al. on pressure injury prevention identified that the priority in the prevention of pressure injuries was to identify and address underlying causative and contributing factors rather than focus on local wound care. They found that the differences between specific treatment strategies were minimal.[102] Focus should be on forces associated with immobility such as shear, friction, temperature and moisture management to effectively reduce the risks of pressure injury development.[103]

Managing Pressure, Friction and Shear

Managing pressure, friction and shear forces is important in any pressure injury prevention and management plan.[2,16]

The optimal management of these forces requires an integrated team skilled in the management of pressure, friction and shear within the context of the person's goals and lifestyle. When considering interventions, the focus should be on maintaining mobility while reducing these forces. Interventions may need to be adjusted in the presence of presence of complicating factors and should achieve a balance among social, physical and psychology needs (for example, the use of a pressure redistribution surface on a bed shared with a partner).[2, 16]

Given the lifestyle factors that influence pressure injury development, the individual or POA and care partners should receive collaborative education regarding pressure, friction and shear, including the importance of reducing these forces, as well as specific information about reducing these forces based on their unique abilities and context. Individuals should be encouraged to apply this knowledge in their daily lives, particularly when their routine changes. Health-care providers may think they are addressing lifestyle factors by simply telling the patient they need to stop activities or stay in bed.[104] However the best approach is to work with the individual to assist them in finding ways to continue to participate in their life while managing pressure, friction and shear.[104, 105]

For Patients

The SSKIN bundle (skin assessment, surface, keep moving, incontinence, nutrition) is a group of interventions implemented by the team to support improved patient outcomes.[106] The RNAO "suggests that nurses and health providers implement preventative care bundles for persons at risk of pressure injuries."[16] The SSKIN bundle is a useful tool to open up communication between the team members, particularly with patients and their care partners. The + (plus) refers to additional interventions such as patient education, empowerment through self management and engagement and use of prophylactic dressings.

Utilization of the five As of self-management—(1) assess, (2) advise, (3) agree, (4) assist and (5) arrange—may be a useful technique to assist in the facilitation of, "effective collaboration between health-care professionals and persons and their primary caregiver(s) self-management education."[16] Growing patients' self-management skills helps establish a healthy pattern early in life and when living with chronic conditions.[105] Socio-economic challenges must be acknowledged and can be a barrier to patients adopting self-management skills.[107] Consider referral to a social worker to assist with finding resources.

Equipment and Supplies

All patient care across the continuum of care must be able to access the appropriate equipment and supplies to meet specific patient needs for managing pressure, friction and shear. Helpful equipment may include repositioning sheets, a trapeze bar, pressure redistribution surface in bed, a fitted wheelchair with a pressure management cushion and other equipment. Regardless of the pressure redistribution surface used,, it is important that care providers are knowledgeable regarding the use, maintenance and operation of these devices.[6] Refer the patient to a clinician skilled in wheelchair and seating assessment. Annual assessment by an expert clinician has been shown to reduce the incidence of pressure injuries.[108]

Sitting

All patients who have a pressure injury, or are at risk of developing pressure injuries should be positioned on a skin protection cushion when sitting, as skin protection cushions reduce the incidence of pressure injuries.[108-110]

Cushions with contours should be positioned so the contours are on the top of the cushion, and the rise in contour on the middle of one side (pummel) should be at the front of the wheelchair. Cushions with air should have their inflation checked regularly as per the manufacturer's instructions.[2,16]

OT/PT and rehabilitation assistant involvement is beneficial to ensure that the individual is positioned properly on a pressure-redistributing cushion when sitting in a chair.[2]

Cushions that are worn should be evaluated by an expert clinician; however, age of the cushion is not necessarily an accurate predictor of the need to replace a cushion; in some cases replacing the patient's skin protection cushion with a new version of the same cushion may actually produce increased pressure.[109]

Tilt (where the orientation of the seat and back of the wheelchair change in relationship to gravity) and recline (where the hip to back angle increases) used in combination have been shown to have a greatert reduction in pressure over the buttocks than tilt used in isolation.[111] Note: Recline alone should not be used as this increases the pressure and shearing forces over the sacrum and ischial tuberosities.

Patients may spend time sitting in other locations, such as on a power-lift recliner, in a car, on a commode or on sporting equipment. Limited research exists about best approaches to reducing pressure, friction and shear in these circumstances. Use of a skin protection cushion has been recommended when sitting on a power-lift recliner.[110,112] Skin protection cushions may also be used in the car (or other vehicles) but should be used with caution, with attention paid to the potential reduction in head clearance between the individual's head and ceiling of the vehicle (potentially dangerous when going over bumps in the road).

For patients with a pressure injury on the buttocks and/or trochanter, mobilization should be a priority. At a minimum, sitting should be encouraged where pressure on the ulcer can be managed to promote mobility and the minimization of bed rest.[16] Bed rest has known complications such as anorexia, decreased executive functioning, de-conditioning and potential pulmonary embolism. There are no randomized controlled trials (RCTs) that indicate that bed rest is effective in the treatment of pressure injuries.[113,114] Confining patients to bed often results in the person positioning the head of the bed at greater than 30 degrees for important activities such as eating, sponge bathing and visiting with family. Raising the head of the bed over 30 degrees increases the pressure and shear over the client's bony prominences and increases the risk of tissue damage. This increase may be beyond that of the same forces when sitting in the wheelchair. Managing pressure, friction and shear throughout activities of daily life likely results in an improved quality of life for the person with a pressure injury and decreases the risk that a pressure injury could develop in fragile tissues. Factors influencing shear force in bed include body type (slender individuals tend to have the highest shear force at the coccyx and sacrum), whether or not the knee is raised (raising the knees tends to decrease shear) and whether or not the position of the person with a pressure injury (bending points) in a supine position matches those of the bed.[2,115]

Patients and Family as Partners in Care

There has been an important shift toward developing self-care skills in persons with pressure injuries.[2] Engaging individuals in prevention of complications and in treatment and interventions is recommended. Incorporate evidence-based resources relevant to the individual and care partners focused education and self-care on relevant learning. Utilizing multi-facited approaches including verbal, web based tools, communication journals, phone and written materials is important with the patient and care partners.[2,16]

In Bed

When patients are in bed, the head of the bed is often set with an angle greater than 30 degrees for important activities such as eating, sponge bathing and visiting with family. Rebumbent pressure redistribution surfaces may not adequately manage pressure, friction and shear when the head of the bed is elevated to greater than 30 degrees. The patient may have better pressure management sitting up on a skin protection cushion for these activities. Managing pressure, friction and shear throughout activities of daily life likely results in an improved quality of life for the person with a pressure injury and decreases the risk that a pressure injury will develop in at-risk tissue.

It is also important to pay attention to the risk of "Patient Entrapment Hazards, Side Rail Latching Reliability, and Other Hazards" guideline by the Government of Canada. Entrapment is a critical issue that health care providers should be

aware. For example: "If a powered air mattress is replacing a mattress on a bed system that meets the recommendations in the guidance with the original mattress, the resulting bed system with the new air mattress may now pose a risk of entrapment. When these products are used, Health Canada recommends that steps be taken to ensure that the therapeutic benefit outweighs the risk of entrapment." As well, "suppliers of such mattress products should both warn and help facilities assess the potential impact these products may have on patient entrapment risks or patient falls." For more information on Patient Entrapment Hazards, Side Rail Latching Reliability, and Other Hazards visit: https://www.canada.ca/en/health-canada/services/drugs-health-products/medical-devices/application-information/guidance-documents/guidance-document-adult-hospital-beds-patient-hazards-side-rail-other-hazards.html.[2,26,191]

For more information on pressure redistribution surfaces, please see Product Picker: Integrated Therapeutic Support Surface Selection for Pressure Injury Prevention and Management, available at: https://www.woundscanada.ca/docman/public/2882-wc-product-picker-surfaces-for-review/file.

Repositioning

Repositioning should be considered for all those at risk of pressure injury development.[104] Personalized repositioning protocols should be based on the patient's tissue tolerance, level of mobility, medical condition, treatment objectives and the existing pressure redistribution surfaces.[2] The RNAO states: "that repositioning every two to four hours is recommended depending on the client situation, and for those at risk of pressure injuries"[16]

The use of a pressure-redistributing surface does not eliminate the need for repositioning, but it may extend the length of time before repositioning is required.[2,12,62] An individual assessment evaluating the skin's response to extending the time between turns (e.g., development of redness/or other skin changes) will help to determine the optimum turning schedule. Patient positioning and repositioning should be carefully assessed by a PT/OT. Several positions, such as semi-Fowler's with the head of the bed at greater than 30 degrees, and sitting in recline significantly increase the forces of friction and shear experienced by the patient. Elevating the patient's knees in bed prior to bringing the head of the bed up, utilizing tilt rather than recline and ensuring that the patient's feet are supported while sitting can help to decrease these forces.[2,115] Frequent repositioning is important to redistribute pressure on bony prominences but must be done in a manner that minimizes friction and shear by utilizing lifting sheets and positioning wedges. It is also very important that everyone involved in the patient's care is made aware of the patient's risk of tissue injury in order to ensure that safe transfers and adequate safe positioning and repositioning occur.[2]

Heels: The management of heels needs to be considered independently of the pressure redistribution surface.[6] A systematic review by Junkin and Gray found that pressure redistribution surfaces vary in their ability to prevent heel pressure injuries, but there was insufficient evidence to determine which surfaces were optimal.[116] A pressure redistribution surface tool has been developed based on the available evidence to assist clinicians in selecting the most appropriate support surface based on the risk level for developing pressure injuries of the person with a pressure injury and their level of mobility.[6,30] Evidence suggests that the use of a wedge-shaped cushion to suspend the heels off the bed is more effective in reducing the incidence of pressure ulcers than the use of a standard pillow.[117]

For more information on pressure redistribution surfaces, please see Product Picker: Integrated Therapeutic Support Surface Selection for Pressure Injury Prevention and Management, available at: https://www.woundscanada.ca/docman/public/2882-wc-product-picker-surfaces-for-review/file.

Positioning patients for the prevention and management of pressure injuries can be very challenging. The following positioning tips will assist the clinician in preventing or managing pressure injuries.[16]

- Follow a positioning schedule. Position every two to four hours while in bed; weight shift every 15 minutes when sitting. For clients who are able, self repositioning and weight shifting should be encouraged
- Avoid positioning the person with a pressure injury on bony prominences or on existing pressure injuries
- Limit head of bed elevation to less than 30-35 degrees if not contraindicated by medical condition
- Use pillows or wedges to assist with proper positioning and body alignment. Do not use donut-type devices. Utilize assistive devices (such as bed rails, transfer boards, trapeze bars) to increase the patient's independence and

safety with repositioning and transfers
- Develop a modified sitting schedule based on equipment availability (e.g. use of a pressure redistribution surface in sitting as approiprate), quality-of-life goals and evidence of wound healing. Ask an occupational therapist or physical therapist for a patient-specific transfer technique to minimize shearing effects and maintain the patient's independence
- Inform the patient, family and care partners about the positioning schedule and proper transferring and weight-shifting techniques
- Ask an occupational therapist to assess the wheelchair and cushion for at-risk patients and for patients with known pressure injuries on the ischial tuberosities, coccyx or sacral area. Ensure feet are supported
- Check your sling! Some types of slings are designed to be left under patients, while others are to be removed after transfer. When using slings, there needs to be a balance between the impact to transfers and repositioning and pressure management with the removal of the sling. Evaluate each situation individually considering these factors.

Safe Patient Handling

Reviewing the safety of patient handling procedures is essential and should be ongoing.[118,119] Transfers in particular should be assessed both at the beginning and end of the day when patient/clinician/care partner fatigue may impact the quality of the transfer. There are several devices available to aid in transfers and positioning, including transfer boards, trapezes and slider sheets, all of which help to reduce the forces of pressure, friction and shear. These devices, however, need to be used properly and by trained staff. Improved functional status translates into improved transfers, positioning and bed mobility. It is essential that patients, where possible, care partners and care providers have the necessary knowledge and skills because poorly executed positioning, transfers or shifts in bed can result in increased tissue injury due to friction and shear.[6] Transfer techniques should therefore be assessed by physical and/or an occupational therapists for all people with pressure injuries and those at risk for developing pressure injuries.[2,6,102]

Other Considerations

Because the effects of friction and shear are increased in the presence of moisture, and moisture from incontinence can be a risk factor for pressure injury development[114], an individualized bowel and bladder program for patients with incontinence should be established[16] including offering a bedpan or urinal in conjunction with turning and oral hydration schedules. See Table 6: Managing Moisture of Intact Skin for more on moisture and skin breakdown. As with all wound types, the clinician must establish effective pain management strategies to optimize comfort, especially prior to movement and positioning.

Managing Moisture of Intact Skin

The management of moisture of intact skin can be applied to all patient populations. In addition extra care is needed for patients utilizing dressings and or experiencing urinary and/or fecal incontinence (e.g., liquid stool) especially coccyx or sacral dressings, due to the risk of maceration.[16] Chapter 5: Best Practice Recommendations for the Prevention and Management of Moisture-Associated Skin Damage.[39]

Specific Information for Care of Specific Populations

Care for the older adults and vulnerable populations: Pressure injury prevention and treatment plans should be developed with consideration of the person's values and goals as well as their cognitive status to promote adherence.[2,16]

Care should include promotion of skin health and the use of barrier products to protect skin from excessive moisture. As well, strategies need to include protection from medical devices, use of atraumatic wound dressings, and the establishment of an individualized continence (bladder and bowel) program.[120] Repositioning (manual handling as well as equipment) and pressure redistribution surfaces should address pressure redistribution and reduction of shearing forces.

Care for the patient with a spinal cord injury: Because of the patient's immobility, muscle atrophy, weight changes, decreased sensation and changes in skin perfusion, the use of seating surfaces, transfer devices and mattress pressure redistribution surfaces are essential.[51,81] Providing education, training and assistance to the individual so they can apply the concepts of reducing pressure, friction and shear into their daily activities will help them prevent pressure injuries in a way that is relevant to their unique situation.[2,16]

Care for the patient in critical care: Pressure redistribution surfaces and repositioning are crucial for this vulnerable—and largely immobile—patient population. According to the European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel and Pan Pacific Pressure Injury Alliance, redistribution surfaces should be, " chosen based on the patient's needs including, but not limited to, their need for pressure redistribution, shear reduction, reducing moisture at the client-surface interface, postural drainage and percussion". [2,16]

Patients who cannot be turned for medical reasons should also be evaluated for a therapeutic redistribution surface. The European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel and Pan Pacific Pressure Injury Alliance also state, "In some instances individuals cannot be safely repositioned due to temporary oral-pharyngeal airway, spinal instability or the risk of fatality due to hemodynamic status. Indications of an individual being too hemodynamically unstable for repositioning include being actively fluid resuscitated to maintain systemic blood pressure, active hemorrhaging, life-threatening arrhythmia or changes in hemodynamic parameters that do not stabilize with 10 minutes of repositioning. Regular repositioning should be implemented as the patient stabilizes and reassessed ongoing."[2,16]

Repositioning schedules that employ slow, gradual turns should be initiated for each patient with consideration of their current oxygenation and hemodynamic tolerance to position change. For patients who cannot tolerate major changes in body position, small, frequent shifts in body position are beneficial to promote reperfusion.[2,16] Patients should be positioned off pressure injuries as much as possible. The lateral rotation surface function is not recommended for patients with existing pressure injuries. If the lateral rotation feature of the pressure redistribution surfaces (beds) needs to be used, the patient should be secured with bolster pads to prevent sacral shear.[50]

Heels should be floated off the bed surface to reduce pressure injury development. Knees should be slightly flexed to prevent popliteal vein obstruction and avoid pressure over the Achilles tendon.[50]

Care for pediatric populations: Teach children (and their care partner, family member) the importance of checking their skin for redness or other changes and how to redistribute pressure. For pediatric populations the presence of medical devices requires interventions to prevent and address pressure under intravenous infusion equipment (e.g., ventilation tubes, intravenous tubing, tapes), splints, braces, traction boots, tracheostomy equipment and arm boards/ splints.[51] Schluer et al. found increased pressure injuries under blood pressure cuffs, transcutaneous oxygen pressure probes, nasal prongs, CPAP masks and plaster casts.[61]

Pediatric pressure injury interventions should be based on their needs. Other medical devices such as orthotics, wheelchairs and wheelchair cushions should be frequently reassessed in growing children.

Providers should not treat children simply as scaled down adults, as the development of the integumentary system means that the development of pressure injuries in this population could be inherently different in etiology. Remember that because of integumentary system development, signs of tissue damage can be difficult to visualize in neonates. The Dubowitz Neonatal Maturity Assessment Scale provides a measure of skin texture/maturity in neonates.[2,121]

There appears to be a natural division for care pathways and overall approach to care when guided by a framework based on selection of some defined age range according to characteristics such as integumentary development and ability to participate in care. Care pathways must be multifactorial, ensuring that moisture, mobility, nutrition and medical device-related pressure are addressed. Neonates and children are at higher risk of nutritional deficiencies due to having an increased nutritional requirement per unit weight to meet normal growth needs, as well as having smaller appetites and dietary intake (see See Appendix 1: Nutrition for Skin Health, Wound Prevention and Wound Healing in

Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]) Immature skin is at increased risk of damage due to epidermal stripping from wound dressings or toxicity from exposure to topical agents.

Medical devices are a leading cause of PIs in the younger pediatric population (neonates and children) and need to have very special consideration. Children often end up using devices that are meant for adults, resulting in devices that are ill-fitting, thereby becoming sources of pressure.

Care for bariatric populations: Due to the increased difficulty obese patients may have with moving, it is important to have bariatric management strategies to safely optimize manual handling techniques. Friction and shear injuries are increased, as patients often drag their heels and sacrum during transfers. Patients and all other team members should have access to equipment (such as beds, chairs and commodes) with the appropriate size and weight specifications to accommodate the patient's body stature.[2] All skin folds and surfaces should be assessed and addressed regularly, as pressure injuries may also develop over areas of high adipose tissue concentration such as across the buttocks and between skin folds.[2]

Care for patients during peri-operative stage: While specific patient positioning is crucial for access and exposure to the surgical site, special attention is required when positioning the patient on the operating table to protect pressure points during surgery[2], redistribute pressure and minimize the effects of shearing as much as possible.[122,123] Reactive redistribution surfaces are recommended for patients identified as being at risk. Protection of accessible bony prominences and heel elevation with protection of the Achilles tendon are also recommended.[2]

Care for patients at end of life: While palliative care focuses on symptom management and comfort measures, the prevention of pressure injuries is an important aspect of care. However, during the time of active dying, the patient's wishes for pain control and comfort may outweigh the desire for pressure injury prevention.[2]

Completion of the Skin Changes at Life's End (SCALE) holistically contributes to development of effective treatments and comfort measures.[124] Comfort measures may include skin emollients to maintain adequate skin moisture and prevent dryness. Pre-medicating the person with a pressure injury prior to repositioning, respecting the patient's choices in turning schedules and utilizing a pressure redistribution surface may be beneficial. Hydration goals should be compatible with the patient's condition and wishes.[125]

Wound care for existing pressure injuries should focus on reduction of pain, minimizing odour, managing exudate and addressing other symptoms that may impact quality of life.[2]

The patient's choices and involvement in co-creating the plan of care, as able, regarding turning should be respected and include whether they have a 'position of comfort' after an explanation of the rationale for turning. The family and care partners should be an integral part of setting the goals and plan of care. Social work and spiritual care are important resources to consider for this population in order to provide holistic care.[2,16]

Management options for wounds that are non-healable because of factors such as an inability to effectively offload sitting pressures for a person with a Category/Stage 4 ischial pressure injury due to restricted finances should focus on the promotion of quality-of-life improvements such as comfort and management of wound symptoms as identified by the patient.

Additional Considerations

Medical device-related pressure injuries: The NPIAP states, "Medical device-related pressure injuries result from the use of devices designed and applied for diagnostic or therapeutic purposes. The resultant pressure injury generally conforms to the pattern or shape of the device".[2,16]

Routine skin inspection should include areas beneath medical devices for edema and potential skin breakdown if not medically contraindicated. Medical device-related injuries should be categorized/staged according to the degree of

tissue injury. All staff members should be educated on the correct size of device to be used and proper positioning and placement of the device based on location, presence of existing pressure injuries and the patient's mobility status. High-risk areas, such as the nasal bridge, should be cushioned with protective dressings.[2,16]

Mucosal membrane pressure injuries: The NPIAP states, "Mucosal membrane pressure injuries are located on mucous membranes with a history of a medical device in use at the location of the injury. Due to the anatomy of the tissue these injuries cannot be staged."[2] Mucosa inspection should occur in conjunction with skin assessment and areas of compromised mucosa documented for health-care team awareness and continued monitoring. All health-care providers should be educated about appropriate anchoring techniques, according to anatomical location, to prevent friction from movement, shearing and pressure.

Pain: Pain is often considered one of the most problematic aspects of wound management, and pharmacotherapy continues to be the mainstay of pain management.[126] Pain medication may mask the body's normal cues that signal the need for repositioning making the need for a specific, individualized turning schedule even more important. There is also a need to balance repositioning with the position of comfort. Turning schedules should be based on the tolerance for pressure, the available positions of comfort, effectiveness of the pain management techniques. Appropriate agents should be selected based on severity and specific types of pain according to the World Health Organization's Analgesic Ladder[127,128] and the modified WHO Analgesic ladder for chronic non-cancer pain.[129] Some evidence suggests that topical agents such as ibuprofen[130] and morphine and dressings[131] play a role in alleviating wound-related pain.

Support pain management with non-pharmacological pain management strategies, including adjunctive therapies (e.g., music, distraction, activity, massage, journaling, art).[2,16]

Use repositioning techniques and equipment with consideration to preventing and managing pressure injury pain. Please see Chapter 4 for more on pain management.[15]

Surgical management of pressure injuries: Surgical intervention may be an option for Stage 3 and 4 pressure injuries provided it is consistent with the patient goals of care.[2,16] This will require multidisciplinary team discussions if pressure injuries are reoccurring, as it may indicate the risk factors have not yet been addressed or resolved. The decision-making process should be done in collaboration with the individual with the pressure injury and the interdisciplinary wound care team. Potential risks and benefits must be discussed with the patient, care partners and team to ensure to ensure that the patient's expectations and condition are understood and optimized prior to surgery.[132]

Psychosocial and socioeconomic factors that may impact surgical wound healing and the patient's willingness/ability to participate in all post-operative activities must also be considered and addressed prior to surgery.[2,16]

Some persons may have a pressure injury caused by a one-time only incident and they are at low risk of recurrence, so early surgical management may be appropriate, especially if it helps them to reintegrate to their community or return to work earlier.

The focus of post-operative flap care should be protecting the blood supply to the incisions from pressure and tension through the use of pressure redistribution techniques. These techniques might include the use of a pressure redistribution surface capable of reducing shear and pressure.

The recurrence rates for pressure injuries treated with plastic surgery have been reported to be high (13 – 31%).[132-134] Risk factors contributing to recurrence should be assessed and reassessed at regular intervals.[135] For persons with a spinal cord injury and risk of pelvic recurrence, Morel el al. reported approximately half (n=85) has a recurrence and in one-third the recurrence was at the surgical site.[136] To prevent recurrence it is crucial to engage the patient in per-operative care planning and to involve the rehabilitation team early after surgery.

4.2 Optimize the local wound environment

4.2.1 Cleansing: Wound cleansing and irrigation promote the removal of exudate, slough, debris (dressing) and bacterial contaminants from pressure injuries, as well as the periwound skin. Use room temperature fluids at a pressure between 8-15 psi to cleanse a wound using up to 100-150 mls of solution. Larger PIs may require more cleansing fluids.[137,138]

Discussion: Optimizing local wound healing is multifaceted. Expert opinion recommends that:

- Pressure injuries and surrounding skin can be cleansed using solutions with low toxicity such as saline, water[84] or acetic acid (0.5%–1.0%)
- Tap water should not be used for wound cleansing for persons who are immuoe-compromised[2]
- Aseptic technique using sterile products should be applied for persons who are immuno-compromised[2]
- Irrigation of wounds should be avoided when you cannot see where the solution is going or cannot retrieve/ aspirate the irrigation solution[84]
- Cleansing solutions containing surfactants and/or antimicrobials can be effective in critically colonized or infected wounds.[2] Clinicians should be aware of the cytotoxicity of each solution, appropriate concentrations and the individual wound requirements when choosing the most appropriate solution[86]
- Ensure skin cleaners are not used as wound cleansers[139]
- Cleansing the periwound skin is associated with reduction of skin microbials for up to 24 hours[2]
- Wound cleansing solutions vary and should be used at body temperature. Cleansing solutions should be nontoxic, hypoallergenic, readily available, cost-effective and easy to use
- Wound cleansing is likely to cause pain during dressing change. The routine practice of using abrasive materials and gauze to scrub the wound surface is discouraged. Use of analgesics prior to wound cleansing should be considered.

For more information on cleansing, see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview - Section 4.2.1.[15]

Wounds Canada Product Picker: Skin and Wound Clean-up. Available at: https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/library/183-resources-industry-partner/288-product-picker

4.2.2 Debriding

Discussion: Debridement of healable pressure injuries continues to be recommended when compatible with patient goals, the comprehensive wound assessment, underlying medical/ surgical issues, the environment, the scope of practice of the person conducting the debridement and the resources available for the various debridement methods.[84,140] As described in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[15] there are many methods of debridement to remove, "necrotic material, eschar, devitalized tissue, sero-crusts, infected tissue, biofilm, hyperkeratosis, slough, pus, hematomas, foreign bodies, debris, and bone fragments from a wound to promote wound healing".[15,141]

Surgical debridement of pressure injuries is recommended in the presence of advancing cellulitis, crepitus, fluctuance and/or sepsis from wound-related infection and considered with the presence of undermining, tunneling or extensive necrosis.[2] For non-healable wounds, only conservative debridement should be performed.

Assessing the underlying vascular supply is critical to pre-planning any surgical event.[15] It is recommended that dry, stable eschar on ischemic limbs not be debrided.[2,141] Debridement methods may be selective (removing only non-viable tissue).

For more information on debridement see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

4.2.3 Managing bacterial balance

Discussion: Bacterial balance is essential for wound healing.[143,144] Management needs to address the interaction between the individual and the infecting pathogen by optimizing the host response, reducing the number or virulence of micro-organisms in the wound and optimizing the wound environment including removal of slough.[90] Wound deterioration or failure to progress toward healing is an indicator of potential wound infection when other potential causes have been managed. Therefore, the rate of healing in conjunction with subtle or overt signs of infection can help to guide intervention decisions.[90]

Standard medical practice for osteomyelitis also includes a prolonged course of antibiotics of at least a six-week duration. If surgical intervention is planned, the infected bone should be resected prior to surgical closure.[145]

For more information on managing bacterial balance see Chapter 4: Prevention and Management of Wounds: An Overview[15] and the International Wound Infection Institute's Slough: Composition, Analysis and Effect on Healing.[142]

4.2.4 Managing moisture balance

Discussion: Moisture balance within the wound base can be achieved through dressing selection. Dressings should be selected according to the amount of available moisture within the wound bed and the cause of any excess of wound drainage. An increase in wound exudate may be the result of recurrent trauma, unmanaged co-morbidities, such as congestive heart failure, or wound infection. These comorbidities should be addressed. For more information on managing moisture balance, see: Chapter 4: Prevention and Management of Wounds: An Overview.[15]

4.3 Select the appropriate dressing and/or advanced therapy

Discussion: Research indicates that application of a prophylactic dressing can influence the microclimate of the wound and periwound area. In some cases, the construction of prophylactic dressings significantly influences moisture trapping and humidity close to the skin. Accumulation of moisture at the skin surface decreases the ability of some dressings to work effectively.[2] For some care settings, use of a prophylactic dressing may not be appropriate due to toileting preferences, incontinence (fecal and/or urine).

Emerging evidence suggests that a dressing with a slippery backing placed over areas at risk for pressure injury development may help to reduce friction and shear and lower the incidence of pressure injuries.[147]

A systematic review by Clark et al. studied the evidence regarding the use of prophylactic dressings for the prevention of pressure injury.[146] They report that several cohort studies, weak RCTs and case series all suggested that the introduction of a dressing as part of pressure ulcer prevention may assist to reduce pressure ulcer incidence associated with medical devices, especially in immobile intensive care unit patients. Silicone dressings, film and foam dressings have been studied for their use as a preventative measure to protect bony prominences for those at risk of pressure injury. Clark et al. commented on dressings for wound healing by stating they did not identify clinical evidence that one dressing type was more effective than other dressings. One identified RCT suggested that dressings can be of use for preventing wounds. This study found that the, "placement of a soft silicone foam dressing over the sacrum significantly reduced the incidence of pressure ulcers compared to similar patients who received preventive care but no dressing". The RNAO (2024) state: "that nurses and health providers apply multilayer foam silicone dressings as a prophylactic measure for individuals at risk of pressure injuries, in addition to other preventative care strategies. These dressings should be applied to specific at-risk body locations, considering the potential for shearing,friction, and pressure."[16]

Table 5: Additonal Therapies

Electrical stimulation therapy (EST)	EST has been demonstrated to be effective in enhancing the healing of recalcitrant Category/Stage 2, 3 and 4 pressure injuries.[16] There are 12 randomized controlled studies involving the study of a total of 404 subjects. No new trials were identified for this update. Ten of the 12 studies report that EST accelerated wound healing compared with subjects in the control group. The results of these clinical trials are to be combined in a meta-analysis.[148] Preliminary findings demonstrated a significant increase in closure rates of pressure injuries of EST compared with controls.[149] Meta-analysis identified 17 studies with 768 randomized participants that showed that EST could both reduce pressure injury area and accelerate the healing of pressure ulcers.[150]
Platelet-derived growth factor (PDGF-BB)	The clinical evidence on platelet-derived growth factor (PDGF) suggests that PDGF-BB may improve healing of pressure injuries. However, the evidence is not sufficient to recommend this treatment for routine use (cost).[2] In the past, three trials (RCTs) examined the impact of using PDGF on pressure injuries. Only one reported a significant increase in wound healing rate for chronic pressure injuries treated with PDGF-BB.[151]
Electromagnetic therapy (EMT)[2]	EMT could be considered a treatment for recalcitrant Category/Stage 2, 3 and 4 pressure injuries. The literature reports two randomized controlled trials (RCTs), involving 60 participants. Both trials compared the use of EMT with sham EMT, although one of the trials included a third arm in which only standard wound care was applied. The results of this review provided no strong evidence of benefit in using EMT as an adjunctive modality to treat chronic pressure injuries.[148] In addition, the RNAO state: "nurses and health providers, in collaboration with the person and their essential caregivers, consider using electrical stimulation for treatment of pressure injuries if the person meets indications and there are no contraindications".[16]
Negative pressure wound therapy (NWPT)[2]	The evidence for the use of negative pressure wound therapy with pressure injuries is not sufficient to recommend its use; more research is needed. In three studies, the wound improvement was similar with NPWT when compared with standard care.[152] NPWT may be considered in the preparation of pressure injuries prior to surgical closure, with the aim of reducing the wound surface area and to stimulate wound bed vascularization, but no RCTs have been published to support this application. As found in the Cochrane Review published in 2008 and reviewed in 2011, there are now seven trials (RCTs) that report the effects of NPWT on chronic wounds but only one on patients with chronic pressure injuries.[153] At present, there is no meta-analysis published on the effects of NPWT on chronic pressure injuries specifically. Recently the RNAO stated: "that nurses and health providers, in collaboration with the person and their essential caregivers, consider using negative pressure wound therapy for treatment of pressure injuries if the person meets indications and there are no contraindications."[16]
Ultraviolet light C (UVC)	One small RCT (n = 16) demonstrated that UVC combined with standard wound care generated a greater effect on wound healing of chronic pressure injuries[154] than standard wound care alone; however, no evidence exists to clarify whether UVC or ultrasound, used alone, exerts any beneficial effect.[155] One study reported a significant reduction in semi-quantitative swab results following a single treatment with UVC.[156] If one of the goals of care is to reduce bacterial burden in clean but critically colonized Category/Stage 3 and 4 pressure injuries, UVC may be considered but should not be used instead of other products, dressings or therapies to reduce bacterial burden.[2]

Warming therapy	Two RCTs support the use of the warming therapy or noncontact normothermic wound therapy (NNWT) in the treatment of chronic pressure injuries. Subjects received three treatments daily during which the dressing was warmed for one hour. The results of the two trials are similar and report an increased healing rate for the warming therapy group.[157,158]
Laser	Two trials (RCTs) on the use of laser as an adjunctive therapy in the treatment of chronic pressure injuries reported no difference between laser therapy and standard wound care, which presents a contradiction to what may be believed in clinical practice.[154,158]
Topical oxygen therapy (TOT)	Only one research study has been completed on the subject and it included only three patients.[159] Results showed a positive effect on the healing rate, but more research is needed to confirm that TOT is a useful adjunctive modality in the treatment of chronic pressure injuries.
Ultrasound therapy[2]	Three RCTs involving[146] subjects have been published on the use of ultrasound therapy in the treatment of chronic pressure injuries. Results showed no significant difference in healing rates between the ultrasound treated and the control group.[152,160]
Hyperbaric oxygen therapy[2]	Hyperbaric oxygen therapy is considered useful for ischemic wounds, but there is a lack of data concerning the correlation of this modality and the treatment of chronic pressure injuries. No RCTs on the subject have been found.[161]
Skin equivalents	The literature review did not find a single published RCT exploring the effect or benefit of skin equivalents on chronic pressure injuries. There is insufficient scientific evidence to support their use at this time.
Proteases modulating[2]	The literature review did not find a single published RCT exploring the effect or benefit of protease modulating products on hard to heal pressure injuries. For example, use of protease modulating products may be of benefit for chronic pressure injuries only when all underlying factors have been optimized.

Dressings/devices should be selected to contain wound exudate and maintain exudate off periwound skin with slight moisture at wound base.[83] It is also important to choose products that will prevent trauma or injury to fragile/friable tissue—including the periwound area—such as those that are silicone based or non-adherent.[78]

Dressing considerations for non-healable wounds may include the use of products that reduce moisture, bacteria and odour and are atraumatic to reduce painful removal and contribute to conservative debridement. The use of advanced active therapies is often contraindicated when goals are not related to healing.[28,84]

There are various categories of antimicrobial dressings, including antiseptics and products containing silver, honey, slow-release iodine and polyhexamethylene biguanide (PHMB). Topical antimicrobial dressings are to be discontinued once critical colonization has been corrected or if a beneficial effect is not evident after two to four weeks of use.[28, 84] Topical dressings exist to reduce matrix metalloproteinases (MMPs) and can be used in combination with topical antimicrobials or systematic anti-inflammatories/antimicrobials.[28,84]

Additional Therapies and Devices

Additional therapies and device options are available to promote PI healing.[2,16] Determining when to introduce additional therapies is a discussion that should include the patient, care partners and team.[28] A person with a hard-to-heal pressure injury may be a candidate for these therapies when other aspects of the treatment plan have been optimized. These are therapies that support, enhance or replace traditional therapies (see Table 5: Additional Therapies).

4.4 Engage the team to ensure consistent implementation of the plan of care

Discussion: Clear instructions to all care providers, including the person at risk or with a pressure injury, care partners and family are essential. The team should have the confidence to implement and maintain the individualized pressure injury prevention and treatment plan because they have the appropriate knowledge and training. Education on the

prevention and management of pressure injuries should be designed to incorporate the principles of age-specific learning and the level of information required by all team members. The mode of delivery must be flexible to accommodate the needs of the learner. To maximize retention of information and to facilitate translation into practice,[16] information needs to be presented at a level that is appropriate for the target audience.

Health-care providers may think they are addressing lifestyle factors by simply telling the patient they need to stop activities or stay in bed; however the best approach is to work with the individual to assist them to find ways to continue to participate in their life while managing pressure and shear forces.

Patients should also be encouraged to reposition themselves when they have the ability to do so. Education should include information regarding appropriate use of therapeutic surfaces, the roles of various health professionals, strategies to manage pain and discomfort, expected outcomes and duration of treatment, if known.[2,16]

Individuals with spinal cord injuries who have a wound often depend on informal care partners for follow-up and prevention, and health-care professionals in non-SCI specialties often lack the knowledge needed to manage pressure injuries in this specific patient group. Tailored education and peer support help self-managing individuals set boundaries, be assertive and cultivate a positive attitude when dealing with pressure injuries.[81]

Patient and Care Partner Resources

Wounds Canada
Pressure Injuries: The problem and the solution: Action is needed to prevent pressure injuries. Available at: https://www.woundscanada.ca/docman/public/1842-pressure-injuries-action-sheet-a-1595e/file

Caring for Pressure Injuries at Home. Available at:
https://www.woundscanada.ca/docman/public/patient-or-caregiver/1691-home-pi-care-1940e/file

Do It Yourself Skin Health Series.
All Types of Wounds, Pressure Injury, Incontinence Associated Dermatitis
Available at: https://www.woundscanada.ca/patient-or-caregiver/resources/diy-series

Wounds International
Pressure Ulcers and Skin Tone. Available at: https://woundsinternational.com/made-easy/pressure-ulcers-and-skin-tone/

Health-care professionals: Engaging health-care professionals in comprehensive, evidence-based educational skin and wound care programs is an essential component of effective pressure injury prevention and management. Programs need to be readily available and funded for health-care professionals, with implementation across the continuum of care[6,2] to ensure accurate, consistent and uniform assessment, treatment and management of pressure injury prevention programming for the interdisciplinary team.[44] RNAO (2012) has available an implementation toolkit to support uptake of best practice.[162]

This is important, as Magnan and Maklebust identified a relationship between scores on Braden subscales and nurses' selection of commonly used best practice interventions for pressure injuries prevention.[163] Their data analysis provided evidence that accurate risk assessment promotes increased attention to preventative measures, thereby reinforcing the importance of staff education programs focused on both accuracy of pressure injury risk assessment and aggressive preventative interventions.[163]

Education programs should outline the roles of health-care professionals in the prevention of pressure injuries, including skin inspection for signs of pressure injuries, skin care regimens, pressure management, reduction of friction and shear injuries, positioning and transfer techniques [44] and monitoring for poor nutritional status.[2,16]

Critical analysis and auditing of current practice and outcomes, formation of an interdisciplinary team, development of simple prevention protocols, selection of therapeutic pressure redistribution surfaces and mandatory staff training[164] have all been identified as essential for program success.

Detailed components of education for health-care professionals should include instruction on how to achieve accurate and reliable risk assessments by incorporating clinical judgment of risk factors, and how to conduct comprehensive skin assessments, including special assessment techniques for unblanchable erythema, especially for those with darker skin tones.[89] Education should also include the development of the integumentary system and the differences across the age span. The importance of documentation of all risk and skin assessments and the necessity for ongoing assessment to detect early signs of pressure damage are described as essential in ensuring accurate communication within the integrated team, providing evidence that care planning is appropriate and is serving as a benchmark for monitoring progress.[2]

Educational programs also need to include strategies to differentiate pressure injuries from other types of wounds and the appropriate use of a classification system, including the appearance of different tissue types. Training regarding repositioning strategies and the use and maintenance of pressure management devices is essential for all those involved in the prevention and care of pressure injuries, including the person at risk of or with a pressure injury.[2,44] Prevention programs should be structured, organized, comprehensive, sustainable and be updated on a regular basis to incorporate new evidence and technologies.[6] Integrating a process for continuous program improvement (including understanding the root cause) and evaluation into the planning process is essential.[165]

The creation of pressure injury prevention teams, use of champions to assist with local implementation of pressure injury prevention programs, establishment of goals for pressure injury reduction and maintenance of data on identification, prevention and outcomes assists facilities with the evaluation of their nursing practice based on nurse-sensitive indicators.[166] Identification of facility-wide barriers, including failure to consistently differentiate community-acquired versus hospital-acquired pressure injuries, is also important for the creation of successful pressure injury prevention and management programs.[165]

Additional quality improvement strategies to facilitate culture change should include health-care professionals in partnership with patient and care partners. Activities include, but are not limited to, involvement in skin-care-unit-based council meetings and activities, lectures, newsletters, informal one-on-one bedside clinical instruction, networking opportunities, positive feedback and reinforcement of learning.[6,167]

Technology-assisted education, including web-based training modules and resources, has been identified as an effective method to improve knowledge and the abilities of health-care professionals in pressure injury risk assessment and pressure injury identification and staging.[168]

Step 5: Evaluate Outcomes

Recommendations
5.1 Determine if the outcomes have met the goals of care

Discussion: Through the use of validated tools, the clinician can determine if the goals of the prevention or treatment plan have been met.[169] Prevention of pressure injuries is the ultimate goal; however, if wounds occur, signs of progress toward healing should be evident for most wounds within two weeks of treatment.[170]

5.2 Reassess patient, wound, environment and system if goals are partially met or unmet

Discussion: Goals of care such as the maintenance of skin health, pressure injury prevention and wound closure, quality-of-life issues and symptom control may not occur until all the underlying causes have been optimized. It is important to return to the assessment and recommendations and re-evaluate and potentially revise the treatment plan to address gaps and areas for modification. As well, at all transitions of care between health-care settings, it is important to reassess goals of care.

Reassess the patient, wound and environment: Validated and reliable tools that have been tested for responsiveness are essential in assisting the wound team in evaluating wound healing and other wound-related goals.[11] If wound closure is expected, goals should be based on the patient's condition and ability to heal. If there is no evidence of progress toward the goals within two weeks, a return to Step 1 of the Wound Prevention and Management Cycle (WPMC) reassessment of the patient and wound is required. Goals and plan of care may need to be adjusted based on the new assessment. Although rare, chronic pressure injuries that are not healing as expected can become malignant and form a Marjolin's ulcer. A biopsy of the wound during reassessment may be considered.[171]

Reassess the system: A root cause analysis (RCA) process, as recommended by the NPIAP, provides a systematic process to assist a facility to, "gain insight into the development of a pressure injury through a review of the timeline of events. In this case, using the PCA process could be used for all facility acquired pressure injuries."[170] Such a review can help to identify why a PI developed and what strategies, including improvement to the facility's skin management program, can be implemented to prevent further pressure injuries. The NPIAP emphasizes that an RCA is to be an opportunity for the team to look at all levels of their organization for improvement and for ways to lower risk.[170] The NPIAP also recommends that quality councils track trends using event forms such as the RCA, to identify and investigate facility acquired pressure injuries.[2] These trends can then be compared with similar facilities to assist with benchmarking.

Soban et al. (2016) identified five essential components of pressure injury prevention toolkits,[169] such as he Veterans Health Administration (VHA) Handbook (2019)[172] and the Agency for Healthcare Research and Quality[173] toolkit for PI prevention. These components include policy, committee/team, wound specialist/team, monitoring performance and staff education. Evaluation of these components on a regular basis is crucial to ensure pressure injury prevention program success and show improvement over time.

Evidence suggests that a well-designed pressure injury prevention program can reduce the incidence of pressure injuries in an acute orthopedic environment.[174]

Evaluation of prevention equipment, devices and supplies: All equipment, such as pressure redistribution surfaces and medical devices used by patients, needs to be regularly maintained and re-evaluated. These activities must be documented. Most equipment manuals will provide information on preventative maintenance requirements as well as the life expectancy of the equipment. The appropriateness of a well-maintained piece of equipment for a specific patient also needs regular evaluation. Ideally, this evaluation should occur annually or with any change in equipment/device.
Evaluation of supplies should also occur regularly. Cost effectiveness, rather than straight cost, should be considered in conjunction with patient satisfaction and care provider satisfaction. This has been of increased concern during the coronavirus pandemic where patient,[175] care partner, health-care provider and systems were under increased pressure.[176,178] More research is needed to understand the Canadian context.[178]

Evaluation of policy/programs: The RNAO has made the following recommendation for the evaluation of policies and programs: "Organizations must lead and provide the resources to integrate pressure injury management best practices into standard and interprofessional clinical practice, with continuous evaluation of outcomes".[16] The provision of, "organizational support", including identification of barriers to implementation, decision support tools, a communication mechanism and standardized metrics were identified as key to the successful implementation of pressure injury best practices.[16] Collaboration with the integrated team to support best practices and identify resources was also highlighted as an important component of quality management of pressure injuries.

Staff-to-patient ratios: During the coronavirus pandemic the risk of pressure injuries increased related to staffing challenges[179] and increased use of medical devices. Researchers found that low saturation of oxygen and several non-modifiable variables increased the risk of developing dependency-related injury.[175] Specifically, anterior pressure ulcers were related to proning and mechanical ventilation, and the use of invasive medical devices such as urinary catheters, feeding tubes and central venous and arterial lines,[180] and with longer lengths of stay.[179]

It is well documented that the ratio of patients to staff has also been identified as having an impact on pressure injury occurrence. A systematic review by Backhaus et al. found that the availability of more staff resulted in a decrease in pressure injury development.[181]

Prevalence and incidence studies using validated collection tools and focused audits have been identified as useful methods to monitor performance, interventions and outcomes, as well as embedding prevalence of pressure injury studies into assessment of risk/quality and professional practice.[182] Quality indicators such as those identified by national accreditation organizations should also be used to monitor outcomes.[6]

Review of patient records, and the use of administrative health databases such as the Discharge Abstract Database has not presented valid and reliable data about pressure injuries and often under-predicts prevalence rates.[183] It is recommended that more attention be focused on the quality of documentation of the data to enable the reliable use of the electronic patient record for data collection in the future.[6]

Evaluation of committee and teams: Quality reviews assist with the assessment of teams and culture. Sullivan identified key recommendations to prevent hospital-acquired pressure injuries with a "focus on accountability, continued measurement of performance, staff autonomy with interventions, consistency in staff training relating to documentation and recognition of front-line staff success".[75]

According to Bales et al., sustainability requires an environmental assessment to determine the existence of strong leadership, involvement of staff in decision-making and a desire of the team to develop and foster relationships.[78] Hospitals with a wound care specialist staff resource had a high association of successful performance monitoring, staff education and lower pressure injury rates. Further studies are needed to investigate the relationship between key operational components to prevent pressure injuries and the influence of a wound-care specialist.[172] Staffing should also be considered when evaluating a pressure injury program. Trinkoff et al. noted that higher turnover of CNA staff was linked to higher rates of pressure injuries.[184]

Organizational Culture: Successful pressure injury prevention programs require assessments of communication and routines. Niederhauser et al. recommend evaluating routine care and communication strategies to improve programs.[185] Evaluating practices and bundling common care activities can successfully assist care partners with prevention activities when added to routine practices already built into their day.

The Attitude towards Pressure ulcer Prevention instrument (APuP) may help to illuminate some of the barriers to prevention. This instrument has been designed to measure five factors:[186,187]

1. Attitude toward personal competency to prevent pressure ulcers,
2. Attitude toward the priority of pressure ulcer prevention,
3. Attitude toward the impact of pressure ulcers,
4. Attitude toward responsibility in pressure ulcer prevention,
5. Attitude toward confidence in the effectiveness of prevention.

With appropriate, multifaceted education, adherence to guidelines increases.[188] Paquay et al. also found that while almost all recommended prevention strategies were implemented, repositioning in bed and in the armchair decreased significantly, likely because the nurses mistakenly believed the pressure management materials in place were sufficient and, therefore, repositioning was unnecessary. Knowledge of pressure injuries and pressure injury prevention is not enough—the attitudes of nurses toward pressure injuries are significantly correlated with the implementation of prevention activities.[188]

Evaluation of education programs and the health-care team: Interdisciplinary education should be standardized and reviewed for application of knowledge.[16] The RNAO recommends pre- and post-assessment of knowledge related to pressure injury prevention. Assessments of knowledge transfer to practice should be assessed through audits and case study exercises. Recommendations related to frequency or timing of post evaluations are lacking in the literature. The RNAO recommends post-test assessment of knowledge, attitudes and skill to reinforce previous learning.[16]

The Pieper Pressure Ulcer Knowledge Test (PPUKT) is a valid and reliable tool to assess knowledge of pressure injury prevention and management and has been in use since 1995.[189] In 2014, Pieper and Zulkowski added improvements to their test and renamed it the Pieper/Zulkowski Pressure Ulcer Knowledge Test (PZ-PUKT); however, this has not been tested for validity and reliability.[97]

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Discussion: Sustainability of an individualized pressure injury prevention protocol or maintenance of a healed pressure injury is dependent on access to appropriate equipment and services, collaboration among the person with or at risk for a pressure injury, their care partners, service providers and the interprofessional team of health-care professionals and other care and service providers. This is especially important with any transitions of care. During these times patients, care partners and health-care providers all benefit when clear communication is used to reiterate focus on pressure injury prevention and the current plan of care.[53,190] Ongoing evaluation, as well as clear, effective communication regarding the plan and follow-up, is required by all involved across the continuum of care.

At the system and institutional levels, successful sustainability of pressure injury prevention programs was described by Bales and Padwojski as dependent on strong leadership and management skills to identify prevention as a key priority within organizations and promote the involvement of staff in decision-making and interdisciplinary participation to ensure optimal outcomes.[78] In addition, a systematic review by Sullivan et al. identified that measures of performance, such as conducting quarterly prevalence studies and continually monitoring all hospital-acquired pressure injuries, were key components to sustaining improvements.[75] Prompt identification of pressure injuries that fail to progress to sustained closure is essential for reassessment and evaluation of the treatment plan. As well, a rapid response to Category/Stage 1 injuries, including pressure management strategies, will provide a sustainable, cost-effective model to support improved outcomes.

Conclusion

Prevention of pressure injuries is of paramount importance in any health-care setting.[2,16] Despite a focus on prevention to date, pressure injury incidence rates have not significantly decreased. An integrated approach focused on prevention is required across all areas of health-care systems to make a significant difference in incidence rates. For optimal acceptance and effectiveness, integrated teams need to include other departments, such as purchasing and housekeeping, and be driven by well-informed patients, care partners and their families. Collaboration and communication across all departments and sectors of care are vital to ensure that outcomes are optimal.

Immediate implementation of pressure management strategies has been shown to be effective when a Category/Stage 1 pressure injury is identified, yet our systems may not be set up to support this rapid response, even though it is important they be structured to facilitate it. It is also important to return to the basics of prevention: look at all surfaces upon which the person at risk for, or with, a pressure injury sits or lies, as well as at transfer techniques during all points of care, such as in acute care, operating and interventional room tables, emergency room stretchers, ambulatory departments, rehabilitation settings, community and long-term care. Focusing on treating the potential causes of pressure injuries is essential, while at the same time remembering that not all pressure injuries are preventable.[42]

In all cases of injury prevention or management, customized plans of care should be implemented. The use of metrics to monitor clinical outcomes is essential to drive culture and practice changes that may be necessary to prevent and manage pressure injuries. Identification of facility barriers and implementation of strategies to resolve these issues are imperative to support the changes required.

Pressure injury prevention and management have now been recognized as measures of quality by Accreditation Canada in both long-term care and hospitals, and national hospital pressure injury rates are being reported, with facilities being named.

It is time to ensure that pressure injury prevention becomes a critical component of all aspects of safe patient care. Prevention is key!

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Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 8

Prevention and Management of Burns

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INTRODUCTION



Burns are injuries to the skin that occur when the skin or other tissues are damaged by contact with heat from, "friction, cold [frostbite], heat, radiation, chemicals or electrical sources, but the majority of burn injuries are caused by heat from hot liquids, solids or fire."[1]

Burn injuries can be devastating and, without appropriate treatment, can result in slow healing, infection, scar formation and disfigurement, contractures, joint dysfunction, pain, as well as poorer mental health, well-being and quality of life (QoL).[2] Burn victims may have to have multiple surgeries, undergo grafting, wear compression garments for several years and live with physical disability, body image disturbance, disfigurement and emotional and employment (schooling, training) challenges. Infants and children are increasingly vulnerable as they are growing, and the burn scarring and skin contracture lead to long-term care needs.[3]

Worldwide, burns are among the leading causes of death of young people. In 2023 the World Health Organization (WHO) listed fire-related burns as more common in adult women and the fifth most common cause of non-fatal injuries in childhood, often linked to lack of adult supervision and child maltreatment.[4] Globally, most children with burns are boys, who also have a higher mortality rate related to burn injuries. The WHO links the risk of death from injuries such as burns with poverty, noting a pattern of injury-related deaths in many low- and lower middle-income countries.[5] The reasons for this include unsafe living and working conditions, lack of focus on prevention efforts and poor access to high-quality emergency trauma care and rehabilitation services.[4]

In 2021, Statistics Canada explored the mortality and morbidity related to fire, burns and carbon monoxide poisoning among First Nations, Métis and Inuit people using findings from the 2011 Canadian Census Health and Environment Cohort.[6,7] They reported higher rates among First Nation people than non-Indigenous persons, confirming previous reports. In Canada, this is reflected in the disproportionate age-standardized rate (2001–2006) of hospitalizations for fire-related injuries (excluding Quebec, population aged 0–19) in areas where at least 33% of the population reported a First Nations or Métis identity, especially First Nations and Métis children aged 0–9 and First Nations children aged 10–19.[8]

Although the age-standardized rate of emergency room visits and hospitalizations related to fire/burn injuries in Canada has declined over time, burn injuries continue to be a concern. In Canada, from 2011 to 2020 there were approximately 220 fire-related deaths reported each year,[6] slightly less than the 234 deaths reported in 2010 (See Table 1). More research is needed on persons who sustain burns related to substance use (alcohol, cocaine, marijuana), when judgment and decision making may be altered or impaired. Williams et al. report these patients (n=3,476) experience increased length of hospitalization and use of intensive care services.[9]

Table 1: Fire/Burn Injury Morbidity/Mortality in Canada, 2022[10]
https://parachute.ca/en/professional-resource/cost-of-injury-in-canada/the-human-cost-of-injury/

Description (Cases)	Deaths	Hospitaliza-tions	Emergency Room Visits	Disability (all ages)
Fire/Burn Injuries	162	2,193	51,904	386
Total Injuries	17,475	231,530	4,555,865	61,400
Percentage	0.93	0.94	1.14	0.63

In 2017, a search of the electronic Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) database for emergency department visits revealed that just over half the burns sustained in 2013 were scalds (52.3%), followed by contact with hot objects (29.9%), fire, flames, smoke (11%), electrical (4.7%), electrical (1.4%), and sun (0.7%) (See Figure 1).[11]

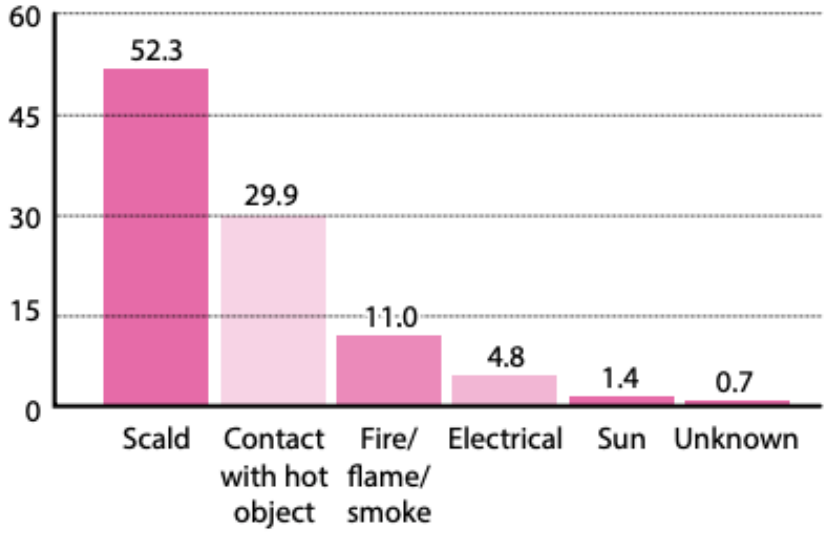


Figure 1: Distribution (Percentage) of Burn Injuries by Cause, 2013

While the overall proportion of burns was slightly higher among females, with females experiencing scald-related burns more often than males, males experienced burns from hot objects, fire/flame/smoke, electricity and the sun slightly more frequently than females (See Figure 2).[11]

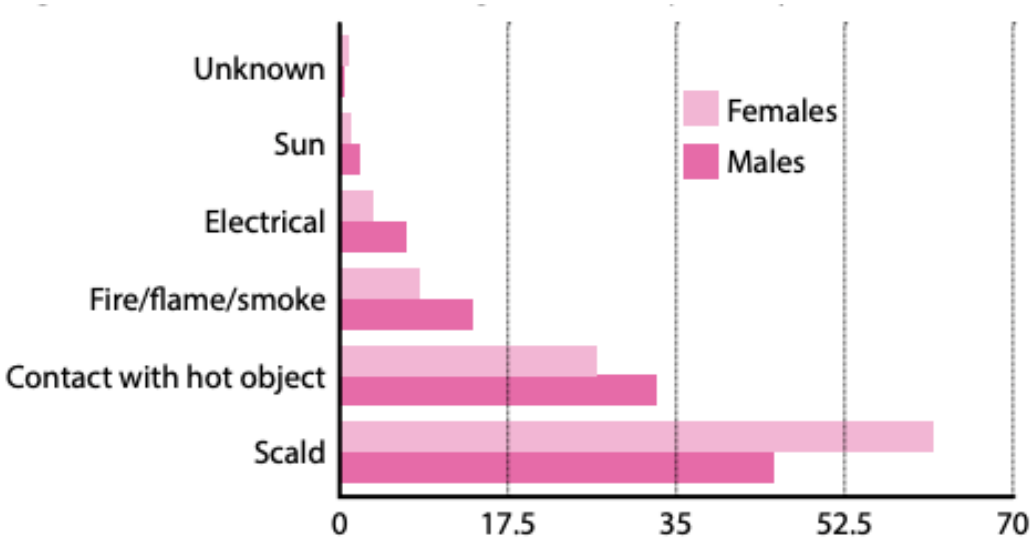


Figure 2: Distribution (Percentage) of Burn Injuries by Cause and Sex, 2013[11]

Residential fires, recorded and analyzed in the Canadian National Fire Information Database, are one cause of heat-related burns. Between 2005 and 2015 there were approximately 7,130 residential fires per year in Canada, with a total of 830 non-firefighter deaths and 4,656 injuries.[12] Of these fires, just over two-thirds had no present and/or functioning life-safety system (e.g., smoke alarm and/or sprinkler protection); these fires resulted in 80% of deaths. Residential fire deaths most often involve persons who are males, older adults, children under the age of five and Indigenous individuals.

In Canada, burns are the fifth leading cause of serious work injury. In 2013, 5.7% of people aged 15–74 who experienced a serious injury at work sustained a burn, scald or chemical burn.[13]

A retrospective study of 1,427 patients admitted to a regional burn centre at a university teaching hospital in Ontario, Canada, reported that, of the 23% admitted between January 2001 and December 2010 for work-related burns, the mean age was 40.5 + 11.9 years, 95% were males, and 69% were from the immediate urban area. Work-related burns in this study also predominantly affected the upper extremities, head and neck, with the most common causes being flame (32.7%), electrical (27%) and scald (19.7%), and the most common groups affected being manual labourers (44.5%) and electricians (13%). The most severe burns were associated with truck drivers, who, because of motor vehicle accidents, sustained flame or tar burns.[14]

Burn injuries are not only a burden in Canada due to mortality and morbidity, they also place a strain on health-care resources (acute, rehabilitation and community). In 2018, the total injury costs related to fire/burns in Canada was $299 million, with the direct costs (health-care costs) being $201 million and the indirect costs $89 million (costs related to reduced productivity, disability and premature death).[10] (See Table 2)



Table 2: Total costs of burns in Canada in 2018 by age category, both sexes[10]

Age Category	Total costs in millions
Children 0–14	$54
Youth/ young adults (15–24)	$43
Adults (25–64)	$164
Seniors (+65)	$37

This document is written with the intent to encompass the quintuple aim for health care improvement. This is to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity. This equity piece is particularly important for patients living with skin issues, wounds and specifically burn injury. Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers (See Table 3).[15]

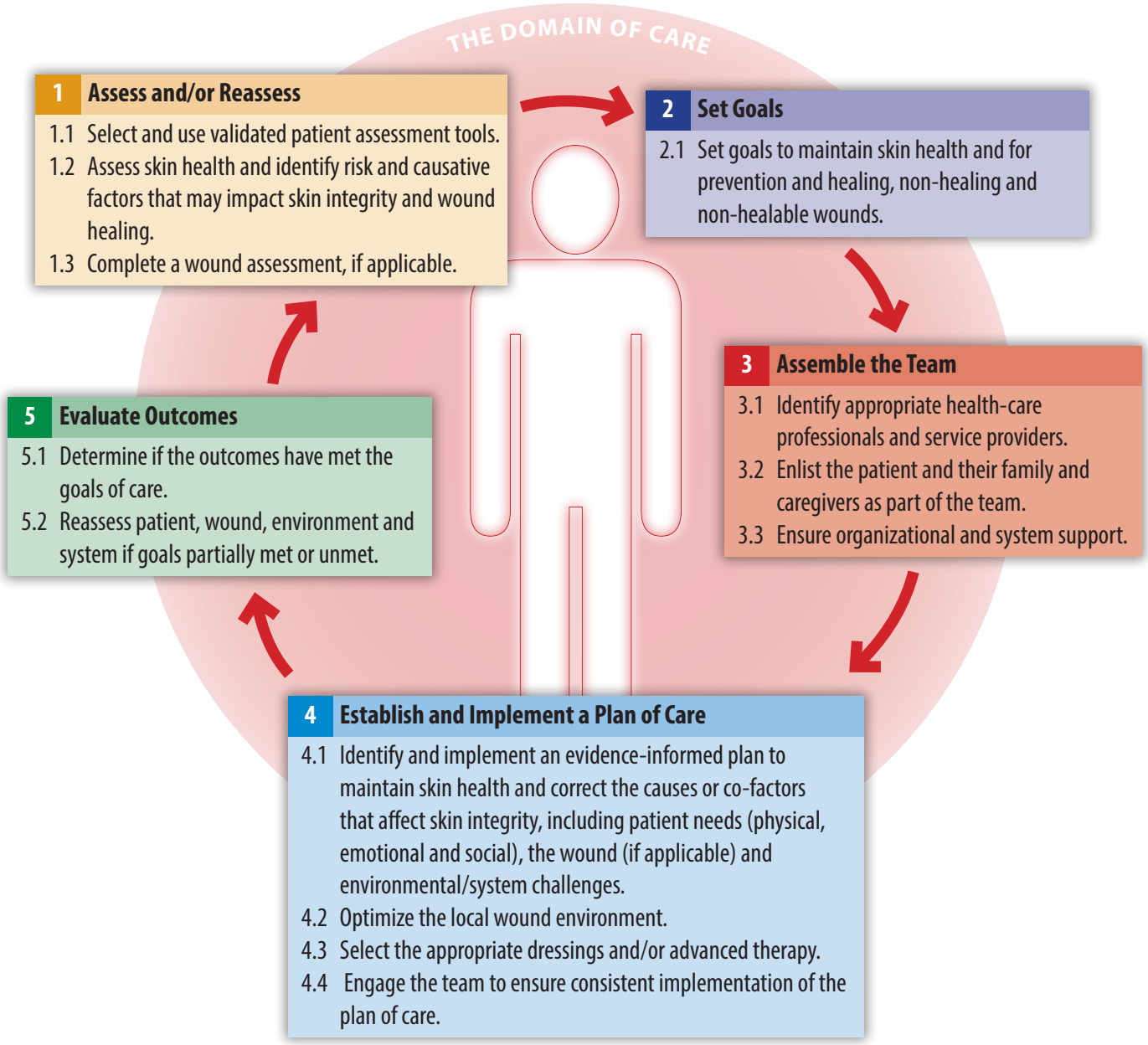
Table 3: Quintuple Aim and Management of Burn Injury

5 Components	Applied to Burn Injury
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practice to ensure most effective treatment Appropriate use of resources - prevention strategies in homes, workplace and community; screening, burn prevention, dressings, compression garments
Advancing health equity	Application of principles to all those at risk for, or affected by, a burn injury
Care team well-being	Providing clinically usable information for front line clinicians
Enhancing the patient experience	Providing a supportive process of care for all those living with a burn injury

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide that incorporates the best available evidence. It outlines a process, or series of consecutive steps, that supports patient-centred care using the Wound Prevention and Management Cycle (See Figure 3), which guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of burn injuries, from the initial assessment to a sustainable plan targeting self-management for the patient.

Figure 3: The Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence and are intended to support the clinician, the patient, care partners, their family and the health-care team in planning and delivering the best clinical practice. Two foundational chapters supplement this chapter with additional evidence-informed information and recommendations that are general to all wound types: Chapter 3: Skin: Anatomy, Physiology and Wound Healing[17] and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[16]

There are three guiding principles within the best practice recommendations (BPRs) that support effective prevention and management of skin breakdown:

1. The use of the Wound Prevention and Management Cycle, regardless of the specifics, to prevent and manage skin breakdown,
2. The constant, accurate and multidirectional flow of meaningful information within the team and across all care settings, and
3. The patient as the core of all decision making.

Step 1: Assess and/or Reassess



Recommendations
1.1 Select and use validated patient assessment tools

The use of validated and standardized patient and risk assessment tools is essential for identifying factors that may impede healing and quality of life and for providing direction for preventative care or management.[17] Most existing validated tools are for use with the adult population.

Discussion:
Burn size: The total burn area is expressed as a percentage of the total body surface area (TBSA). The most common methods used to estimate the TBSA involved in a burn injury include palmar surface, the Lund and Browder chart and the Wallace Rule of Nines. These tools are further discussed in Recommendation 1.3.

Hand burn severity: Although the surface area of the hand is relatively small compared with total body surface area, the functionality of the hand is significantly important in the completion of activities of daily living, and thus hand burns are considered major. The importance of the hand was demonstrated when the universal Hand Burn Severity (HABS) score was devised and validated to quickly describe the severity of a hand burn injury.[18]

Mortality risk assessment: Prediction of mortality secondary to burn injury is useful, as knowing a patient's projected mortality may improve triage and help to identify the most appropriate plan of care. The FLAMES score is an example of a validated tool that can predict burn-injury-related mortality of patient populations of similar characteristics, e.g., age or sex.[19,20] Frailty is also a predictor of adverse outcomes for patients with burns.[21]

Anxiety assessment: Anxiety experienced by burn patients is often related to pain-producing situations, such as confrontation with wounds, dressing changes and surgical procedures.[22] The Burns Specific Pain Anxiety Scale is a valid and reliable tool that provides a standardized assessment for identifying burn patients with feelings of anticipatory anxiety and worry who require further assessment and intervention.[23] In a recent review, researchers discuss the role of massage therapy in pain and anxiety reduction.[24]

Quality-of-life assessment: Burn injuries that are extensive, slow healing, disfiguring, painful or that result in contractures and/or joint dysfunction may cause psychological stress and significantly impact the patient's quality of life.[22] Use of a validated quality-of-life (QoL) assessment tool may be beneficial to identify potential barriers and patient lifestyle issues that may interfere with positive participation in the plan of care. Examples of validated tools to assess burn-injury-related QoL in adults include the following:

- Burn Specific Health Scale—Abbreviated,
- Burn Specific Health Scale—Revised, and
- Burn Specific Health Scale—Brief (BSHS-B).[25]

For the pediatric population, burn-related QoL tools include the range of age-specific Burn Outcomes Questionnaires[25-27] and the series of Health Outcomes Burn Questionnaires (for children aged 0–5 years and 6–17 years).[27,28]

Coping assessment: Burn patients undergo extreme physical and psychological stress. Bosmans et al. (2015) state burn survivours live with symptoms of, "acute stress disorder (ASD), post-traumatic stress disorder (PTSD), anxiety, depression, as well as delirium and problems with sleeping, and frequent nightmares are commonly experienced."[29] To promote recovery after hospital discharge, patients must be equipped with productive coping skills. The Coping with Burns Questionnaire was developed to measure coping (re-evaluation/adjustment, avoidance, emotional support, optimism/problem-solving, self-control and instrumental action) of adult burn patients after discharge.

Empowerment: Empowerment is an important aspect of emotional care. Shorke et al. (2024) in a large study with 80 adult burn survivours that were, "randomly divided into an intervention group, receiving the psychosocial empowerment program, and a control group, continuing standard care". The program used various tools to measure a range of elements, such as satisfaction with appearance, coping abilities and symptoms of post-traumatic stress disorder (PTSD). "The intervention focused on enhancing resilience, self-efficacy, and adaptive coping, through targeted skill building in stress management, adaptability to coping, social reintegration, emotion regulation, and problem-solving. Participants in the intervention group demonstrated significant improvements in body image satisfaction, coping abilities, and symptoms of PTSD compared to the control group."[30]

Scar assessment: Scar assessment scales provide a systematic approach for assessing and documenting scar quality and evolution and are valuable instruments in the clinical evaluation and follow-up of scars. Examples of validated scar assessment scales include the following:

- Matching Assessment of Scars and Photographs,[31]
- Patient and Observer Scar Assessment Scale,[32]
- Satisfaction with Appearance Scale[33] and
- Vancouver Burn Scar Assessment Scale.[34]

Wound assessment tools: Assessment of any wound and documentation of findings also requires a standardized approach using a comprehensive, validated and reliable wound assessment tool. Such tools not only provide a baseline of wound characteristics, but also identify wound change over time, which helps determine if a wound is progressing toward closure or is deteriorating. Currently, there are no burn-specific wound assessment tools.

Pain assessment: Pain assessment tools provide a systematic approach for assessing and documenting pain as well as the factors that are causing or exacerbating wound-related pain. The accurate assessment of pain is essential to ensure patients experience effective pain management. Currently, there are no burn-injury–specific pain assessment tools. Examples of validated pain assessment tools that could be used to assess for burn-injury pain include the visual analogue scale, the numeric rating scale, the verbal rating scale, the Brief Pain Inventory and the McGill pain questionnaire.[35]

Nutrition screening: Nutritional screening tools provide a standardized approach for identifying patients who are at risk of compromised nutrition and who require further nutritional assessment and intervention. Currently, there are no burn-injury-specific nutritional screening tools. Examples of validated nutritional screening tools that could be considered for use with patients with burn injury include the following:

- Subjective Global Assessment,
- Malnutrition Screening Tool,
- Nutrition Risk Screening-2002,
- Malnutrition Universal Screening Tool,
- Subjective Nutrition Assessment Questionnaire and
- Canadian Nutrition Screening Tool.[36,37]

Wound and pain assessment and nutrition screening tools are discussed in detail in
Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.

1.2 Assess skin health and identify risk and causative factors that may impact skin integrity and wound healing

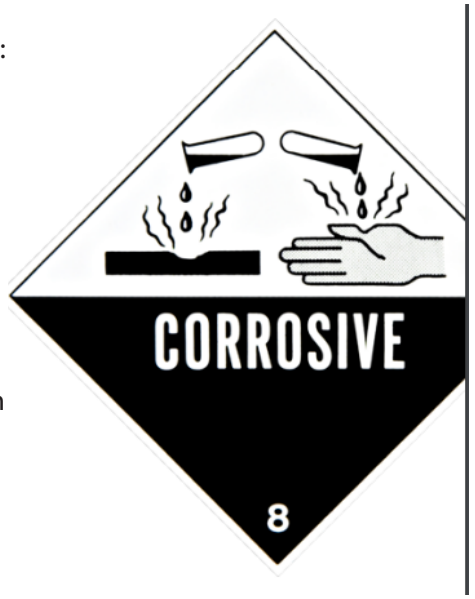
Discussion:
Risk assessment: Different populations have statistically higher or lower risk for different types of burn injuries. Table 4 reflects the highest proportion of burn injuries by age, sex and cause in 2013. Injury statistics were obtained from the database of the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP), Public Health Agency of Canada.[11]

Table 4: Highest Risk for Burn Type by Age and Sex[11]

Burns Cause	Most at Risk (by Age and Sex)
Scalds: Includes contact with hot water, steam, food, oil, grease, liquid glue or liquid wax	Children under 1 year
Fire, flame, smoke (highest proportion)	Males aged 50–64 Females aged 20–29
Fire, flame, smoke (highest count)	Males aged 15–19
Sunburns (highest proportions)	Males/females aged 20–29
Electrical (highest proportion)	Males under 1 year Males 20–29 years
Electrical (highest count)	Males aged 2–4 years

The CHIRPP database revealed the two most common overall causes of burn injuries are:

Scalds: hot beverages (34.1%) and hot water (not tap water) (28.9%) and
Contact burns: stoves/ovens (22%) and fireplaces/accessories (19.6%).



Common causes of electrical burns (tissue damage caused by the heat energy of an electrical current flowing through the body) in children are electrical and extension cords and wall outlets. Adults most often experience electrical burns both at home and at work caused by electronically powered devices.

Most chemical burns result from workplace-related injuries; however, those that occur in the home are most often the result of exposure to corrosive agents. Common alkali substances in the home that may cause burn injury include: cleaning products (ammonia), drain cleaners (caustic soda), oven cleaners,plaster or cement (lime) and fertilizers. Common acidic substances in the home that may cause chemical burns include: glass polish (hydrofluoric acid), vinegar (acetic acid) and nail polish remover (acetic acid).

Patients using home oxygen therapy and smoking cigarettes are at a higher risk of inhalation injury and longer hospitalizations.[38] Recent rises in substance use have increased risks of burn complications, length of hospital stay and use of critical care services.[39-41] As well, the medical equipment (polyvinyl chloride products in nasal cannulas) contribute to intense flames in the facial area. Therefore, home safety education is essential.[42]

For children, most burn injuries occur in the home, whereas adults most commonly experience burns in the home, outdoors or in the workplace. In addition, although children and the elderly are most vulnerable to burn injury, those who cannot recognize or react to a dangerous burn-risk situation are at increased risk for burn injury, including persons with:

- Cognitive or mental impairment,
- Impaired mobility and sensation and
- Musculoskeletal or nervous system disorders.[43]

People with mental illness are also vulnerable to burn injury. In their retrospective study of patients 16 years and older admitted to hospital in Ontario, Canada, and treated for a major burn injury (April 2003 to March 2011), Mason et al. observed that in a three-month period immediately preceding the burn there was a greater number of emergencies related to mental health issues.[44] These authors further stated that, "mental illness is an independent risk factor for unintentional injury and injury recidivism"... "the treatment of mental illness might be an important target for burn prevention efforts".[44]

Although there is no comprehensive tool available to assess one's general risk of burn injury, the statistics noted could aid one in developing a prevention plan (individual, community) based on age, sex and environment.

1.2.1 Patient: Physical, emotional and lifestyle

Discussion: Assessment – Primary Survey: All people with burn injuries requiring or receiving assessment by a health-care professional should be evaluated first using the ABCDEF mnemonic, listed in the order of priority, to identify any life-threatening injuries.

Airway: Assess for airway obstruction and for injuries that are physically restricting breathing, e.g., a burn or fracture to the jaw area, a circumferential burn around the chest or a lung penetration injury secondary to an explosion.

Breathing: Evaluate breathing and ventilation. Watch for chest movement, auscultate and percuss to detect any conditions impeding ventilation, e.g., hemothorax, pneumothorax or flail chest. Observe for the signs of smoke inhalation, including facial burns and swelling, singed nasal hairs, blackened sputum, hoarseness of voice and respiratory distress. Romanowski, et al. (2016) reported that more than one-third of intubations in patients then transferred to burn centres were unnecessary.[45] More research is needed to determine when intubation is needed. Ching et al. stated that singed nasal hair, carbonaceous sputum and facial burns were not automatic predictors of the need for intubation.[46] Again, more research is needed. In a recent study, Flinn et al. (2023) recommend repeated assessment of respiratory status.[47] PF ratio and bronchoscopy are the only modalities that can determine severity of inhalation injury.[48]

Upper Gastrointestinal Burns: Ingestion of caustic materials may cause chemical burns to the oropharynx, tongue, esophagus, stomach and duodenum. Laryngeal edema may occur, producing upper airway obstructions.

Circulation: Assess for signs of bleeding, hypovolemia and burn shock, e.g., low blood pressure and body temperature, rapid/weak/thready pulse, rapid breathing, cool/clammy/pale skin, confusion/anxiety/weakness and unconsciousness. Pulse oximetry can be used to quickly measure oxygenation of hemoglobin. If burn shock is suspected or the burn is of an electrical origin, consider the need for a 12-lead electrocardiogram, cardiac enzymes and continuous cardiac monitoring. In hospital, burn shock can be further evaluated using blood work (complete blood count, packed cell volume, urea and electrolyte concentration, clotting screen, arterial blood gases, blood group and save or crossmatch serum), echocardiogram, endoscopy, urinary catheterization (to measure output) and cardiac catheterization depending on the suspected severity of the burn injury. Chest, pelvic and lateral cervical spine x-rays, ultrasounds and CT scans may also assist with identification of injury secondary to blunt trauma.

Disability: Complete a neurological assessment to establish the patient's level of consciousness (using a valid and reliable tool like the Glasgow Coma Scale), pupil size/symmetry/ reaction and evidence of spinal cord injury or compartment syndrome. Symptoms of acute compartment syndrome include a new and persistent deep ache in a limb, numbness/ tingling/ electricity-like pain in a limb, swelling, tightness and bruising. Abdominal compartment syndrome may present as a tense, distended abdomen, low blood pressure, poor or absent urine output and abdominal pain with palpation. Blood work, ultrasound and use of a pressure monitor can help confirm the diagnosis.

Exposure: Expose the patient's skin to determine the area of burn injury more accurately (this will be discussed in the secondary survey). All clothing and jewellery (especially rings, watches and bracelets with hand/arm burns) must be carefully removed to visualize the burned area and avoid the 'tourniquet-like' effect of constricting items left in place when the resulting tissue edema increases.



Fluid resuscitation (to be discussed in Step 4: Establish and Implement a Plan of Care).

Assessment – Secondary Survey: Once the primary survey has been completed and resuscitation is successfully underway, the secondary survey should begin. The secondary survey consists of:

- A head-to-toe examination to rule out secondary injuries,
- A systematic and detailed history of the patient's general health,
- Identification of specific issues related to the burn injury and
- A wound (burn injury) assessment (first responders should avoid putting any products on the burn before the medical assessment is completed).

Minor Burn Assessment: Not all burns require assessment by a health-care professional. If a person has experienced a small (e.g., less than [<] 1% TBSA) minor superficial burn, e.g., a sunburn, or superficial partial-thickness burn that does not involve the face, eyes, ears, hands or perineum, that does not impede joint function, that is not caused by electricity or chemicals and that does not involve an inhalation injury, self-management may be appropriate. Those who are immunocompromised or medically complex, who cannot identify infection and complications and those who do not know when to seek medical attention, or do not have the physical ability to self-treat, should seek assessment by a health-care professional.

Common secondary injuries that may present as the result of a major burn include:

- Upper gastrointestinal (GI) erosions and ulcers/Curling's ulcer (which usually present clinically with painless GI hemorrhage),
- Myoglobinuria and acute renal failure (manifested by an elevated serum creatinine and a fall in creatinine clearance),
- Sepsis,
- Venous thromboembolism and
- Microangiopathic hemolytic anemia.

If the patient has experienced a chemical burn, it is important to consider the systemic effects of the absorption of the chemical product.

Heterotopic ossification is a less common burn injury complication, associated with larger burns located (most often) adjacent to the elbow joint. While rare, the rehabilitation implications of heterotopic ossification can be severe and should be considered in situations of increased pain and range of motion losses.[49]

As previously mentioned, patients with burns that are the result of fire or flame may have an associated inhalation injury and/or carbon monoxide poisoning, which must be assessed for. Cyanide toxicity is also a systemic sequelae of inhalation injury.[50] Patients presenting with electrical burns may also have bone fractures, spinal cord injury, peripheral nerve injury, neurophysical complications, electrocardiographic alterations, amputation and or visceral injuries.[51] Peripheral nerve injuries (commonly affecting the median, ulnar and peroneal nerves) are associated not only with electrical burns, but with large, major burns, and in patients who are on mechanical ventilation or in hospital for longer periods of time, or who have increased surgical requirements.[52] Peripheral nerve injuries can happen acutely, but also often develop in the first weeks post-injury. Serial screening for sensory or motor changes, especially in higher risk patients (as previously noted), should be considered.

A detailed patient history should identify comorbidities that may interfere with healing and/or impair immunity, including diabetes mellitus, peripheral arterial disease, collagen vascular diseases, organ transplants, cancer and psychological factors. Choice of treatment may also be dependent on comorbidities, such as choice of oxygen therapy concentration in patients with chronic obstructive pulmonary disease. In their assessment clinicians also need to gather information on known allergies, current medications (prescription and non-prescription), lifestyle choices (e.g., smoking, substance use, level of physical activity, participation in high-risk activities), vocation and avocation, level of physical functioning (including mobility, gait, fatigue, eyesight, hearing, activities of daily living and use of assistive devices), hydration and nutrition, spiritual health and psychological functioning (e.g., behavioural conditions, cognitive ability).

In addition to a nutrition-related blood screen, validated nutritional screening tools, such as those noted in Recommendation 1.1, provide a standardized approach for identifying patients who are at nutrition risk and who require further nutritional assessment and intervention.

The secondary survey should also identify the events preceding the burn injury. Circumstances of the injury should be explored, as care and outcomes can be influenced by the timing and mechanism of injury, duration of exposure to the burn agent and first-aid measures provided. Non-accidental injuries must be considered when the patient's history does not match with the observed injury or if there are inconsistencies with the history provided. Young children,[53] the elderly and people with cognitive impairment are at risk for non-intentional burn injuries.[54]

If non-accidental injury is suspected, health-care providers are mandated to report to the appropriate authority, e.g., children's aid societies, provincial/ territorial ministries of health, retirement home regulatory authorities, police.[55] Note that comorbid conditions may have contributed to the burn injury—for example a person having a stroke while boiling hot water. Social workers may play a role in the investigation, and clinicians need to be aware of the reporting of abuse in the health system in which they are employed.

The mnemonic AMPLE can be used as a reminder of pertinent patient history information that must be collected during the secondary survey.

Allergies
Medications
Previous illness, past medical history, illness/pregnancy
Last meal or fluid intake
Events preceding injury (such as exposure to chemicals, toxins or radiation because, "exposure to chemical agents can cause pulmonary, cardiac and other internal organ dysfunction, or hazardous environment can pose a threat to the health".[56]

Pain assessment: Burn-injury-related pain involves both peripheral and central processes and may present with the combined features of acute nociceptive and inflammatory pain (presenting as sharp, aching or throbbing sensations) and neuropathic pain (initially presenting as shooting, lancing, burning, electric shock, squeezing, throbbing, and knife-like sensations and allodynia, and later presenting as numbness, tingling and prickling sensations).[57] The background burn pain experience, which may fluctuate, is not only dependent on the mechanism of the burn injury, burn depth and burn size, but may be influenced by the presence of inflammation and/or infection.

Patients with burns may also suffer from incident, procedural or operative wound pain. Incident pain may occur during the normal day-to-day activities of the patient and may result from otherwise benign activities like standing or sitting, turning, walking, coughing or laughing. Procedural pain is pain experienced during procedures, such as dressing changes, wound debridement and other wound treatments. Like procedural pain, operative pain is the result of procedures complex enough to require anesthesia, such as major burn injury dressing changes. The burn injury-related pain experience is also influenced by biologic, psychosocial, spiritual and environmental factors, which must be assessed for, and that may include:

- Biological factors: genetics, sex and endogenous pain control,
- Psychosocial factors: anxiety, stress, depression, coping skills, behaviour and cognitive status and spiritual resources and
- Environmental factors: lifestyle, employment type, socialization, cultural background and life traumas.

Validated pain assessment tools, such as those noted in Recommendation 1.1, provide a standardized approach for identifying, assessing and documenting the factors that are causing or exacerbating burn-injury-related pain, so that appropriate interventions can be implemented to ensure patients experience effective pain management.

Quality-of-life (QoL) assessment: Burn injuries may have profound physical/aesthetic, psychological, social and vocational (schooling) and/or employment consequences. Individuals with burn injuries may have to cope with itching, tightness to skin and changes to functional ability. To optimize the rehabilitation of a patient with a burn, it is important to assess the predictors of health-related quality of life (HRQL). A recent systematic review (2018) found the following poor HRQL predictors related to burn injuries: burn severity (greater length of hospital stays, burn size, depth of injury and number of surgeries), post-burn depression, post-traumatic stress symptoms, avoidance coping, less emotional or social support, higher levels of neuroticism as well as unemployment post-burn injury. Additionally, weaker predictors of poor HRQL related to burn injuries include pain, a post-burn substance use disorder, and being female.[58]

Validated burn-injury-related anxiety scales, QoL assessment tools and coping questionnaires, such as those noted in Recommendation 1.1, provide a standardized approach for identifying potential barriers and patient lifestyle factors that may interfere with positive participation in the plan of care and identify patients in need of extra rehabilitation care.

1.2.2 Environmental: Socio-economic, care setting, potential for self-management



Discussion: Closely linked to the quality-of-life assessment, an environmental assessment that incorporates an assessment of the social determinants of health is essential in determining if the patient has the care partner and/or family and socio-economic support needed to meet any goals of care that may be considered. Determinants that should be assessed include income, employment and working conditions, food security, environment and housing, early childhood development, education and literacy, social support and connectedness, health behaviours and access to health care. For example, a study of the global burden of child burn injuries showed that most preventable burn injuries occur in low-income countries (in part due to open-fire cooking), and that low income was associated with higher mortality and morbidity rates, noting barriers such as limited knowledge of first aid for burns, availability of transportation to specialized burn care centres, and limited supplies, beds and staff at specialized burn care centres. Furthermore, the study suggested that improving the wealth of poor households may lead to better living conditions, nutrition and access to medical services, thus reducing burn injury risk and outcomes.[59]

1.2.3 Systems: Health-care support and communication

Discussion: A systems assessment takes into consideration the patient's access to emergency services, funding, availability of support services and wound-related products, devices, diagnostic services, service delivery personnel and co-ordination of care, all of which vary widely from province/ territory and from one interprovincial/ interterritorial region to another. Health-care support and communication can even vary from one service delivery site to another.

When setting patient goals and developing a plan of care, early communication with the care partner and/or family, clinicians must take into consideration the patient's access to health-care supports, as an organized, interprofessional and collaborative approach to care is critical to improving burn-injury-related outcomes.

1.3 Complete a wound assessment, if applicable

Discussion:

Burn injury assessment: When assessing a burn injury, it is important to determine the underlying cause or mechanism of the injury—this is key as the cause influences the pathophysiology of the injury and its management—burn depth and size, and severity of the burn injury (See Figure 4). Assessment of the burn can help the team to determine the ability of the person to heal their burn injury, plan treatment, facilitate communication, monitor treatment and predict and verify outcomes.

Figure 4: Burn Classification



Used with permission of Mölnlycke.

Mechanism of Injury

Heat-related burn injuries vary in depth and size and are caused by scalds from liquids spilled or liquid immersion, grease or steam; contact burns and fire, flash or flame. The severity of the injury is related to the rate at which the heat is transferred from the heating agent to the skin, which depends on the heat capacity and temperature of the agent, duration of contact with the agent, transfer coefficient, and heat and conductivity of the local tissue.

Scalds tend to be superficial partial-thickness tissue damage and may involve a large area of skin. Scalds with viscous liquids like oil, grease, liquid glue or liquid wax that are splashed on a person's skin tend to cause more severe burn injuries than scalds from liquids with greater fluidity, like hot water. Fluids that are more viscous tend to roll off a person's skin at a slower rate or cling to a person's skin, increasing the duration of exposure. Scald burns may present as a first degree burn on initial assessment but may develop into a superficial partial-thickness (second degree) burn within 24 hours. Blisters that were not present initially may develop within the first 24 hours.

Immersion scalds can result in more severe burn injuries because of the increased duration of contact between the heat agent and the skin. Such burns can cover a large skin area.

Contact burns tend to cause deep partial-thickness or full-thickness tissue damage and involve less skin area than other types of burns.

Flame injuries are of various depths (superficial partial-thickness to full-thickness) and cover varied amounts of skin.

Cold-related burns may occur through exposure to extreme cold. Across the spectrum of tissue damage patients may experience a freezing injury (FI) from frostnip, to superficial injury, to deep tissue freezing caused by crystallization of water in the cells, which may cause ischemia, leading to skin necrosis and damage to the deeper tissues.[60] The Hennepin Score may be used to quantify injury and tissue loss of frostbite injury, similar to TBSA calculators in burn patients.[61]

Electrical burns outwardly may not reflect the true extent of the injury, as internal tissue and organ damage may have ensued.[62] The extent of electrical burns is related to the voltage of the current. With low-voltage electrical burns, small, deep burns are seen at the contact points. Assessing the contact points help to determine the probable path of the electrical current and thus the potential areas of injury is required. High-voltage burns (greater than 1,000 volts) may cause extensive deep tissue damage, limb loss and death. Electrical current takes the path of least resistance through the body, allowing for the electrical energy to be transformed to heat, damaging the tissue it contacts. Least resistance is offered by nerves and blood vessels, whereas bone and fat offer the most resistance. If major body organs, such as the heart, brain or kidneys are involved, the damage can be profound. Because much of the damage is below the skin at the level of muscle, fat and bone, the severity of the injury can be difficult to determine (the 'iceberg' effect). High voltage flash burns occur when electrical current does not actually enter the body; rather, the person is exposed to an arc of high-voltage current. The resulting burns may manifest as superficial partial-thickness damage to body parts exposed to the arc. If clothing ignites, deeper burns may result.[62]

Radiation burns are injuries to the skin or tissue caused by exposure to ultraviolet rays (sunburn), radiation therapy for cancer treatment and, in rarer instances, nuclear emissions or explosions. The effect of radiation reactions is dependent on the type of radiation, its energy, penetration and ionization power, total dose, fractionation and overall exposure/treatment time.[63] Radiation-induced skin injury ranges from erythema (redness) to dry or moist desquamation, skin necrosis, ulceration and death.[63]



The extent and depth of a **chemical burn** is directly proportional to the amount, type and strength of the agent, its concentration, extent of penetration, mechanism of action and length of contact time with the skin/tissue. Chemicals will continue to destroy tissue until inactivated by reaction with tissues, neutralized, brushed off (powders), or diluted with the appropriate neutralizing agent (it is important to note that, in some cases, water may favour skin disruption*). Therefore, it is essential for the health-care provider to find out the chemicals involved in the injury. The burning process may continue for variable and often prolonged periods of time, e.g., up to 72 hours, after the initial contact with the chemical agent. Acids, in general, cause coagulation necrosis with protein precipitation. Alkalis produce liquefaction necrosis, which allows the alkali to diffuse more deeply into the tissues. Therefore, on a volume-to-volume basis, alkaline material can produce far more tissue damage than acids.

*Safety data sheets (SDS) in workplaces provide first aid measures information which describes actions to be taken immediately in case of chemical exposure. The purpose of first aid is to minimize injury and future disability.[64]

Regardless of the mechanism of injury, the pathophysiology of a full-thickness burn wound involves a local and systemic response. Locally, a burn may be divided into three zones.

1. Zone of Coagulation
- Centre of the wound – the area that had the most contact with the burn source
- Irreversible full-thickness tissue damage with no tissue perfusion
- Tissue appears white or charred and will not recover.

2. Zone of Stasis
- Surrounds the zone of coagulation
- Deep partial-thickness injury with decreased tissue perfusion
- Tissue appears red initially and later turns white and may blanche with pressure. Petechial hemorrhages may be present
- With good management, tissue will likely recover.

3. Zone of Hyperemia
- At the periphery of the wound
- Superficial partial-thickness injury with good tissue perfusion
- Tissue appears red, blanches with pressure and will likely recover.[65]

In complex burns, there is also a systemic response secondary to the systemic release of cytokines and other inflammatory mediators, catecholamines, vasopressin and angiotensin. This can result in hypovolemia, systemic hypotension, increased vascular permeability and compromised organ perfusion, bronchoconstriction, hypothermia, hemolysis (requiring blood transfusions), an increased basal metabolic rate (which can impede wound healing, increase infection risk and impede physical rehabilitation) and a reduced immune response.[66]

Burn Depth

Burn depth is subjectively determined based on the characteristics of the burn wound (See Table 5) and is key to informing the plan of care.

Table 5: Characteristics of Burn Types According to Depth

Classification	Depth of Injury	Appearance	Sensation	Most Common Cause of Injury
Superficial (first degree)	Epidermis	• Intact skin (red, shiny) • Blanchable erythema and mild edema • Brisk capillary refill • No blisters • May scar[60]	Tactile and pain sensation intact Pain ranging from itching to sharp[67]	• Scalds from spilled liquids (low viscosity) • Electrical flash • Sunburn
Superficial partial thickness (second degree)	Epidermis with partial-thickness loss of dermis Dermal appendages intact	• Blanchable erythema • Brisk capillary refill • Intact or ruptured thin-walled serum-filled blisters (blisters may increase in size) • If blisters ruptured, tissue is pink or red and moist • Mild to moderate edema[67]	Sharp pain. Potential residual sensitivity to sun, cold, friction, months after healing. Possible residual pruritus[67]	• Scalds from spilled liquids (low viscosity) or steam • Electrical flash • Brief exposure to flame • Brief contact with hot object • Sunburn

Deep partial thickness (deep second degree)	Epidermis with deep partial-thickness, loss of dermis Underlying structures are not exposed. Some dermal appendages intact	• Non-blanchable erythema • Sluggish capillary refill • Intact or ruptured thick-walled serum-filled blisters (blisters may increase in size) • If blisters ruptured, tissue is blotchy/mottled, cherry red/blanched white and dry (plaque like) • Will scar and may require surgery[60]	Deep pressure sensation intact Pinprick sensation absent Variable pain sensation	• Scalds from spilled liquids (low and high viscosity) or steam • Exposure to flame • Contact with hot object
Full-thickness (fourth degree)	Full- thickness skin/tissue loss Exposed or directly palpable underlying structures (muscles, fat, bones, tendons) Dermal appendages destroyed	• Non-blanchable • Tissue leathery, pale, mottled, red/ brown/ white in colour and dry • Eschar may be present • Thrombosed vessels visible (dry, carbonization, no blisters) • Involves deeper tissues, and frequently leads to loss of the burned part[60]	Insensitive to pain and pressure; pain may be present at the periphery, and absent at the level of the burn	• Prolonged liquid immersion scald • Prolonged contact with hot flame, hot objects, or chemicals • Electricity

Adapted from the Ross Tilley Burn Centre[57,60]

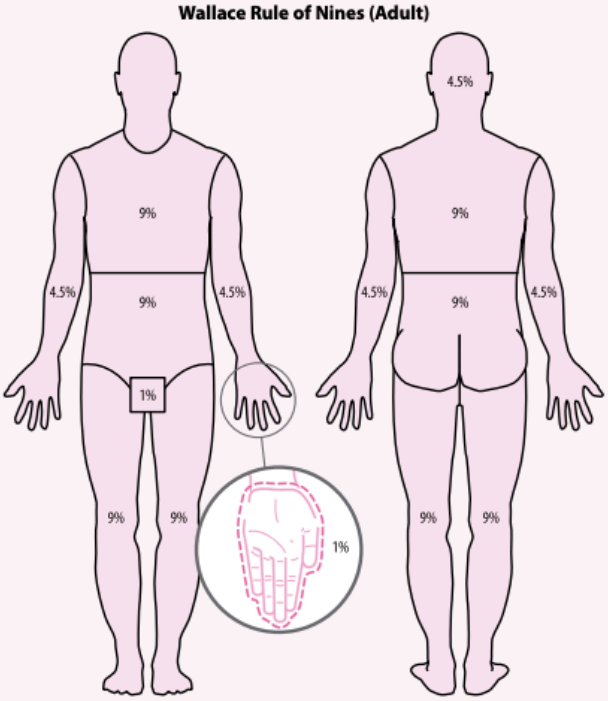
Assessment of burn depth can be precarious even for experts in the field. Given that burn experts are only 64–76% accurate in determining burn depth,[68] there has been a push to develop more objective methods to determine burn depth. Therefore, technologies have been and continue to be developed and utilized in this field.[69] These include biopsy and histology, thermography, photometry, pulse-echo and Doppler ultrasound, laser Doppler imaging, nuclear imaging, liquid crystal film, and use of radioactive isotopes and non-fluorescent and fluorescent dyes. Laser Doppler imaging (LDI) is the most accurate and validated technology in determining burn dept.[70,71] These methods, however, are either invasive, and/or require expensive equipment and/or access to expert technicians and are, therefore, limited to use on specialist burn units and in research.

Burns are dynamic: Burn depth may increase over time. Therefore, reassessment after 24–72 hours is important in establishing accurate burn depth.

Burn Size

In addition to accurate estimation of the burn depth, determining burn size (surface area) is essential to inform the plan of care. The total burn area is expressed as a percentage of the total body surface area (TBSA). The most common methods used to estimate the TBSA involved in a burn injury include palmar surface, the Lund and Browder chart, and the Wallace Rule of Nines (See Figure 5).

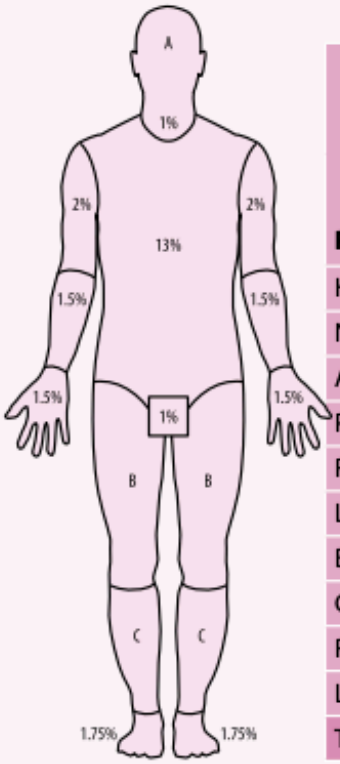
Figure 5: Common Methods to Estimate Burn Surface Area



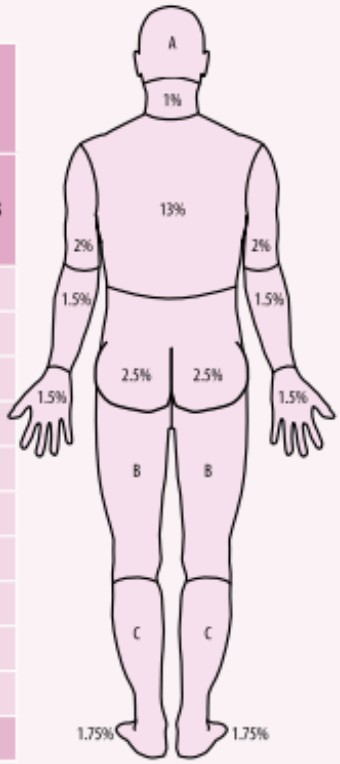
Palmar Surface: This is the simplest and quickest method that requires the least amount of training.[72] This method involves estimating the TBSA involved in a burn injury using the palm and fingers of the patient's hand as ruler. The patient's hand area (inclusive of the palm and fingers) represents approximately 1% of their TBSA. The palmar surface method is more accurate in estimating the size of small and large burns than it is for medium-sized burns.

Lund and Browder: The Lund and Browder chart, considered the gold standard due to its high validity and ease of comparison during subsequent treatment, is used across age groups, as it takes into consideration the variations in TBSA as a person grows. Modified versions are available for children under age 15 to correct for the smaller surface area of the lower extremities. Weaknesses of the Lund and Browder chart include difficulties in assessing lateral burns, the lack of anatomical landmarks for reference and the inability to accurately represent obese or female patients, which can make calculation of the TBSA in a burn injury more difficult and time consuming.[73,74]

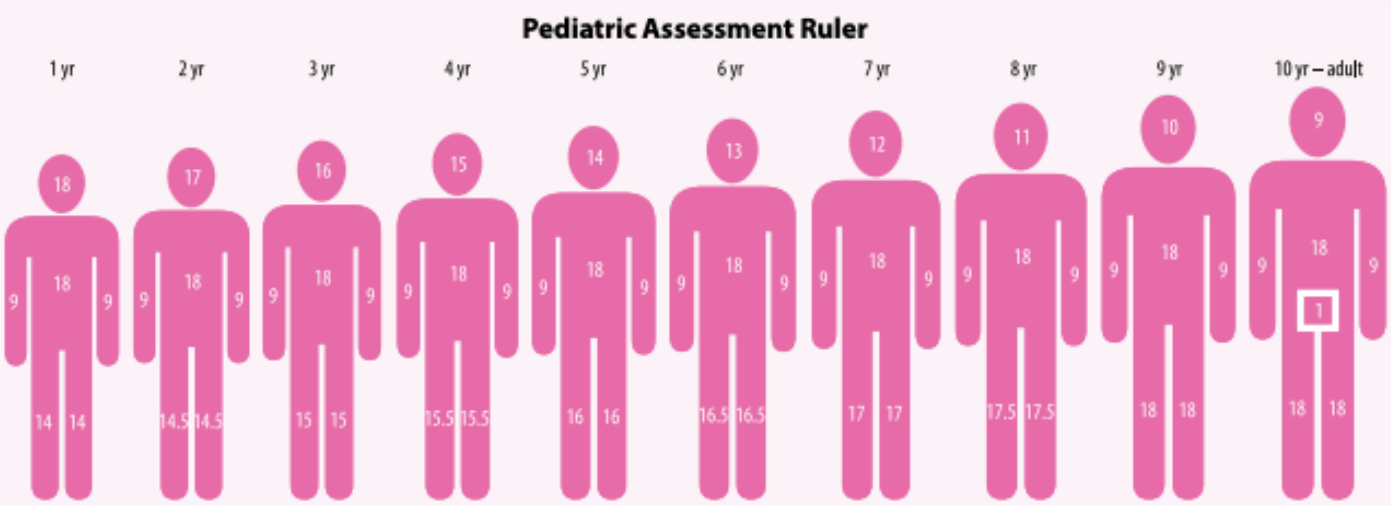
Lund and Browder Chart



Region	% of total body area surface burn	
	Partial Thickness Loss	Full Thickness Loss
Head		
Neck		
Ant. Trunk		
Post. Trunk		
Right Arm		
Left Arm		
Buttocks		
Genitalia		
Right Leg		
Left Leg		
Total Burn		



Area	Age					
	0	1	5	10	15	Adult
A = 1/2 of head	9.5	8.5	6.5	5.5	4.5	3.5
B = 1/2 of one thigh	2.75	3.25	4	4.5	4.5	4.75
C = 1/2 of one lower leg	2.5	2.5	2.75	3	3.25	3.5



Body surface area percentiles for each age group. Select the patient's age to determine the body surface area ratio for each body area to calculate the burn size.

Adapted from Victoria Burns Service www.vicburns.org.au.

Wallace Rule of Nines: The rule of nines is another means of estimating TBSA involved in a burn injury in adults. With this tool, the TBSA is divided into major anatomic regions divisible by nine (portrayed on a standardized chart). The TBSA is calculated by estimation using the chart. Pediatric versions of this tool for children under age 10 have been created to account for the variations in TBSA in childhood.[72,74] This tool has been shown to be a quick, simple, familiar and reasonably accurate method of assessing TBSA in burn injury.

Note: SUPERFICIAL (FIRST DEGREE) BURNS ARE NOT INCLUDED IN THE CALCULATION OF BURN SIZE (SURFACE AREA)

Like burn depth, assessment of burn size can be precarious for even the most skilled clinician. Given that burn size is only ever estimated correctly one third of the time,[75] there has been increased interest in developing technologies to improve accuracy. These include mobile software applications that use 1D, 2D or 3D modelling or imaging, and 3D scanners.

Severity of Burn Injury



Once burn depth and area have been estimated (and taking into consideration the cause of the burn, presence or absence of inhalation injury and comorbidities of the patient), the severity of the burn injury can be determined.

As with all wounds, burn injuries must be assessed for:

- Tissue types and amounts, e.g., epithelium, granulation, slough or eschar,
- Bacterial balance, e.g., localized, spreading or systemic infection,
- Exudate type and amount, e.g., none, scant, small, moderate, large, copious, colour, e.g., serous, serous-sanguineous, sanguineous, or purulent,
- The presence or absence of odour,
- The type of wound edge, e.g., attached, unattached, rolled and
- Periwound tissue appearance, e.g., intact, reddened, indurated, macerated, excoriated.



These considerations are elaborated on in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds,[17] which also provides information on wound assessment tools.

American Burn Association's (ABA) Proposed Indicators for Sepsis in Burns[76]

The leading cause of death in burns is sepsis.[77,78] As major burns typically present with signs of systemic inflammation, diagnosing infection can be a challenge. The ABA suggests that if a patient with a burn injury presents with three or more of the following findings, sepsis should be suspected, and the underlying cause investigated and treated:

- Temperature >39° C or <36.5° C
- Progressive tachypnea (>25 breaths/min if not ventilated or >12 L/min if ventilated)
- Progressive tachycardia (>110 beats/min)
- Thrombocytopenia (<100 000/uL; applied only after day 3 post-resuscitation)
- Hyperglycemia (untreated glucose >200 mg/dL, >7 units/hour insulin infusion, or >25% increase in insulin dosing over 24 hours)
- Enteral feeding intolerance (abdominal distention, residuals over twice the feeding rate, or diarrhea >2500 mL/24 hours).

Step 2: Set Goals

Recommendations
2.1 Set goals to maintain skin health and for prevention and healing, non-healing and non-healable wounds

Discussion: Burn injury prevention should be considered a primary safety goal for all people and in all employment, home and social settings. The CHIRPP database revealed the populations at greatest risk for burn injuries in Canada (See Recommendation 1.2).[11]

Research has also shown that the social determinants of health impact one's risk of burn injury (See Recommendation 1.2.2). Despite knowing such information, ultimately all people are at risk for experiencing a burn injury in their lifetime. When related to health issues such as radiation therapy, preventative measures should be implemented. Knowing one's personalized risk factors can help to tailor prevention strategies.

The following are examples of community-based, provincial and national burn prevention programs and organizations which aim to identify risk factors, educate and heighten awareness of individual risk, and encourage people to practice strategies to decrease their level of burn injury risk:

Canadian Fire Safety Association: https://canadianfiresafety.com/
Public Services Health & Safety Association: https://www.pshsa.ca/
National Fire Protection Association: https://www.nfpa.org/
Canadian Burn Survivors Community: https://www.canadianburnsurvivors.ca/
Parachute Canada: https://parachute.ca/en/injury-topic/burns-and-scalds/
Workplace Safety and Prevention Services: https://www.wsps.ca/ and
WorkSafe (provinces and territories have their own sites).



2.1.1 Identify goals based on prevention or healabilty of wounds

Discussion: Where a burn injury has already occurred, goals must be set to reflect the overall healing ability of the wound (healing, non-healing or non-healable). This decision is made based on identified risk factors and a comprehensive patient, wound, environment and systems assessment. Goals must be developed according to the SMART principle,[79] in collaboration with the patient, family and or care partner, and adjusted accordingly, as goals can change over time, e.g., wound closure as evidenced by complete wound re-epithelialization and absence of drainage within 12 weeks.



Starting points for common goals related to the overall healing ability of burn injuries include:

- Prevent further progression of burn depth using cool water for for 20 minutes,[80] once the causal agent has been identified,
- Wound closure, stabilization or prevention of deterioration,
- Reduction in the amount of necrotic tissue,
- Reduced bacterial burden or prevention of increased bacterial burden,
- Establishment or maintenance of an appropriate amount of wound moisture,
- Decreased number of dressing changes,
- Prevention of scarring or improved scar quality,
- Limb preservation,
- Improved nutrition and hydration and
- Mental health and well-being, and spiritual care

2.1.2 Identify quality-of-life and symptom-control goals

Discussion: A comprehensive patient, wound, environment and systems assessment will also allow for the development of goals related to the impact of the burn injury on the patient's daily life. Such goals may include:



- Pain reduction and management,
- Reduction and management of wound-related itch,
- Maintaining or improving joint range of motion and function of the burn-injured area,
- Contracture reduction,
- Restoration of independence,
- Return to work, home, school or leisure activities,
- Reduced anxiety and/or psychological stress and
- Improved coping mechanisms and supported spirituality.

Step 3: Assemble the Team

Discussion: Prevention, assessment and management of burn injuries require an integrated team to optimize the patient's overall health and well-being. The team must work closely and collaboratively with the care partners and family to address the complex physical, emotional and social impacts of surviving a burn injury. All team members must work together to create and implement a sustainable plan of care based on the identified goals.

Recommendations
3.1 Identify appropriate health-care professionals and service providers

Discussion: Health-care professionals working with patients with burn injuries need to be trained to do so, through organizations such as the American Burn Association, which offers advanced burn life support education for providers.[81] Advanced Burn Life Support (ABLS) educational programs and conferences are available across Canada.[82] Caring for patients with burn injuries requires that clinicians have the knowledge, skills and judgement to assess the severity of the burn injury; achieve hemodynamic stability and end-organ perfusion; identify and treat inhalation injury; maintain thermoregulation; identify and manage compartment syndrome; recognize non-accidental injuries; provide physiologic support for all body systems; deploy therapeutic burn wound treatments; provide support and resources for the unique emotional, spiritual, cultural and social needs of burn patients, their family and care partners; develop individualized rehabilitation care plans to maximize return to function, and more, depending on their professional role.

Ideally the professional members of the team, except first responders, will be in one location, which is often the case with specialized burn centres in large urban areas. Outside of such centres, however, this may not be the case and will necessitate the establishment of a clear, comprehensive communication plan. For community, rural and remote care, burn assessments and reassessment may be completed via telemedicine or web-based platforms.[83]

In any case, effective communication among team members is essential for supporting the short- and long-term management of the patients' needs. Table 6 lists some of the potential interprofessional burn injury team members and their roles. The selection of team members is based on the comprehensive assessment of the patient with the burn, their wound, environment and systems and the established goals. Not every burn patient requires involvement of all team members listed. This is especially true of patients with minor burns that are treated on an outpatient/clinic basis. Other service providers on the team may include shoe fitters, meal delivery services, homemakers, garment fitters and transportation providers, among others.

Burn team members are a specialized community of practice. It is important to note that burn rehabilitation team members in acute and critical care are connected to community-based prevention strategies/programs, post-acute teams, ambulatory care, community clinics, rehabilitation and home care programs. Specifically, burn rehabilitation physiatrists may work with patients in critical care and continue to support them in settings such as inpatient rehabilitation, out-patient/clinics and community care.

Table 6: Team Members and their Roles in the Management of a Patient with a Burn Injury

Team Member	Roles
Anesthesiologist	• Optimize mechanical ventilation, fluid management and circulatory support • Assist with pain management
Nurse practitioner	• Assessment and treatment of burn • Assist with evaluation of care plan, pain and patient outcomes[84,85,86]

Burn nurse	• Co-ordinate inpatient care and patient discharge • Provide daily care, positioning, edema care and complete/assist with dressing changes • Manage fluid resuscitation • Administer medication and enteral nutrition, provide health teaching and monitoring • Provide palliative care • Deliver patient, care partner and family education
Burn surgeon	• Prescribe medications, order tests, provide referrals • Oversee medical management • Perform surgical intervention, grafts and flaps, amputations • Provide burn debridement and blister management
Critical care specialists and post-critical care physicians	• Provide care based on their specialty (e.g., nephrology, rehabilitation, orthopedics, emergency) according to the needs of the patient and the resources of the care centre.
Physiatrists (burn rehabilitation speciality)	• Focus on physical medicine and rehabilitation post-burn[87,88] • Support rehabilitation to reduce length of stay (acute) and readmission • Monitor rehabilitation progress and transitions of care: critical care, inpatient rehabilitation and home and community care
Physician assistants	• History taking, assessment/physical exam, treatment plans, education with patient and or care partners[84,89]
Emergency room clinician	• Initiate fluid resuscitation and treat burn shock • Assess and treat smoke inhalation, hypothermia and any other secondary injuries • Determine the burn severity and decide if the patient needs to be transferred to a specialized burn centre • Assess and manage pain
First responder	• Stop the burning process, and cool and cover the burn • Establish an airway and provide cervical spine control • Attempt resuscitation • Control hemorrhage and assess for and treat burn shock • Transport to hospital for assessment
Occupational therapist (OT)/ Occupational therapist assistant (OTA)	• Provide scar management • Prescribe adaptive devices and manufacture splints to prevent contractures • Perform activities of daily living assessment • Support vocational/employment goals and activities • Provide cognitive and psychosocial assessments, support and counselling with family members
Pharmacist	• Assist with management of pain, infection • Provide medication reconciliation, information, education or teaching, monitoring for medication interactions • Communicate with family members and provide education
Physiotherapist (PT) Physiotherapy assistant (PTA)	• Assess functional status and provide training • Prescribe and facilitate exercise and movement • Evaluate strength and administer treatment • Prescribe gait aides • Apply biophysical agents • Communicate with care partners and provide education
Registered dietitian	• Monitor dietary needs and provide nutritional recommendations • Provide nutritional education • Communicate with family members and provide education

Respiratory therapist	• Assess pulmonary mechanics • Enhance patient ventilation by assisting with airway management and diagnostic bronchoscopy, assess arterial blood gas, optimize mechanical ventilator settings and chest physiotherapy • Provide education
Counsellor, social worker psychologist, psychiatrist	• Address anxiety and or psychological stress • Contribute to understanding cause of burn (e.g., abuse, neglect) • Improve coping mechanisms • Support communication with team and care partners/family members • Assist with social and financial supports • Link to peer supports • Provide palliative support
Speech and language pathologist	• Assess and recommend strategies for improving swallowing and communication • Evaluate and treat microstomia • Assist with head/ neck burn scar management
Spiritual care professional	• Support and counsel those with slow-to-heal, non-healing and non-healable burn injuries • Support links to patients' spiritual, faith or religious community • Provide palliative support
Vocational/ Educational professional[60]	• Support return, adaptation to school, employment/work (paid, unpaid, volunteer), sport, activity • Collaborate with school teachers, counsellors, therapists to support educative and employment (role in society), leisure or sport • Coach and mentor • Peer support partners

3.2 Enlist the patient and their family and care partners as part of the team

Discussion: The success of a plan of care for the prevention and management of burn injuries relies on the collaboration of the person with the burn injury (or at risk), their support system(s) and communication among the team involved in the development of the plan of care.[90] For pediatric patients, parents or legal guardians need to be part of the care-planning team, and for those with cognitive impairment, the person(s) who has/have been assigned their Power of Attorney for Personal Care must be involved. To be effective team members, the person with the burn injury and their support system must have the motivation, capacity, ability and commitment to act, as well as the personal ability to interact effectively with each other.

Ideally, the patients with the burn injury and their care partners will be willing and able to work with the rest of the team to set goals and participate in the development, implementation and evaluation of the plan of care. Every attempt should be made to have meaningful and culturally and age-appropriate communication with the patient and family regarding interventions that will result in the best possible long-term outcomes.[91] Communication must consider the patient's literacy level, language ability, cultural background, and learning style and abilities.

To help ensure active participation, patients with burn injuries and their care partners and families should be offered timely, consistent information that is tailored to enhance self-care strategies and management practices and behaviours.

3.3 Ensure organizational and system support

Discussion: Successful burn injury programs are designed and evaluated in collaboration with clinical practice leaders, educators, researchers, policy makers and administrators at a local, regional, provincial, territorial and national level.[92] Organization and system support is required to ensure that patients receive a coordinated transition of care through community and health-care agencies. This level of collaboration and co-operation is essential as patient's have needs that will be ever changing, specifically as they gain community-level functioning, improved quality of life,[93,94] and return to work and engagement in life.[60]

Organizations must support the education of staff members so they may obtain and maintain the required knowledge and skills to be effective members of the burn care team. For OTs and PTs, core competencies (knowledge, skills, attitudes) have been developed to effectively care for the multiple complex issues related to burn injuries.[95,96] In 2017, the Burn Rehabilitation Therapists Competency Tool (Version 2), was expanded to include therapists in long-term rehabilitation and outpatient care.[97] Routine educational needs assessment should be undertaken to identify knowledge gaps in team members. Education should address the identified short and long-term gaps and be provided using the principles of adult learning.

Step 4: Establish and Implement a Plan of Care

Discussion: The development and implementation of a sustainable plan of care must be based on the identified goals and be collaboratively created with the patient, their family and care partners, and relevant health-care team members.

Recommendations

4.1 Identify and implement an evidence-informed plan to support healthy skin, to correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional and social), the wound (if applicable) and environmental/system challenges

Discussion: Prevention of burns occurs through public awareness programs and education initiatives. Prevention includes recognition of at risk homes, schools and workplaces and in the community. Each province, territory or First Nation offers programs throughout the year.[4,10]

The management of patients with burn injuries may require only pre-hospital care; however, it may include transportation to the closest emergency department for assessment based on the Advanced Trauma Life Support and Advanced Burn Life Support[98] guidelines, as well as the following:

- Discharge to outpatient/community-based services for treatment for minor (non-complex) burns,
- Admission to hospital for care of moderate burns and
- Transfer to a specialized burn centre for treatment of major (complex) burns.[98]

The decision to transfer to a specialized burn centre is made by the physician and team (See Table 7). This requires, in part, consideration of the updated American Burn Association (2022) Burn Patient Referral criteria: https://ameriburn.org/aba-releases-new-guidelines-for-burn-patient-referral/

Table 7: Criteria for Transfer to a Burn Unit[98]

	Immediate Consultation with Consideration for Transfer	Consultation Recommendation
Thermal burns	• Full-thickness burns • Partial thickness ≥ 10% TBSA • Any deep partial- or full-thickness burns involving the face, hands, genitalia, feet, perineum or over any joints • Patients with burns and other comorbidities • Patients with concomitant traumatic injuries • Poorly controlled pain	• Partial-thickness burns <10% TBSA • All potentially deep burns of any size
Inhalation injury	• All patient with suspected inhalation injury	• Patient with signs of potential inhalation such as facial flash burns, singed facial hairs or smoke exposure
Pediatrics (less than or equal to 14 years or <30 kg)	• All pediatric burns may benefit from burn centre referral due to pain, dressing change needs, rehabilitation, patient/caregiver needs or non-accidental trauma	

Chemical injuries	• All chemical injuries	
Electrical injuries	• All high-voltage (≥1,000 volts) electrical injuries • Lightning injury	• Low-voltage (<1,000 volts) electrical injuries should receive consultation and consideration for follow-up in a burn centre to screen for delayed symptom onset and vision problems

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Management – Primary Survey: After ensuring personal safety, it is critical to remove the source of the burn injury. This means removing the heat source for patients who have experienced a thermal injury, turning off the electricity supply for those with electrical burns, brushing off dry chemicals or diluting liquid chemicals (*depending on the chemical)* with water for those who have experienced chemical burns, or removing the patient from the source of radiation for those with radiation burns. In conjunction with the treatment of life-threatening injuries, most burn wounds need to be cooled.

Thermal burns should be cooled with clean, tepid running water or wet towels and compresses to stop the burning process, limit tissue damage, minimize swelling, cleanse the wound and aid in pain control. Very cold water and ice should not be used to cool burn injuries, as these can cause local vasoconstriction, which can increase tissue damage and may contribute to hypothermia.

For freezing injuries, moist rewarming, possible thrombolysis and watchful waiting[60] are recommended. Organizations should have frostbite protocols in place for providers and regular education should be available.

- Once the initial treatment phase has passed in severely affected or symptomatic individuals or those at risk for re-injury, consider an assessment of quantitative peripheral sensory testing, using a tool such as Semmes-Weinstein monofilament.
- Freezing injuries, like other cold injuries, should be treated as an acute traumatic injury.
- Rewarm actively and rapidly in a water bath (40–42°C).
- Passive rewarming is only acceptable when the first option is unavailable.
- Have the patient avoid nicotine or other vasoconstrictors during the period of rewarming.
- Provide thrombolytic therapy to identified candidate patients but only in an appropriate medical setting.
- Debride necrotic tissue, if necessary, at a later stage and only after completion of the rewarming cycle.
- Provide supportive care of post-injury nerve and skin damage.
- Educate patients to prevent repeat injury.[32,99]

Chemical burns require copious irrigation with tepid water or an appropriate antidote to remove the corrosive agent and stop the burning process. This irrigation process may be lengthy, e.g., 15–120 minutes, and should continue until the patient stops complaining of discomfort and the tissue pH normalizes. Electrical burns should not be irrigated.[100]

Rogers et al. (2022) also remind health-care providers involved in burn care, their patients, care partners and family members, about the importance of adopting the Choosing Wisely recommendations regarding the overuse of unnecessary procedures and investigations.[101]

Eleven recommendations were developed to reduce the costs and adverse effects of "unnecessary therapeutic and diagnostic procedures, while still maintaining high standards of evidence-based burn care."[101] For more on the recommendations, please visit Choosing Wisely Canada: https://choosingwiselycanada.org/recommendation/burns/

All individuals with burn injuries who require a health professional's care should then be treated using the ABCDEF mnemonic, listed below in the order of priority, to treat any life-threatening injuries.

The ACBDEF mnemonic includes:

Airway: If the patient has an airway obstruction or an injury that is physically restricting breathing, attain and maintain a patent airway. Depending on the type and severity of injury, this may require administration of beta agonists to prevent or treat bronchospasm, intubation, tracheostomy and/or an escharotomy for deep dermal or full-thickness circumferential neck and/or chest burns. This step also includes the provision of cervical spine control prior to transport to hospital (especially in instances of high-voltage electrical burns or falls), unless spinal injury is not suspected.

- In a recent review, researchers noted that, "unnecessary endotracheal intubation was performed in 28% to 53% of transfers."[102]

Breathing: If the patient is not breathing, immediately initiate cardiopulmonary resuscitation (CPR). In addition, treat any conditions impeding ventilation, such as hemothorax, pneumothorax, flail chest, smoke inhalation, carbon monoxide poisoning and cyanide toxicity. Depending on the type and severity of injury, interventions may include needle aspiration or chest tube insertion to treat hemothorax or pneumothorax, mechanical ventilation for flail chest, mechanical ventilation and aggressive pulmonary toilet to manage inhalation injury.[101] "Do not recommend the administration of hydroxycobalamin (Vitamin B-12A or 'cyanokit') to patients prior to assessment in the burn centre, unless the history and investigations strongly support its use."[101]

- Position the patient in a semi-Fowler's or Fowler's position to decrease facial/airway edema. Reassess respiratory status at regular intervals.

Note: All patients with burn injuries should be administered 100% oxygen through a humidified non-rebreathing mask on presentation; 100% F_iO_2 should be administered until normal blood carboxyhemoglobin level return, monitored by blood gasses for high-risk cases.

Circulation: If the patient is bleeding or has hypovolemia or burn shock, treat accordingly. Depending on the type and severity of injury, interventions may include:

- immobilization,
- the application of pressure dressings or tourniquets and surgical interventions to stop bleeding,
- intravenous access with two large bore cannulas (preferably placed through unburned tissue) and fluid resuscitation for patients who have a burn injury of >20% TBSA (some sources reference >10% in children and adults greater than 50 or 60 years of age),
- the insertion of a Foley catheter (to monitor urine output) to treat hypovolemia and burn shock,
- use of vasopressors/ inotropes and thermoregulation to treat shock and
- hydrocortisone to treat adrenal insufficiency (secondary to refractory shock). Expected urine output is 0.5ml/ kilogram (kg) per hour for adults and 1ml/kg/hour for children.[103]

Rogers et al. (2022) state: "do not transfuse red blood cells to patients with burn injuries who have haemoglobin levels greater than 70 g/l, unless active haemorrhage or myocardial ischaemia is present."[101]

Disability: If the patient presents with an altered level of consciousness, it is imperative to treat the underlying cause, e.g., hypoxia secondary to carboxyhemoglobin level or hypovolemia.

Exposure: Removing clothing and jewellery from the area of a burn injury or close to, and/or distal to a burn injury allows for accurate determination of the area of burn injury and prevention of the 'tourniquet-like' effect of constricting items left in place when the resulting tissue edema increases. Clothing that has stuck to the burn injury must carefully be removed by soaking the material off. Patients should be covered and warmed as soon as possible to prevent hypothermia, as this can lead to hypoperfusion and deepening of the burn wounds.

Fluid resuscitation: For patients with major (complex) burns (e.g., adults TBSA greater than 20%; children under 10 years and adults over 50 years, with TBSA greater than 10%), fluid resuscitation is key to combating the profound loss of intravascular fluid into the interstitial space, which can lead to organ dysfunction and death, and should be initiated as soon as possible after injury (ideally pre-hospitalization). Several fluid formulas and protocols have been proposed for resuscitation, each requiring crystalloid infusion with or without the addition of colloids. It is important to note that there is no absolute consensus on fluid type or fluid formulas.

Fluid formulas are guidelines, and the calculation needs to include the patient's mental status, level of consciousness, vital signs (heart rate, blood pressure, pulse pressure, distal pulses, capillary refill) turgor of injured skin, blood gasses and urine output. Lactated Ringer's or other balanced salt solutions will be used. It is important to monitor fluid status continuously. Fluid resuscitation should be guided by physiological parameters and laboratory findings to prevent under- or over-resuscitation. The goal of resuscitation is restoration of intravascular volume and maintenance of organ perfusion and function while preventing burn wound conversion. "Burn conversion refers to the phenomena whereby superficial burns that appear to retain the ability to spontaneously heal, convert to deep wounds in need of excision."[104]

Traditionally, the endpoints of resuscitation of a thermally injured patient have been determined via physiological parameters, but the use of global end organ functions such as urinary output, heart rate and blood pressure is inadequate in determining the adequacy of resuscitation.[105] While the addition of measurements of base deficit and lactate have become commonplace as markers of adequate resuscitation, it is difficult to ascertain their importance as markers of burn resuscitation, as there are multiple episodes of ischemia and reperfusion injury with fluctuation in serum lactate and base deficit level.[106] In some studies, it appears that elevated lactate and base deficit levels on admission do correlate with overall organ dysfunction and mortality. However, there is no absolute number or threshold that determines non-survivability.[107-109]

Moreover, further studies have concluded that elevated lactate levels are an independent risk factor for mortality.[110] Since there is no ideal method at this juncture for determining the endpoints of resuscitation, some researchers have begun to adopt new techniques. Light et al. demonstrated the use of tissue pCO_2 monitoring to better correlate with tissue perfusion; however, its use is not yet commonplace.[106] Clinical assessment is outdated, the use of resuscitation markers is flawed, but there is some correlation with overall risk of organ dysfunction and mortality. Newer techniques are under examination but have not gained broad acceptance for use. Until a widely accepted method has been validated, care must be taken and as many tools as possible used to determine adequate resuscitation.

Management– Secondary Survey: The secondary survey should commence to diagnose any other injuries from head to toe, including the depth and extent of burn injuries. Once this thorough survey has been performed, appropriate and targeted treatment and management can begin.

This includes correcting any modifiable comorbidities assessed during the detailed patient history that may negatively impact wound healing and general burn injury recovery. In addition, depending on the severity of the burn injury, interventions may need to be put into place to address specific related issues such as upper gastrointestinal erosions and ulcers, such as Curling's ulcer (e.g., through the use of proton pump inhibitors and H2-receptor antagonists), and acute renal failure (e.g., adequate fluid resuscitation), treatment of any infections and, in severe situations, renal replacement therapy, sepsis (e.g., appropriate systemic treatment of burn wound infections and other infections that may be present or occur, like pneumonia; antibiotic prophylaxis is not advised), venous thromboembolism (e.g., prophylactic treatment), microangiopathic hemolytic anemia, bone fractures, spinal cord injury, peripheral nerve injury, neurophysical complications, amputation and/or visceral injuries.[111]

In addition, a fasciotomy may be required to treat compartment syndrome affecting a limb. Abdominal compartment syndrome may require mechanical ventilation, vasopressors, dialysis and surgery such as escharotomy and/or laboratory tests.

A Word on Escharotomies:[112-115]

All deep circumferential burns to the extremities have the potential to cause neurovascular compromise and therefore benefit from escharotomies. Early assessment and, "recognition of the need for escharotomy and other decompressive therapies is imperative for experienced burn providers, as to avoid reversible tissue ischemia and necrosis."[116] The typical clinical signs of impaired perfusion in the burned extremity/hand include cool temperature, decreased or absent capillary refill and tense compartments with the hand held in the claw position. The absence of pulses is a late sign. On occasion, non-circumferential deep burns or circumferential partial-thickness burns might require a prophylactic escharotomy as the patient might need large resuscitation volumes due to overall injury or the inability to perform serial reassessments. Escharotomies of the extremities are performed along the medial and lateral lines, with the extremity held in the anatomic position. For the hand, the escharotomy is performed along the 2nd and 4th metacarpals, and for the fingers care is taken to prevent any neurovascular damage. Therefore, escharotomies are typically not performed along the ulnar aspect of the thumb, the radial aspect of the index finger or ulnar border of the small finger.

Pain management: The intensity and impact of pain on a person's quality of life, including their emotional, physical, psychological well being, must be taken into consideration when creating a personalized plan of care. Patient's perception of pain is individual and varies throughout the healing process.[117] Pain management is a challenge and a foundation of care from the time of injury, through acute, rehabilitation and community care. Table 8 summarizes some common pain management strategies used in Denmark, Sweden, New Zealand and the United States, based on a review of four clinical guidelines.[118]

Table 8: Management of Burn Pain

Cause of Pain	Management Strategies
Background pain	Acetaminophen, non-steroid anti-inflammatory drugs (NSAIDs), opioids
Procedural pain	Opioids, transmucosal fentanyl, anxiolytics and general anesthesia for initial wound care Ketamine and potentially inhaled nitrous oxide
Post-operative pain	Acetaminophen, non-steroid anti-inflammatory drugs (NSAIDs), opioids, nitrous oxide, ketamine, transmucosal fentanyl, peripheral blocks, patient-controlled analgesia
Neuropathic pain	Nortriptyline, gabapentinoids

Non-pharmacological interventions include the development of coping skills via referrals to psychology, therapeutic touch, cognitive enhancement, hypnotherapy, visualization and virtual reality. Massage and distraction may also be of benefit.[119-121] In children (0.5 to 19 years) pain intensity has been shown to have been reduced with non-pharmacologic interventions (e.g., aromatherapy, music therapy, hypnosis, and auditory and visual stimulation).[122]

Regarding the management of neuropathic pain post burn injury, a systematic review suggested that pregabalin has been demonstrated to be effective, whereas gabapentin has not. The review further stated that the use of tricyclic antidepressants and anticonvulsants, which are common in treating neuropathies of other origins, have not been systematically investigated in the burn population.[123] Additionally, pregabalin (and gabapentin) are effective in relieving pruritus associated with burn injuries.[124]

A structured approach to pain management, such as the World Health Organization's Pain Relief Ladder, should be considered (in addition to non-pharmacological methods of pain control) when developing an individualized pain management plan.[125]

Quality of life (QoL): Once psychosocial issues, such as anxiety, depression and post-traumatic stress disorder, are identified, appropriate interventions, referrals and education need to be provided. Treatment and intervention options may include: coping self-efficacy,[29] cognitive behavioural therapy and medications to treat anxiety and depression.

Greenhalgh states that faces are a part of the body that cannot be hidden; therefore strategies must reduce scarring and optimize healing.[126] Peer support is critical to recovery; support groups include the:

- Canadian Burn Survivors Community www.canadianburnsurvivors.ca,
- Camp Bucko www.campbucko.ca,
- Saskatchewan Burn Support Network https://www.canadianburnsurvivors.ca/saskatchewan-burn-support-network,
- Camp Phoenix https://www.burnedchildrenrecovery.org/camp-phoenix
- Entraide Grands Brûlés https://www.entraidegb.org/ and
- Life After Burns (virtual peer support group) https://www.lifeafterburns.ca/peer-support-groups.

Nutrition: Metabolic and nutritional management play a vital role in the management of burn injuries.[127,128,129] Proportionate to the severity of the injury, patients with major burn injuries often experience oxidative stress, intense inflammatory response, and a long hypermetabolic and catabolic response.[60] A burn >40% TBSA is considered a severe burn.[129]

Nutritional requirements must be assessed regularly, individualized and continually modified throughout care in partnership with the registered dietitian, taking into consideration cultural perspectives and patient preferences. Individuals who are malnourished, underweight and/or older adults are at greater risk of delayed wound healing and require long-term monitoring of nutritional status, often up to several years.[130]

For persons not intubated, a regular non-restricted diet is recommended.[131] For those who are not able to meet their nutritional requirements with volitional oral intake (e.g., intubated, altered level of consciousness, poor appetite), nutrition support should be initiated early, preferably by the enteral route.[129,132] Nutrition should be started as early as possible (four to six hours) after burn injury, ideally within 24 hours of injury and, at most, 48 hours after injury.[129,133,134] Enteral nutrition solutions should be polymeric and high nitrogen.[132,135]

Energy: Calorie requirements increase as the size of the burn increases.[129] As patients with major burns have significantly higher energy needs, indirect calorimetry (IC) should be used to assess for energy requirements.[129,132,134] When possible, resting energy expenditure should be measured using IC within a week of admission to hospital.[136] If IC is not available or suitable, the Xie, Zawacki, or Milner equations should be employed for adult burn patients.[137,138] For children, the Schofield or Galveston equation for children are appropriate.[135,139] (See Table 9 and Table 10).

Table 9: Mathematical Calculation to Estimate Energy Needs after Burns

Zawacki	1440 kcal/m2/day
Xie	(100 kcal/m2/day) plus (25 x BSAB)
Harris Benedict (BEE)	Men: [66.47 + (13.75 x W) + (5 x H) – (6.76 x A)] x AF x IF Women: [655.1 + (9.56 x W) + (1.85 x H) – (4.68 x A)] x AF x IF AF: Bed Rest 1.2, Ambulatory 1.3, Sepsis 1.5 IF: Minor surgery 1.2, Skeletal Trauma 1.35, Severe Burns 2.1
Calories per Kilogram	Non-obese population: 25-35 kcal/kg body weight
	Obese, critically ill population: 21 kcal/kg body weight
Curreri	(25x W) + (40 x % TBSA burn)

Key:
BSA = body surface area in m^2 = [ht (cm) + wt (kg) – 60]/100
BSAB = % body surface area burn; W = weight in kilograms
H = height in centimeters; A = age in years ; AF = activity factor
IF = injury factor; TBSA = total body surface area burned

Body Surface Area (BSA) method – m^2 x 1600 ml = maintenance fluid requirement

Table 10: Common Formulas Used to Estimate Calorie Needs in Burnt Children[139]

Formula	Calories per day
Curreri junior (year): Commonly overestimates caloric needs	
Less than 1 year	Basal requirement + 15 kcal% TBSA
1 to 3	Basal requirement + 25 kcal% TBSA
4-15	Basal requirement + 40 kcal% TBSA
Galveston: Focuses on maintaining body weight	
Less than 1 year	2,100 kcal/m2 BSA + 1,000 kcal/m2 TBSA
1-11	1,800 kcal/m2 BSA + 1,300 kcal/m2 TBSA
≥ 12	1,500 kcal/m2 BSA + 1,500 kcal/m2 TBSA
WHO	
Male (year)	
0-3	(60.9 x weight in kg) - 54
3-10	(22.7 x weight in kg) + 495
10-18	(17.5 x weight in kg) + 651
Female (year)	
0-3	(60.0 x weight in kg) - 51
3-10	(22.5 x weight in kg) + 499
10-18	(12.2 x weight in kg) + 746
Mayes	
Male (year)	
3-10	(19.6 x weight in kg) + 1.033 x height in cm) + 414.9
10-18	(19.25 x weight in kg) + 1.372 x height in cm) + 515.5
Female (year)	
3-10	(19.97 x weight in kg) + 1.618 x height in cm) + 371.2
10-18	(8.365 x weight in kg) + 4.65 x height in cm) + 200
TBSA, total burned surface area; BSA, body surface area	

Protein: Increased protein turnover is common post major burn injury and can contribute to the loss of lean body mass.[60] Adults and children should be assessed for optimal amount of protein based on current recommendations.[129,140] Hampton et al. state more research is needed to determine optimal protein intakes to improve clinical outcomes and nutritional status for patients with burns.[131] Glutamine supplementation should also be considered,[132] with the exception of patients with multi-organ failure.[141]

Carbohydrates: Hyperglycemia and insulin resistance are not uncommon post major burn injury. Interventions should aim for moderate glycemic control based on current guidelines and status of the patient.[132,142]

Lipids: Fats are required to prevent essential fatty acid deficiency. Total fat delivery should be monitored, and energy from fat should be less than 30% of the total energy intake[129] for adults and 35% for children.[139] More research is needed on the role of omega-3 fatty acids (fish oils) for burn patients.[143]

Fluids: Fluid intake supports skin turgor and promotes tissue oxygenation/perfusion. Daily intake is determined in consultation with the team and burn healing state.

Micronutrients: Supplementation of zinc, copper and selenium (which enhance the immune defence and wound healing) and vitamins B1 (normalizes lactate and pyruvate metabolism), A (wound healing, immunity, epithelial cell differentiation), C and E (reduce oxidative stress and enhances wound healing), and D (prevents post-discharge fracture and osteoporosis) are suggested.[132,135]

Non-nutritional strategies: Non-nutritional strategies should be considered to address hypermetabolism and hypercatabolism, including maintenance of a warm room temperature (28–30 degrees celsius), early excision and surgical coverage of wounds and administration of medications that stimulate protein synthesis (e.g., non-selective beta-blockers). In addition, administration of recombinant human growth hormone (rhGH) to children with burns with TBSA greater than 60% should also be considered to prevent growth deficit, reduce hypermetabolism and enhance wound healing.

Rehabilitation: Therapeutic exercise-based interventions for burn survivors should be goal-oriented and include care partners and family in partnership with the team.[144] Activities should be directed at promoting mobilization, maintaining or improving function and strength and elongating scar tissue. Rehabilitative exercise, therefore, should include stretching, strengthening, cardiovascular training and functional activities.[145,146] Stretching can include passive activities, such as splinting (single or multiple joints) along with gentle sustained single joint stretches. These activities should continue until full range of motion (ROM) is achieved. Progression to active-assisted and active exercises is desirable to maintain ROM and prevent contraction of scar tissue. The burn therapist, PT or clinical exercise physiologists can use their clinical judgement along with consultation from the burn surgeon/ physiatrist as to when ROM and mobilization activities can begin. These should be done as early as possible after the burn injury and incorporate normal movement patterns that are tailored to the individual and continue long-term.[147,148]

Strengthening activities, including resistance training, are recommended after burn injury. Procter and colleagues suggest that the stress response in severely burned individuals includes hypermetabolism, muscle wasting and insulin resistance, which result in significant cachexia that can last for several years post burn.[147] They did show a benefit to children participating in a 12-week strengthening regimen instituted six months after a burn injury. Gittings et al. (2017) performed a systematic review and meta-analysis of resistance training (RT) for adults post burn injury and concluded that low-quality evidence is suggestive of some positive effects on muscle strength and psychological well-being after burn injury.[150] They recommend more research more research is needed in this area. Practice recommendations concluded that:

- "Burn survivors' strength and cardiovascular endurance should be evaluated in individuals seven years of age and older. Those who test below normal levels should be prescribed a supervised resistance and/or aerobic exercise program."
- "Exercise programs may begin as early as post discharge from acute care and as late as 14 years after burn."
- "Exercise programs should last six to 12 weeks for adults and up to 12 weeks for children".[151,152]

Palackic et al. recommend rehabilitation exercise training (RET) be established as part of care several years post burn injury. The RET approach, "is a proven effective treatment to restore lean body mass, glucose and protein metabolism, cardiorespiratory fitness, and muscle strength in burn survivors".[153]

Cardiovascular conditioning post burn injury has also been recommended.[149] Severe burn injuries are often associated with inhalation injuries, especially if the patient was involved in a flame-related burn. Thus, damage to the pulmonary system is often a component of a major burn injury and can be long-lasting, depending on the severity. Therefore, aerobic conditioning should be considered in rehabilitation after burn injury. In a study of pediatric patients with severe burns, Suman and colleagues found that a 12-week regimen of both aerobic and resistance training improved peak oxygen uptake in this population.[154]

Focused pulmonary rehabilitation should also be considered. Won et al. (2020) completed a prospective randomized single-blind study (n=120) and reported that patients with major burns and smoke inhalation benefited from focused pulmonary rehabilitation.[155] A literature review by Barnat and Mysliwiec explored physiotherapeutic methods used in the rehabilitation of children post burns (46 studies). They state scar massage and myofascial manual lymphatic drainage improves scar quality; scar cosmesis is improved with physical interventions based on exposure to light; splints prevent contractures; aerobic and resistance exercises strengthen muscles and improve pre-burn fitness levels; yoga and virtual reality support exercise; and neither music or hypnosis are confirmed to reduce pain (more research is needed).[156]

With all these exercise activities, patients should have or be directed toward some functional activity or goal. The burn therapist should consult with the rest of the integrated team to help confirm activities and identify new goals with function in mind. The OT may also help to identify activities of daily living that require specific strength or cardiovascular training to improve. Serghiou et al. suggest that a pre-exercise evaluation be undertaken to identify any underlying medical conditions, as well as any interests or goals the individual may have.[145] This will help the burn therapist to formulate a program that is challenging, fun, safe and effective, and meaningful to the patient's goals.

Return to Work (RTW). Rehabilitation also includes the patient's return or reintegration to school, family and social activities and work. Mason et al. stated that approximately 28% of patients with burns never return to any form of employment.[157] An individual's RTW can be challenging for complex reasons and may take longer than initial estimates.[158] As well, patients may return to paid or unpaid roles depending on the community in which they live.[60] Katsu and colleagues conducted a review n=6 studies focused on adult participation in return to employment. Limited information is available on the experience of adults with burn injuries, many of whom must overcome physical, psychological, social, economic and environmental barriers. The findings discuss patients consistently overcoming barriers, new or renewed vocational/ occupational/volunteer goals, knowledge and skill of health-care providers across the spectrum of care (acute to rehabilitation) and support from family, friends, and communities.[159] Finally, Van Bentum et al. state team members should address the burn complexity and its impact on the patient's present employment/role in society, and the need to identify the importance of trusted, personal supports. Meaningful activity other than paid employment must also be considered. The importance of long-term support, psychological support and social support are key to improving outcomes. More research is recommended.[160]

Positioning and splinting of the burn patient becomes increasingly important as the TBSA increases. Larger TBSA burns will require specialized sleep surfaces (pressure redistribution) along with positioning devices within the patient's bed environment. Minor burn injuries may simply require a supportive splint for the affected area. Splinting and positioning should be designed to:[145]

- Allow for edema reduction,
- Maintain joint alignment,
- Maintain tissue elongation,
- Promote wound healing,
- Relieve pressure points,
- Protect operative sites (new skin flaps or grafts),
- Assist in functional activity,
- Be pain free,
- Be lightweight (breathable, manage moisture) and
- Be easy to don and doff.[152]

Serghiou et al. in the *Clinical Practice Recommendations for Positioning of the Burn Patient,* provides detailed information on this subject.[152] Splinting and positioning are typically within the scope of practice of the OT, but strong communication with the rest of the team members will help patients and staff adhere to the plan of care and achieve optimal results. The OT will be able to provide specific positions for each area of the body to help prevent contracture. The PT may be required to apply compression wraps to assist in ambulation after skin grafting to the lower extremity (after a vascular assessment to rule out arterial insufficiency). Serial casting, skeletal traction and even amputation may be required in severe burn injuries.[161]

Orthoses

Orthoses are rigid or semi-rigid devices that play a significant role in burn rehabilitation alongside a prosthetist or orthotist. Parry et al. evaluated the evidence for the use of orthoses with persons who have burns. They recommended that ready-made or customized orthotic devices, such as casts, masks or positioning devices be considered to improve range of motion, protect against injury, reduce contractures and assist function as well as promote healing in adults with a burn injury[162] (See Table 11 for more on orthotic devices).

Table 11	Orthosis Types
Static orthosis	An orthosis that immobilizes joint(s) or tissue(s) surrounding a joint or articulating surfaces and is designed to maintain tissue length, rest injured or inflamed tissue, stabilize injured structures, promote healing, improve function, correct joint instability, prevent deformity and/or enhance joint alignment
Serial-static orthosis	An orthosis that immobilizes joint(s) or tissue(s) at maximal length to increase range of motion and/or tissue elongation and is designed to be modified or remolded serially to accommodate tissue changes for correction of a contracture
Static progressive orthosis	An orthosis that mobilizes joint(s) or tissue(s) in an elongated position utilizing adjustable, non-elastic components to apply low load and prolonged forces to mitigate or correct contracture
Dynamic orthosis	An orthosis that uses energy-storing components to provide controlled mobilization forces in one direction while permitting active motion in the opposite direction to correct contracture, promote tissue elongation, provide support to tissue or assist with weak motor function

Scar Prevention and Management

Cutaneous scar management and prevention of hypertrophic scar and keloid development are important components of burn care. Scars develop in approximately 70% of patients with burns, within four to eight weeks after injury. They mature and gradually flatten over two years. Keloids develop months and years after the injury and may spread beyond the wound edges.[130]

Burn scar contractures are a condition caused by, "the replacement of skin with pathological scar tissue of insufficient extensibility and length resulting in a loss of motion or tissue alignment of an associated joint or anatomical structure."[162] Scarring may contribute to social and emotional issues, physical limitations, neuropathic pain, irregular skin surfaces, stiffness and contractures that can be debilitating.[130] Approaches, or combinations of non-surgical treatments, include compression therapy, laser therapy, steroid injections, each with benefits and limitations.[130] Examples of therapy approaches include:

- **laser therapy:** increased pliability of scar, reduced scar height, reduced pain and improved colour and texture (e.g., pulsed dye lasers, carbon dioxide laser);
- **compression therapy:** reduced blood flow and effect on collagen remodelling, which may lead to smaller scars;
- **scar massage**: uses compressed air: focused on reducing pain and itching;
- **pressure garments therapy**: use of compression, custom fabricated garments reduce blood flow and effect on collagen remodelling, which may lead to smaller scars.[30] Includes wearing garments for up to 23 hours a day. Garments are produced from elasticized fabrics; the amount of pressure applied (5-40 mmHg) varies and is individualized based on needs[83,163] and
- **injection of fat**: reduces scar height, increases scar flexibility, improves wound closure.

More research is recommended for each.

Research on management of novel approaches to scar tissue is underway in Canada. Amini-Nik et al. focus on scar treatments that aim to improve patient-centred outcomes and quality of life. For example, new therapies are focused on, "drug delivery that targets the molecular cascades of wound healing to attenuate or prevent hypertrophic scarring is a promising approach."[130]

4.2 Optimize the local wound environment

Discussion: Local wound management strategies should be part of the plan of care and fit within the context of the overall healability of the burn injury. To optimize the local wound environment, clinicians must consider wound cleansing and debridement, management of bacterial burden and moisture control.

4.2.1 Cleansing

Discussion: To aid in minimizing the bacterial burden of a burn injury, wound cleansing is required to flush away surface microbes and foreign bodies, soluble debris and non-viable tissue. The challenge is in selecting the appropriate type of solution and application method. Cleansing solutions commonly used in wound management include sterile normal saline, sterile water, potable tap water, commercial wound cleansers and liquid antiseptics.[17] Such cleansing solutions may be appropriate in the management of burn injuries depending on the goals of care.

Expert opinion recommends that sterile solutions be used for acute burn injury management and in situations where underlying structures are exposed, to cleanse tunnels or sinuses, where the patient is immune-compromised or is suffering from a current wound infection (or has a history of recurrent wound infections), or in situations where potable tap water is inaccessible or the environment in which the wound is being cleansed is less than hygienic.

The Wounds Canada Skin and Wound Clean-up Product Picker: https://www.woundscanada.ca/dhfy-doc-man/public/health-care-professional/1307-product-picker-skin-and-wound-clean-ip/file is a useful tool to help clinicians choose the most appropriate type of wound cleanser. Regardless of the type of cleanser chosen, solutions should be applied in copious amounts at body temperature. Regarding the application method, safe irrigation (4–15 psi) is preferred to help flush away surface microbes, foreign bodies, soluble debris and non- viable tissue.

Chemical Burns of the Eye: Chemical burns to the eye require copious flushing and an ophthalmology consult upon arrival at the hospital. Late complications such as corneal ulceration, secondary glaucoma and cataracts are common and require follow-up. A Morgan Lens is used for emergency hand-free ocular irrigation and for multiple uses (e.g., acid burns [solvents, gasoline, detergent], alkali burns, non-embedded foreign bodies, foreign body sensation with no visible body, eyelid surgery and severe infection). Instructions for use are available at https://www.morganlens.com/media/1202/mortan_lens_instructions-2019v3.pdf.

4.2.2 Debriding

Discussion: Debridement serves to remove microbes, foreign bodies, debris and non-viable tissue from a wound to promote wound closure. As with wound cleansing, the appropriate method of debridement should be determined based on the needs of the patient and their wound, the environment, available resources and the scope of practice of the health-care clinician completing the debridement. Biological, mechanical, hydro surgical, chemical, autolytic and enzymatic debridement methods have all been reported in the literature as effective options for burn injuries to various degrees, although most research focuses on surgical debridement (either using xenografts, allografts, autografts or skin substitutes).

The Wounds Canada Skin and Wound Clean-up Product Picker is a useful tool to help clinicians choose the most appropriate form of wound debridement Hyperlink https://www.woundscanada.ca/dhfy-doc-man/public/health-care-professional/1307-product-picker-skin-and-wound-clean-ip/file and more information on debridement is available in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[16]

Debriding Blisters: If blisters are greater than 1 cm^2, are filled with cloudy serous fluid or blood, are in an area where they are prone to break with routine activities or are impeding joint function they should be deroofed. All blisters secondary to chemical burns should be deroofed. Areas that are difficult to debride include the interweb spaces of the feet and hands, thin areas on the face and dorsum of the hands and areas that are edematous secondary to fluid resuscitation.[164]

4.2.3 Managing Bacterial Balance

Discussion: Acute burn injury infections are one of the most serious complications.[165] Infections contribute significantly to burn morbidity and mortality.[166] Infections are the result of the interruption in the skin's barrier, immune dysfunction and from invasive procedures. Management must focus on optimizing the host response, reducing the number or virulence of microorganisms in the wound and optimizing the wound environment.[17] Jeschke et al. discuss

the importance of topical antimicrobials as the mainstay of non-surgical burn treatment; no one dressing or agent is superior, and antimicrobial choice is often determined by the burn unit product/dressing availability, the preference of the staff and historical experience. Strategies to manage bacterial burden at the surface of the burn wound include prophylactic and therapeutic use of topical antiseptics and antimicrobials (See Table 12).

The Wounds Canada Wound Dressing Formulary and Wound Dressing Selection Guide https://www.woundscanada.ca/docman/public/health-care-professional/1114-product-picker-2017-selection-guide-1/file product pickers are useful tools that can help clinicians choose the most appropriate antimicrobial dressing.

In the presence of spreading or systemic infection, systemic antimicrobials are indicated and are selected based on the results of a wound swab (obtained using the Levine technique) or tissue biopsy and histopathology. Common organisms in critically ill burn injured patients with bacteremia include: *Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella, Escherichia coli, Enterococcus* and *Acinetobacter* species.[167,168] Such infections typically require surgical interventions such as debridement of the involved tissue in conjunction with systemic broad-spectrum antimicrobials.[169] The International Wound Infection Institute has created several enablers for optimal infection management that can be useful tools for clinicians. Their resources can be found at www.woundinfection-institute.com

Table 12: Common Topical Antimicrobials Used in Burn Management

Agent	Description
Silver dressings*	• Silver-containing calcium alginates, foams, gels, gelling fibres and non-adherent synthetic contact layers • Some formulations kill bacteria within the dressing, others release silver into the wound bed itself • Broad-spectrum coverage • May be toxic in high concentrations to fibroblasts and keratinocytes or if not delivered in a sustained release manner • Most require less frequent dressing changes (except for the silver gel)
Honey (medical grade)	• Leptospermum honey-containing calcium alginates, gels and pastes • Biocidal effect is multifactorial • Broad-spectrum coverage • Low toxicity • Most require less frequent applications (except for the gel and paste) • Promotes autolytic debridement
PMHB (Polyhexa-methylene biguanide)	• Polyhexamethylene biguanide (PHMB)-containing ribbon gauze, gauze squares, transfer foam, foam, gel and non-adherent synthetic contact layer • Bacteria kill occurs largely in/on the dressing • Broad-spectrum coverage • Low toxicity • Most require less frequent dressing changes (except for the PMHB gel)
Gentian Violet/ Methylene Blue	• Gentian violet- and methylene blue-containing polyvinyl alcohol or polyurethane foam • Biocidal effect is multifactorial • Broad spectrum coverage • Non-cytotoxic • Require less frequent dressing changes
Hypochlorous acid (NaOCL/ HOCL)[170]	• Broad spectrum coverage • Used for multi-drug resistant organisms (MDRO) • Penetrates biofilm rapidly, killing formations from within; does not promote resistant bacteria strains

OCT (Octenidine Dihydro-chloride)[165]	• Broad spectrum coverage • Eradicates bacterial biofilm for up to 72 hours • Gel, irrigation and surfactant preparations • Does not promote bacterial resistance • Good tissue tolerability, not shown to disrupt healing • Anaphylaxis and allergic response rarely observed
PVP-I (Iodophors (Poly-vinyl alcohol)	• Knitted viscose fabric impregnated with polyethylene glycol containing 1% povidone iodine • Biocidal • Broad spectrum coverage • Require less frequent dressing changes • Used specifically for prevention of infection in minor burns
Silver sulfadiazine (SSD) cream	• Topical, water-soluble cream containing 1% silver sulfadiazine • Bacteriostatic • Broad-spectrum, but lacks fungal and vancomycin-resistant enterococci activity • Has cytotoxic effects on fibroblasts and keratinocytes and may delay healing of superficial burns[71] • May create a pseudo eschar • Once-daily dressing change versus twice daily[171] • Avoid in patients with sulfonamide allergies (sulfa) • Avoid applying to the face as in rare cases localized argyria may develop[172-174]

Adapted from: International Wounds Infection Institute, 2022.[165]

***A Note on Silver Dressings**
The 2018 International Society for Burn Injuries (ISBI) Practice Guidelines for Burn Care made the following recommendations for the use of silver as a topical agent: "Silver-containing compounds and dressings are effective topical antimicrobial agents. However, silver also has cytotoxic effects which may delay wound healing. Silver-based topical agents are appropriate for deeper burns (essentially those awaiting surgery)".[166] (ISBI 2018).

4.2.4 Managing Moisture Balance

Discussion: In addition to strategies noted in Recommendation 4.1 to improve the overall hydration status of a patient with a burn injury (such as fluid resuscitation and nutrition interventions), moisture balance within the wound base can be achieved through appropriate dressing selection and dressing change frequency. Planning dressing changes can be done in partnership with the OT/PT mobilization activities (mobilization allows prone areas like the back and posterior legs to be exposed to the air and dry out).

4.3 Select the appropriate dressings and/or advanced therapy

Discussion: A good burn injury dressing has the following characteristics (where indicated):[175]

- Promotes autolytic debridement of non-viable tissue,
- Protects against infection and environmental contamination/ trauma,
- Maintains a moist wound environment while containing or wicking away excess moisture,
- Reduces evaporative losses,
- Is non-adherent to protect delicate skin,
- Contours easily and conforms to the wound bed,
- Aids with splinting or immobilization,
- Is aesthetically pleasing,
- Is easy to apply and remove,
- Is painless on application, with wear and on removal and
- Is cost-effective (including the cost of the product, frequency of dressing change and the cost of health-care professional time).



The Wounds Canada Wound Dressing Formulary and Wound Dressing Selection Guide https://www.woundscanada.ca/docman/public/health-care-professional/1114-product-picker-2017-selection-guide-1/file product pickers are useful tools that can help clinicians choose the most appropriate wound dressing. Table 13 lists the common dressings that meet the characteristics noted above and that are commonly used on burn injuries. This table does not reference antimicrobial dressings, which were discussed in Recommendation 4.2.3.

Table 13: Common Dressings Used in Burn Injury Management

Dressing Category	Indication (based on a review of manufacturer dressing indications)
Acrylic dressings	Superficial partial-thickness burns, donor sites
Calcium alginates	Superficial partial-thickness and deep partial-thickness burns, donor sites
Film/ membranes	Superficial partial-thickness burns
Foams	Superficial partial-thickness and deep partial-thickness burns, donor sites
Gelling fibres	Superficial partial-thickness and deep partial-thickness burns, donor sites
Hydrocolloids	Superficial partial-thickness burns, donor sites
Hydrogels	Superficial partial-thickness burns
Non-adherent contact layers	Superficial partial-thickness and deep partial-thickness burns, grafts
Pain controlling dressings	Superficial partial-thickness burns, donor sites

A Cochrane review of dressings for superficial and partial-thickness burns conducted in 2013 revealed that, "silver sulphadiazine was consistently associated with poorer healing outcomes than biosynthetic, silicon-coated and silver dressings, whilst hydrogel-treated burns had better healing outcomes than those treated with usual care."[176] The authors noted, however, that there was a lack of high-quality evidence from which to draw conclusions.

Advanced therapies: In the absence of robust evidence, expert opinion suggests that the use of common advanced therapies, such as electrical stimulation therapy, low-level laser therapy, negative pressure wound therapy, therapeutic pulsed ultrasound and ultraviolet C light therapy is not appropriate in the treatment of acute burn wounds. Such therapies activate healing by stimulating inflammatory processes (growth factor release) and proliferation, and, in an acute burn situation, may result in excessive tissue growth and scarring. The same may not be applicable for chronic burn injuries; however, evidence supporting the use of common advanced therapies in such situations is also lacking. As previously mentioned, xenografts, allografts, autografts or skin substitutes are commonplace in the management of major burns, used to facilitate early wound coverage and reconstruction.[60] Once the thermally injured patient has been admitted, resuscitated, and all wounds have been assessed and managed appropriately with escharotomy and dressing, the surgeons need to determine the most efficient course of action regarding excision of burn and coverage. This should be undertaken as soon as the patient is resuscitated, usually within 24–48 hours post-injury. There is also emerging experimental data that supports cell salvage in burn injuries using non-ionic surfactants such as poloxamers, poloxamines and plurogel micelle matrix.[177]

4.4 Engage the team to ensure consistent implementation of the plan of care

Discussion: To ensure the best experiences and outcomes for patients with burn injuries, it is imperative that health-care professionals involved in the care of people with burns keep abreast of current research and innovations in burn wound management. This may be challenging for teams working in, "resource-challenged or austere environments (RAEs) where even basic burn care may not be available".[60] Whether it be developments in burn injury prevention, assessment or management knowledge and/or skills, all professional members of rescue teams, emergency services, community-based, acute and rehabilitation health care providers have an obligation to remain up-to-date and to share information on the latest evidence, practice and self-management strategies. Burn care team members also must focus on collaborative, timely communication through web-based, charting, verbal and written approaches. Team cohesion, trust and education remain foundational to burn management success.[178]

Step 5: Evaluate Outcomes

Recommendations
5.1 Determine if the outcomes have met the goals of care

Discussion: Routine reassessment using validated tools helps clinicians determine if the goals of the prevention and/or treatment plan have been met. If the person with the burn injury:

- Is progressing in a timely manner toward the achievement of their goals, carry on with the plan of care
- Is not progressing in a timely manner toward the achievement of their goals, return to Step 1 of the Wound Prevention and Management Cycle and reassess the patient, their wound and the environment and system factors
- Has met their goals, plan for discharge by reviewing self-management strategies.

Common expected outcomes for people with burn injuries by depth are noted in Table 14.

Table 14: Common Expected Burn Outcomes by Burn Depth

Classification	Expected Outcomes
Superficial (first degree)	Healing within 3–5 days* No scarring
Superficial partial-thickness (second degree)	Healing within 14–21 days* No scarring
Deep partial-thickness (deep second degree)	Prolonged healing (may require skin grafting) Minimal scarring and contractures
Full-thickness (third degree)	Prolonged healing (will require skin grafting) Moderate to considerable scarring and contractures
Full-thickness (fourth degree)	Prolonged healing (amputation possible and will require skin grafting) Moderate to severe scarring and contractures

*These times may vary based on a patient's pre-existing comorbidities.

5.2 Reassess patient, wound, environment and system if goals are partially met or unmet

Discussion: When the goals of care have not been met in a timely manner (See Table 11), it is imperative to go back to Step 1 of the Wound Prevention and Management Cycle: Assess and/or Reassess. Careful reassessment of the patient, their wound and environment and systems factors will most often reveal modifiable factors that need to be addressed.

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Discussion: At transitions of care (from acute to rehabilitation to community care), people with, or at risk for, burn injuries and their care partners, require relevant, focused information regarding the cause and risk factors for burn injuries, as well as their risk for re-injury. Both formal and informal educational methods are beneficial, including the use of standardized patient-education materials, as well as individualized demonstration and review of prevention and management techniques. Burn management should focus on skin care, scar/keloid management, and reduction of itch and complications. Therefore, specific teaching relevant to a newly closed burn injury includes the following.

Skin care: For at least 12 months (or longer) post closure, burn-injured skin requires daily (or more frequent) cleansing and moisturizing (using an emollient). Products that are pH-balanced, non-scented and non-sensitizing are preferred. The fragile tissue should also be protected from the sun during this period, as it is more prone to sunburn, and sun exposure may cause further pigmentation changes.

Burn itch: Itchiness at the site of the burn injury is common post wound closure and can be worsened by heat, stress and physical activity. Keeping the tissue moisturized as noted above, keeping the area cool, employing techniques such as relaxation and distraction, and using pressure garments are some non-pharmacological techniques effective in reducing itch. Topical and oral antihistamines may also be required.

Hypertrophic scarring: Burn wounds, like all wounds, heal with the formation of scar tissue. For infants and children, parents and care partners play a key role in scar management.[179] The amount of scar produced generally relates to the depth of the injury sustained. If not managed appropriately, scars can become hypertrophic, and if they happen to cross one joint or more, can cause contracture and, as a result, decreased function of the area. The length of time for a burn scar to mature can be two years or more.[145] Treatment of hypertrophic burn scars involves several different modalities. Monstrey et al. suggest that pressure and silicone therapy should be applied in burn wounds that take longer than two to three weeks to close or after skin grafting.[180] Nedelec et al. support the use of non-silicone and silicone gels and gel sheeting after burn injury.[181] Pressure is strongly recommended to decrease scar erythema and scar height.[182]

Pressure is applied in the form of pressure garments—often custom measured and fit for each patient—as soon as possible after wound healing.[83] It is important that the rationale for using compression be regularly discussed with the patient.[183] Despite the widespread use of pressure garments, the mechanism of their function is not well understood. Some authors suggest they can help by reducing oxygen tension in the scar,[184] while others believe it has cellular effects on mechanoreceptors regulating apoptosis of dermal fibroblasts and cytokine regulation, which would reduce scarring.[185] Pressure garments may also be helpful with the edema, pruritus and pain that can be associated with burn scars.[186] Silicone gels and silicone gel sheeting have been used in combination with compression. Borgognoni suggests that possible mechanisms of action could be occlusion and hydration of the scar surface (stratum corneum),[187] and this is not limited to just silicone products.[188] Other products such as mineral oil-based gel sheeting, hydrocolloid products, silicone-based elastomer inserts and splinting material are also useful and require more research. Burn scar massage may also be beneficial to reduce scar thickness, reduce pruritus and anxiety; more research is needed.[189]

Scar massage therapy is an important part of scar care. Massage must be tailored to the patient's symptoms. Barnes et al. in a review (n=10) studies reported the majority of the studies (9) showed significant improvement with varied techniques. Oscillation and friction and oscillation massage used together improve scar function, where petrissage and effleurage improved scar visibility and pain.[190] Patients and caregivers can be taught how to correctly do burn massage.

Teamwork must continue and be focused on activities of daily living and reintegration into life, work and social activities.

Burn prevention is a topic relevant to both individuals with burn injuries and those at risk for such injuries. The simple safety measures below are a sample of interventions that reduce the risk of burn injury. They should be discussed with all patients to whom they are relevant.

Strategies to Support Burn Prevention

Scald Prevention
- Ensure water heater temperatures are not too high (50° C)
- Keep hot drinks away from tables or counter edges
- Avoid drinking hot liquids through a straw
- Turn the handles of saucepans inward
- Put cold water into baths first, followed by hot water, and test the temperature before using

Contact Burn Prevention
- Test the temperature of car seats before placing children in them
- Unplug hot irons and keep them out of reach of children
- Keep children away from grills
- Use approved glass or metal protective screens in front of fireplaces
- Wear oven mitts to remove items from the stove

Fire/Flash/Flame Prevention

- Install smoke alarms and consider installing sprinklers
- Make a fire escape plan and have regular fire drills
- Use child resistant-lighters and safely store lighters and matches
- Use space heaters carefully and keep them away from anything that can burn
- Never leave candles unattended

Electricity Burn Prevention

- Put covers on electrical outlets that are within a child's reach
- Throw out electrical cords that are frayed or damaged
- Avoid overloading extension cords or outlets
- If flooding occurs, turn off electrical circuits before stepping into the water
- Avoid using hair dryers or other electrical appliances near water

Radiation Burn Prevention

- Avoid direct sun exposure between 10 a.m. and 4 p.m.
- Wear clothing with UPF 50+ protection
- Wear sunglasses with UV protection
- Avoid tanning and UV tanning beds
- Apply sunscreen to your entire body 30 minutes before going outside and reapply every two hours and immediately after swimming

Chemical Burn Prevention

- Store chemicals in their original containers
- Maintain labels on containers holding chemicals
- Store chemicals out of the reach of children
- When possible, purchase chemicals with the least toxicity
- Purchase chemicals with child-resistant closures
- Wear protective clothing/equipment when handling chemicals (follow manufacturer labels).

At discharge, the plan of care needs to be revisited and revised as needed to ensure that appropriate self-management strategies are in place to support the patient and sustain outcomes.

Conclusion

This chapter identifies the need for wound specialists across Canada and is a practical guide for interprofessional wound care providers, administrators and educators to assist them in developing patient-driven, comprehensive, evidence-informed plans of care.

In summary, the first step is to holistically assess the needs of the patient and their burn wound. Determining burn severity is an important outcome of this assessment, as this will dictate the most appropriate location for care. Most minor non-complex burns can be managed on an outpatient basis, whereas moderate burns may require hospitalization and major burns need immediate transfer to a burn centre. Patient and burn wound assessment will also allow for prediction of outcomes based on burn severity, as, generally, superficial burns heal spontaneously with no scar within one week, superficial partial-thickness burns close with conservative treatment and no scar within three weeks, and deep partial-thickness and full-thickness burns heal (with varied amounts of scarring and contracture) over greater periods of time and may require surgical intervention. Furthermore, there is a complexity that needs to be considered when a patient is assessed for morbidity and mortality risk, mental health, quality of life, and coping and social environment. These recommendations delineate these aspects and give the reader guidance into the complex assessment of burn wounds.

Once the patient is properly assessed, realistic goals need to be set, and a plan of care developed, which is reflected in steps 2 and 4 of the Wound Prevention and Management Cycle. The management of burn wounds requires an integrated team approach, the importance of which cannot be overemphasized (See Step 3). Such interventions can be divided into emergent and non-emergent patient needs and may include fluid resuscitation, escharotomies, fasciotomies, transfer to a burn centre, treatment of inhalation injury, and maintaining organ function and circulation.

The general rule is, if in doubt, call a burn centre to receive appropriate guidance and support.

The surgical plan for a patient with a burn injury may include debridement and auto-grafting. At this time there is no alternative to the gold standard: using split-thickness skin grafts from the burn patient (autologous skin grafting). There are various means to temporize or augment that goal, such as the use of skin or dermal substitutes. Currently, the ultimate success depends on the patient's healing, and therefore split-thickness skin grafting is the treatment of choice.

There are a variety of dressings from which to choose. Availability may differ between burn centres or localities. Each dressing has its own indications, but no single one guarantees success.

Long-term outcomes of a burn patient are very different than previously thought, as burn wound closure historically was synonymous with recovery. This dogma has changed significantly over the last 10 years, however, as we realize a burn patient who has healed may not have entirely completed their treatment. There are long-term consequences for burn patients. These consequences not only include scarring or scar contracture restriction in mobility, strength and quality of life, but also metabolic and physiologic aspects as well as mental health.

Mental health has a significant impact on successful long-term outcomes, and in fact dictates the degree of recovery and quality of life. Therefore, following up with a burn patient for a prolonged period is essential.

This chapter provides clinicians with focused and practical guidance to assess a burn patient, create goals, assemble a team and develop, implement and evaluate a plan of care that includes sustainability over the long term and through transitions of location and healing phase. Burn care can be delivered in many settings, depending on the severity and type of injury. When in doubt, however, it is best to call a specialized burn centre to receive information and assistance in developing a plan of care, delivering care or identifying the need for specific interventions.

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Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 9

Prevention and Management of Surgical Wound Complications

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INTRODUCTION

Healthcare Excellence Canada (formerly Canadian Patient Safety Institute) considers surgical care safety a priority.[1] The International Surgical Wound Complications Advisory Panel (ISWCAP) defines a surgical wound complication as, "a disruption to normal incisional wound healing following surgery".[2] ISWCAP lists the most common surgical wound complications as: surgical site infections (SSI), wound dehiscence, scarring/hypergranulation, periwound maceration and breakdown, seromas/hematomas and medical adhesive-related skin injury (MARSI).

Surgical wound complications have negative impacts for patients, including pain, increased length of stay, delays in adjuvant therapies/treatments (e.g., chemotherapy, radiation, and plastic surgery reconstruction), negative psychological and quality of life (QoL) outcomes, readmission to hospital and increased mortality.[2]

Surgical site infection (SSIs) are a major concern and account for 20% of all hospital acquired infections (HAIs). SSIs are associated with a two- to 11-fold increase in the risk of mortality; and SSIs can extend hospital length of stay by 9.7 days and affect patient quality of life and outpatient and community care health-care costs.[3] Seventy-seven percent of surgical patient deaths are reported to be related to infection.[4,5] Infection has a direct correlation to open surgical wounds. Surgical site infection (SSI) is the most common health-care-associated infection among surgical patients. The costs of SSI hospitalizations can increase by more than $20,000 per admission, making prevention and education initiatives on reducing SSI crucial.[6,7]

Surgical procedures can be performed either as an inpatient or day surgery with admission of at least one night or, depending on the procedure, in outpatient ambulatory care settings. It is estimated that 75% of surgical procedures are performed on outpatients, making the issues of prevention, detection, treatment and reporting of SSIs in the community or long-term-care sectors challenging and essential.

SSIs are of growing concern to health-care systems due to a negative impact on health-related quality of life, increased length of stay in hospital, financial burden to health-care system and patient morbidity.[8] SSIs account for 16% of all health-care-associated infections; of these, 1% related to orthopedic procedures and 10% to large bowel surgery. SSIs can often be prevented through initiatives focused on pre-, intra- and post-operative care and education and through a collaborative approach to teamwork and communication.[9]

Surgical teams are responsible for establishing clinical and system reviews to identify any issues, review incidents, develop solutions and improve outcomes.[10,11]

The Government of Canada created the Canadian Nosocomial Infection Surveillance Program (CNISP), a network that conducts surveillance of health-care-associated infections in several areas including: "surgical site and device related infections associated with:

- central lines,
- hip and knee arthroplasty,
- cerebrospinal fluid shunts and
- adult and pediatric cardiac surgery".[6]

For more information visit the CNISP web page at: https://www.canada.ca/en/public-health/programs/canadian-nosocomial-infection-surveillance-program.html#a1

For more information see Health Care Excellence - Enhanced Recovery Canada. https://www.healthcareexcellence.ca/en/what-we-do/all-programs/enhanced-recovery-canada/

This document is written with the intent to encompass the quintuple aim for health care improvement. This is to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity. This equity piece is particularly important for patients living with surgical site infections (See Table 1). Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[13]

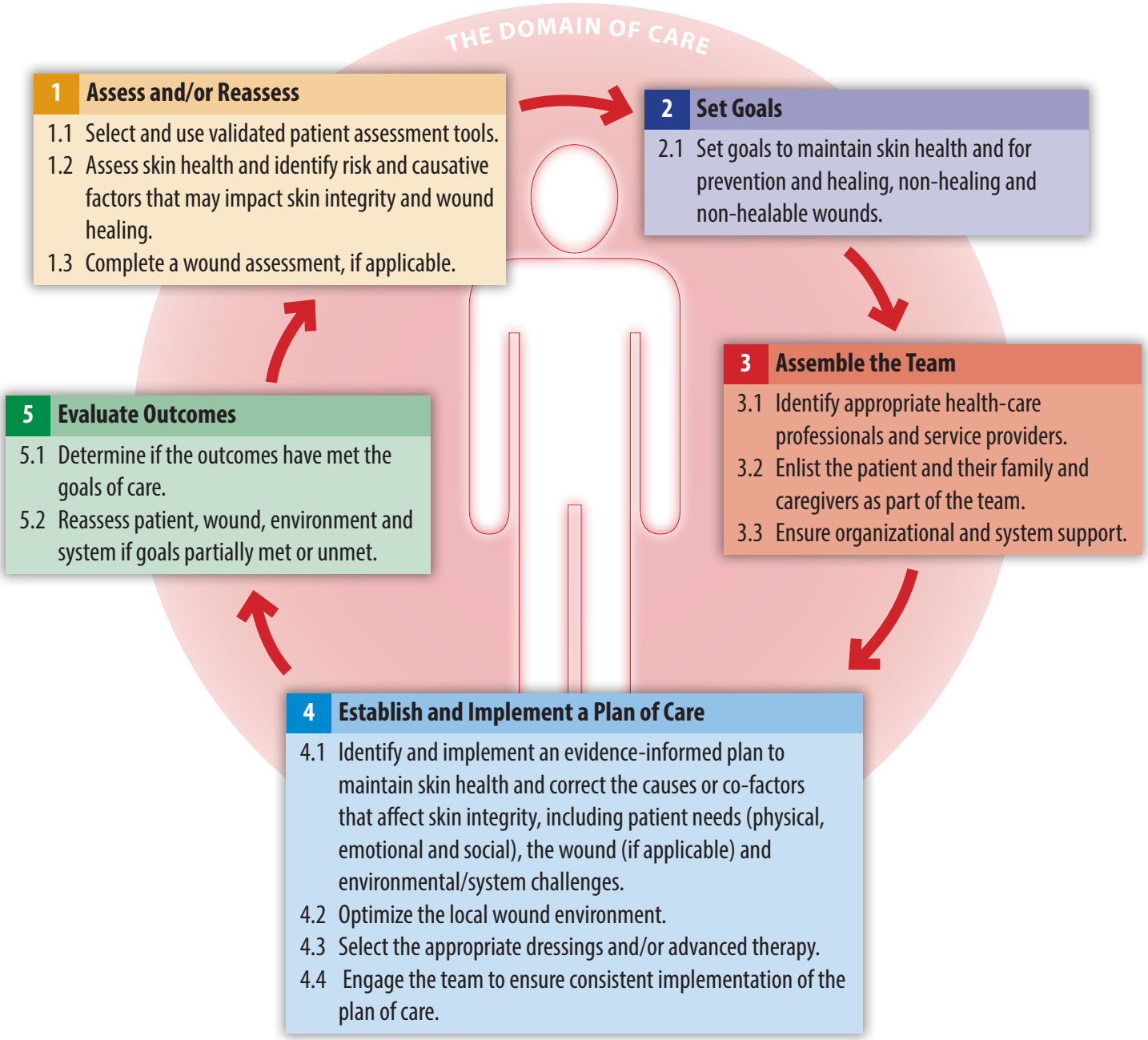
Table 1: Quintuple Aim and Management of Surgical Site Infections

5 components	Applied to Surgical Site Infections
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practice to ensure most effective treatment Appropriate use of resources- screening for risk, intraoperative and postoperative dressings, nutrition, devices
Advancing health equity	Application of principles to all those at risk or affected by surgical site infections
Care team well-being	Providing clinically usable information for front line clinicians
Enhancing the patient experience	Providing a supportive process of care for all those with surgical site infections

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide that incorporates the best available evidence. It outlines a process, or series of consecutive steps, that supports patient-centered care. This process, called the Wound Prevention and Management Cycle (See Figure 1) guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of wounds from the initial assessment to a sustainable plan targeting self-management for the patient.

Figure 1: The Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence using electronic databases to identify relevant articles. They are intended to support the clinician, patient, family and health-care team in planning and delivering the best clinical practice. Two foundational papers supplement this document with additional evidence-informed information and recommendations that are general to all wound types: Chapter 3: Skin: Anatomy, Physiology and Wound Healing[14] and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

Three guiding principles within the best practice recommendation papers (BPRs) support effective prevention and management of skin breakdown.

- Use of the Wound Prevention and Management Cycle regardless of the specifics to prevent and manage skin breakdown
- Constant, accurate and multidirectional flow of information within the team and across care settings, and
- The patient as the core of all decision-making.

Step 1: Assess and/or Reassess

Discussion: Clinicians should complete a holistic patient assessment to identify patient factors that may affect surgical wound healing in the pre-, intra- and postoperative phases.[9] The pre-operative phase is a critical time, offering the opportunity to create an environment that prevents surgical wound complications. It is important to note that reassessment needs to occur during the entire post-operative phase including transitions of care across the health-care system. Surgical wounds should be assessed and the findings documented using a standardized documentation and reporting approach including the integrated team.[3,16]

The pre-operative assessment assessment includes review of intact skin and any current skin issues and treatments being used. Immediately post-operatively, a comprehensive wound assessment tool should be used to establish a baseline to assist with identification of any wound changes. This information helps identify either wound healing or deterioration and should guide ongoing treatment decisions. Assessment of the person with a surgical wound begins immediately post-op; however, most surgical incisions are not usually assessed until 48 hours after surgery since, in most cases, the original post-operative dressing remains in place for the first 48 to 72 hours.[9,16]

Recommendations

1.1 Select and use validated patient assessment tools

Discussion: In addition to the wound assessment tools discussed in Chapter 4, the following are focused on assessment of surgical wounds:

- The ASEPSIS online calculator tool was developed to evaluate the effectiveness of antibiotic treatment on surgical site infections by examining wound characteristics.[17] It was validated for high inter-rater reliability but not evaluated for validity, intra-rater reliability or responsiveness.[18] Available from: https://www.medicalalgorithms.com/the-asepsis-scoring-method-for-postoperative-wound-infections
- The Granulometer's purpose was to assess the status of skin grafts and had inter- and intra-rater reliability when used by surgeons to determine wound-healing progression. It was not tested with other health-care professionals. It had a non-significant predictive ability for graft take, suggesting that it was not sensitive to small changes.[19]
- The Surgical Wound Assessment Tool (SWAT) was recently developed.[20] The developers reported intraclass correlation coefficient value of the overall scale was 0.79 (95% CI 0.67–0.89), $p < .001$, confirming excellent inter-rater reliability. Cohen's kappa value ranged from 0.5 to 1, demonstrating moderate to almost perfect level of agreement for individual items, except for one item on pain. Available from: https://www.swrwoundcareprogram.ca/uploads/contentdocuments/hcpr%20-%20surgical%20assessment%20guide.pdf

An additional assessment tool, which contains a section specifically for surgical wounds, is the Outcome and Assessment Information Set-C (OASIS-C), a modification of the Outcome and Assessment Information Set (OASIS) that home health agencies in the United States must collect in order to participate in the national Medicare program.[21] It provides guidance regarding what is and is not considered a surgical wound,[21] and how to classify surgical wounds.[22] OASIS-C

states that surgery on a pre-existing wound, or due to a traumatic injury involving the skin, is not classified as a surgical wound; however, surgery to repair or remove an injured internal organ due to trauma, where the skin was intact is considered a surgical wound.

Also according to OASIS-C, skin grafts over existing wounds are *not* surgical wounds, but donor sites are surgical wounds.[23] These definitions are open to discussion and interpretation and, generally, if a surgical procedure is involved, any resulting incision, wound or skin graft is considered either a surgical incision or a surgical wound. If it is not healed in 30 days, it is still considered to be a surgical wound. It is important that there is agreement within each health-care organization about what is and what is not categorized as an open surgical wound.

In OASIS-C item M1342, *Status of Most Problematic (Observable) Surgical Wound*, there are four possible choices, each with further description:[24]
0: Newly epithelialized,
1: Fully granulating,
2: Early/partial granulation and
3: Not healing (may or may not be associated with infection).[24]

For wounds healing by primary closure with well-approximated incisions, the close proximity of the incisional edges leaves no areas for granulation to occur. Therefore, only the, "newly epithelialized" and "not healing" choices apply. For wounds healing by secondary intention, all four choices would apply.[22] This guidance applies to surgical wounds closed by either primary intention (specifically, approximated incisions) or secondary intention (specifically, open surgical wounds).

1.2 Identify risk and causative factors that may impact skin integrity and wound healing

Discussion: Performing a thorough and holistic pre-operative assessment will identify any patient-specific risk factors that can be addressed in preparation for surgery.[9] When the surgery is emergent and risk factors cannot be addressed before the intervention, it is important to identify any intrinsic and extrinsic factors that can be mitigated in the post-operative period and to intervene as soon as possible.[25]

1.2.1 Patient: Physical, emotional and lifestyle

Discussion: Many surgical procedures are complex and may carry significant risks for patients regardless of the health-care setting.[26] The patient facing surgery brings their own unique individual health, lifestyle and travel history.[27] Some bring excellent health with the expectation of rapid healing, while others have surgery when their complex health history or issues puts them at risk for impaired general recovery and wound healing.[16] Knowing which patients are at risk for a surgical wound complication such as an SSI, what to look for, and recognizing the signs and symptoms as early as possible are crucial in order to implement the appropriate plan of care. SSIs are one of the leading causes of nosocomial infections impacting patients.[3]

The American College of Surgeons Surgical Risk Calculator https://riskcalculator.facs.org/RiskCalculator/ is an invaluable tool designed to provide evidence-based insights into assessing the risk of SSI. With the ever-evolving landscape of health care, precise risk evaluation is crucial for timely and effective decision-making. This user-friendly online platform offers health-care professionals a systematic approach to estimate the risk of SSI events in individual patients. By inputting relevant patient data, including clinical history, biomarkers and risk factors, the Surgical Risk Calculator generates personalized risk assessments, aiding clinicians in identifying high-risk patients and tailoring interventions for optimal patient care.

Pre-operative Physical Assessment

An important strategy to prevent surgical wound complications is completion of a detailed pre-operative assessment to identify potential factors that may impact healing and increase the risk for an SSI. All factors identified pre-operatively that may affect wound healing must be reported to all health-care professionals involved in the

patient's post-operative care.[25] If the surgery required is urgent, pre-operative assessment should focus on the body system immediately involved.

The American Society of Anesthesiologists (ASA) 25 Class is a tool for communicating patient pre-anesthesia comorbidities. It was not specifically designed to predict perioperative risks like wound infection. The classification system alone does not predict risks like wound infection, but used with other factors, it can be helpful in predicting peri-operative risks. Patients assessed in Class III to V are at higher risk.[28] The physical status of the patient is classified by ASA as follows:

- Class I: A normally healthy patient with no functional limitations, non-smoking and minimal alcohol use
- Class 2: A patient with mild systemic disease without substantive functional limitations, current smoker, social alcohol use
- Class 3: A patient with severe systemic disease that limits activity, with substantive functional limitations
- Class 4: A patient with severe systemic disease that is a constant threat to life
- Class 5: A moribund patient who is not expected to survive without the operation
- Class 6: A patient who is declared brain-dead and whose organs are being harvested for donation.

See Statement on ASA Physical Status Classification System at: https://www.asahq.org/standards-and-practice-parameters/statement-on-asa-physical-status-classification-system for more information.

The following are key patient and surgery-related risk factors that contribute to surgical site infections.[29,30]

Patient-related factors
- Advanced age[1,9,31]
- Obesity[1,8,9,31]
- Hyperglycemia/diabetes[1,8,9,31]
- Dyspnea[31]
- Hypoxia[9]
- ASA class>II[14,31]
- Smoking[1,8,15,31]
- Substance use (alcohol)[31]
- Steroid use[1,31]
- Recent radiotherapy[31]
- Preoperative albumin ≤3.5mg/dL[31]
- Total bilirubin >1.0 mg/dL[31]
- Trauma/shock[9]
- Transfusion[9]
- Hypothermia[9]

Surgery-related factors
- Inadequate surgical scrub or skin preparation[9]
- Abdominal surgery[9,31]
- Surgery requiring a bowel anastomosis[9]
- Contaminated or dirty/infected procedures[9,31]
- Surgery for cancer[9]
- Emergency surgery[31]
- Complex surgery (work relative value unit ≥10)[31]
- Prolonged procedure[9]
- More than three diagnoses at time of discharged[9]

In relation to surgery, malnourishment is an independent risk factor for surgical site infection (SSI).[32] Malnutrition is either a lack or excess of nutrients, including protein, that affects overall health and function. It can be difficult to address when trauma has occurred or chronic conditions that cause inflammation are present and/or when appetite

is decreased.[33] Malnourishment slows and delays wound healing and increases SSI risk.[34,35] For patients of advanced age,[25] or who are obese and/or those living with diabetes mellitus,[36] the risk of infection increases.

A body mass index (BMI) that is above or below the recommended level will place the patient at increased risk of poor outcomes.[37] Of concern are males with a BMI > 25 kg/m2 and women with a BMI > 30 kg/m2, as these are associated with a five times greater risk of an SSI with subsequent complications than for non-obese individuals.[25,38] This is thought to be related to the increased cardiac output, stroke volume and poorly oxygenated adipose tissue in obese individuals.[39] When there is fatty tissue around the neck and diaphragm and laparoscopic gasses, breathing is hindered, causing hemodynamic compromise and further tissue hypoxia.

Surgical patients at risk of possible malnutrition should be screened by a registered dietitian. For hospitalized patients, the assessment should be conducted using a valid and reliable tool appropriate to the patient population. Screening should occur at admission or as soon as possible after admission and findings should be integrated in to the patient specific holistic plan of care.[40]

Patients living with diabetes mellitus (DM) are at double the risk of SSIs compared with persons without diabetes.[41] Elevated post-operative glycemic levels are a significant risk factor for SSIs and should be aggressively treated.[42] Ata et al. state that post-operative glycemic control is of more importance than pre-operative levels in relation to SSIs.[43] Hyperglycemia is associated with surgical mortality and morbidity.[44]

In a meta-analysis completed by Sorenson, it was identified that SSIs are two times as likely to occur in patients who smoke than those who do not smoke. Assuming that pre-operative screening can occur, smoking cessation should be encouraged for at least four weeks prior to surgery.[45] Discussion regarding risk of smoking when surgical interventions are planned should be part of informed patient consent.[44] In 2020, the World Health Organization released a statement on how smoking greatly increased risks of complications after surgery. Individuals who quit smoking approximately four weeks or more before surgery can lower their risks and have better surgical results up to six months afterward.[46]

Pre-operative preparation

Patients undergoing surgery require education as to specific activities they may be asked to undergo. They will be advised to have a pre-operative shower, remove nail polish and false nails and/or undergo nasal decolonization.[9,47] Depending on the type of surgery, patients may be given pre-operative prophylaxis antibiotics in accordance with antibiotic stewardship guidelines.

During this time, risk assessment and prevention of skin pressure injuries (care bundles) is completed and preventive measures such as positioning and repositioning, use of surfaces and pillows is recommended.[48] Consider use of prophylactic dressing to protect bony prominences and utilize offloading heel devices. For more information on pressure injuries see Chapter 7: Prevention and Management of Pressure Injuries.

Pre-operative Mental Health and Spiritual Assessment

Patient readiness for surgical intervention and mental health and wellbeing can impact healing and surgical outcomes such as pain and satisfaction.[49] Care of an individual includes recognizing their spiritual health in order to maximize their healing and recovery, so an early assessment is important.[50] For some, the surgery is a welcome solution to a physically limiting condition. For other patients, however, the surgery may be unexpected or consented to only as a life-saving procedure—for example, a motor-vehicle accident, where the patient may not be fully prepared for this body alteration. The emotional results of this will impact the engagement of the patient to participate in their health and recovery.

For some patients, surgery may mean the end of pain or hope for a cure. It is important to clearly communicate with the patient, family and care partners the intended clinical surgical outcomes and the potential unexpected results.

Some patients experience anxiety prior to surgery, and for people with pre-existing anxiety, it can be exacerbated. It is important clinicians offer patients and family members concise, clear and relevant information and support through all phases of surgical care, including during assessment.[9] Some methods to reduce anxiety include education and patient handouts, with opportunities to talk, and be listened to, about their concerns.[51] Also, listening to music, reading meditations, or using relaxation techniques may be of support.[52] Sedatives are often administered within two hours prior to surgery, which can help to relieve immediate stress. A comprehensive literature review by Rosenberger et al. found in five orthopedic studies that patients who were worried, anxious or depressed pre-operatively were likely to experience a slower recovery, but it did not link these factors to an increased risk of surgical site infection.[53] While we know that psychological stress impacts the immune system and can negatively impact wound healing, at this time the literature does not show a direct link to surgical site infections.[54]

Intra-operative Risk

The intra-operative risk of developing an SSI can be affected by the nature of the intended surgical procedure; whether or not an SSI develops can depend upon how these factors interact.[9] There are a number of potential risks.

- Patients with high ASA index[55]
- Hypothermia[55]
- Advanced age[55]
- Length of procedure (greater than 75th percentile of predicted operating time increases risk)[55]
- Status of surgery: i.e., clean; clean surgery involving placement of a prosthesis or implant; clean-contaminated; contaminated; or dirty and infected
- Type of surgery: Colon surgery carries the highest risk of an SSI, followed by vascular surgery, cholecystectomy and organ transplant
- Method of surgery: Laparoscopic versus open colorectal surgery has a statistically lower rate of SSI ($P < 0.0001$), although risk for both types is dependent on the classification (clean versus dirty) and length of surgery.[56] For patients who are obese, laparoscopic surgery reduces the SSI rate by 70 to 80% compared with open surgery across general abdominal surgical procedures[44]
- Level of oxygenation of the tissues: Surgical wounds are at high risk of hypoxia, so preventative measures should include keeping subcutaneous perfusion and oxygenation optimal (arterial pO2) and preventing conditions that restrict peripheral perfusion, such as hypovolemia, excessive pain, vasoconstricting drugs and hypothermia[9]
- Emergent (vs. elective) surgery[55]
- Implants (vs. no implants)
- Use of internal mammary artery grafts (for coronary artery bypass graft)
- Prolonged ventilation
- Use of blood products

During a surgery the risk of developing a pressure injury exists depending on the length of the procedure. A pressure injury risk assessment should be completed pre-operatively, and the findings integrated into post-operative care plan, including the use of pressure redistribution surfaces.

Although it can be assumed that the patient's stress levels are reduced with medication during surgery, Nilsson et al. examined the use of relaxing music played in the operating room and concluded that it may decrease post-operative pain.[57] There are pros and cons to playing music in the surgical theatre. In a review of 18 studies, researchers noted that certain music elements affect performance on a surgical task positively or negatively. Classical music when played softly can improve accuracy and speed of surgical tasks.[58]

Post-operative Risks

Wound dehiscence is a complete or partial disruption of wound closure with or without evisceration and protrusion of tissue or organs. This is a severe complication that may lead to immediate surgical intervention, the possibility of repeat dehiscence, a surgical site wound infection[61] and/or development of incisional hernia formation.[62]

While many of the SSI risks following surgery are the same as the pre-operative ones, there are some additional risk factors.

Post-operative dressing selection and integrity:
- Saturated and/or leaking dressings allow migration of bacteria to the wound in a rapid manner[59]

Wound care:
- Disruption of the sutured or staple incision by vigorous cleansing before it has re-epithelialized can introduce bacteria below the dermis[59]

Wound dehiscence:
- Exudate extending past the 48 hours post-operative period increases the potential for wound dehiscence, and often occurs around the seventh day post-op[22]
- Poor glycemic control, malnutrition, smoking, obesity and mechanical stress on the wound bed from heavy lifting, coughing, vomiting, sneezing and straining increase the risk of dehiscence[60]

Patient condition and interventions:
- Post-operative respiratory and urinary infections
- Infections secondary to wound sepsis or medical devices such as indwelling Foley catheters and intravenous (IV) lines, and diarrhea related to use of antibiotics (e.g., *Clostridium difficile* associated disease)[9]

In addition, hematomas or seromas may develop and require intervention.[16] The presence of hematomas and/or seromas increases pressure and compresses blood vessels, causing wound ischemia and, if untreated, may cause tissue necrosis. Hematomas can also cause flap necrosis due to a free-radical-induced cytotoxic mechanism.[63] There is an increased occurrence of hematoma or seroma in surgical wounds associated with the increased clinical use of anticoagulants and prophylactic treatments now recommended and implemented for deep vein thrombosis.[16]

1.2.2 Environmental: Socio-economic, care setting, potential for self-management

Discussion: Poor patient self-efficacy, knowledge required for post-operative wound monitoring and communication may lead to negative clinical outcomes.[64] In the RNAO's Person and Family-Centered Care Nursing Best Practice Guideline, it is recommended that to achieve the goal of, "having the person's proactive and meaningful engagement as an active partner in their health care, we should listen and seek insight into the whole person to gain an understanding of the meaning of health to the person and to learn their preferences for care".[65] A therapeutic relationship between the person with the surgical wound, the care partners and family, and health-care professionals is needed to build a genuine, trusting and respectful partnership. Through surgical transitions of care (acute, rehab, home) or services, patients should have the opportunity to share any concerns related to wound care, devices, medications, appointments and transportation.[66,67]

It is essential to respect individuals as experts on their own lives, recognizing everyone's choices are shaped by their unique circumstances. Health-care professionals should engage with strong communication skills and a commitment to culturally sensitive, non-judgmental approach. Maintaining a respectful and supportive stance is essential to fostering trust and encouraging positive outcomes.[65] Families and care partners also have an important role in the care for and recovery of people who have had surgery, and if those supports are not part of an individual's normal life, the patient may be at increased risk for complications.[68]

The patient's values, preferences, literacy, beliefs, culture, ethnicity, spirituality, interests, life circumstances (including financial security or worry) and previous health experiences all affect their priorities, concerns and preferences.[65,66]

To support self-management skills, consider the following resources:
Self-Management BC https://www.selfmanagementbc.ca/home

Here is a list for the other provinces https://www.selfmanagementbc.ca/selfmanagementprogramsoutsidebc

1.2.3 Systems: Health-care support and communication

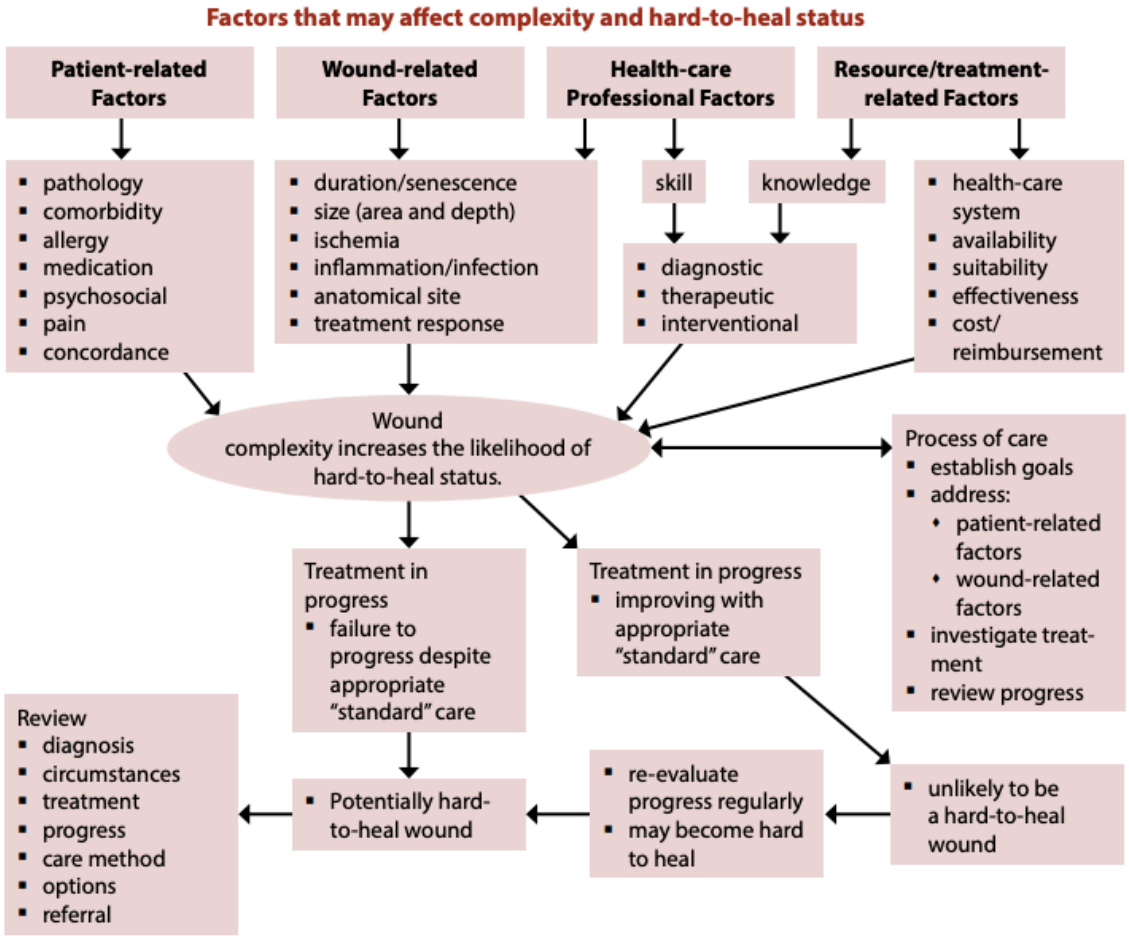
Discussion: It is the responsibility of health-care organizations to reduce harm, improve health care and protect Canadians by establishing SSI surveillance programs.[69] The National Healthcare Safety Network (NHSN) in the United States recommends that SSI surveillance periods be at least 30 days for superficial incisional, deep incisional and organ/space SSIs.[69] In addition, 90-day surveillance is required for specific surgeries (prosthesis/implants). The list of surgical procedures can be found at the National Healthcare Safety Network site[70]: https://www.cdc.gov/nhsn/pdfs/pscmanual/pcsmanual_current.pdf.

With an increasing number of surgical outpatient procedures taking place,[71] many SSIs will not be captured by hospital SSI surveillance programs. Post-discharge surveillance should occur, with participation of family physicians, nurse practitioners, community home-care agencies and long-term care facilities, and with a mechanism to report and track recognized signs and symptoms of SSI, so that outcomes and trends can be reported back to hospitals, surgeons and health authorities (e.g., surgical quality, surveillance and risk teams).[3]

Effective surveillance of SSI includes a focus on targeted high-risk and high-volume operative procedures. According to the Centers for Disease Control in the United States, successful SSI surveillance includes, "epidemiologically sound infection definitions and effective surveillance methods, stratification of SSI rates according to risk factors associated with SSI development, and data feedback".[71]

There are four main factors that may affect hard-to-heal wounds.[72] The algorithm in Figure 2 outlines the relationships among patient, wound, health-care professional and resource/treatment-related factors and is intended to support clinicians in recognizing the complexity of wounds.[48]

Figure 2: Predictors for Wound Healing



Source: *Moffat C, Vowden P. Hard-to heal wounds: a holistic approach. London: MEP Ltd; 2008. Reprinted with permission.*

1.3 Complete a wound assessment, if applicable

Discussion: Before completing the wound assessment it is important to complete a head-to-toe skin assessment to determine risk or presence of additional skin issues not directly related to the surgical interventions.[48]

A complete surgical wound assessment includes the peri-incisional skin and the incision line. When assessing the peri-incisional skin ensure to assess and address any medical-adhesive related skin injury (MARSI), which may present as dermatitis, skin stripping, maceration, folliculitis, skin-tears, or blistering.[73] In addition, assess for any skin and wound issues separate from the post-operative wound assessment (See Table 2).

Table 2: Surgical Wound Descriptions[23]

0 Newly epithelialized: • wound bed completely covered with new epithelium • no exudate • no avascular tissue (eschar and/or slough) • no signs or symptoms of infection
1 Fully granulating: • wound bed filled with granulation tissue to the level of the surrounding skin • no dead space • no avascular tissue (eschar and/or slough) • no signs or symptoms of infection • wound edges open
2 Early/partial granulation: • ≥ 25% of wound bed covered with granulation tissue • < 25% of wound bed covered with avascular tissue (eschar and/or slough) • no signs or symptoms of infection • wound edges open
3 Not healing: • wound with ≥ 25% avascular tissue (eschar and/or slough) OR • signs/symptoms of infection OR • clean but non-granulating wound bed OR • closed/hyperkeratotic wound edges OR • persistent failure to improve despite appropriate comprehensive wound management

Source: Wound, Ostomy and Continence Nurses Society (WOCN). WOCN's Nurses Society's guidance on OASIS-D integumentary items: best practice for clinicians. 2019. Available from: https://cdn.ymaws.com/member.wocn.org/resource/resmgr/docs/OASIS-D_Best_Practice_Docume.pdf

The following three steps provide a systematic approach to surgical wound assessment, goal planning and treatment. Depending on their organization, clinicians should follow the recommended assessment for post-operative surgical wound assessment.

1. What are you seeing? MEASURE is one example of a mnemonic that helps the team assess wound parameters.[74,75] The following parameters identified in the MEASURE mnemonic should be included in the wound assessment and may help the team connect in a common language when monitoring a wound.[74]

2. When are you seeing it? It is equally important to note when to look for changes in the surgical wound. Bates-Jensen and Woolfolk describe outcomes and expected time frames for positive and negative results of surgical wound healing.[76] (See Table 3).

3. What should you consider if you see it? Early recognition of alterations in healing, as outlined in point number 2, will support early intervention to return the patient to a healing trajectory.

Table 3	Positive	Negative
Incision	Colours of the incision progress Days 1–4: red with approximated edges Days 5–14: bright pink Day 15–1 year: pale pink The incision is well approximated and does not show signs of tension	Days 1–4: evidence of tension on the incision line Days 5–9: the incision may no longer be well-approximated, and the tension remains, and may progress to incisional dehiscence; the colour may remain red Days 10–14: the colour may remain red or progress to bright pink
Scar Tissue	Light-skinned persons will have white or silver scarring Persons with darkly pigmented skin will progress from pale pink to darker than usual skin colour	There may be prolonged epithelial resurfacing and/or keloid or hyper-trophic scarring that may present in the first year of healing
Peri-incision	Days 1–5: signs and symptoms of normal inflammation will be present, including: edema, erythema, warmth and mild pain	Absence or delay of normal inflammation Days 1–5: no evidence of edema, erythema, skin discolouration or warmth, and minimal pain at the incision site Days 5–9 extending to days 10–14: signs and symptoms of inflammation demonstrating a delay in healing progression Beyond this, healing can stall or plateau, with no healing and ongoing inflammation lasting 1–2 years or longer Hematoma or seroma formation which can progress to days 10–14
Exudate	Minimal/moderate sanguineous to serous exudate may be present between days 1–3 but should resolve by day 5	Minimal to moderate serosanguinous exudate between days 5–9 Serous or purulent; any type or amount of exudate beyond day 9 is abnormal
Closure	Epithelial closure should be seen by day 4 along the entire incision A healing ridge of newly formed collagen can be felt along the whole incision line during days 5–9 Wound closure materials are removed at some point between days 9–14, with skin closure strips or tape strips used after their removal	Removal of skin closures will be delayed when healing is not progressing as expected For wounds healing by secondary intention, the edges do not approximate, and the wound fails to contract There will be a lack of epithelial resurfacing of the entire incision by day 4, or it may be only partially present, with lack of the collagen healing ridge and dehiscence evident by day 14

SSIs can be acute (occurring within and lasting < 30 days) or chronic (occurring after 30 days) and range from superficial to deep incision or organ/space infection (See Figure 3).

After surgery, the wounds (not procedures) are classified as follows by the Centers for Disease Control and Prevention.[5]

Clean: An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital or uninfected urinary tracts are not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow non-penetrating (blunt) trauma should be included in this category, if they meet the criteria.

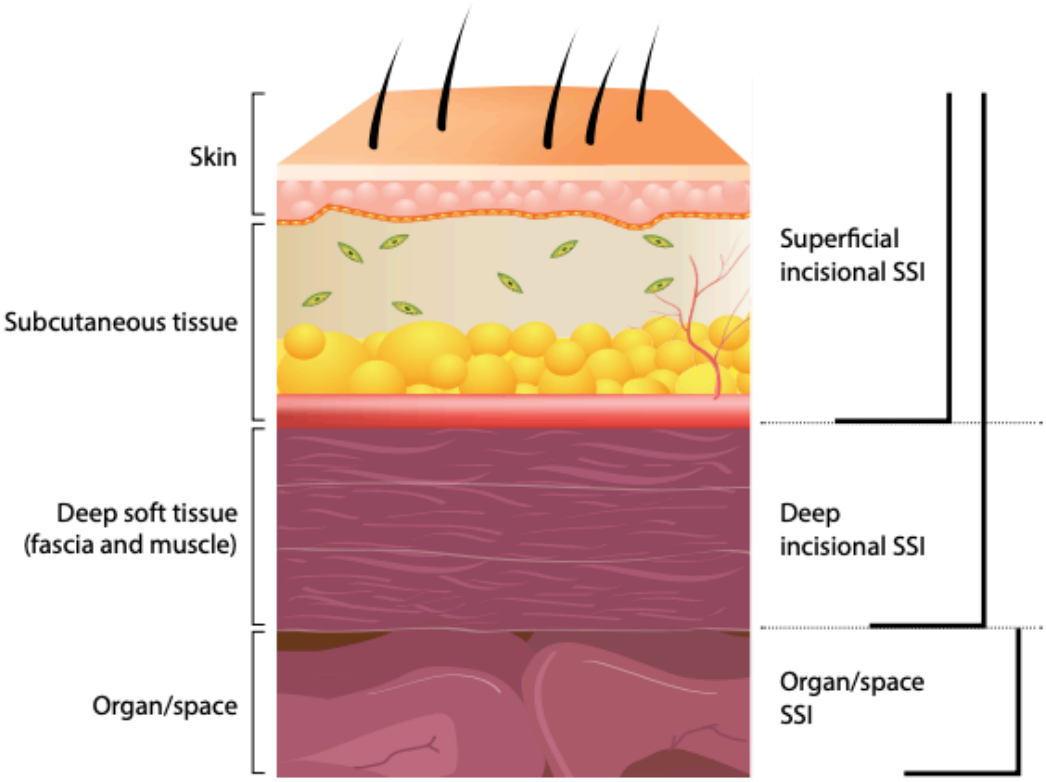
Clean-Contaminated: Operative wounds in which the respiratory, alimentary, genital or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, surgery involving the biliary tract, appendix, vagina and oropharynx is included in this category, provided no evidence of infection or major break in technique is encountered.

Contaminated: Open, fresh, accidental wounds. In addition, surgeries with major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, non-purulent inflammation is encountered, including necrotic tissue without evidence of purulent drainage (e.g., dry gangrene), are included in this category.

Dirty or Infected: Includes old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing post-operative infection were present in the operative field before surgery.

Figure 3: Cross-section of Abdominal Wall Depicting CDC Classifications of Surgical Site Infection[77]

The respective clinical presentations are different, with differing long-term outcomes. Studies have identified the importance of SSI surveillance for at least 30 days, if not for a year, following surgery.[78] SSIs related to artificial hardware, such as total hip or knee arthroplasty, can occur up to a year following the surgery and need to be identified as such.



SSIs can be divided into three categories, with various signs and symptoms. The three categories are:

- Superficial incisional SSI (primary or secondary): infection occurs in the skin (localized) where the incision was made,
- Deep incisional SSI (primary or secondary): infection occurs beneath the incision and in the tissues and surrounding muscles and
- Open or space SSI: involves any part of the body deeper than the fascial/muscle layers that is opened or manipulated during the operative procedure.[3]

For a detailed description of the criteria for each of the three categories of SSI—superficial incisional, deep incisional and organ/space—please visit the following page: https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf

Step 2: Set Goals

Discussion: Goals are set with patients about to undergo surgery and those living with surgical wounds, their family and/or care partner(s) and the interprofessional care team. Realistic goals should be based on identified risk factors and complete patient, wound and environmental assessments. Patient priorities and goals for health care in regard to the surgical wound must be identified along with the available options so that informed decisions can be made. Health-care providers must respect the person's right to choose the interventions they prefer for their health, even when those decisions are in conflict with medical opinion or recommendations.[65] There *are* times when the patient's wishes cannot be consulted: during surgery, if a decision must be made, based on clinical decisions alone, to leave the wound open to heal by secondary or tertiary means, or if a primarily closed wound continues to drain beyond the expected 48-hour timeframe and/or if the wound dehisces.

Recommendations

2.1 Set goals to maintain skin health and for prevention and healing, non-healing and non-healable wounds

Discussion: Ideally, goals for the prevention of complications of the surgical wound should be set before the surgery takes place. Afterward, when the person is initially recovering from their surgery, they are also coping with the effects of anesthesia, analgesia, disrupted sleep patterns, bodily changes, changes to nutrition, and they may have weakness, nausea and pain. The initial short-term goals should address these issues and promote healing and prevention of complications, and the restoration of general health.

2.1.1 Identify goals based on prevention and healability of wounds

Discussion: In the absence of an SSI, the factors that delay healing in surgical wounds are similar to those in any healing wound. There are some significant differences, however, regarding the results of an SSI, when there are implanted devices, hardware, mesh or organ transplants.

From a clinical perspective there are three surgical wound closure goals:

1. Closed surgical wounds that heal by primary intention are those where the skin edges are joined together, without any areas of separation, eliminating dead space and minimizing the need for new tissue formation.[79] These wounds generally heal without complications and with minimal scar formation and do not contain granulation tissue. Exudate from acute surgical wounds is rich in white blood cells, essential nutrients and growth factors that support the stimulation of fibroblasts and production of endothelial cells.[80] Re-epithelialization of the uppermost approximated skin edges normally occurs within 24 to 48 hours and wound closure at two to three days.[81,82] Normal practice, however, is to keep sutures or staples intact for seven to 10 days and sometimes longer at the surgeon's discretion. Acute surgical wounds heal within an expected time frame and without complications.[16]

2. Delayed primary closure of a surgical wound may be used to prevent infection in contaminated surgical wounds. The wound is allowed to remain open for several days before final closure to ensure all sources of contamination have been removed and/or infection is resolved.[79] Another term for this method is *healing by tertiary intention*.

3. Surgical wounds that may be dirty or infected heal best by secondary intention, where the wound is left open and heals when granulation tissue fills the wound from the base up.[79] Failed primary closure incisions that dehisce or separate are often best left to heal by secondary intention.



It may also be that the wound is deemed 'non-healable', because there is no opportunity for healing due to co-morbid factors, or that major surgery is required to close the wound but the person's health precludes that from happening.

2.1.2 Identify quality-of-life and symptom-control goals

Discussion: Patients may not identify wound healing as a goal of care. Pain or tenderness alone can be a symptom of an SSI, and pain levels need to be

consistently addressed to determine if pain reduction goals are being met.[71] Patients are affected by surgical interventions in several ways, including their ability to return to driving, employment, school, social life, body image and overall functionality.[83,84]

Step 3: Assemble the Team

Discussion: Health-care professionals, patients, their care partners and family must take responsibility for doing all they can to support a holistic, integrated approach to care and work together to ensure the best possible outcomes. As surgery-related procedures, including preparation, intervention, discharge and follow-up, involve shorter hospital stays, a trusting, culturally sensitive, positive relationship must be developed among the patient, care partners, surgical team and follow-up clinicians. Patients need to know who the members of their team are, and the roles each plays, if they are to fully participate in the planning of their care long-term.

Recommendations
3.1 Identify appropriate health-care professionals and service providers

Discussion: Surgical-wound healing requires a collaborative team approach.[9] An integrated approach allows for the safe and efficient treatment of patients who are at high risk for surgical site complications.[85] From the physician consult to the laboratory and diagnostic department, community pharmacists, the pre-admission care team, community nurses, dietitians, spiritual care providers, physiotherapists, social workers, wound care clinicians, ostomy/continence nurses, discharge and transition of care planning teams[66] and the in-house surgical team—in pre-, intra- and post-operative phases—many clinicians are involved with the patient and family. It is important that the goals that are set support the patient and care partners through the physical and psychosocial challenges that arise from having a surgical wound—especially one with complications—and that the right team members are in place to do so. Managing an SSI may require that an infectious disease practitioner be added to the integrated team.



Collaboration and mutual respect, leadership sharing, decision-making, authority and responsibility are key elements of successful integrated teams, and this applies whether the team is within one organization, is using web-based or virtual communications, or practices remotely.[66] Surgeons hold primary responsibility for the patient's surgical care, including postoperative wound management and monitoring until healing is complete. Nurses play a role in wound care management and must adhere to the scope of practice and standards set by their College, and employer limits and conditions, ensuring they practice within their authorized scope and competencies.

For example, in Ontario, initiation of wound care below the dermis is within the controlled acts authorized for Registered Nurses (RNs) and Registered Practical Nurses (RPNs). The College of Nurses Ontario notes that, "Nurses may

independently decide that a specific procedure is required and initiate the procedure in the absence of a direct order or directive from a physician.[86] When a surgeon, or other provider, has provided an order for a specific wound treatment, a nurse does not have authority to change the order. Doing so, without contacting and communicating with the physician, jeopardizes the surgeon-patient-nurse relationship.

Instead, through surveillance and collaboration, teamwork helps to prevent surgical wound complications and manage them when they occur. Effective teamwork requires clear communication. Several researchers report that communication failures contribute to adverse events and patient injury, and many lead to malpractice claims.[87,88]

3.2 Enlist the patient and their family and care partners as part of the team

Discussion: Patient involvement starts in the doctor's office or emergency room, as soon as patients are made aware of the need for a surgical intervention.[9] When possible, patients and care partners can work with their family doctor, the surgeon and the pre-operative team for optimal surgical preparation to reduce post-surgical complications. Health-care professionals can help patients verbalize their wishes and set short- and long-term goals for transitions to sub-acute, rehabilitation and/or community care.

All communication should be individualized and consider the persons goals, culture, experiences, and values.[65] The plan of care needs to be meaningful to the person and their care partner within the context of their life.[65] In our richly diverse country, care should be culturally appropriate, sensitive to traditions and meet patient and family needs. Patients and care partners must be offered relevant, consistent communication (in most appropriate form) for all aspects of care, including risk of surgical site infection—or other complications—and how to prevent, and to whom to report, any concerns.[9]

3.3 Ensure organizational and system support

Discussion: The RNAO Intra-professional Collaborative Practice - Best Practice Guideline[89] has clear recommendations for leaders of key agencies to strengthen collaborative practice among interprofessional teams to ensure this type of care is a collective strategic priority.[89] Interprofessional care must align with organization initiatives for healthy work environments, including an evidence-informed approach to planning, implementation and evaluation of joint activities. This is especially important when patients are moving through the health-care system (called transitions in care and/or discharge planning).[66] As well, the Agency of Healthcare Research and Quality in the U.S. offers additional strategies and supports for transitions in care for health-care teams, especially related to effective and consistent communication with patients and their care partners.[67]

The reality is that the integrated health-care team for care of an open surgical wound may work for and report to a number of agencies, depending on the province or territory. For example, the surgical operating theatre personnel may write a report or discharge summaries that are not, or cannot be, shared with the regulated health-care providers responsible for patient care in the community (e.g., the primary care general practitioner, physician, nurse practitioner, home-care staff or long-term care staff). In the same way, community nurses are often challenged by a lack of patient post-operative surgical information and a secure electronic way of sending wound photographs to the surgeon. As well, there is a need for more research to develop and test options for integrated care/case conferencing and securely sharing patient information in a timely way within a virtual environment.

Step 4: Establish and Implement a Plan of Care

Discussion: The integrated team needs to create a treatment plan to eliminate or reduce factors that may negatively affect surgical-wound healing in the pre-operative, intra-operative and post-operative phases of care. Strategies that promote timely healing of surgical wounds are essential in all phases of care.

Recommendations
4.1 Identify and implement an evidence-informed plan to maintain skin health and correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional and social), the wound (if applicable) and environmental/system challenges

Discussion:
Pre-operative Strategies

Pre-operative treatment plans can reduce the risk of a surgical wound failing to heal, a wound dehiscence, an SSI or any surgical-wound complication. Focused assessments (i.e., respiratory, physical activity, obesity etc.) and malnutrition screening will assist in the development of the pre-operative plan. These plans may include smoking cessation (four weeks or longer ahead of surgical date), improved glycemic control, and nutritional adjustments to support intra-operative experience and post-operative healing.

Pressure injury prevention begins pre-operatively by completing a pressure injury risk screening and intervening (surfaces, prophylactic dressings over bony prominences, pillows).[48]

Medications for diabetes and autoimmune issues should be reviewed with specific instructions for use before surgery.[90]

The Canadian Malnutrition Task Force has guidelines and a screening tool, found at http://nutritioncareincanada.ca.

In addition, Healthcare Excellence Canada supports the understanding of the pre-operative mental health status (dementia, depression) of the person by establishing a baseline status.

Delirium is of great concern after surgery, medication changes, sleep changes, catheter use, and or change of living situation. Delirium increases the patient's length of hospital stay, increases mortality and reduces physical and mental functioning.[91]

Healthcare Excellence Canada has excellent resources to support delirium assessment, available at: https://www.healthcareexcellence.ca/en/what-we-do/all-programs/hospital-harm-is-everyones-concern/hospital-harm-improvement-resource/delirium-introduction/

Assess and address use of substances including opioids (strong opioids, or weak opioids)[92] pre-operatively (short-term, long-term- 90 days plus). Assess current usage, purpose and discuss with physicians and the pharmacist.[93,94] Golpen et al. reported long-term opioid users stayed one day longer in the hospital.[94] An expert consensus group released opioid prescribing guidelines for common surgical procedures to guide clinician decision making.[95]

Individuals having surgery and their care partners should receive information and advice on potential wound and dressing care including any ostomies, fistulas or drains, role of antibiotics and how to recognize problems with the wound and whom to contact if they are concerned.[9] Pre-operative education should involve a review of post-operative instructions with the patient, family and/or care partners. Patients may choose a family member or caregiver to participate in the education sessions.



Pre-op surgical education should be reinforced and continue post-operatively with the patient and family-designate.[9] Education materials for patients must reflect each individual's needs in terms of language, reading level, culture and traditions. Post-operative education topics should include hand hygiene, SSI risks, signs and symptoms of complications and team members' contact information. Education will need to be updated depending on the surgical phase of the patient's care, especially if they are readmitted to the hospital.

Recommendations for SSI reduction during the pre-operative phase include several strategies. Patients should be advised or helped to have a shower, bath or bed bath using soap on the day before or the day of surgery.[9] Recent studies report the role of pre-operative showering or bathing with antiseptics in preventing surgical site infections to be uncertain. More research is needed on this important topic.[9] Nasal decolonization (following protocol) in combination with a chlorhexidine body wash may be considered before procedures in which *Staphylococcus aureus* is likely to cause an SSI.[9] Similarly, evidence related to the role of pre-operative hair removal in reducing SSIs is insufficient. If hair removal is needed, it is best to clip hair the day of surgery using a single-use clipper.[9] Mechanical bowel preparation in colorectal procedures must follow protocols.[90]

International Guide for Infectious Diseases (2018). Guide to infection control in the healthcare setting: Preparing the patient for surgery. Available at https://isid.org/guide/infectionprevention/preparing-the-patient-for-surgery/

Individuals having surgery for which antibiotic prophylaxis is indicated receive this in accordance with the local antibiotic formulary.[9] Local epidemiology and resistance patterns do vary, especially as antibiotic choices can change with specific cases.

Enhanced Recovery Canada provides clinical pathways to support Enhanced Recovery After Surgery (ERAS) which include antibiotic protocols and SSI prevention strategies. These clinical pathways can be found at https://www.healthcareexcellence.ca/en/what-we-do/all-programs/enhanced-recovery-canada/

Safer Healthcare Now recommends the initiation of four key strategies in the peri-operative phase to reduce an SSI[69]:

1. Perioperative antimicrobial coverage
   a. appropriate use of prophylactic antibiotics
   b. antiseptic use – bathing, showering
   c. decolonization
   d. antiseptic-coated suture
2. Appropriate hair removal
3. Maintenance of peri-operative glucose control
4. Peri-operative normothermia.

Intra-operative Strategies

Surgical patients are cared for by an operating team that minimizes the transfer of micro-organisms during the procedure by following best practice in hand hygiene and theatre wear, and by not moving in and out of the operating area unnecessarily.[9] Staff protocols should include the removal of all hand jewelry, artificial nails and nail polish before operations.[9]

The skin should be prepared at the surgical site immediately before incision, using an antiseptic (aqueous or alcohol-based) preparation. Povidone-iodine or chlorhexidine are most suitable. Caution should be exercised regarding the use of skin antiseptics in babies (chlorhexidine, both alcohol-based and aqueous solutions).[9]

The recent NICE guidance does not recommend the use of diathermy for surgical incisions to reduce the risk of i nfection.[9] Diathermy increases the risk of an SSI, even though it is faster than a scalpel and causes less bleeding, both of which individually, when not associated with diathermy, *decrease* the risk of an SSI. If diathermy must be used, antiseptic skin preparations and alcohol-based preparations should be allowed to dry by evaporation.[9]

When using sutures, clinicians should consider using antimicrobial triclosan-coated suture, especially for pediatric surgery, to reduce SSI risk.[9]

As well, for cesarean surgery, clinicians should consider use of suture, not stapes to reduce risk of superficial wound dehiscence.[9] Studies comparing different closure techniques, such as continuous versus interrupted sutures, have not found a statistically significant difference in the SSI rate, but using continuous sutures is quicker.[96,97]

Suturing techniques such as progressive tension closure using a regular or a barbed suture technique in conjunction with drains for abdominoplasty are being explored as ways to decrease the risk of seromas.[98,99] Low-tension sutures are more conducive to healing than those applied with too much tension, which can cause skin injuries on their own.

Retention sutures, which are intended to prevent wound dehiscence in abdominal surgery, can cause increased pain, lacerations and device-related pressure injuries. A prospective study examining the benefit of prophylactic retention sutures post-laparotomy concluded there was no significant decrease in incidence of post-operative evisceration, wound infection and post-operative pain.[99]

Adults having surgery under general or regional anesthesia must have normothermia (normal body temperature) maintained before, during (unless active cooling is part of the procedure) and after surgery.[9] Strategies to maintain patient homeostasis and normal body functions during the intra-operative and post-operative periods include maintaining a body temperature of 37°C or 98.6°F, providing supplemental oxygen in the recovery room and maintaining a hemoglobin saturation rate (SpO2) of 95% during the operation and the immediate post-operative period.[9]

Proper hydration during the peri-operative period is warranted, although further research is required to demonstrate whether supplemental fluids reduce the risk of an SSI.[9]

Post-operative Strategies

Incisional healing: SSIs resulting from inpatient procedures may be recognized while the patient is still in hospital or, more commonly, after discharge. Furthermore, since up to three-quarters of all surgical procedures are performed in the hospital outpatient setting, most SSIs will be recognized in the community; therefore, discharge planning must address the recognition of the early signs and symptoms of surgical wound complications.[100]

Pain: Depending on the surgery type, post-operative pain can be either nociceptive or neuropathic, or a combination. Prescribed opiates remain key to post-operative pain management, but nonsteroidal anti-inflammatory agents (NSAIDS) can help to reduce the amount of opiates required in the acute phase, thus reducing opioid side effects, misuse, overdose or death.[95,101] Patients using opioids pre-operatively should be in consultation with the medical and pharmacy team to offer support in prescribing medication that is in line with the surgery type.[95]

Post-operative music therapy may reduce the patient's anxiety, pain and opiod/narcotic consumption.[102] Additional comfort measures such as non-adherent dressings, warmed solutions and sitz baths for perineal wounds can be tailored to the patient's needs and situation but need to be evaluated for effectiveness.[9] The patient must be given an opportunity to discuss their knowledge and beliefs about pain management strategies and provide information as needed. Their response to the pain management interventions must be consistently reassessed using the same re-evaluation tool. The frequency of reassessments will be determined by presence and type of pain, e.g., acute versus persistent, pain intensity, medical condition and practice setting.[9]

Nutrition: Consider prompt post-operative nutritional support to prevent wound dehiscence caused by malnutrition.[60]

System Support

SSIs affect 26,000 to 65,000 patients annually in Canada, and they cause considerable morbidity and increased medical costs.[36] Therefore, maintaining only in-hospital surveillance can conceal significant SSI rate increases or outbreaks and prevent timely feedback and implementation of interventions to improve patient outcomes. Because many post-operative infections occur after discharge from acute care, careful follow-up in the community is essential.[68] Community home health nurses are well-positioned to support post-discharge SSI surveillance programs among the various types of patients in which SSIs can occur.[103,104]

4.2 Optimize the local wound environment through:

4.2.1 Cleansing

Discussion: Wound cleansing at its best should remove foreign bodies such as organic or inorganic debris, inflammatory contaminants such as devitalized tissue, bacteria and wound exudate without causing trauma to healthy cells or introducing bacteria deeper into the wound.[105,106]

Care of a post-operative wound healing by primary intention should employ a non-touch aseptic technique using sterile saline up to 48 hours after surgery. Showering is permitted 48 hours after surgery in most cases; however, the decision is up to the attending surgeon and will be tempered by factors such as drains, hardware and skin grafts.[9] Attempts to cleanse a primary incision in early stages can disrupt the pathogenic organisms along the suture line.[107] Most surgical incisions do not require cleansing,[108] but cleansing may contribute to patient comfort and remove any materials that may delay the healing process.[77]

According to Rosen and Manna, "Wound dehiscence is a partial or total separation of previously approximated wound edges, due to failure of proper wound healing. This scenario typically occurs five to eight days following surgery when healing is still in the early stages. The causes of dehiscence are similar to the causes of poor wound healing and include ischemia, infection, increased abdominal pressure, diabetes, malnutrition, smoking, and obesity."[109]

Cleansing of surgical wounds that dehisce should be left to heal by secondary intention. These wounds may have an increased bacterial load which requires clinical assessment and consideration of the type of cleansing agent and technique to be used. Each of the options may have clinical benefits as well as precautions. The NICE guidelines recommend that tap water be utilized for wound care after 48 hours if the incision has separated or has been surgically opened to facilitate the drainage of pus.[9]

The Joanna Briggs Institute cautions that tap water for post-operative wounds should not be used if it has been declared non-potable.[110] If used, the tap should be run for 15–30 seconds prior to use, and safety of the tap water must be assured in rural areas. The choice of solution should reflect patient preference and a formal economic evaluation. Boiled and cooled water is an acceptable solution in the absence of potable tap water, although in the authors' experience, many health-care professionals still prefer to use sterile normal saline in their care of dehisced incisions, high-risk wounds and particularly when vascular grafts or hardware are involved.

A primary incision that has even small areas of dehiscence should never be irrigated without speaking with the surgeon first; irrigation can introduce pathogens into deeper compartments, causing increased risk of infection, particularly in highly vascularized areas such as the scalp and face.[111]

There are a number of wound irrigation considerations:

- Hand hygiene procedures and aseptic technique should be employed
- The clinician and patient should wear protective goggles and clothing as required
- Some clinicians advise that irrigation is not appropriate if you cannot see the base of the wound; decisions about irrigation of surgical wounds should rest with the surgeon, as noted above
- Forcing the irrigation fluid should never be done, as it can breach the fascial plane
- The volume of irrigation solution should be dependent on the size of the wound and the amount of infection and/or devitalized tissue. An adequate volume of solution should be used to assist in removal of debris (biofilm)[112]
- A non-sterile container should be used to catch and measure the amount of irrigation solution. Use of gauze, blue pads or abdominal pads to catch irrigation returns is needless and costly
- The tissue above the tunnel or undermining should be massaged gently to expel the irrigation fluid
- Where possible, the patient should turn from side to side to assist with irrigation returns
- It is important to ensure that the majority of the irrigation fluid is recovered. If it is not, irrigation is not appropriate
- Two adages may apply here: "The solution to pollution is dilution" and "Irrigate until the returns are clear."[111]

For more on cleansing, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

4.2.2 Debriding

Discussion: The removal of necrotic tissue will help to reduce bacterial burden in the management of an SSI. In collaboration with the surgeon, clinicians must determine what method of debridement or combination of methods is most appropriate. When considering who will be carrying out the debridement, consider scope of practice, competency (knowledge, skill, attitude, mentorship), environment and patient comfort.[113] Sharp debridement requires that appropriate analgesia be provided to the patient before, during and after the procedure, and that the setting allows for the achievement of hemostasis.

For more on debridement, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

4.2.3 Managing bacterial balance

Discussion: Management of bacterial balance is essential for decreasing SSI risk. A complete and holistic patient assessment prior to surgery will allow the health-care team to identify and address factors that increase a patient's risk of developing an SSI to more effectively reduce bacterial load and optimize patient status. If an infection is diagnosed clinically, a semi-quantitative wound swab for culture and sensitivity should be done to help determine the appropriate antimicrobial.

The use of peri-operative prophylactic antibiotics can effectively decrease bacterial load and SSI risk.[90] However, the indiscriminate use of antibiotics has contributed in part to the development of antibiotic-resistant strains of bacteria (e.g., methicillin-resistant Staphylococcus aureus [MRSA], vancomycin-intermediate or -resistant strains of Staphylococcus aureus [VISA/VRSA], vancomycin-resistant Enterococcus faecium and multi-drug-resistant Pseudomonas aeruginosa and Acinetobacter species). Peri-operative antibiotic prophylaxis should be used based on SSI risk assessment. Surgeries that require the use of antibiotic prophylaxis include clean surgeries involving the placement of a prosthesis or implant, clean-contaminated procedures and contaminated surgeries.[9]

When SSI occurs, treatment decisions are based on a number of patient and pathogen factors.

Acute SSI

Recommendations for the treatment of acute SSIs are shown in Table 4, organized by the parameters of time. SSIs uncommonly occur during the first 48 hours after surgery, and fever during this early period usually arises from noninfectious or unknown causes. Superficial SSIs are monitored for 30 days from the surgery for all procedure types. Surveillance timeframes for other SSIs are generally determined by the operative category and range from 30 to 90 days.[114]

Chronic SSI

Managing a chronic SSI requires treatment based on the duration (generally more than one month) and location of the wound and the type of infection involved. Clear guidelines for the management of chronic infection in a surgical wound are less well defined and usually rely on expert consultation (See Table 4).

Chronic SSI requires clinicians take a multimodal approach with medical and surgical interventions, as well as address any patient factors that have led to the infection. Further surgical intervention is frequently required, depending upon the problem, usually to remove devitalized tissue or infected foreign material, close a fistula or ulcer space or drain/remove a sinus tract.

Multi-resistant micro-organisms such as MRSA, Gram-negative bacteria or fungi may be involved. Long-term antimicrobial therapies are usually required, based on the antimicrobial susceptibility patterns of the isolated microbiota. Rehabilitation is frequently needed as part of the recuperation phase. In part, depending on the type of surgery involved, such as hip or knee arthroplasty, an SSI may mean a further loss of mobility.

In the Canadian Institute for Health Information (CIHI) report on compromised wounds in Canada 2011–2012, iatrogenic wounds, which include post-procedural complications/infection/disruption, post-device, implants and graft infection and obstetric surgical wound or puerperal infection, accounted for the following numbers:[115]

- Acute care 41,255 (1.7%),
- Home care 3,152 (2.9%),
- Continuing complex care 2,753 (13.8%) and
- Long-term care 1,818 (1.3%).

Table 4: Management Recommendations for Acute Surgical Site Infections[116-118]

Note: Empiric antimicrobial choices may differ based on local epidemiology; please refer to local guidelines for details.

Parameters of time	Action

Fever < 48 hours after procedure (and up to 96 hours)	• Less likely to represent SSI in this time period
	• If no other systemic signs/symptoms are present, observation is indicated
	• True soft-tissue emergencies include necrotizing clostridial, streptococcal or mixed anaerobic infections. Management for these cases includes the following:
	  • urgent surgical consultation for debridement of involved tissue
	  • administration of empiric antimicrobial therapy, based on the diagnosis, likely causative micro-organisms and local resistance patterns
	  • specialist (infectious disease) consultation may be required. Antimicrobial combinations (narrow based on infection / culture results) may include:
	  • piperacillin/tazobactam, ampicillin/sulbactam or carbapenems +/– vancomycin (empiric therapy choices)
	  • cefazolin + metronidazole
	  • penicillin G + clindamycin (definitive therapy)
	  • vancomycin + metronidazole

Fever > 96 hours after procedure	• Conduct a wound assessment for signs/symptoms of infection and assess for systemic signs/symptoms of infection • When applicable, remove sutures, perform incision and drainage of the surgical site and (sterile) culture for bacterial pathogens • Consider imaging studies to assess for abscess formation (e.g., ultrasound, CAT scan) • Empiric antibiotic therapy is indicated for cases with systemic signs of infection • For surgical procedures conducted above the waist (i.e., trunk, head, neck or extremities), consider the following antimicrobial therapy: first-generation cephalosporin with MSSA activity (e.g., cefazolin) vancomycin or linezolid (based on local MRSA rates) For surgical procedures involving the axilla, gastrointestinal tract, perineum or genitourinary tract, agents with activity against Gram negative and anaerobic bacteria are recommended: • cefazolin + metronidazole • ciprofloxacin + metronidazole • vancomycin + ciprofloxacin + metronidazole

Localized Infection

Wolcott et al. found that 95% of all bacteria that might be associated with, or causative factors for SSIs, are never isolated and so have never been identified and actually require molecular techniques to detect. More than 99% of bacteria identified in every environment are organized in biofilm communities (natural state of existence).[117] Biofilms are more successful on surfaces, especially interfacing wound surfaces, such as those found in many types of surgical wounds.[119]

Physical removal of biofilm by thorough and frequent debridement and/or wound cleansing (7 – 12 psi, 100 – 150 mL) forces the biofilm to reconstruct and makes it more susceptible to effective antimicrobials, antibiotics or antiseptics to prevent re-formation (using a debride-and-cover with antimicrobial dressing strategy).[117] Topical antimicrobials are not recommended without prior debridement of necrotic tissue and debris and thorough cleansing, as they need to be in contact with viable tissue and may be ineffective due to poor penetration.[120] Selection of antimicrobial depends on multiple factors; wound type, cost, availability and microbial burden.[121]

For more on managing bacterial balance, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

4.2.4 Managing moisture balance

Discussion: Provide optimal wound moisture balance to promote surgical wound healing by choosing an appropriate dressing for the different phases of surgical wound healing. Appropriate wound care and dressing selection promotes healing and reduces the risk of infection.[9] Surgical wounds often are associated with high levels of exudate due to complications such as inflammation, infection, seroma or hematoma, causing increased capillary leakage and edema, which can have an adverse effect on wound healing.[122] Drains used to support wound drainage should be removed when clinically indicated (there is no optimal time for removal).[123] Excessive moisture slows down wound healing by preventing cell proliferation, interfering with growth factor availability and elevating levels of inflammatory markers and cytokines. Excessive exudate will also cause the periwound tissue to become macerated (white, overly moist and non-viable), impairing the advancement of the wound edge and risking periwound skin injury.[124]



Moisture-associated skin damage (MASD) can occur in the tissue surrounding the surgical wound as a result of prolonged exposure to excessive wound exudate. The volume and composition of the wound exudate are key factors that contribute to development of MASD. Wound exudate containing heparin-binding proteins, proteolytic enzymes, high concentrations of inflammatory cytokines or high bacterial burden and their associated toxins all increase the likelihood of MASD.[125] Essential to the protection of periwound skin, while still keeping the wound bed moist, is choosing a dressing capable of containing wound exudate and wicking it from the periwound skin, and changing the dressing at a frequency that prevents skin irritation. For more on MASD, please see Chapter 5: Best Practice Recommendations For Prevention and Management of Moisture-associated Skin Damage.

For more on managing moisture balance, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

4.3 Select the appropriate dressing and/or advanced therapy

Discussion: Appropriate wound care and dressing selection promote healing and reduce the risk of infection. Surgical wounds should be covered with an appropriate interactive dressing at the end of surgery. The patient should be referred to a wound care clinician with advanced education and training in wound management for advice on appropriate dressings for the management of surgical wounds that are healing by secondary intention.[9]

Most closed surgical wounds have minimal amounts of exudate and only require a simple dressing. However, large amounts of exudate may occur due to complications such as inflammation, infection, seroma or hematoma, causing increased capillary leakage and edema, which can have an adverse effect on wound healing.[117]

Post-operative Strategies

The post-operative team members that provide wound care and dressing changes for patients, and the patient's care partners, should receive education and support in order to provide care that reflects best practices.[9] Education for surgical staff should include the importance of continued assessment,[126] hand hygiene and the use of aseptic non-touch technique for changing or removing surgical wound dressings.[9] Dressing selection for surgical wounds is determined by the type of closure (primary, delayed primary or secondary intention), as well as the amount of infection, wound exudate and the presence of any tunnels, undermining, underlying vascular grafts or hardware. Consideration should also be given to patient concerns, care partner and family knowledge and time, setting and available resources.[124]

Primary intention

Incisions closed by primary intention generally require only the application of a dry, sterile semipermeable cover dressing for 24 to 48 hours, as the wound will re-epithelialize within two to three days.[127] More evidence is needed to support the use of any specific dressings immediately post-operatively for wounds healing by primary intention; the recommendation is that dressings should be selected on the basis of cost and the interactive properties of the dressing.[9] As reviewed by NICE, silver nylon dressings appear to be more effective than gauze in preventing surgical site infections.[9] Limitations were that the silver nylon was compared with gauze (not another advanced dressing), that infections were diagnosed by an unblinded member of the operating team, a potential bias, and that the length of the incision was not documented in each case. Further research is needed that compares silver dressings with other commonly used modern wound dressings.



Secondary intention

Acute surgical wounds that are left open to heal by secondary intention require a moist wound environment to support healing.[79] In addition to preserving moisture balance, the dressing should function to prevent bacteria from entering and critically colonizing wound tissue.[124,128] Interactive advanced wound products have an advantage over wet gauze dressings as they prevent bacterial penetration of the wound.[129]

Pouching is another option for the management of heavily exudating wounds[130] and associated fistulas (enterocutaneous & enteroatmospheric).[131] Although minimal research exists in this area, expert opinion supports the use of pouching when exudate, significant odour or the need for skin protection from exudate are of concern.

Generally, wounds with > 25 mL discharge or those requiring dressing changes more than three to four times per day may be considered for this option. Other important considerations for pouching include the location of the wound, patient comfort and mobility and staff time. Troughing a wound—using ostomy paste strip products and film dressings to channel the exudate into a pouch—may be an option for larger wounds. The involvement of an ostomy nurse and or a wound clinician with advanced training in ostomy, continence and wound management is encouraged when exploring pouching or troughing options.[132]

Negative Pressure Wound Therapy

There is an evolving body of evidence in support of prophylactic negative pressure wound therapy (NPWT) over closed incisions in adult patients on primarily closed surgical incisions in high-risk wounds (e.g., where there is poor tissue perfusion, bleeding or hematoma, dead space, intraoperative contamination), taking resources into account, for the purpose of preventing SSI.[123] When NPWT is used, communication with patients and care partners is essential to support engagement in care.[133]

The benefits of NPWT are thought to be the control of skin flora exposure, with the dressing being applied in the operating room under sterile conditions and remaining in place for five to seven days, the removal of exudate, the reduction of lateral incisional tension and the reduction of hematoma or seroma formation at the surgical site.[134] Evidence supporting the application of NPWT to the primary incision has been demonstrated in sternotomy, orthopedic[134] and vascular surgeries,[135,136] with multiple ongoing randomized controlled studies for a variety of surgical procedures currently underway.

The use of NPWT for open wounds has been an accepted wound treatment modality for many types of open wounds, as well as a method of bolstering flaps and skin grafts.[137,138] When the wound is highly exudative, the periwound skin benefits from protection with a barrier film/hydrocolloid and may also benefit from NPWT.[124] NPWT therapy should be considered as, "first-line treatment for dehisced sternal wounds following cardiac surgery".[139] There is also interest in using NPWT to prevent dehiscence, though there is little evidence to support it at this time. The NICE Evidence Update did report that NPWT appears to reduce SSI rates following invasive treatment of lower-limb trauma, but cautioned that it may be less effective in other patient groups with multiple co-morbidities and that further research is needed.[9]

NPWT is used when clinicians have been successful in advanced education required by their organization/agency. Policies and procedures and supported clinician education must be established prior to use of this therapy. NPWT use is accompanied with warnings, contraindications and precautions for each device and application use. Clinicians are responsible for being knowledgeable about the specific uses of NPWT, which offers advanced management of many wound types, including surgical. Patient selection, wound bed preparation, debridement, dressing selection, application and clear interprofessional team communication are crucial for successful use of NPWT.[140]

Dry Wounds

For some wounds, too little moisture causes the wound bed to dessicate, preventing growth of granulation tissue and re-epithelialization.[124] Dry surgical wounds with healing as a goal may benefit from the addition of a hydrogel, hydrocolloid, non-adherent mesh dressing or transparent film to hold moisture in and protect the wound bed.[124] For more information on dressing selection, please refer to the Wounds Canada Product Picker series, available at https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/library/183-resources-industry-partner/288-product-picker These can be adapted to be fillable PDFs so that once completed with the formulary for the given area, health-care providers can use them to guide decision-making, specific to their agency or institution.

Common Types of Surgical Wounds

The following discussion covers those types of surgical wounds commonly seen in wound clinics and community settings, but it is not inclusive of *all* types of surgical wounds that may be encountered.

Abdominal wound/ open abdomen +/– new ileostomy or colostomy, enterocutaneous fistula

An open abdomen surgical wound occurs when intra-peritoneal organs are exposed as a result of surgery for complex intra-abdominal situations where primary closure is not appropriate, such as in the case of severe sepsis, abdominal trauma and after grafting of ruptured aortic aneurysms.[9] When perforation of the bowel has occurred, and there is pus and fecal contents present in the abdominal cavity, surgeons usually choose to leave the abdominal wound open to heal by secondary intention to prevent further abscesses.[60] This may result in a large, heavily exudating wound with a new ostomy in close proximity. Due to the complexity of this type of wound the involvement of a nurse with expertise in ostomy, continence, fistula and complex wound and pouching management is recommended.[131]

Several wound and fistula management systems are available, although their success in managing large wounds close to a new ostomy or those containing a fistula will be dependent on the amount and type of fecal output and bodily contours that lead to leakage. Negative pressure wound therapy is often appropriate for these wounds. The end point is to achieve healing, either as delayed primary closure of the abdomen (particularly after an abdominal aneurysm repair), secondary healing, split-thickness skin grafts, mesh repair, muscle components separation, flaps or a combination of these.[9]

The presence of an enteric fistula within an open abdominal wound is called enteroatmospheric fistula and is a complication with a mortality rate as high as 70%.[131,141] The high mortality rate is directly related to the septic response arising from the bacterial load accompanying the bowel content soiling the open abdomen. Both surgical management and conventional wound care options are often ineffective.[142] There are a number of novel treatment options utilizing negative pressure wound therapy that might be considered, such as a fistula in an open abdomen.[143] One such option places the polyvinyl alcohol foam on the mouth of the fistula, so long as there is no mucosal eversion leading to primary closure.[142] Other primary closure treatments include the use of fibrin glue or fistula coverage with a muscular flap. If primary closure is not a possibility, then isolating and diverting effluent out of the abdominal wound and collecting it in an ostomy pouching system may prevent sepsis and promote wound healing.[142] The care of a patient with an enteroatmospheric fistula is complex and requires a team approach that includes the expertise of the ostomy and wound care clinician and a team that is aware of the risks.

Caesarian (C) section incision

C-section surgery has a five to 20 times higher risk of postpartum complications such as wound infections, endometritis, pelvic peritonitis or pelvic abscesses, compared with vaginal deliveries.[144,145] Premature rupture of the membranes, diabetes, obesity, hypertension, anemia, emergent rather than planned C-section and post-op wound hematoma have been identified as risk factors that need to be addressed.[146] Since hematoma was the strongest independent risk factor for SSI development post low-transverse C-section, the incision should be monitored for redness, swelling and pain.[147] In obese women, a vertical incision may be necessary. A vertical incision is associated with a higher rate of infection, as is the use of interrupted sutures or staples rather than a continuous intercutaneous suture.[148-150] The patient dealing with complications post C-section incision is also coping with a baby, physiological and hormonal changes, pain, inconvenience and concern regarding use of antibiotics which may be transferred to the baby if breastfeeding.

Hernia repair with infected mesh

The use of prosthetic polypropylene mesh is associated with fewer recurrences in ventral or inguinal hernia repair. In a 2022 review, three major modifiable patient issues were identified as significantly associated with SSI: obesity, tobacco smoking and diabetes.[151] Unfortunately, the risk of superficial SSI or deep infection of the mesh with complications resulting in exposed mesh or unincorporated mesh or the formation of chronic abscesses, sinuses and/ or drainage or development of spontaneous enterocutaneous fistula is as high as 3%.[149,152] Removal of the infected mesh is a difficult surgery that should be considered if local wound care cannot manage the wounds and drainage.[153] Prevention of post-operative evisceration and maintenance of a competent abdominal wall are key secondary goals of hernia mesh removal.[154] Many patients must live or choose to live with small, chronic draining areas that periodically require debridement of mesh, as it protrudes out of the wound. In these cases, the principles of long-term

wound self-care should be applied along with management of bacteria, odour, exudate and periwound irritation. Supports must be in place for patients with non-healable wounds, as management of wound drainage will impact an individual's quality of life, including patient frustration and disheartenment. Psychological and physiological stressors such as depression and anxiety have a relationship to delayed wound healing.[132,155]

Hip and knee arthroplasty

Chowdry and Chen described an ideal dressing to prevent SSIs in a post-operative orthopedic surgical incision as being absorbent, protective, permeable, transparent, able to provide a moist environment, able to remain *in situ* (i.e., to require minimal changes), able to act as a complete barrier, having low adherence and being cost-effective.[156] Orthopedic total joint arthroplasty incision complications include blistering and infection that may lead to dehiscence. A dressing requiring frequent changing, and skin trauma caused by dressing adhesive or blistering, can lead to exposure of external infectious sources. Although the incidence is low (1 – 2%), periprosthetic joint infection (PJI) after total hip or knee arthroplasty is considered to be a catastrophic complication. The infection may be just in the incision (localized SSI) or it may be deep at the area of the prosthetic (PJI). Santoso and colleagues identified multiple Mycobacterium species that could be responsible for hip/knee prosthetic joint infections (PJI); although *M. tuberculosis* is the most common causal pathogen, nontuberculous mycobacteria (NTM) should be considered as an emerging cause of hip/knee PJIs.[157]

The orthopedic surgeon needs to assess this as soon as possible and, until then, local interventions such as wound irrigation, probing or packing should be avoided due to the risk of inadvertently introducing bacteria. Diagnosis is often difficult and relies on the surgeon's judgment of the clinical presentation, the findings on physical examination and the interpretation of relevant investigations.[164] Deep infections that are caught early (within several days of their onset) and those that occur within weeks of the original surgery may sometimes be cured with a surgical washout of the joint and debridement of all contaminated soft tissues. The implant is thoroughly cleaned and plastic liners or spacers are replaced. After the procedure, intravenous antibiotics are prescribed for approximately six weeks. Sometimes, two or more surgeries are required, with removal of the prosthesis, an implant of antibiotic-laden cement and eventual replacement of the prosthesis. Amputation is also a possible consequence.[159,160]

Incision and drainage (I&D) of abscesses

Incision and drainage is historically the treatment of choice for cutaneous abscesses.[161] Treatment is dependent in part on the etiology, such as of sebaceous cyst, pilonidal sinus, hidradenitis suppurativa, foreign body; but generally abscesses requiring I&Ds are either sutured primarily or left open and packed loosely or not packed and dressed, with or without an oral antibiotic.[162] Community-associated MRSA is considered to be endemic in North America and is a frequent cause of abscesses, making it important to:

- Confirm the diagnosis of MRSA infection in immunosuppressed patients by Levine method semi-quantitative swab culture[163]
- Recognize that treatment with systemic antimicrobial therapy to which the bacterial isolate is susceptible is controversial[161]
- Recognize that for cases of mild illness (patient afebrile, abscess < 5 cm, no other medical co-morbidities) I&D with or without topical antibiotics may be sufficient.[164]

Packing of these wounds is controversial, yet a large number of patients in the home care setting are admitted with orders for daily packing for incision and drainage of abscesses (See Table 5).

Table 5: To Pack or Not to Pack

Study	Intervention	Packing versus No Packing
Mohamed Ahmed et al. 2021. 8 RCTs, n=485 patients[165]	cutaneous abscesses	I&D of cutaneous abscess with or without packing have comparable outcomes. However, considering the cost and post-operative pain associated with packing, performing the procedure without packing of the abscess cavity may be more favourable. More RCTs are needed
Nour et al., 2023. 3RCTs, n=490[166]	perianal abscesses	Not packing the wound post I&D of perianal abscess is associated with significantly reduced VAS pain scores, which may result in improved recovery and patient satisfaction and has no effect on recurrence rate or the occurrence of perianal fistula. More RCTs are needed
O'Malley et al. 2009. RCT (n = 48)[167]	I&D of simple cutaneous abscesses	There was no difference in complication or infection rate between groups, but it had limited real-world applicability due to the small size of the study
Tonkin et al. 2004. Randomized (n = 43)[168]	anorectal abscesses	There was a similar time to healing, but the median pain score in the non-packing group was significantly lower
Kessler et al. 2012. RCT (n = 57) pediatric patients[169]	abscesses	The failure rates were 19/27 (70%) with packing and 13/22 (59%) without. The difference was 11%, 95% confidence interval 15 – 36%
Schmitz 2011.[163]	cutaneous abscesses	The study suggests packing does not provide additional benefit
Liu et al. 2011.[170]	uncomplicated skin and soft tissue infections	I&D was recommended, but the authors' opinion was that antibiotics were not likely needed and did not mention packing
May et al. 2012. retrospective audit (n=135)[171]	inconsistencies in technique, irrigation methods, use of antibiotics and variation in packing techniques	The audit did not include outcomes for the types of packing. In the panel's opinion,packing is best used to wick the wound open to facilitate drainage

Tight packing allows the edges to scar and become fibrotic, which delays wound healing. Larger studies are needed to better validate the equivalency of these two strategies, which could potentially result in savings of many thousands of dollars spent on needless packing materials, prolonged need for analgesia and nursing visits. Retained packing or lost packing is a foreign body and becomes a source of infection. Each facility or organization should have a policy and procedure regarding types of packing agents to use (e.g., high tensile strength), strategies to avoid loss of packing agent (e.g., one piece of packing agent only, secure tail of packing on intact skin, etc.) and procedure to follow when unable to locate packing that should have been in the wound. Documentation of size and length of packing materials used in the wound is essential. Patients can tell you if they visualized packing that, "fell out," but if they did not see it, and you cannot find it, this must be reported to the responsible physician and an appointment made so that they can examine the patient and the wound.

Lower leg vascular bypass/saphenous vein harvesting

SSI incidence is between 3.5 and 32% with peripheral vascular surgery. SSIs can lead to major amputation as well as mortality.[172] An unfortunate fact is that the patients who require lower leg bypass surgery or coronary artery bypass graft (CABG) with saphenous vein harvesting often have diabetes, hypertension and obesity as well as other co-morbidities. Selected patients undergoing elective femoral popliteal bypass of a leg without critical limb ischemia

(CLI) required discharge to a rehabilitation or skilled nursing facility rather than to the home. Multiple risk factors such as diabetes, dialysis, congestive heart failure and cerebrovascular accident contribute to prevention of discharge back to the home. Patients who require discharge to a facility (either rehabilitation or skilled nursing) have higher rates of infectious complications, myocardial infarction, operative transfusion and unplanned reoperation while hospitalized for the initial surgery.[173]

Post-operative edema of the lower legs, lasting up to three months, often contributes to failure of primary closure of these incisions.[174] Edema is a multifactorial problem not only with vascular surgery, but also with orthopedic surgery and surgical interventions following trauma. Alterations in arterial and capillary perfusion, transcapillary fluid filtration and lymph transport all contribute to the formation of edema.[175] A lower level of physical activity in the initial post-operative period decreases the calf-muscle pump activity and increases the risk for accumulation of edema in the lower limb. Various methods of edema management are being utilized with varying effectiveness. Intermittent pneumatic compression (IPC) following femoropopliteal bypass surgery compared with compression stockings failed to show any statistical difference in reduction in edema in a small (n = 35) study, but the length of intervention was only one week.[175] In real-life practice, one week may be the usual time of hospitalization for these patients, and it would seem prudent to continue compression once discharged home.

Alireza et al. in a study with 100 patients having saphenous vein harvesting for coronary artery bypass graft surgery (CABG), compared the use of thigh-high medical grade compression stockings versus no compression stocking/stocking applied irregularly, for four weeks post-op.[176] There was a statistical difference in edema of the calf between the two groups at one, two and four weeks post-op ($P = 0.004$, $P < 0.001$, and $P < 0.001$ respectively), with the stocking group having less edema. Wound complications (ecchymosis and infection) occurred in 12 patients with edema but did not occur in patients without peripheral edema at four weeks ($P = 0.09$). They found that patients who were more physically active also had decreased edema, although low compression elastic stockings do not improve calf-muscle pump activity when the patient is walking.[177] Additional research is needed to look at the role of resistant compression bandages in preventing/reducing post-operative edema and wound healing.

With venous leg ulcers, pro-inflammatory cytokine and matrix metalloproteinase levels are reduced, and the anti-inflammatory cytokine IL-1 Ra are increased in response to multi-layer high-compression therapy.[178] In addition to having an anti-inflammatory effect, compression bandaging that provides resistance and is safe to use when the ankle brachial pressure index (ABPI) is between 0.5 and 0.8 actually increases laser Doppler flux under the bandage without decreasing the toe pressure or transcutaneous oxygen pressure ($TcPO_2$) distal to the bandage.[179] Resistant compression also potentiates the action of the venous pump by increasing the ejection fraction.[179] Compression therapy would ideally need to be used immediately post-operatively and for as long as the risk of edema is present, which may be weeks or months.[180] Further robust studies are needed to determine the best choices.

Pilonidal sinus surgery

The Harris Pilonidal Sinus Protocol outlines the complex reasons for failure of pilonidal sinus wounds to heal, whether they are healing by secondary intention or are a failed primary intention closure.[180-182] Recognition and treatment of signs and symptoms of localized and deep infections is key, particularly as there are three signs that happen with pilonidal sinus wounds that are not found in others: bridging and pocketing in the base of infected granulation tissue and premature epithelialization with corresponding tunneling running underneath. Treatment is aimed at multiple factors that contribute to the infection and lack of healing. Frequent meticulous removal of periwound hair, decontamination of periwound skin, optimal personal hygiene practices with increased self-care management strategies, reducing causes of chronic inflammation, optimizing nutrition and pain management, hygiene and dressing changes following bowel movements and modified physical activity all play a role. An update to the protocol is now available, which debates the use of silver nitrate in these wounds.[182]

Skin graft and donor sites

Skin grafts are a section of epidermis and dermis that has been completely separated from its blood supply in one part of the body (donor site) with the goal of transplanting it to another area of the body (recipient site).[183] Although the

OASIS tool (See Step 1.1) does not consider skin grafts to be surgical wounds if done to repair an existing wound, donor sites and skin grafts are the result of surgical interventions. Full-thickness skin grafts are used for small areas. Skin can be acquired from the pre-and post-auricular region, the neck, upper and lower extremities, groin and abdomen. Split-thickness grafts use the epidermis and a portion of the dermis. This skin is harvested from any body location, but the thigh is most common. Grafts may be non-meshed or meshed. If meshed, then it is created by pie-crusting with a scalpel or with a mesher that creates fenestrations at equal distances. The purpose of meshing is to create a larger surface area from a smaller graft. It also permits drainage of fluid from the wound to prevent hematoma or seroma formation.[184]

Donor site wound care requires the application of moist wound healing principles. There are many commercial dressings available to support moist wound healing.[184,185] Donor sites heal by re-epithelialization usually requiring transparent dressings or fine mesh gauze. The donor site can be more painful than the graft site and requires protection and patient education to heal.[184,186]

Recipient sites

Full-thickness and partial-thickness skin grafts are sutured, stapled or glued in place, treated like a primary incision and covered with a dressing. If a bolster dressing is utilized it should only be removed by the treating physician unless otherwise specified. NPWT is sometimes utilized as a bolster for skin grafting, as previously stated.[187] It is important that movement in the area of the graft site be minimized in the first five to seven days. The decision about which dressing is appropriate for the grafted recipient site usually remains with the surgeon responsible for the wound.

Post-operative risks are an SSI, seroma and/or hematoma formation and graft contracture. An SSI can lead to disintegration of the graft or excessive exudate that prevents the graft from adhering to the bed.[188] It can take three to six weeks for the skin graft to turn a normal colour and, until then, it may look gray, pale, purpuric or dull. Scars can take from 18 months to two years to mature and for inflammation to resolve. Unfortunately, grafts to the scalp following removal of skin cancers can be problematic, with chronic small areas of exposed skull or skull replacement materials at the margins of the graft. These wounds may never resolve and may require ongoing dressing use and protection.

Advanced Therapies

When warranted, the clinician should consider the use of advanced therapies and biologically active dressings as they pertain to surgical wounds.

Hyperbaric oxygen therapy (HBOT)

The Cochrane Review of HBOT for acute surgical and traumatic wounds reported two small trials suggesting that HBOT may improve the outcomes of skin grafting and trauma; these trials were at risk of bias. Further evaluation by means of high-quality RCTs was recommended.[189]

Zhou and colleagues (2023) completed a narrative review (14 studies) They stated, "HBOT, as primary or adjunctive therapy, showed many advantageous effects in the treatment of several medical conditions, especially for wound healing and infections. Despite the lack of valid randomized controlled trials, retrospective studies and case reports showed beneficial effects of HBOT in the treatment of SSIs or other similar infections. Considering increasing trends in the incidence of MDROs, HBOT can be effective in the prevention, management, or treatment of acute or chronic infections induced by such pathogens. We suggest conducting more research, especially randomized clinical trials and longitudinal investigations, to better standardize the treatment as well as to determine the full benefits and possible side effects of HBOT. We also suggest the development of specific indications to specify the potential contraindications to receiving this therapy".[190]

Electrical stimulation (ES)

In a review of 21 RCTs involving electrical stimulation for wound healing, Thakral et al. concluded that it is underutilized in plastic surgery and could improve flap and graft survival, accelerate post-operative recovery and decrease necrosis following foot reconstruction.[191] The authors described ES as addressing three key factors in surgical wound complications: decreasing bacterial proliferation and increasing local perfusion, thereby accelerating wound healing. They recommended more clinical trials to better determine the dosage, timing and type of ES for care of surgical wounds. A new muscle-pump activator worn at the knee electrically stimulates the common peroneal nerve, causing muscle activation replicating at least 50% of blood flow generated by walking.[192] It is recommended for prevention of vein thromboembolism (VTE).[9] Alharbi et al. demonstrated applicability of this device for kidney and pancreatic transplant surgery in preventing post-operative lower leg edema and improved blood flow.[193] Further research and evaluations are underway.

4.4 Engage the team to ensure consistent implementation of the plan of care

Discussion: Individuals within the circle of care must understand their roles and responsibilities in relation to the formal care team for each specific element of care.[65] Early recognition and treatment of surgical complications, including SSI, is important.

Providing the following information to patients, families and care partners improve prompt treatment and reduction of infection-related morbidity[9]:

- the risks of an SSI and what is being done to reduce it, including any antibiotics given in hospital,
- the signs and symptoms of an SSI, how they are managed and who to contact if they are concerned,
- the signs and symptoms of other surgical site complications such as a hernia or a wound dehiscence,
- who is responsible for what portion of their care and when follow-ups should be booked,
- who to call when they have concerns and
- how to care for the wound after discharge, including hand hygiene.

The team should use an integrated care pathway for preventing complications to help communicate this information to patients and all involved in their care after discharge from hospital. Documentation of the information shared is necessary. Several patient handouts are available online for public use. Examples can be found at the following websites:

Wounds Canada. Care At Home Series: Changing a Dressing https://www.woundscanada.ca/docman/public/patient-or-caregiver/1680-care-at-home-series-changing-a-dressing/file
Wounds Canada. Care At Home Series: Caring for Yourself After Surgery https://www.woundscanada.ca/docman/public/patient-or-caregiver/1772-home-surgical-wound-care-1943e/file
Wounds Canada. Care At Home Series: Preventing Skin Injuries for the Whole Family.
https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series
South West Regional Wound Care
https://swrwoundcareprogram.ca/53/Resources_By_Wound_TypeTopic

Step 5: Evaluate Outcomes

Discussion: Determine the effectiveness of interventions and reassess if healing is not occurring at the expected rate and if the goals the team has set have not been met or have been only partially met. Assess the wound and periwound regions to identify rate of healing and determine if the treatment approach is optimal.

Recommendations
5.1 Determine if the outcomes have met the goals of care

Discussion: The overall goal is to assist patients and their care partners in maximizing their rehabilitation potential. Progress toward achieving established goals is monitored with the patient, documented using standardized patient assessment tools and communicated to the appropriate team members. The responses observed in the patient's surgical wound are compared with the responses specified in the stated goals and expected outcomes. The patient and families and care partners should participate in decision-making and evaluation. The effectiveness of the interventions must be determined by a clinician who has the knowledge and skills to assess.

5.2 Reassess patient, wound, environment and system if goals are partially met or unmet

Discussion: A healable wound that is not responding to the treatment plan needs reassessment. Has the cause of the wound been addressed? What host factors are contributing to delayed healing?[15,124,132] Is the treatment optimal for the situation? When wound healing is not feasible, assess whether the treatment is preventing infection and deterioration, decreasing dressing frequency, managing pain and improving the patient's quality of life, where possible.[124,132]

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Discussion: Primary care physicians, nurse practitioners and visiting health-care professionals should recognize wound complications and immediately communicate and/or refer the patient back to the surgeon. However, it is patients and their care partners who are the first line of defence in preventing and identifying complications. As per Step 4.4, informational materials should be available for the patient and caregiver and discussed both before (if possible) and following surgery. This is essential so patients can prepare appropriately. They will need time to make adjustments to their environment, activities, nutrition, working lives, support system and more.

Outpatient clinics' and surgeons' time are important resources that should be optimized so that follow-ups for patients whose situation warrants it can be done in a timely manner, possibly avoiding unscheduled trips to hospital emergency departments.

Conclusion

While advances have been made in infection control practices, including improved operating room ventilation, sterilization methods, barriers, surgical technique and availability of antimicrobial prophylaxis, SSI remains a substantial cause of morbidity, prolonged hospitalization and death.[71,114] Therefore, the prevention and management of surgical wound complications remains an area of concern for patients, health-care professionals and administrators alike. Especially in these times of rationalization of health-care dollars, it is important to ensure that patients receive appropriate screening and care, beginning at the pre-operative assessment and continuing through to post-operative care and monitoring in the community.

The best practice recommendations presented in this chapter synthesize these resources and, when combined with evidence-informed interventions found in the discussions, should help clinicians develop the knowledge and skills needed to identify those at risk for complications and develop plans in collaboration with their patients to ensure a best practice approach to reduce the incidence of surgical wound complications.

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Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 10

Prevention and Management of Peripheral Arterial Ulcers

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INTRODUCTION

It is estimated that 1.5 million Canadians (older than 40 years) live with symptomatic peripheral arterial disease (PAD).[1]

The Canadian 2022 Society for Vascular Surgery discusses the importance of peripheral arterial disease prevention as it can lead to chronic limb-threatening ischemia (CLTI),[2] resulting in chronic pain, tissue breakdown (ulcers/wounds) or tissue death (gangrene), amputation and death.

This chapter provides information on the prevention and management of PAD, specifically those of the lower extremity. Historically, the main recommendations for the management of peripheral arterial ulcers have focused on two primary objectives: determining if there is adequate blood flow to promote skin health and heal the wound and assessing for signs and symptoms of PAD.[3,4]

Arterial insufficiency that affects skin health also inhibits the wound healing process as tissues are poorly perfused and the delivery of nutritional requirement and systemic antimicrobials is often compromised due to the lack of blood supply to the wound site.[5] Therefore, addressing the underlying PAD is essential when caring for patients who present with lower extremity ulcers.[5]

Prevention of PAD takes a co-ordinated, interdisciplinary team that focuses on screening for risk of atherosclerosis and generalized vascular disease.[6] Teams should work to engage patients and their care partners in managing modifiable risk factors that increase risk, such as smoking, diabetes mellitus, high blood pressure and cholesterol levels,[1] as well as certain lifestyle choices.[7] Non-modifiable factors include age and hereditary.[6] Sex and gender effects on PAD warrant further study.[2]

This chapter will also focus on the most severe form of PAD: chronic limb-threatening ischemia (CLTI). The term *CLTI* is preferred over *critical limb ischemia*, as the latter implies threshold values of impaired perfusion rather than a continuum. CLTI is a clinical syndrome defined by the presence of PAD in combination with rest pain, gangrene or a lower limb ulceration over two weeks' duration.[8] Of concern is the presence of diabetes mellitus, as it increases the incidence of PAD, accelerates disease progression and worsens patient healing and overall outcomes.[5]

Indigenous peoples in Canada face a higher rate of diabetes and complications such as foot ulcers, lower-extremity amputations and peripheral arterial disease.[9,237] In Canada, First Nations are over-represented among persons experiencing a non-traumatic lower extremity amputation.[10] In Saskatchewan, diabetes was the most prevalent factor.[11]

Development of an arterial ulcer may result in gangrene or infection that may ultimately require multiple surgeries or major amputation, which can lead to hastened mortality.[2,5] Of concern is that 15% of patients with PAD will develop CLTI.[5] All patients with suspected CLTI should be referred urgently to a vascular surgeon and an interdisciplinary team.[8] The five-year mortality rate is significant and is higher than some cancer rates.[5] Globally, CLTI is widely believed to be a growing health problem, and more research is urgently needed.[8]

Advancements in medical and wound therapies, along with the establishment of integrated, interdisciplinary wound care centres, have impacted the care of patients with CLTI and, therefore, may have also helped to decrease the overall rate of amputation.[12]

In the United States, the prevalence of PAD in men ranged from 6.5% (aged 60–69 years) to 11.6% (aged 70-79 years) to 29.4% (>80 years). There were similar age-related increases in PAD prevalence in women (5.3%, 11.5%, and 24.7% in these age categories, respectively).[13] Given that the life expectancy of women still exceeds that of men, the overall burden of PAD (total number of individuals affected) is likely to be greater in women than in men. The epidemiology of PAD is likely to be similar in other developed countries, such as the United Kingdom and European nations.[14-16] This staggering increase in PAD prevalence, along with the impact of associated comorbidities, demands a responsive approach to ensure the early detection and treatment of PAD, particularly since arterial insufficiency is identified as the

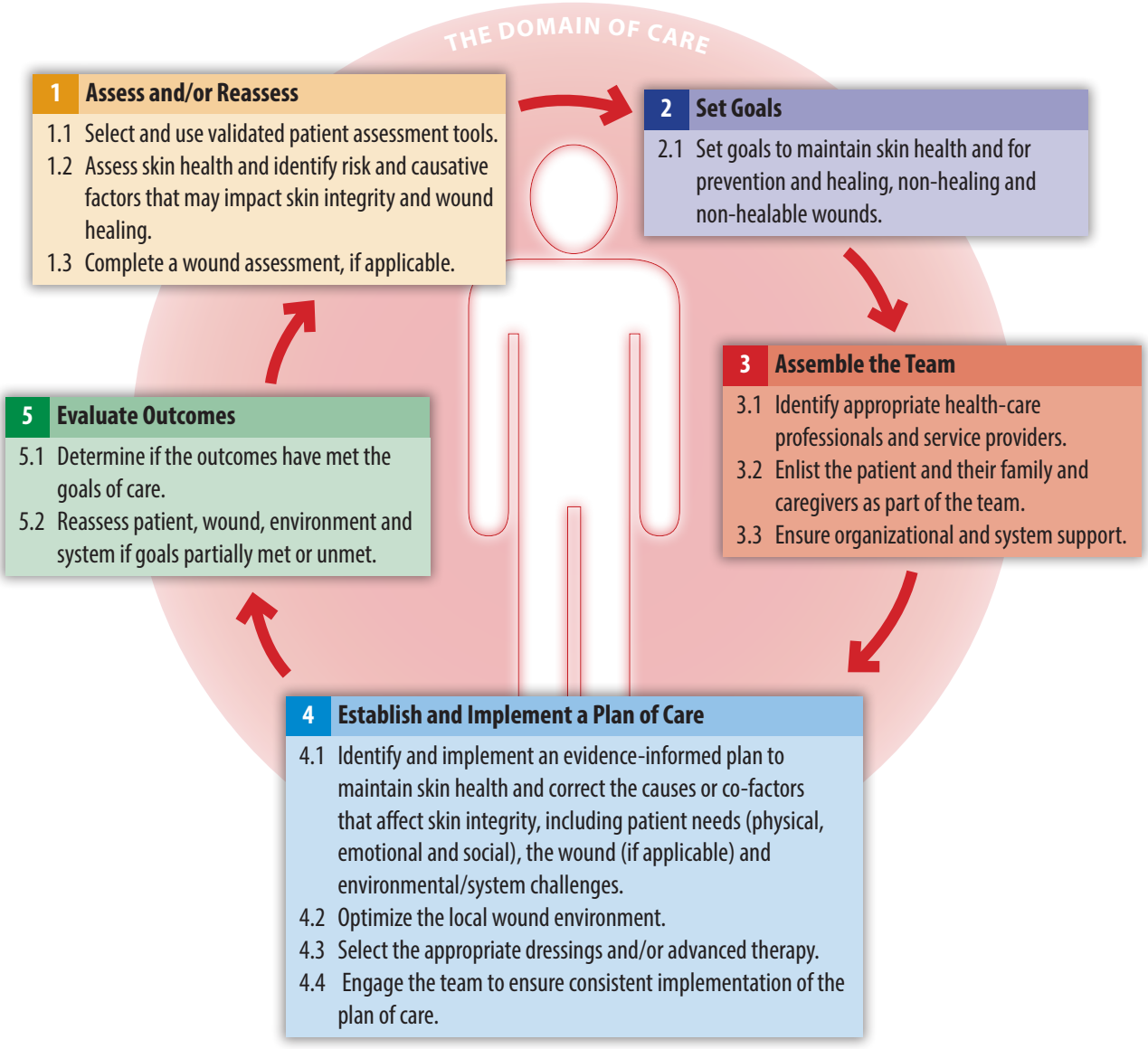
primary causative factor for arterial ulcers.[2,8] Although PAD is a chronic disease that can impact both the upper and lower extremities, it is more common in the lower limbs. Lower extremity arterial disease can also include diseases in the abdominal aorta and in the iliac arteries, which may contribute to, or result in, arterial insufficiency.[8] Of concern is that only 5%-10% of patients with PAD present with classical symptoms of intermittent claudication (IC).[17]

The European Study Group in Diabetes and the Lower Extremity (EURODALE) study, involving a cohort of 1,088 patients with diabetic foot ulcers (DFUs) from 14 different centres in Europe, reported an increase in impaired healing when PAD co-existed with diabetes mellitus (DM).[18] Patients diagnosed with both PAD and DM have been shown to be seven to 15 times more likely to experience major amputation following the development of an ulcer, as compared with those without DM.[19-21]

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide outlining a process, or series of consecutive steps, that supports patient-centred care. This process, called the Wound Prevention and Management Cycle (See Figure 1), guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of wounds, from the initial assessment to a sustainable plan targeting self-management for the patient.

Figure 1: Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence and the most current best practice guidelines available worldwide. These recommendations are intended to support members of the health-care team, including the patient and their family, in the planning and delivery of care specific to CLTI, as well as associated arterial ulcers. Two foundational chapters supplement this chapter with additional evidence-informed information and recommendations that are general to all wound types: Chapter 3: Skin: Anatomy, Physiology and Wound Healing[22] and Chapter 4: Prevention and Management of Wounds: An Overview.[23]

The three guiding principles within these BPRs that support effective prevention and management of skin breakdown are as follows:

1. The use of a logical and systematic approach, regardless of the specifics, to prevent and manage skin breakdown,
2. The constant, accurate and multidirectional flow of meaningful information with the team and across care settings, and
3. The patient as the core of all decision making.

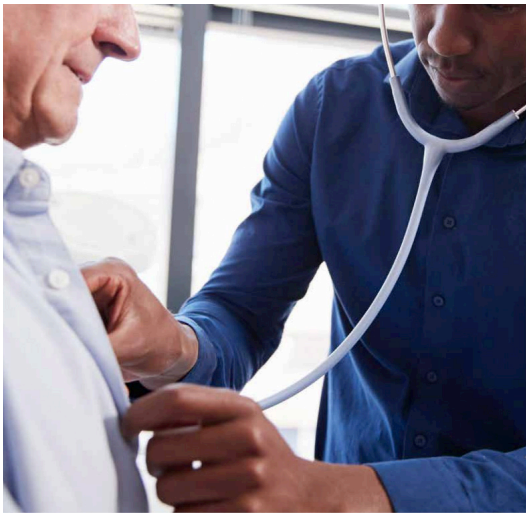
This document is written with the intent to encompass the quintuple aim for health care improvement. This is to enhance the patient care experience, reduce costs, improve population health, improve the clinician experience and enhance equity (See Table 1). This equity piece is particularly important for patients living with skin issues, wounds and, specifically, peripheral arterial ulcers. Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[24]

Table 1: Quintuple aim and management of Peripheral Arterial Ulcers

5 components	Applied to Peripheral Arterial Ulcers
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practice guidelines to ensure most effective treatment Appropriate use of resources - examples: prevention, screening, dressings, devices
Advancing health equity	Application of principles to all those at risk of being affected by peripheral arterial disease
Care team well-being	Providing clinically usable information for front line clinicians
Enhancing the care experience	Creating a process and expectation for care for all those with peripheral arterial issues

Step 1: Assess and/or Reassess

Recommendations
1.1 Select and use validated patient screening and assessment tools



Complete a comprehensive skin assessment as reviewed in Chapter 4: Preventon and Management of Wounds.[23]

According to the global vascular guidelines on the management of chronic limb-threatening ischemia it is recommended that clinicians use a lower extremity threatened limb classification staging system (e.g., Society for Vascular Surgery's (SVS) WIfI classification system that grades the complexity of wounds, including wound extent, degree of ischemia and severity of infection to guide clinical management in all patients with suspected CLTI[8] (See Table 2).

The International Working Group of the Diabetic Foot guidelines (IWGDF, 2023) also recommends use of two classification systems for diabetic foot ulcers that includes ischemic ulcers. The use of these classification systems is important to standardize assessment of ulcers and to improve communication among health-care professionals. The IWGDF recommends use of:

- SINBAD - Site, Ischaemia, Bacterial infection, Area and Depth) classification (first option)
- WIfI - Wound, Ischaemia, foot Infection) systems[25]

The WIfI classification system was developed for use during the initial patient assessment, targeting those who present with ischemic rest pain, diabetic foot ulcers, non-healing lower limb wounds and/or gangrene.[26,27] Similar to the Fontaine and Rutherford classification systems, the WIfI includes scores for varying degrees of ischemia and tissue loss; however, it also adds a score for the presence and severity of infection.[26,27] Although tissue perfusion is considered to be a primary determinant of patient outcomes, the presence and severity of infection can also increase the risk to the limb in regard to potential amputation.[27] Higher WIfI scores also indicate a diagnosis of CLTI and increased risk of lower extremity amputation[26] and survival.[28]

Other existing instruments are available but require confirmed validation. These include: Physical Examination and Chronic Lower-Extremity Ischemia, Intermittent Claudication Questionnaire (ICQ), San Diego Questionnaire, LEGS score based on TASC, Finnvasc and PAD Nomogram.[27,29-33]

Apart from the WIfI classification, the popular Edinburgh Claudication Questionnaire has a 91.3% (95% confidence interval [CI], 88.1-94.5%) sensitivity and 99.3% (95% [CI] 98.9-100%) specificity.[34] The Edinburgh Claudication Questionnaire asks patients:

1. Do you get pain or discomfort in your leg(s) when you walk?
2. Does this pain ever begin when you are standing still or sitting?
3. Do you get it if you walk uphill or hurry?
4. Do you get it when you walk at an ordinary pace on the level?
5. What happens to it if you stand still?
    a. Usually continues more than 10 minutes
    b. Usually disappears in 10 minutes or less
6. Where do you get this pain or discomfort?[2]

A new anatomic scheme for the threatened limb has been proposed by Conte et al. termed The Global Limb Anatomic Staging System (GLASS) for CLTI.[8] This new approach was developed to facilitate clinical decision-making regarding revascularization in CLTI. GLASS incorporates two novel and important concepts, the target arterial path (TAP) and estimated limb-based patency (LBP). The consensus process for developing and assigning GLASS stages was informed by an updated systematic review of revascularization outcomes in CLTI. However, what is important is to always ensure the validity and reliability of assessment tools before using them. More details on chronic limb ischemia tools and ulceration can be found in the global vascular guidelines on the management of chronic limb-threatening ischemia (pages 26S to 30S).[8] Furthermore, more research is needed to study GLASS for CLTI.[35-37]

Table 2 outlines vascular assessment tools.

Table 2: Vascular Assessment Tools*

Tool	Description	Items
Lower Extremity Threatened Limb Classification System: Risk Stratification Based on Wound, Ischemia and foot Infection (WIfI)[25,27]	• Evaluates: - Presence and extent of infection - Degree of ischemia - Tissue loss • Not meant to function as a stand-alone clinical decision-making tool • Validation currently in progress	**W: Wound/clinical** Society for Vascular Surgery (SVS) grades for rest pain and wounds/tissue loss (ulcers and gangrene): 0 (ischemic rest pain, ischemia grade 3; no ulcer), 1 (mild), 2 (moderate), 3 (severe) **I: Ischemia hemodynamics/perfusion** Measure toe pressure (TP) or transcutaneous oxygen pressure ($TcPO_2$) if ankle-brachial pressure index (ABPI) incompressible (>1.3) SVS grades 0 (none), 1 (mild), 2 (moderate) and 3 (severe) **fI: Foot Infection** SVS grades 0 (none), 1 (mild), 2 (moderate), and 3 (severe: limb and/or life-threatening) SVS adaptation of Infectious Diseases Society of America's (IDSA) and International Working Group on the Diabetic Foot's perfusion, extent/size, depth/tissue loss, infection, sensation (PEDIS) classifications of diabetic foot infection
Fontaine Classification[38]	• Identifies clinical presentation of CLTI in 4 stages • Based on clinical symptoms, without other diagnostic tests • Originally in German**	Stage I – Asymptomatic Stage Ia – Mild claudication Stage III – Moderate to severe claudication Stage III – Ischemic rest pain Stage IV – Ulceration or gangrene
Rose Questionnaire[39,40]	• Determines pain experience of patients with cardio-ischemic disease • Standardizes identification of angina to exercise, pain due to myocardial infarction and intermittent claudication • Moderate sensitivity and high specificity[41] • Validated with 2000 subjects to become WHO/Rose Questionnaire	Includes eight questions: 1. Do you get pain in either leg while walking? 2. Does pain begin when standing still or sitting? 3. Do you get this pain in your calf/calves? 4. Do you get it if you walk uphill or hurry? 5. Do you get it when you walk at an ordinary pace on the level? 6. Does it ever disappear while walking? 7. What do you do if you get it while walking? 8. What happens to the pain if you stand still?
Rutherford Classification[41,42]	• Classifies PAD into acute and CLTI • Provides definitions and criteria to standardize: - Severity of PAD - Therapeutic intervention - Outcomes • Approved by the Joint Council of the Society for Vascular Surgery and the North American Chapter of the International Society for Cardiovascular Surgery • Evidence based on other variables (concurrent, predictive and convergent validity) for each clinical symptom	Grades/Categories: • Grade 0 Category 0: Asymptomatic • Grade I Category 1: Mild claudication • Grade I Category 2: Moderate claudication • Grade I Category 3: Severe claudication • Grade II Category 4: Ischemic rest pain • Grade III Category 5: Minor tissue loss, non-healing ulcer, focal gangrene with diffuse pedal ischemia • Grade III Category 6: Major tissue loss extending above trans metatarsal level, functional foot no longer salvageable

Edinburgh Claudication Questionnaire (ECQ)[34]	Updated Rose Questionnaire with improved sensitivity while maintaining high specificity. Also available in French Tested on 300 subjects > 55 years of age. High sensitivity and specificity; high negative predictive and positive predictive value Excellent reproducibility after six months	Include six elements: 1. Pain or discomfort in the legs with walking 2. Pain on sitting or standing 3. Pain going up stairs or hurrying 4. Regular walking pain 5. Pain duration of 10 minutes or more 6. Site of pain

*The decision to employ one of the previously described measurement tools is most often based on personal preference of the specialist or vascular surgeon. There is no current literature or consensus that supports use of one over the other. Even though different vascular measurement tools have been described, they should be used cautiously, and they should never replace a thorough vascular assessment and clinical judgment.
**Clinicians should be aware that measurement tools originally created in another language must have the comparability of translated and adapted scores evaluated to confirm both validity and reliability/precision.[44-46]

Literature review used with permission from Dr. Maryse Beaumier.

A more detailed discussion of validated screening and assessment tools to assess pain, quality of life, nutrition and wound status can be found in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[23]

To support nutritional screening refer to the Canadian Malnutrition Task Force for the most appropriate screening tool based on the population being served: https://nutritioncareincanada.ca/resources-and-tools/hospital-care-inpac/screening

Wound Canada's Nutrition website has additional articles on healthy skin and wound healing: https://www.wound-scanada.ca/health-care-professional/resources-health-care-pros/nutrition

For Indigenous persons refer to Wounds Canada, Professional Guides - Nutrition and Wound Healing for Indigenous Persons for the list of nutrition screening tools:
https://www.woundscanada.ca/doclink/professional-guide-nutrition-and-wound-prevention/eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9.eyJzdWIiOiJwcm9mZXNzaW9uYWwtZ3VpZGUtbnV0cml0aW9uLWFuZC13b3VuZC1wcmV2ZW50aW9uIiwiaWF0IjoxNjg3MTkyODMwLCJleHAiOjE2ODcyNzkyMzB9.uDzTxlPCXzH1LrIccxmZbl2se3Ee695ZrQzb3LdSaTo

1.2 Assess skin health and identify risk and causative factors that may impact skin integrity and wound healing

The overall health status of an individual has a significant impact on skin integrity, risk for ulceration and the trajectory of wound healing. Awareness and recognition of the presence of CLTI by primary health-care providers has a significant impact on the prevention of arterial ulcers and should be emphasized both in education and in clinical practice.[8]
A national cross-sectional survey of PAD Awareness, Risk, and Treatment: New Resources for Survival (PARTNERS) program found that PAD afflicts 29% of patients who are ≥ 70 years of age, and 20–29% of those aged 50 to 69 years who report a 10-pack-per-year or more history of smoking.[26,47]

1.2.1 Patient: Physical, emotional and lifestyle

Physical Health and Vascular Status

Risk factors are conditions or diseases that increase the patient's risk of developing issues.[48] Modifiable factors are those that the patient can change and non-modifiable factors are those not under the patient's control. Table 3 lists the major modifiable and non-modifiable risk factors believed to predispose a person with CLTI and to the development of an arterial ulcer.[2,49]

Ongoing reassessment is the key to sustaining healing and optimizing patient outcomes, and to reducing costs.[50] The prevalence of lower extremity amputation is important to monitor as it is an indicator to measure the quality of care patients have received.[51,52]

Table 3: Modifiable and Non-modifiable Risk Factors

Modifiable	Non-modifiable (not under the patient's control)
Glycemic level: hyperglycemia results in delayed wound healing and compromised chemotaxis and phagocytosis[26] Concurrent diabetes and PAD have a three-fourfold increase in mortality and have a rate of amputation that is five times higher than patients without diabetes[2] **Smoking**: increases the risk of wounds through compromised blood flow and delays healing. Smoking increases the risk of PAD two-threefold as well as the risk of stroke, myocardial infarct, and cardiovascular death.[2] **Comorbidities**: Diabetes[2, 86] Dyslipidemia[8,26] Hypertension[26,86] PAD and intermittent claudication[86] Renal failure Abdominal obesity[86] Lack of physical exercise[26] Adverse health-related behaviours: excess use of alcohol and low fruit and vegetable consumption[2]	**Age**: ≥ 65 years old[2,49] **Age:** 50–64 years with risk factors for atherosclerosis (e.g., diabetes mellitus, history of smoking, hyperlipidemia, hypertension) or family history of PAD[8] **Age**: <50 years, with diabetes mellitus and one additional risk factor for atherosclerosis **History**: Individuals with known atherosclerotic disease in another vascular bed (e.g., coronary, carotid, subclavian, renal, mesenteric artery stenosis or abdominal aortic aneurysm) **Family:** History of PAD[2,49]

CLTI and Smoking

The Canadian Cardiovascular Society 2022 Guidelines for Peripheral Arterial Disease indicate smoking is strongly associated with the development and progression of PAD and its complications as major adverse limb events.[2]

The relationship between smoking and PAD has been recognized since 1911, when Erb reported thatintermittent claudication (IC) was three times more common among smokers than among non-smokers.[53] Heavy smokers have a four-fold increased risk of developing IC compared with non-smokers.[53] PAD is most often diagnosed one decade earlier in smokers than in non-smokers.[53]

A strong recommendation with a moderate level of evidence made by the global vascular guidelines on the management of chronic limb-threatening ischemia is to manage all modifiable risk factors in all patients with suspected CLTI.[8,54]

Heavy smoking decreases tissue perfusion by causing peripheral vasoconstriction.[53] Smoking a cigarette decreases arterial blood supply by more than 30% in 45 minutes in specific areas of the body, especially in distal areas.[55] A recent meta-analysis demonstrated that there is now substantial evidence of the association between active smoking and the progression of CLTI.[56] The risk for CLTI is reported as lower among ex-smokers but, nonetheless, significantly increased compared with those who have never smoked.



CLTI and Diabetes Mellitus

Diabetes mellitus (DM) is the second most significant risk factor for developing CLTI and lower extremity ulcers. Up to 50% of patients with diabetes and foot ulceration have concurrent PAD, which confers a significantly elevated risk of adverse limb events and cardiovascular disease.[57]

PAD frequently coexists with peripheral neuropathy.[54] Neuropathy impairs sensory function, which can result in a lower extremity ulcer.[27,58,59] CLTI is more aggressive with DM and frequently coexists with peripheral neuropathy. Peripheral neuropathy can result in a progression of CTLI that goes undetected or is masked. Masked or undetected CTLI increases the risk for ulceration, infection and limb loss.[57]

Individuals with concurrent diabetes and PAD have a three-four fold increase in mortality and have a rate of amputation that is five times higher than patients with PAD without diabetes.[2] According to a meta-analysis of patients with diabetes, every 1% increase of HbA1c corresponds to a 26% increased risk of PAD.[60]

The Inlow 60-second Diabetic Foot Screen is a predictive tool that has since been validated for interrater and intrarater reliability, as well as predictive validity, and can be used to assess for risk factors that increase an individual's risk for ulceration and amputation.[61,62] The updated Inlow's 60-Second Diabetic Foot Screen: 2022 Risk Screening and Plan of Care tool has been augmented to include the IWGDF's classification tool to support the development of appropriate and timely care plans for individuals at risk of developing an ulcer.[63]

Inlow's 60-Second Diabetic Foot Screen: 2022 Risk Screening and Plan of Care is available at: https://www.wound-scanada.ca/doclink/inlow-60-second-diabetic-foot-screen/eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9.eyJzdWIiOiJpbmx-vdy02MC1zZWNvbmQtZGlhYmV0aWMtZm9vdC1zY3JlZW4iLCJpYXQiOjE2OTMzMjIwNjMsImV4cCI6MTY5MzQwOD-Q2M30.4nAHMINxT5nHQoCl15PpA1uv52fdAmgksSUiaF-oDvM

CLTI and Other Factors

Along with inquiring about diabetes mellitus and smoking, a family medical history is thought to be significant for determining other risk factors and should be obtained during the initial assessment.[2,8] A comprehensive assessment that includes assessing the patient's physical, mental and emotional health, lifestyle, environment and systems enables the health-care team to create appropriate goals and sustainable treatment plans for the prevention and management of arterial ulcers.

An assessment of arterial blood supply using an ankle-brachial pressure index (APBI), a non-invasive test, should be carried out before determining a treatment plan for a person with a lower extremity wound.[2,8,61,64] Blood flow status helps to inform the development of the most appropriate goals of care, such as wound healing, minimizing the risk of infection and preventing further injury. It is important that a clear diagnosis of CLTI be established or eliminated, particularly when other comorbidities exist that may impact the integrity of the skin and tissues of the lower extremities. The presence of PAD is also a marker for systemic atherosclerosis and early death associated with cardiac and cerebrovascular disease and is frequently associated with imminent limb loss.[57] PAD affects 20–29% of individuals over 70 years of age. Most patients do not develop gangrene or require amputations.[26,47] In high-risk coronary patients,

there is no apparent benefit of a systematic detection of asymptomatic extra-coronary atherothrombotic disease and intensified treatment over a two-year follow-up period. More research is needed.[65]

Patients diagnosed with coronary artery disease (CAD) should be screened for PAD.[26] It is recommended that patients over 70 years of age and patients over 50 years of age with atherosclerosis risk factors be screened for a history of walking impairments, claudication, ischemic rest pain and the presence of non-healing wounds on the lower extremities.[66]

Medications

In addition to an overall review of a patient's over-the-counter and prescription medications, special attention should be paid to medications known to interfere with skin health or the healing of arterial ulcers. Medications should be reviewed for continued dose-appropriateness or (temporary) discontinuation.[67-70] As part of this assessment, it is important to consider medications that are prescribed but not consumed by the patient due to costs.[1] Similarly, medications that would be indicated for routine management of CLTI, such as antiplatelet agents, should be assessed for their appropriateness in light of the patient's current health conditions.

Co-morbidities

Conditions such as anemia (iron deficiency)[71] and chronic obstructive lung disease[72] that affect overall tissue perfusion should be taken into consideration. Increased surveillance is required when diabetic neuropathy, venous insufficiency, structural deformities and mobility issues co-exist with an arterial ulcer. These common comorbidities can result in increased risk of injury, skin breakdown and infection when a patient is diagnosed with PAD. As well, assess the patient's history of COVID-19. There is a growing body of research focused on patients who had coronavirus (COVID-19) and have developed post-exertional malaise (PEM) and is similar to myalgic encephalomyelitis/chronic fatigue syndrome.[74,75]

Variations in Presentation PAD/CLTI

The clinical presentation of CLTI may vary significantly in different individuals. More than 50% of patients with PAD are asymptomatic, under-treated and under-recognized, and therefore specific screening and testing are required to diagnose PAD/CLTI.[2] Others may experience significant intermittent claudication, atypical leg pain, rest/night pain, ischemic ulcers and gangrene.[75]

Intermittent claudication affects patient quality of life and increases with age. IC pain affects the patient's calf, and less commonly the thigh and buttock, that is induced by exercise and relieved by rest.[76] Pathophysiology includes muscle ischemia during exercise caused by obstruction of the arterial flow. Symptoms can be described as mild to severe or 'unbearable' by patients.[76] Patients may be less active to avoid triggering the supply-demand mismatch that triggers IC symptoms.[77] Patients may also experience ischemic rest pain; these patients complain of, "burning pain in the soles of their feet that is worse at night."[77] Their sleep is disturbed due to pain and they often sit with their lower legs dangling over the side of the bed in, "an attempt to relieve their discomfort. The slight increase in blood flow due to gravity temporarily diminishes the otherwise intractable pain."[77]

CLTI is classified as symptomatic, asymptomatic or masked. Masked CLTI is a subgroup of asymptomatic PAD/CLTI that remains undetected as a result of the patient's physical inability to walk or the presence of any form of neuropathy that results in a decreased sensitivity to pain.[26] Both diabetic neuropathy and other neurological conditions, such as spinal stenosis, can contribute to masked PAD. Masked PAD, occurring more often in older patients, women and those with multiple comorbidities, should be distinguished from asymptomatic. An assessment of walking capacity is recommended when possible to determine masked PAD.[26]

The 2017 European Cardiovascular Society (ECS) Best Practice Guidelines report that, "While all asymptomatic patients are at risk of CV events, the subgroup with masked PAD is also at high risk of limb events."[26] This explains why an asymptomatic patient can shift rapidly to severe PAD.[26]

Chronic Limb-Threatening Ischemia (CLTI)

Conte et al. propose CLTI be defined to include a broader and more heterogeneous group of patients with varying degrees of ischemia that may delay wound healing and increase amputation risk. A diagnosis of CLTI requires objectively documented atherosclerotic PAD in association with ischemic rest pain or tissue loss (ulceration or gangrene). Ischemic rest pain is typically described as affecting the forefoot and is often made worse with recumbency while being relieved by dependency. It should be present for >two weeks and be associated with one or more abnormal hemodynamic parameters. These parameters include an ankle-brachial pressure index (ABPI) <0.4 (using higher of the dorsalis pedis [DP] and posterior tibial [PT] arteries), absolute highest AP <50 mm Hg, absolute TP <30 mm Hg, transcutaneous partial pressure of oxygen ($TcPO_2$) <30 mm Hg, and flat or minimally pulsatile pulse volume recording (PVR) waveforms (equivalent to WIfI ischemia grade 3). This definition excludes purely neuropathic, traumatic or venous ulcers lacking any ischemic component.[8]

PAD may progress to CLTI,[8] a condition characterized by chronic ischemic rest pain presenting for >two weeks, non-healing ulcers and/or gangrene in one or both lower extremities in conjunction with a clear diagnosis of PAD/CLTI.[53] The diagnosis of CLTI is based on a constellation (a coming together) of signs in lower-limb tissues that include loss of hair on the dorsum of the feet and toes; cool, shiny or dry skin; thickening of toenails; devitalized soft tissue with a dry or wet crust; atrophy of the skin and mummified or dry black toe(s).[8] Another clinical sign, revealed by performing the Buerger's test for thromboangitis obliterans (TAO), is when an elevation of the lower extremity results in pallor, but when the extremity returns to a dependent position the foot is ruborous (often called dependent rubor).[78] This rapid return of colour is called reactive hyperemia and is considered a sign of advanced CLTI.[78]

Pain in advanced CLTI is localized in the toes or the distal foot and not in the calf when the patient is supine. Relief will occur upon sitting or standing.[53] Increased capillary refill time, as well as altered or absent pulses in the lower extremity, may also be indicators of CLTI. However, capillary refill is not a reliable indicator of tissue perfusion.[79] Therefore, a validated assessment tool should be used to provide an accurate measure of peripheral blood flow. The diagnosis of CLTI should be confirmed by diagnostic vascular studies (See Table 7).[53]

Thus, persons with CLTI should always be assessed for the level of risk for amputation.[26] A low ankle-brachial pressure index (ABPI < 0.9) is one of the strongest indicators of CLTI, cardiovascular (CV) risk and associated mortality.[26] Classification systems such as the Fontaine, Rutherford and WIfI are used by clinicians to grade the level of disease, thus the risk of an eventual amputation. In addition to tissue ischemia, the presence of a wound and infection should be considered when determining amputation risk, as presented in the WIfI classification system.[25,26]

Acute Limb Ischemia

CLTI, associated with a progression of PAD/CLTI, should also be differentiated from acute limb ischemia (ALI).[53,80] The clinical presentation of ALI starts with abrupt onset of severe foot pain and the absence of peripheral pulses. Acute arterial occlusion may result from primary arterial thrombosis, arterial embolus or arterial dissection. The heart is the source of the embolus in 85% of episodes. Differentiating between thrombosis and embolic etiology can be difficult. However, a history of claudication points to thrombosis; atrial fibrillation points more to an embolic cause.

The classical 'six Ps' of ALI are strong indicators: pain, pallor, pulselessness, poikilothermia (cold), paresthesia and paresia (paralysis).[53] The presence of paresthesia and paresis favours the diagnosis of ALI, and they should not be present with CLTI. Sometimes patients with some form of symptomatic CLTI will present with acute ischemia; hence the importance of the neurological evaluation of sensation and motor deficit. Assessment by a vascular surgeon is recommended as soon as possible, as this is considered to be a vascular emergency, especially in the interest of limb preservation.[9,58] The three main categories of ALI are viable, threatened and irreversible (See Table 4).

Table 4: Acute Limb Ischemia Classifications[81]

Category	Description
Viable	• Limb not immediately threatened; no sensory loss; no muscle weakness; audible arterial and venous Doppler
Threatened	• Mild to moderate sensory or motor loss; inaudible arterial Doppler; audible venous Doppler • May be further divided into: - IIa (marginally threatened) **or** - IIb (immediately threatened)
Irreversible	• Major tissue loss or permanent nerve damage inevitable • Profound sensory loss, anesthetic • Profound muscle weakness or paralysis (rigor) • Inaudible arterial and venous Doppler

Physical Examination and the Importance of Palpation

Performing a detailed history to determine symptoms, past medical history, and cardiovascular risk factors in all patients with suspected CLTI is a good statement practice of global vascular guidelines on the management of chronic limb-threatening ischemia.[8] Physical examination of a patient with CLTI can confirm the clinical impression and help determine the severity and extent of the disease. The assessment should include a comprehensive examination of the pulses of the lower extremities, along with an inspection of both feet.[49,66]

Examination for vascular status must include palpation of all lower extremity pulses (i.e., femoral, popliteal, dorsalis pedis and posterior tibial), auscultation for abdominal and femoral bruits and inspection of the legs and feet,[8,19,53,82] although pulses can be nonspecific.[8,83]

Arterial palpation can identify a decrease in the amplitude of the pulse pressure, revealing proximal obstruction to blood flow, and can help to identify the disease location.[84,85] For example, finding a normal pulse in the femoral artery and no pulse in the popliteal artery space in a patient with calf claudication would point to a severe stenosis or occlusion of the superficial femoral artery. A decreased femoral pulse signifies aortoiliac disease.[86]

Bruit, a sound heard through a stethoscope placed over the artery, is produced by the turbulence of blood flow in a stenotic arterial segment.[87] The presence of bruit may also be found in the abdomen, indicating aortic, iliac or renal artery stenosis. The lack of bruit, however, does not exclude disease. Any doubt of occlusion or alteration of blood supply should promote further investigations.

When a wound is present, the physical examination should focus on the evaluation of arterial blood flow to determine the degree of healability of the wound site.[2,53]

Diagnostic Studies

Current clinical guidelines recommend performing a comprehensive vascular assessment of lower limbs with the ankle brachial pressure index (ABPI) in patients with a lower limb wound.[25,57,80] However, the validity of this test is known to be suboptimal in the presence of medial wall calcification of the main arteries, especially in the population with diabetes.[25,88,89]

Moreover, noncompressible arteries may affect the ABPI by providing falsely elevated or normal values in patients with diabetes, chronic renal insufficiency, or advanced age[8] leading to inconclusive, distorted results or potentially an overestimation of the actual vascular flow. Therefore, toe pressure is considered more sensitive than ABPI in diagnosing PAD.[8,90]

A strong recommendation is to also measure toe pressure and toe brachial index in all patients with suspected CLTI and tissue loss.[91-93]

Additional diagnostic tests used to screen for and confirm PAD/CLTI include: duplex ultrasound (DUS), pulse volume recording (PVR), transcutaneous oxygen tension ($TcPO_2$), continuous-wave and leg segmental pressure measurements, computed tomography angiography (CTA), magnetic resonance angiography (MRA) and conventional angiography.[26,53,66,94] Some of these investigative methods can also provide valuable information regarding the location, characteristics and severity of occlusive lesions in arterial vessels as a result of CLTI (See Table 5).

Table 5: Diagnostic Tests for Investigating PAD/CTLI

Diagnostic Test	Indications	Contraindications and Limitations	Benefits
Ankle Brachial Pressure Index (ABPI)	First-line test for the screening and diagnosis of PAD/CLTI[26,66,95] May be the only test required to help establish a diagnosis of disease [8,49,53,96] Useful to screen for asymptomatic PAD so that appropriate cardiovascular (CV) prevention strategies can be initiated[66] Useful for surveillance of lower extremity arterial disease after revascularization[26]	Primary limitation is the presence of non-compressible vessels (calcification of the distal arteries in the lower extremities as a result of diabetes),[53,88,90] which may be indicated by an ABPI measure > 1.4026 Requires appropriate diagnostic equipment to be available[26] A trained sonographer is recommended/preferred[26] Use of automated blood pressure (BP) cuffs is **not** recommended[26] Sensitivity is lower in individuals with diabetes	Non-invasive Inexpensive Can be performed resting or with treadmill exercise A strong marker for the presence of CV risk and generalized atherosclerosis[26,96] A two-threefold increase in CV-related death is associated with an ABPI < 0.90[26] Preliminary diagnosis can be made with measures obtained manually with a well-trained clinician[26] but should be interpreted with caution and in the context of a full clinical picture[79]
Ankle Brachial Pressure Index (ABPI) with treadmill exercise	Useful to repeat testing if a normal ABPI measure is obtained with existing IC[26] Performed to rule out asymptomatic or masked PAD[26,66] Useful in differentiating arterial claudication from non-arterial claudication (pseudo-claudication) comparing pre- and post-test measures[66] Useful to detect a proximal lesion on the aorta or iliac artery that contributes to a normal resting ABPI measurement[66]	Requires access to a treadmill in addition to other routine equipment Physical/functional limitations may be a barrier	Better screening for individuals with ABPI measures of 0.91 to 1.30, not exhibiting symptoms of IC, who could be at risk for PAD[8] Useful in assessing functional limitations associated with PAD, and to determine safe parameters for an exercise program[66]

Toe-Brachial Pressure Index (TBPI)	Used when non- compressible vessels exist (calcification of vessels resulting from diabetes)[26] Used to diagnose patients with suspected PAD/CLTI when ABPI >1.40[26,49,80,97-99] Used with normal or borderline ABPI measures when there is the presence of non-healing wounds or gangrene[26] Used to diagnose CLTI[2,8]	Requires appropriate diagnostic equipment to be available[26] A trained sonographer/ technician is recommended[26]	Non-invasive Inexpensive Useful to support the prescribing of compression for cases when significant edema and/or non-compressible vessels hinder reliable ABPI measures Sensitivity and specificity are better than ABPI for patients with diabetes[21,53,90]
Computed Tomography Angiography (CTA)	Can determine the location, characteristics and severity of occlusive lesions in the lower extremities[100] Generally reserved as part of the investigative process when revascularization is being considered[66] Used for patients warranting invasive intervention, such as percutaneous transluminal angioplasty (PTA) or vascular surgery	Requires the administration of nephrotoxic, iodinated contrast medium[8,66] Patients with renal failure, diabetes or dehydration are at risk for contrast- induced renal failure, so caution is warranted[8,66] Image quality may be obscured by the presence of arterial calcification or metallic implants[8] Past or suspected sensitivities to contrast medium should be investigated, along with a review of renal function, prior to test[66]	Can produce a high resolution 3-D visualization of cross sections of vessel lumens, allowing for an accurate determination of vessel diameter and stenosis severity[8] Can be used with end-stage renal patients on dialysis[8] Recommended for optimizing revascularization strategy[66]

Ankle-Brachial Pressure Index (ABPI)

For a detailed description of ABPI and instructions for performing this test, see How-to-Conduct an ABPI.[101] https://www.woundscanada.ca/about-us/68-healthcare-professional/issues/360-2019-vol-17-no-1

For an in-depth discussion of the science underlying the ABPI test, and information about when to use this test, see The Science Behind ABPI.[102]

Health-care professionals should keep in mind that CLTI may affect each of the three primary arterial vessels of the lower extremity in varying degrees. Recent studies show the importance of calculating the ABPI using measures taken from two arteries of each foot.[83] The arterial flow in the foot can be divided into six individual regions, called angiosomes.[103] Recent literature provides some evidence that the specific location of a foot ulcer should be taken into consideration and may provide guidance for vascular and plastic surgery decisions.[83] See Table 6 for interpretation of blood flow and perfusion measures.

Toe-Brachial Pressure Index (TBPI)

A toe-brachial pressure index (TBPI) measure can be obtained similarly to an ABPI. A small, toe-sized cuff is applied, usually to the great toe, instead of the ankle. The availability of the toe cuff is essential. In the case of incompressible arteries, often the result of vessel calcification secondary to DM, a TBPI is a suitable, non-invasive examination that provides an objective indication of distal lower limb vascularization.[104-106]

According to the 2016 American Heart Association (ASA)/American College of Cardiology (ACC) Guideline on the Management of Patients with Lower Extremity Peripheral Artery Disease,[106] when there is possibility of falsely elevated ABPI scores, TBPI with waveforms, along with other appropriate vascular examinations, such as PVR or TcPO2, should be employed to ensure more accurate measures of arterial blood flow.[53,88,107,108]

Arteries in the first digit are narrower and therefore less prone to calcification that may result in false-positive (falsely elevated) measures.[104,105] Current guidelines for PAD/CLTI screening recommend the use of toe pressure with a threshold value <0.70 mmHg to indicate the presence of PAD/CLTI.[21,53]

Obtaining a Transcutaneous Oxygen Tension ($TcPO_2$) Measure

$TcPO_2$ measures are obtained through the use of a transcutaneous oximetry device. The diagnostic test provides information about the supply and delivery of oxygen to the underlying microvascular circulatory system by recording the partial pressure of oxygen at the skin surface.[110] A $TcPO_2$ value of <40 mmHg (at normobaric air) suggests hypoxia sufficient to impair or prevent wound healing (in patients with and without diabetes).[111] Suggested thresholds for arterial wound healing range from 25 to 40 mmHg.[53,111-113]

Table 6: Assessing Arterial Flow and Perfusion

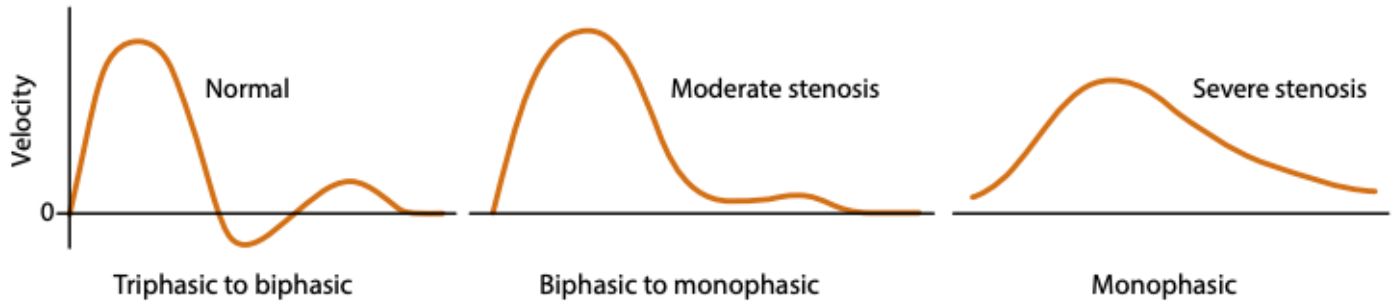
Grade	Ankle-Brachial Pressure Index	Toe Brachial Index	Toe Pressure	Waveforms	Transcutaneous Oxygen Pressure (indicating perfusion)
Non compressible	>1.40 Be aware of possible falsely elevated measures	Preferred when vessels are non-compressible	Preferred when vessels are non-compressible		Preferred when vessels are non- compressible or when localized perfusion may be altered due to previous insult (trauma or surgical repair)
Normal Range	1.0–1.40	>0.7	>70 mmHg	Triphasic	>40 mmHg
Borderline	0.91–0.99	>0.6	>70 mmHg	Biphasic/ monophasic	>40 mmHg
Abnormal: Mild Moderate Severe	<0.90	<0.6	<70 mmHg	Biphasic/ monophasic	<40 mmHg
	0.7–0.9	>0.4	>50 mmHg	Biphasic/ monophasic	30–39 mmHg
	0.41–0.69	>0.2	>30 mmHg	Biphasic/ monophasic	20–29 mmHg
	<0.4 critical limb ischemia (CLI/ CLTI)	<0.2	<30 mmHg	Monophasic	<20 mmHg

Figures 2, 3, 4: Systolic Pressure Measurements for Brachial, Posterior and Posterior Tibial Arteries for Calculating ABPI

Figure 2: Brachial artery	
Figure 3: Left dorsalis pedis artery	
Figure 4: Left posterior tibial artery	

Used with permission from Maryse Beaumier.

Figure 5: Waveforms[109]



Obtaining Continuous-wave and Leg Segmental Pressure Measurements

Obtaining leg segmental limb pressure (CLP) measurements involves a more in-depth process and the availability of appropriate equipment.[114] This diagnostic test requires considerably more time to prepare the patient than a traditional ABPI because it involves the application of inflatable cuffs at multiple levels. Mobility issues and obesity can be hindrances to performing this diagnostic test.

CTA and MRA

Computed tomographic angiography (CTA), magnetic resonance angiography (MRA) and contrast angiography are other diagnostic methods used to determine the location and severity of occlusive lesions in the lower extremities when CLTI exists. CTA examines cross sections of the vessel lumen, allowing for visualization of structures such as vessel diameter and stenosis severity, as well as any existing lesions. The image quality may be obscured by the presence of arterial calcification or metallic implants.

CTA allows a global evaluation of the arterial tree to determine the severity and location of arterial lesions. This information is useful in choosing the revascularization approach—either endovascular, open or hybrid surgery. CTA is often used to intervene in the arteries with balloons and stents. Patients should be screened with appropriate blood work for renal insufficiencies before the CTA is performed.[26] It is generally recommended that patients who have end-stage renal failure have the CTA performed prior to their scheduled dialysis.[26]

MRA requires longer acquisition time and a non-claustrophobic patient. All metal implants such as pacemakers or cerebral clips are contraindication to its use. Finally, a contrast agent in the form of gadolinium must be used. Severe renal insufficiency prevents its use because of the risk of nephrogenic systemic fibrosis.[115]



Conventional Angiography for Diagnostic Purposes

Conventional angiography, a more invasive approach to investigation, provides a comprehensive look at the arterial anatomy through the introduction of a contrast medium (dye) into the arterial system. Contrast angiography is reserved as part of the investigative process for when a patient with PAD is being considered for revascularization.[66] Contrast angiography is used for patients warranting invasive intervention such as percutaneous transluminal angioplasty (PTA) or vascular surgery. Clinicians should be wary of complications related to technique (puncture site hematoma, false aneurysm).

Pain Assessment

Managing pain is a priority for patients with CLTI who are experiencing intermittent claudication , rest pain and/or local wound pain. Therefore, a patient's pain experience should be thoroughly assessed as an essential aspect of the plan of care. Pain assessment requires the use of validated measurement tools, such as the FACES, visual analogue and numerical rating scales.[19] The experience of pain is just one aspect of the differential diagnosis of PAD/CLTI and should be distinguished from other expressions of pain related to other pathologies, such as venous disease and muscular or other neurological conditions.[49,86]

Factors other than ischemic pain and IC may be contributing to the patient's overall pain experience and must be carefully considered and differentiated. For individuals who are likely experiencing IC, the six-minute walk test closely correlates to real-life outdoor walking capacity and quality of life.[116] The distance that the patient can walk in a six-minute period is recorded. As the symptoms of IC decrease, the distance that the patient can walk over the six minutes should increase. Another useful measurement tool is graduated maximal treadmill testing, which records the onset of IC during peak walking times.

Phantom Limb Pain (PLP)

PLP affects up to 80–90% of patients with amputations.[117,118] This type of pain feels like it's coming from a body part that is no longer there, often as a result of surgical amputation secondary to CLTI. In the past it was often thought that this common post-amputation phenomenon was primarily psychological in nature; however, pain experts now recognize that these real sensations originate in the spinal cord and brain.[119]

A characteristic of PLP includes onset within the first few days of amputation, which often affects the part of the limb farthest from the body, such as an amputated foot or leg. PLP may come and go and is often described as shooting, stabbing, boring, squeezing, throbbing and/or burning. PLP may be triggered by pressure on the remaining part of the limb or emotional stress. Finding an effective way to manage PLP can be challenging.[120]

Feet and Footwear Assessment

A thorough assessment of the general condition of the skin and nails of the lower extremities can provide valuable insight into the overall risk level of the patient, particularly when altered skin integrity already exists. Clinicians should look for cool, shiny, dry skin; colour changes (pale, bluish or dark reddish); loss of hair on feet and legs; thickening and brittleness of the toenails; open sores; skin infections or ulcers that will not heal. Clinicians should assess the type(s) of footwear and socks worn for all seasons and multiple uses (employment, leisure, activity, sport).[121]

It is also important to carry out an assessment of the patient's ability to perform foot-related self-care or in partnership with the care partner.[122] For more patient-focused information, please see Wounds Canada's Do It Yourself (DIY) Skin Health Series: Arterial and Leg Ulcers: https://www.woundscanada.ca/patient-or-caregiver/resources/diy-series

As part of integrated team activities, the type and fit of footwear or other custom fabricated orthoses and footwear (orthopedic devices) should be assessed, as they may be a potential source of external pressure and contribute to tissue damage.[66] Burns et al. studied the role of custom foot orthoses in persons with PAD. They report reduction in plantar pressures when compared to 'sham' orthoses[123] (See the Pressure section following for more on pressure and PAD). Clinicians should also assess the ability of the patient to purchase and wear appropriate footwear and receive regular foot care.[53]

Pressure

Patients with PAD/CLTI are at high risk for skin breakdown as a result of poor tissue perfusion. Because of this, pressure over boney prominences on the lower extremities places them at risk for pressure injury and trauma from external forces (See Figure 6). The presence of peripheral neuropathy, with associated loss of protective sensation and/or foot deformity, may further increase the risk for pressure injury.[53,54,124] If there is significant arterial insufficiency, injuries may be unable to heal, potentially leading to infection, CLTI and amputation.

Therefore, it is recommended that a person with CTLI be assessed for level of risk for pressure injury.[80] The Braden Scale for Predicting Pressure Ulcer Risk is one example of a commonly used validated assessment tool for predicting the risk of pressure injury.[125] A 2015 review, Pressure Ulcer Programme of Research (PURPOSE), specified three primary risk factor domains relative to pressure injury risk. These domains were identified as mobility/activity, skin/pressure injury status and tissue perfusion.[126,127]

Quality of Life and Activities of Daily Living

Inquiring about the activities of daily living (ADLs) and instrumental (ADLs), including occupational and leisure tasks, and daily walking patterns provides an indication of a person's overall physical ability and may help to proactively identify potential risk for skin injury. The degree to which a person can participate in everyday activities can impact considerably on their overall sense of health-related quality of life (HRQoL).[94,128] There are several quality-of-life questionnaires available to assess HRQoL, including the Medical Outcomes Study Short-Form 36 General Health Survey.[129,130]

Researchers are working toward developing a quality-of-life tool specific to persons living with PAD titled: Quality of Life Questionnaire for Patients with Peripheral Artery Disease (QOLPAD). Early findings report that the QOLPAD is internally consistent and valid for patients receiving PAD treatment in Germany.[131]

For additional information on QOL tools see Chapter 4: Prevention and Management of Wounds: An Overview.[23]

Figure 6: 63-year-old man, living with type 2 diabetes for 20 years, non-smoker. Ischemic wound created by pressure from work boot; deep tissue infection in progress.



Used with permission from Maryse Beaumier.

1.2.2 Environmental: Socio-economic, care setting, potential for self-management

The socio-economic status of a patient may significantly impact their ability to participate in a treatment plan that has been designed to optimize their sense of wellness and prevent and manage arterial ulcers. A patient's access to items and services to meet needs, their support systems and their educational level (literacy) should be considered when assessing their capacity for self-care and their ability to participate in a plan of care.

Financial concerns, or out-of-pocket expenditures, may restrict the person's ability to take time off from work for medical appointments and to purchase dressing supplies or prescribed medical devices[132] and medications.[1] Poor psychosocial status may be associated with mental health illness, poor well-being, living alone, alcohol or substance use, history of trauma, poor hygiene or malnutrition. All of these factors have been found to be associated with an increased risk of developing an arterial ulcer and should be assessed.[8,53] Current guidelines also recommend that patients with PAD/CLTI be assessed for symptoms of anxiety, depression and hopelessness.[80,133]

1.2.3 Systems: Health-care support and communication

PAD/CLTI is a lifelong medical condition, often requiring surgical intervention and an interdisciplinary team approach.[26,86] Patients suspected of having PAD/CLTI, in conjunction with the presence of a lower extremity ulcer, should be promptly referred to a vascular and wound healing specialists.[8,134,135]

Patients with PAD/CLTI have shortened life expectancies because of severe atherosclerotic disease leading to cardiovascular events and mortality. The five-year survival rate in non-diabetic patients with significant PAD/CTLI is 70%. Patients with both CLTI and renal failure have a two-year survival rate of <50%.[53]

Ensuring that the appropriate interprofessional teams, community-based support services and resources are accessible may be critical to the overall success of a plan of care designed to prevent and manage vascular disease.[8]

1.3 Complete a wound assessment, if applicable

Because arterial ulcers can be the result of multiple disease processes occurring at the same time, clinicians should holistically evaluate the patient, identifying all the underlying and potential external causes (such as trauma) of the tissue damage.[8] An essential aspect of the assessment of an arterial ulcer is the etiology of the wound.[80] It is recommended that wound assessment and local wound care begin with identifying the etiology of the ulcer and minimizing or correcting any other co-factors or conditions that exist.[8]

The assessment of an arterial ulcer should include the location, shape, size, tissue type, presence and nature of wound exudate, presence of malodour, periwound tissue characteristics and wound pain.[80]

Validated assessment tools should be used to measure and describe the characteristics of the local wound environment and surrounding tissues and to determine whether wound healing is taking place. See Chapter 4: Prevention and Management of Wounds: An Overview.[23]

Characteristics of an arterial (ischemic) ulcer include the following:

- Often on the lower extremities; less frequently on the upper extremities, but can occur
- 'Punched out' appearance with well-defined borders (See Figure 7)
- Often associated with little or no exudate or periwound edema
- Often deep, with possible exposure to tendon and/or bone
- Often has yellow slough or black eschar, with minimal or no granulation
- Often associated with moderate to severe pain (See, Figure 8)
- Ischemic regions may appear as dry gangrene (See, Figure 9)
- Periwound tissues may be pale, shiny, dry, with loss of hair and dystrophic nails
- Often appear over boney prominences or other areas being traumatized by external pressures (footwear, pressure, trauma) (See example, Figure 9).

Figure 7: Large, dry arterial ulcer (eschar) on the lower leg of a male, smokes heavily, without diabetes	
Figure 8: 51-year-old female with diabetes, smokes heavily, ischemic pain, TBPI: 20 mmHg	
Figure 9: 57-year-old male with type 2 diabetes with sensitive neuropathy, waiting for revascularization	

Figures 7–9 used with permission from Maryse Beaumier.

After completing a thorough assessment of the local wound site, clinicians should determine the risk of complications, including infection and amputation.

Assessment for Risk of Infection

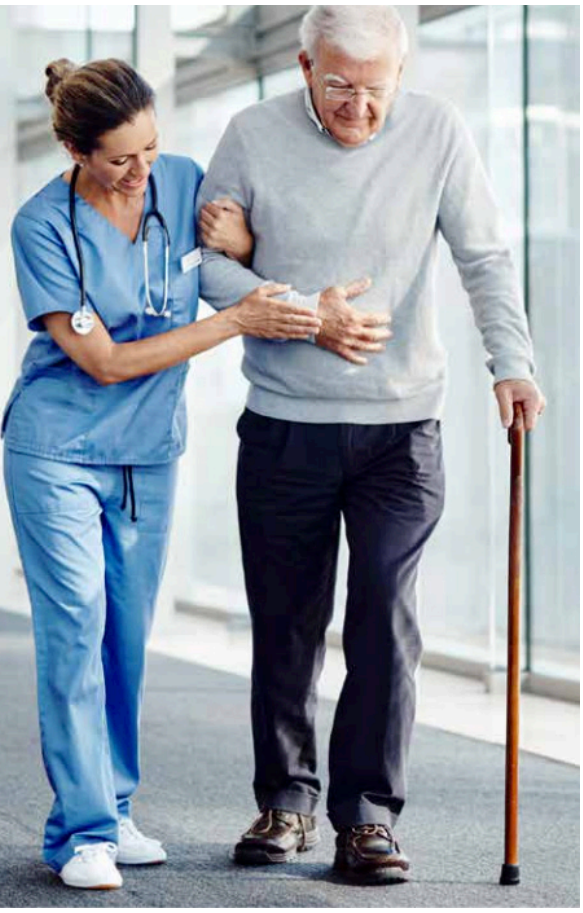
Wound infection is the most common complication of non-healing wounds.[136] Poor arterial blood supply to a wound site, along with the effects of other comorbidities that impact overall tissue perfusion, will contribute to poor resistance to wound infection.[136] Vigilant monitoring of arterial ulcers during the healing process is recommended because inadequate blood flow can suppress signs and symptoms of wound infection and impede the body's ability to fight the infecting pathogens.[136] A clinical diagnosis of wound infection should be determined only after careful consideration of several factors. Assessment should begin with a comprehensive physical exam, followed by a careful assessment of the wound site.

Severe arterial insufficiency inhibits the normal wound healing process because tissues are poorly perfused and the delivery of nutrition and systemic antimicrobials may be less effective due the lack of blood supply to the wound.[8] Inadequate local vascular supply leading to poor tissue oxygenation can favour microbial proliferation, increase the risk of infection and reduce the likelihood of healing.[136] These wounds can appear either with an eschar corresponding to a dry and black skin necrosis or with a heavily exudating and colonized gangrenous stage.

Tips for Obtaining Wound Culture Specimens: Wounds Canada's Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[23]

A clinical diagnosis of wound infection is sometimes made based upon clinical signs, patient-reported symptoms and good clinical judgement.[136] However, a more definitive diagnosis of infection can be made with the support of microbiology testing (culture and sensitivity) and blood specimens. Although antimicrobials are sometimes prescribed based on a clinical diagnosis, culture-specific directed care is the preferred approach, because it can identify specific pathogens that may be causing the infection, along with sensitivity guidelines for prescribing specific antimicrobials.

Poor blood flow may suppress inflammatory signs of infection,[137] including erythema, heat and induration.[137] Therefore, a high degree of suspicion may be warranted for PAD/CLTI-related wounds. For detailed information on how to manage PAD-related wound infections, clinicians are referred to the current IDSA guidelines.[137]



Step 2: Set Goals

Recommendations

2.1 Set goals to maintain skin health and for prevention and healing, non-healing and non-healable wounds

Following a comprehensive assessment of the patient, their wound, environment and systems factors, goals for prevention and management can be determined in a collaborative process carried out between the health-care team, the patient and their care partners. Patient-driven goals should be developed based on SMART (specific, measurable, attainable, relevant, timely) principles.[23]

Health-care professionals need to consider the patient's goals, such as: Is the patient's primary goal to close the ulcer? Is it to manage pain? Is it to be able to walk as far as the bathroom? An important aspect of the early stages of treatment is establishing realistic, achievable goals that are mutually understood and agreed upon by the clinicians and the patient.

2.1.1 Identify goals based on prevention or healability

For individuals with PAD/CLTI, goals should be centred around preventing all skin breakdown and the development of wounds.

For individuals with existing wounds, goals should be developed that reflect their healability based on the assessments undertaken by the team (see above). Arterial wounds fall into several healability categories, based in part on tissue perfusion, that can guide realistic goal setting.[21,53,57,138,139] Healability may change over time post-vasculatization. Table 7 identifies examples of goals based on perfusion status.

Adequate perfusion indicates that there is sufficient blood flow to the limb to support tissue viability and wound healing.

2.1.2 Identify quality-of-life and symptom-control goals

Generally, the primary patient-centred goals in the treatment of CLTI are usually to alleviate pain, prevent amputation and improve patient HRQoL, including the healing of any existing arterial ulcers (See Table 8). Patients will often prioritize symptom management, such as alleviating pain, when determining treatment goals. However, health-care professionals should encourage patients to identify HRQoL priorities as well. A decrease in overall sense of wellbeing and HRQoL is often associated with the experience of intermittent claudication, rest/night pain and decreased mobility.[140,141] In patients with pure arterial ulcers, some of the pain may be associated with the ulcer; however, most pain is associated with ischemia. Pain associated with the arterial wound, intermittent claudication and/or ischemia may contribute to patients becoming sedentary.[16]

Table 7: Patient Goal Setting Based on Perfusion

PAD/CLTI Status	Perfusion	Examples of SMART Goals
Borderline*	Adequate	Wound closure within 12 weeks following revascularization Satisfaction with local wound care with every dressing change[142,143] Pain management regimen implemented within 12 hours[2,8,26] Appointment with a vascular surgeon as soon as possible[2,8,26,49,66] Prevention strategies implemented immediately in relation to wound infection[136] Prevent new trauma and pressure injury[2,49,80,66,86]
Post Re-Vascularization	Adequate	Wound closure within 12 weeks following revascularization Pain management regimen implemented within 12 hours[2,8,26] Appointment with a vascular surgeon in accordance with surveillance protocols; potential re-stenosis monitored as per protocol[2,8,26,49,66] Prevention strategies implemented in relation to wound infection[136] Prevention of new trauma and pressure injury[2,49,66,80,86]
Post Re-Vasculari-zation (re-stenosis)	Inadequate	Pain management regimen implemented within 12 hours[2,8,26] Vascular appointment for reassessment (surveillance) and pending revascularization[2,8,26,49,66] Prevention strategies implemented in relation to wound infection[136] Prevention of new trauma and pressure injury[2,49,66,80,86] Satisfaction with local wound care with every dressing change[142,143]
Pending revascularization	Inadequate	Timely and successful revascularization to optimize blood flow[2,8,26,49,66] Prevention strategies implemented in relation to wound infection[136] Prevention of new trauma and pressure injury[2,49,66,80,86] Satisfaction with local wound care with every dressing change[142,143] Ischemic pain controlled in conjunction with primary health-care provider[66]
Not a candidate for revascularization	Inadequate	Wound care appropriate for a non-healing wound initiated immediately[26] Prevention strategies implemented in relation to wound infection[136] Prevention of new trauma and pressure injury[2,49,66,80,86] Satisfaction with local wound care with every dressing change[142,143] Optimization of management of ischemic pain in conjunction with primary health-care provider[66]
Un-determined		Timely vascular assessment[8,26,49,66] Satisfaction with local wound care with every dressing change[142,143] Prevention strategies implemented in relation to wound infection[136] Prevention of new trauma and pressure injury[2,49,66,80,86] Ischemic pain controlled in conjunction with primary health-care provider[2,8,26]

*Borderline would refer to a patient with just enough blood flow for healing; this assessment is difficult to make and should be part of the expert opinion regarding adequate perfusion to heal even though circulation may not be within optimal ranges.

Table 8: Health-related Quality of Life and Symptom-control Goals

Patient Concern	Examples of SMART Goals
Comorbid Conditions	Based on the Canadian Cardiovascular Society 2021 dyslipidemia guidelines[145] • if TG ≤1.5 mmol/L: LDL-C <1.8 mmol/L • if TG >1.5 mmol/L: ApoB <0.7 g/L or non-HDL-C <2.4 mmol/L on maximally tolerated statin dose. Manage lipids, blood pressure and cholesterol to target levels.[2]
Rest and walking pain	• Pain decreased to 1/10–2/10 at rest within one-two weeks. • Taking anticoagulant medication as prescribed within one-two weeks. • Taking maximally tolerated statin as prescribed within one-two weeks to improve walking distance. • Keeping legs in a dependent position (below heart level) as much as possible
Activities of daily living	• Walking 10–15 minutes longer before experiencing PAD claudication symptoms within three - six months of initiating a tailored exercise program • Participating in supervised exercise at a level recommended by a health-care professional within three months • Patients should be instructed to avoid long periods with the hip or knee bent (e.g., gardening). They need to move about every 30 minutes to avoid a thrombosis of the vessel or the graft • Maintaining a healthy diet to support glucose levels that are stable and within the target range and support appropriate body mass index (BMI) and healthy skin within three-four months[144]
Emotional, cognitive, behavioural, mental health factors	• Participating in a smoking cessation program to reduce cigarette consumption to less than one pack a week within three months • Engaging in self-care activities and adhering to a plan of care aimed at prevention and management of ulceration and amputation within one-two months
Infection prevention	• Participating in activities to maintain healthy feet, including not walking in bare feet, daily foot inspections and skin care immediately after assessment with a multidisciplinary team or foot specialist • Regular professional foot care every four-six weeks • Footwear fitted by a qualified health-care professional immediately following the closure of a foot ulcer plus planned follow-up • Follow-up with primary care provider at first sign of ulceration or foot infection • Acquisition of knowledge of signs and symptoms of infection and complications and changes that may be affecting blood flow to the lower extremities • Keeping feet clean and dry; no soaking of feet



Step 3: Assemble the Team

Discussion: Preventing and managing arterial ulcers requires the input of many health-care professionals and service providers. The patient and their care partners are essential members of the integrated team.[2,8]

Recommendations
3.1 Identify appropriate health-care professionals and service providers

Patients with, or at risk for, arterial ulcers have specific concerns and risks that require a team of health-care professionals and supportive services that can work collaboratively with each other, the patient and their care partners.

These team members might include a family physician, vascular surgeon or specialist, orthopedic surgeon, plastic s urgeon, internal medicine specialist, risk reduction and modification specialist (internal medicine physician with a specialty in vascular medicine), infectious disease specialist, nurses specialized in wound and foot care, nurse practitioners, physical therapist, occupational therapist, diabetes educator, pharmacist, dietitian, pedorthist, orthotist, prosthetist, podiatrist or chiropodist, pain management specialist, psychologist, social worker and spiritual care eaders.

See Table 9 for a description of the role each team member plays.

Table 9: Potential Professional Members of the Integrated Team

Team Member	Indication for Referral
Vascular surgeon or specialist	Manage symptoms and reduce risk of ulceration, infection, CLTI and amputation in patients diagnosed with or suspected of having arterial insufficiency[2,8,26]
Hyperbaric medicine specialist	May assist in measurement of localized ischemia via $TcPO_2$ in some cases[135,146147]
Orthopedic surgeon	Support complex surgical interventions resulting from amputation, remodeling/ reconstruction when extensive tissue loss results from CLTI
Plastic surgeon	Consulted when surgical skin flaps and grafts are required post amputation or there is significant debridement of revascularized tissue
Internal medicine specialist and risk-reduction and modification specialists	Consulted regarding the assessment and optimization of systemic comorbidities such as smoking status, lipid lowering, blood glucose, activity and hypertension[2]
Infectious disease specialist	Chronic infection secondary to CLTI may result in acute cellulitis, gangrene and chronic and acute osteomyelitis. Timely consultation with a specialist who has expertise in empirical and culture-specific antimicrobial treatment can support the healing of arterial ulcers[136]
Nurse with specialized wound and foot education	Provide specific clinical and educational support pertinent to the co-ordination of complex plans of care when multidisciplinary efforts are required; pain assessment, wound care planning Provide preventative and maintenance foot care
Physical therapist (PT)	Conservative treatment strategies may include exercise programs aimed at improving symptoms of intermittent claudication[86] Reconditioning and training programs are often required following a surgical amputation associated with CLTI, especially when prosthetics have been prescribed Nonpharmacological treatment of pain Safe exercise intervention to prevent tissue trauma
Occupational therapist (OT)	Pressure risk assessment and pressure redistribution and protection of areas at risk for tissue trauma Activity modification/aides Rehabilitation pertaining to a patient's employment, employability, social and activities of daily living
Diabetes educator, pharmacist, registered dietitian	Assist in identifying and optimizing co-factors such as smoking, hypertension, glycemic control and obesity[80] Assist in appropriate calculations for renal dosing Assist in identifying and managing drug-drug and drug-disease interactions

Pedorthist, orthotist or prosthetist	Manage intrinsic pressure associated with existing foot deformities or extrinsic pressure associated with inappropriate footwear or other mechanical devices[80] In cases where the amputation of a foot or lower limb has occurred, the patient may be a candidate for a prosthetic to aid in ambulation and/or transfers. The risk of falls and other mobility-related injuries should always be taken into consideration. Collaboration with an OT/PT may be beneficial
Physiatrist	Focus on prevention, diagnosis, evaluation, treatment and rehabilitation of the whole person, specifically improving patient functioning through medical and rehabilitation assessment and interventions in partnership with the integrated team: PT, OT, dietitian, speech therapy, spiritual and social works, psychology, and prosthesis, orthoses, engineering and vocational services[148]
Podiatrist, chiropodist	Involved in preventative foot care and regular foot inspection[66] Support treatment of infection in collaboration with infectious disease specialist; prescription of offloading modalities considering bio-mechanics of the foot areas at risk of ulceration; prophylactic surgical offloading correction in carefully selected patients in collaboration with vascular surgeons
Pain management specialist	The level of pain associated with ischemia often requires narcotics and a combination of analgesics and pain management strategies[2,80]
Psychologist, social worker, spiritual leader	Hospital-based, rehabilitation and community-based supports to help patients navigate financial, social, spiritual and relationship, employment concerns
Family physician, primary care provider, nurse practitioner	Participates in decisions concerning choices in pain management and referrals to other specialists for the management of comorbidities, and the ongoing management of this chronic disease





It is common for individuals with CLTI to receive concurrent treatment for other comorbidities. Professional team members need to possess the expertise to manage a variety of co-factors, as well as modify the risk factors that will impact the patient's overall condition. When caring for patients with CLTI, the team should include individuals who are skilled in endovascular and surgical revascularization, wound healing therapies, foot surgery and medical management.

For further information related to assembling a team, refer to Chapter 4: Prevention and Management of Wounds: An Overview.[23]

3.2 Enlist the patient, care partners and family as part of the team

The coming together of ischemic and claudication pain, loss of function and mobility, depression, anxiety, embarrassment, social isolation, financial burden, employment changes, prolonged hospital stay, and chronic morbidity or death are all commonly associated with PAD.[149] In the US, Demas et al. state that though there have been improvements in medical, endovascular and surgical techniques, there continues to be disparities based on sex, race, ethnicity, colonization patterns and socioeconomic status.[149] Therefore, there needs to be a continued effort to increase PAD prevention, advocacy and awareness programs focused on making linkages between smoking, blood glucose and risk of diabetes mellitus, cholesterol, activity and hypertension.[150,151] More work needs to be done to promote prevention, as well as partnerships, in an effort to develop better patient outcomes for people with chronic diseases such as PAD and CLTI.

Engaging individuals who live with PAD/CLTI in the management of their chronic illness is imperative. The Canadian Patient Safety Institute provides a guide focused on strategies to engage patients, families and care partners.[152]

The Chronic Care Model (CCM) is designed to guide teams in delivery of high-quality PAD and CLTI care that aims to improve patient health outcomes. This model of care encourages self-management, use of decision-making tools and delivery of ambulatory care services through several integrated system initiatives designed to make patient-driven, evidence-based care easier to deliver and evaluate.[153-155]

3.3 Ensure organizational and system support

Organizational support for arterial wounds is limited. In 2007, an exploratory study in Quebec revealed the lack of collaboration and consistency among health professionals and difficulty in accessing professionals specialized in complex wound care.[156] In 2013, the Canadian Institute for Health Information (CIHI) looked at the prevalence of compromised wounds in Canada by type, health-care setting and risk factors to inform better prevention and management of wounds.[157] Unfortunately, CIHI reported venous ulcers and arterial ulcers in the same category, not distinguishing wound type clearly enough to provide information relating to specific organizational or system support needs.

In a survey carried out to determine knowledge levels and attitudes regarding lower extremity ulcer care, the following problems were reported: lack of evidence-based clinical practice guidelines for leg ulcer care (82%), absence of evidence-based protocols in home-care agencies (72%), lack of access to wound care products (69%), lack of access to wound care centres (66%) and poor communication among health-care workers (60%).[158] Transfer of knowledge from research to practice is poorly funded, and literature reports that it is a slow and challenging process.[159] Delays in knowledge translation often mean treatments and modalities that have proven beneficial may not be readily available or recognized because the evidence has not yet been incorporated into current health-care policy and procedure.

The 2020 version of this chapter was the first Canadian best practice recommendation dedicated primarily to the prevention and management of arterial ulcers, and even now only a few are available worldwide.[8,16,79]

According to current guidelines for the prevention of lower extremity arterial ulcers, there have been numerous educational efforts, such as national advertising campaigns, designed to promote increased public awareness of PAD/CLTI and the prevention of arterial ulcers. These types of campaigns should be continued more broadly to provide information to patients, care partners and communities:

- Information for patients, care partners and health-care providers in all care settings
- A system to identify at-risk patients
- Risk reduction measures
- Prompt, effective treatment
- Service audits to align local practice with accepted standards of care



Overall, such programs should be built on a structure designed to meet the needs of patients who require chronic care.[8,160] Developing system-supported strategies that focus on the prevention and management of risk factors for arterial ulcers is essential if better patient outcomes are to be achieved. Raising awareness of these risk factors will support early diagnosis and intervention, impacting both the incidence of arterial ulcers and mortality.[8,138]

To support quality of care, health-care systems will also have to generate higher quality data for all long-standing wounds across all health-care settings.[157] Improving recording and reporting of the prevalence and incidence of wounds, the progression of healing and outcomes of all wound types is also significantly important.[157] With better and more consistent data, the process of translating research into treatment and intervention becomes easier, with a stronger influence on improving the overall quality of patient care.[159]

Step 4: Establish and Implement a Plan of Care

An effective plan of care needs to be both evidence-based and allow for patient participation throughout the decision-making process. Successful chronic disease management requires the patient and their care partners to be engaged in a plan of care designed for prevention and management.

Recommendations
4.1 Identify and implement an evidence-based plan to correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional, social), the wound (if applicable) and environmental/ system challenges

An individual diagnosed with PAD/CLTI may be asymptomatic. In such cases the integrated, interprofessional health team should still work collaboratively to monitor and to manage risk factors and to ensure that appropriate strategies are implemented to prevent the loss of skin integrity. Once the CLTI status is determined treatment plans are developed to reflect goals.



Preventative and management plans of care for a person with PAD often include addressing smoking, nutrition, medications, exercise and activities of daily living, chronic pain, offloading and factors that affect quality of life.[66]
Patients who have been diagnosed with CLTI often require urgent referral to a vascular surgeon to determine the appropriateness of revascularization to restore blood flow in accordance with surveillance protocols.[26,66]

As up to 85% of amputations may be prevented by early detection and appropriate treatment,[53] the principal objectives for a plan of care for a wound should be:

1. to focus on healing process if the blood supply is sufficient and
2. to limit infection if the blood supply is insufficient, or in doubt, during the waiting time for vascular assessment.

For arterial ulcers with sufficient arterial inflow to support healing, use a dressing that will maintain a moist wound-healing environment.[161,162]

Dry gangrene or eschar is best left dry until revascularization is successful.[138] In wounds with insufficient arterial blood supply, PVP-I can also dry out the wound and reduce bacterial load and prevent bacterial infection.[163,164]

Table 10 provides an overview summary of the principal considerations when creating a plan of care based on CLTI status.

Table 10: Summary of Treatment Plan

CLTI Status	Perfusion	Treatment Plan
Prevention	Adequate	• Treat CV risk factors • Manage diabetes mellitus • Smoking cessation • Activity
Borderline*	Adequate	• Treat CV risk factors • Early vascular referral • Offload ulcer site and manage PI risk • Cautious moist wound care
Post revascularization (remains patent)	Adequate	• Treat CV risk factors • Monitor for re-stenosis (surveillance) • Offload ulcer site and manage PI risk • Cautious moist wound care
Post revascularization (re-stenosis)	Inadequate	• Treat CV risk factors • Refer for vascular assessment • Manage ischemic pain • Offload ulcer site and manage PI risk • Monitor vigilantly for infection • Avoid moist wound healing • Keep ulcer clean and dry with antiseptic • Consider adjunctive therapies
Pending revascularization	Inadequate	• Avoid moist wound healing • Keep clean and dry with antiseptic • Offload ulcer site and manage PI risk • Manage ischemic pain • Treat CV risk factors • Consider adjunctive therapies
Not a candidate for revascularization	Inadequate	• Treat CV risk factors • Monitor for increasing symptoms • Manage ischemic pain • Offload site and manage PI risk • Monitor vigilantly for infection • Avoid moist wound healing • Keep ulcer clean and dry with antiseptic • Consider advanced therapies
Undetermined		• Treat CV risk factors • Refer for vascular assessment

* Borderline here refers to a patient with just enough blood flow for healing; this assessment is difficult to make and should be part of the expert opinion judging healability of the wound based on the presence of adequate perfusion to heal even with impaired circulation.

Skin and Nail Care

Peripheral vascular disease increases the risk of foot ulcers and nail changes. PAD/CLTI impacts the layers of the skin, making the tissue susceptible to injury. Therefore, the skin on the lower extremities should be protected from trauma caused through mechanical, chemical and thermal insults;[80] otherwise, even minor injuries can lead to significant tissue loss, infection and failure to heal. Appropriate foot care, including skin cleansing, foot inspection, podiatry care and prompt assessment of lesions, is recommended for an individual diagnosed with PAD/CLTI.[66] Care of the toenails on the limb that has evidence of PAD/CLTI or peripheral neuropathy should be performed by a specialist.[138]

Smoking

Patients and anyone they are living with or regularly visiting the home should be actively encouraged to engage in a smoking cessation program.[2,8] Referral to such a program, along with counselling and pharmacotherapy support, is strongly recommended.[66] Cessation in patients with asymptomatic PAD optimizes the patient's tolerance to ambulation.[2,8] Unless contraindicated, the following pharmaceutical approaches to smoking cessation should be considered: varenicline, nicotine replacement therapy and bupropion.[2,8] When patients are not ready to stop smoking completely, a reduction in smoking by half or the use of an electronic cigarette are recommended as alternative options; however, the long-term safety of electronic cigarettes is unknown.

Glycemic Management/ Control

Effective glycemic management is recommended for patients with asymptomatic PAD.[2,8] For most adults with diabetes, Diabetes Canada proposes a HbA1c target of ≤7.0%. For people with type 2 DM at low risk of hypoglycemia, a lower target of ≤6.5 is recommended. However, a target HbA1c between 7.1% and 8.5% may be the preferred measure in a person with PAD when other comorbidities such as limited life expectancy, recurrent severe hypoglycemia and/ or hypoglycemia unawareness, functional dependency, frailty, advanced age or dementia (delirium, depression) are present.[144]

When poor glycemic control is a suspected factor, patients with CLTI should be encouraged to follow up with their primary health-care provider, diabetes educator or other appropriate specialist for supportive services, technologies or devices that could optimize glycemic control. For more information, please refer to Chapter 11: Prevention and Management of Diabetic Foot Ulcers.

Physical Activity

Assessment of footwear by a foot specialist should be conducted prior to beginning any exercise programs and recommendations made for proper fit and appropriate type for each activity.

Exercise programs should be considered for patients with CLTI as a risk-reduction strategy and as an alternative to revascularization, particularly in the early stages of the disease.[165] Structured, supervised exercise programs are recommended as first-line therapy for the treatment of intermittent claudication.[66] Unsupervised exercise may have some patient benefit when supervised programs are not feasible.[26] These programs aim to manage the symptoms of IC by improving exercise capacity, preventing or minimizing physical disability and reducing the occurrence of CV events. Taking into consideration that patients with CLTI belong to a high-risk population, careful monitoring and evaluation of existing comorbidities is recommended to ensure patient safety during exercise.[49] Take into consideration the patients' history of COVID-19 and risk of long-COVID-19 and post-exertional malaise (PEM).[73,74]

Existing functional limitations associated with claudication pain, along with an evaluation of how well a patient is responding to therapy, are most objectively measured through exercise treadmill tests. Treadmill walking is one example of an exercise program that can be structured and supervised and has demonstrated the best evidence for managing symptoms of IC.[165] Exercise sessions involve selecting a walking speed and degree of incline that will induce symptoms of IC within three to five minutes. When a patient reports moderate claudication pain, they are instructed to stop and rest until the symptoms subside. The exercise cycle is repeated for at least 30 minutes. In subsequent visits, the speed and/or degree of incline of the treadmill can be increased if the patient is able to tolerate walking for 10 minutes or longer at the increased workload without experiencing IC. Exercise sessions longer than 30 to 60 minutes and more often than three sessions per week are considered to have the most benefit.[165] Sessions lasting longer than 12 weeks and up to six months demonstrate the longest-lasting benefit. More research is needed.[165]

Alternative forms of exercise may also benefit the patient, including pain-free walking exercise training, leg-cycling exercise training, aerobic arm exercises, leg-cycling and resistance training.[165] However, current evidence suggests that these are not as effective as treadmill training.

Home-based, self-directed exercise programs are recommended, and may also be of benefit to patients who do not have access to a supervised program.[165] Home-based programs should have a goal of 30 minutes of walking three to five times per week.[49] The presence of lower-extremity wounds and severe IC may potentially exclude a patient from participating in a treadmill exercise training program. As an alternative option, arm ergometry has been shown to improve lower extremity perfusion and alleviate pain in patients with known PAD. Participating in a supervised or home-based exercise program is recommended for patients who have undergone a revascularization procedure.[49]

Medications: Pre-revascularization

Medications prescribed for the treatment of PAD/CLTI are outlined in Table 11; in consideration of four clinical objectives: cardiovascular risk reduction, claudication management, CLTI management and treatment for limb preservation. Cardiovascular risk-reduction medications include lipid-lowering agents, antihypertensive agents, antiplatelet and antithrombotic agents, smoking cessation options and antihyperglycemic and renal agents.

Table 11: Cardiovascular Risk Reduction and Medical Management[2,26,144,166]

For more information see The Canadian Cardiovascular Society 2022 Guidelines for Peripheral Arterial Disease https://ccs.ca/guideline/2022-peripheral-arterial-disease/

Lipid-lowering Agents	
Statins	Recommend maximally tolerated dose of statin for all persons with established atherosclerotic cardiovascular disease (ASCVD), such as PAD/CLTI even if lipid parameters are at target
Ezetimibe	When TG ≤1.5 mmol/L, if LDL-C is 1.8 to 2.2 mmol/L; or when TG >1.5 mmol/L, if ApoB 0.70 to 0.80 g/L or if non-HDL is 2.4 to 2.9 mmol/L, ezetimibe is recommended as second-line therapy (add-on to maximally tolerated dose of statin) When TG ≤1.5 mmol/L, if LDL-C is >2.2 mmol/L; or when TG >1.5 mmol/L, if ApoB >0.80 g/L or if non-HDL is >2.9 mmol/L, ezetimibe is recommended as third-line therapy (add-on to maximally tolerated dose of statin and proprotein convertase subtilisin/kexin type 9 [PCSK9] inhibitor).
Bile acid sequestrant	Does not reduce CV risk but should be considered in persons with PAD/CLTI who are unable to achieve lipid targets in combination with maximally tolerated statin therapy doses with or without ezetimibe
PCSK9 inhibitor	Considered in persons with PAD/CLTI who are unable to achieve LDL-C, ApoB or targets in combination with maximally tolerated statin therapy doses with or without ezetimibe
Fibrate	Does not reduce CV risk, but should be considered in persons with PAD/CLTI and low HDL-C, and/or elevated triglycerides, to reduce the LDL-C values
Anti- hypertensive agents	Considered for selected high-risk patients, aged ≥50 years, and with systolic blood pressure (SBP) levels ≥130 mmHg, intensive management to an SBP ≤120 mmHg[167,168] Patients with diabetes should be treated to attain <130 mmHg SBP and <80 diastolic BP mmHg[169] Other patients should be treated to attain <140 mmHg SBP and <90 mmHg diastolic BP[2,8]
ACE inhibitors	In symptomatic patients with lower extremity PAD/CLTI, these can reduce the risk of adverse CV events, and should be continued even when the person is at blood pressure targets In asymptomatic patients with lower extremity PAD/CLTI, they may reduce the risk of adverse CV events
Cardiovascular and Renal Protective Antihyperglycemic Agents[145,166]	
Glucagon-like peptide-1 receptor agonists (GLP-1 RA)	At doses that have demonstrated cardiovascular and renal protection, are recommended for all people with established atherosclerotic cardiovascular disease (ASCVD), including PAD/CLTI, to reduce the risk of major adverse cardiovascular events (MACE)

SGLT2i therapy	Is contraindicated in CLTI; and SGLT2i therapies are recommended to be stopped during an active wound. However, in the absence of CLTI and when no active wounds are present, SGLT2i should be considered SGLT2i therapy has been shown to reduce the risk of MACE, hospitalization for heart failure and progression of nephropathy in people with established ASCVD, including people with PAD/CLTI
Antiplatelet and Antithrombotic Agents	
1st Line: ASA 75 mg to 325 mg daily	For individuals with symptomatic atherosclerotic CLTI—including those with IC or CLTI—prior to lower extremity revascularization (endovascular or surgical), or prior amputation for lower extremity ischemia to reduce the risk of myocardial infarction (MI), stroke and vascular death
2nd Line: Clopidogrel 75 mg daily	In asymptomatic individuals with an ABPI ≤0.90, consider antiplatelet therapy to reduce the risk of MI, stroke, or vascular death Note: When ABPI is 0.91–0.99, reduction in MI, cerebrovascular accident (CVA) or vascular death in asymptomatic individuals is not well established
Combination: ASA + clopidogrel	Considered for those who are not at increased risk of bleeding and who are at perceived high cardiovascular risk with symptomatic atherosclerotic CLTI, including those with intermittent claudication or CLTI, prior lower extremity revascularization (endovascular or surgical), or prior amputation for CLTI to reduce the risk of CV events
Combination: Warfarin + ASA or clopidogrel Combination: New oral anticoagulants (NOAC) + ASA	NOT RECOMMENDED In the absence of any other proven indication for warfarin, its addition to antiplatelet therapy to reduce the risk of adverse CV ischemic events in individuals with atherosclerotic PAD/CLTI is of no benefit and is potentially harmful due to increased risk of major bleeding The Compass trial evidence recommends rivaroxaban 2.5 mg BID with (ASA 80-100 mg) for symptomatic lower extremity PAD who are at high risk for ischemic events (polyvascular disease, diabetes, history of heart failure, or renal insufficiency) and/or limb amputation, rest pain, ischemic ulcers AND at low bleeding risk. (Strong Recommendation; High-Quality Evidence).In the absence of high-risk limb presentation or high-risk comorbidities and low bleeding risk, they recommend combination treatment with rivaroxaban 2.5 mg twice daily and ASA or single antiplatelet therapy for patients with symptomatic lower extremity PAD (Strong Recommendation; High-Quality Evidence)[2] Caution is warranted given the incremental bleeding risks associated with combination therapy and because existing evidence is inadequate to support a confident recommendation at this time.
Homocysteine-lowering Agents	
Folic acid and vitamin B12 supplements	Effectiveness is not well established in individuals with PAD/CLTI and homocysteine levels ≥14 mmol/L
Oral zinc	Does not appear to aid in healing arterial wounds[170]
Intermittent Claudication Management Considerations	
Statins	Indicated to improve walking distance when prescribed in conjunction with general prevention strategies[26]
Pentoxifylline 400 mg 3x per day	May be considered to improve walking distance in patients with IC. Note: The clinical effectiveness of pentoxifylline as therapy for claudication is marginal and not well established. Not recommended as a useful agent for the treatment of CLTI[66]

Imaging Studies to Optimize the Revascularization Strategy Arterial imaging are not used only to diagnose CLTI. When a revascularization procedure is being considered, advanced imaging may be employed to identify the target vessels (vessels with lesions) and to determine the most appropriate approach to revascularize the limb. If a normal post-exercise ABPI measurement is obtained, arterial imaging is not recommended, in accordance with surveillance protocols.[66]

Medications: Post-revascularization

The presence of asymptomatic or symptomatic CLTI is an ominous sign that widespread atherosclerosis is present. Patients who experience rest pain in a lower extremity, or have developed an arterial ulcer, have a significantly increased risk of myocardial infarction and cardiovascular accident and cardiovascular-related death.[170,171]

Pharmacological management is recommended for risk reduction and can play a significant role in reducing the prevalence of morbidity and mortality.[2,145,167] Even if blood flow has been restored or optimized in a lower extremity, targeted medical therapy is indicated to prevent further cardiovascular events or the progression of CLTI.

Pharmaceutical therapies can be grouped into three categories: thrombosis-directed therapies, cholesterol-lowering therapies and blood-pressure-lowering (anti-hypertensive) therapies. Standard treatment guidelines for medical therapy (including beta blockers, statins, angiotensin-converting enzyme [ACE] inhibitors and calcium channel blockers) will improve outcomes for not only coronary artery disease (CAD), but also arterial ulcers.

The Voyager PAD trial recommends rivaroxaban 2.5 mg twice daily in combination with ASA (80–100 mg daily), with or without short-term clopidogrel use (30 days), for patients with lower extremity PAD after elective endovascular revascularization (Strong Rec; Moderate-Quality Evidence). They also recommend treatment with rivaroxaban 2.5 mg twice daily in combination with aspirin (80–100 mg daily) for patients with lower extremity PAD after elective open revascularization (Strong Rec; High-Quality Evidence).[72]

See Table 12 for a description of these medications.[8]

Table 12: Pharmacotherapy for CLTI and Post-revascularization Medications

Pharmacotherapy for CLTI	
Thrombosis-directed agents	**Antiplatelet Agents** Long-term single antiplatelet therapy recommended for asymptomatic PAD[26] Recommended in accordance with surveillance protocols Recommended for patients with PAD who are symptomatic for IC or have CLTI, to reduce the risk of MI, CVA and vascular death[53,106,180] Recommended for patients with asymptomatic PAD to reverse adverse cardiovascular ischemic events[66] Clopidogrel 75 mg daily is recommended as a safe and effective alternative antiplatelet therapy to ASA to reduce the risk of MI, CVA or vascular death in individuals with symptomatic atherosclerotic PAD.[106] Current guidelines report that clopidogrel may be preferred over ASA Certain high-risk PAD patients benefit from receiving both ASA and clopidogrel; however, it is recommended that this combination therapy be considered on an individual basis, not for patients with high risk of bleeding, and that this combination therapy should be reassessed every six to 12 months to determine if it is still suitable based on the person-centred characteristics No clinical trials have examined the efficacy of newer antithrombotic medications such as prasugrel or vorapaxar to reduce ischemic events in patients with PAD[86] No difference in MACE (major adverse cardiovascular events) and MALE (major adverse limb events, e.g., major amputation) when comparing ticagrelor and clopidogrel[180]
	Anticoagulation Agents There is evidence for prescribing moderate intensity anticoagulation (INR 2-3) in the presence of ASA, suggesting that combining anticoagulant and antiplatelet therapy significantly reduces recurrent CV events; however, this combination also increases the risk of major bleeding

Cholesterol-lowering agents	Strong evidence supports the lowering of cholesterol with statin medications in patients with CLTI to reduce the risk of major vascular events Lipin-lowering therapy with a high-intensity statin at maximally tolerated doses
Antihyper-glycemic agents	Optimizing glycemic control is recommended for patients with CLTI
Anti-hypertensive IVE agents	Treatment of hypertension recommended to reduce cardiovascular events, including congestive heart failure (CHF), CVA and death. There is some evidence to suggest a definite relationship between hypertension and CLTI Effective management of hypertension recommended for patients with asymptomatic PAD[66] Recommended that patients without diabetes who have been diagnosed with PAD and hypertension be prescribed antihypertensive medication to achieve a blood pressure measurement of <140 mmHg systolic[100] Recommended that the treatment goal for PAD patients with diabetes and/or renal disease should be blood pressure of <130 mmHg systolic over 80 mmHg diastolic[66] Treatment with an ACE (angiotensin-converting enzyme) inhibitor medication is recommended to lower CV risk in patients with either asymptomatic or symptomatic PAD[66] Ramipril should be considered as a first-line choice for hypertension treatment in PAD patients; although it should be used with caution in the presence of renal artery stenosis[8] Beta-blockers are widely used for the management of high blood pressure, either alone or combined with other medicines, including diuretics, ACE inhibitors or calcium channel blockers. May be especially useful in people who also have angina or heart failure, or who have had a heart attack There is no available evidence that beta-adrenergic blockers worsen the symptoms of IC
Post-intervention (Revascularization) Medications[90]	
Antiplatelet agents	Clinical evidence does not conclusively support the routine use of antiplatelet agents to improve lower extremity vein bypass graft patency. Long-term single antiplatelet therapy is recommended for patients who have undergone revascularization[26] Use of anticoagulant therapy is still recommended to reduce future cardiovascular ischemic events and incidence of stroke Bypass graft patency may be improved with antiplatelet therapy in patients undergoing prosthetic bypass Antiplatelet therapy recommended for all patients undergoing revascularization for CLTI, and continued post-operatively, unless contraindicated by a pre-existing condition[66]
Anticoagulation agents	The use of warfarin anticoagulation following lower extremity bypass remains controversial Anticoagulation is used selectively in vein bypass procedures when the graft is not considered to be optimal quality or vessels below the graft site are small or diseased Warfarin, in addition to ASA, is prescribed to many patients receiving prosthetic grafts to reduce the ischemic consequences of bypass graft thrombosis Caution is warranted given the incremental bleeding risks associated with combination therapy and because existing evidence is inadequate to support a confident recommendation at this time[8]

Intermittent Claudication (IC): Medical Management versus Revascularization

Patients who experience IC should be considered for medical management before being offered endovascular and surgical therapies. The cornerstones of management for patients who experience intermittent claudication are cardiovascular protection and exercise.[26]

Surgery still plays an important role in the treatment of patients with arterial disease. When PAD results in impairment of normal activities of daily living (ADLs) or incapacitating IC, revascularization should be considered.[26]

If there is severe impairment of ADLs, exercise therapy should be considered, along with revascularization.[26] Choosing the most appropriate intervention, open or endovascular, will depend on the location and distribution of the arterial lesions, as well as the patient's overall condition and comorbidities.

Endovascular therapy is used more commonly than open surgical therapy because of its minimally invasive nature and the reduction of short-term morbidity and mortality. The trade-off, however, is the long-term durability of endovascular repairs.

CLTI and Revascularization

To alleviate pain, improve the patient's HRQoL, close any existing arterial ulcers and prevent amputation, most patients will require some form of revascularization procedure.[53] In addition, an aggressive plan of care aimed at managing all existing cardiovascular risk factors is essential. Revascularization is a fundamental strategy for limb preservation and is the optimal treatment choice for patients with CLTI.[53] However, in some cases, revascularization does not improve limb function and mobility. Cognitive impairment, a non-ambulatory status prior to developing CLTI, and severe comorbidities may lead to a poor prognosis even when revascularization has been performed.

Acute Limb Ischemia (ALI) and Revascularization

When ALI occurs, assessment and emergent revascularization should be carried out if the affected extremity is considered a candidate for preservation.[53,66] In contrast to treating chronic ischemic disease, current guidelines do not recommend investigative tests to determine the vascular anatomy (or sites of occlusion) when the affected limb is not considered a candidate for preservation.[2,8] If a neurological deficit underlies the acute ischemia, urgent revascularization is recommended.[26]

In the case of acute ischemia, treatment with heparin and analgesics to manage pain are recommended as soon as possible.[26]

Managing Pain: Wound Pain, IC and CLTI

The presence of tissue ischemia or neuropathy will require the clinician's careful attention to pain. Management of pain associated with an arterial ulcer should include consideration of local, regional and systemic modalities.[80] One of the primary strategies to reduce pain associated with CLTI is to encourage the patient to position the lower limb in a dependent position to optimize perfusion to the wound. Making appropriate adjustments to sleeping position by increasing foot dependency can optimize rest and reduce night pain but will result in increased swelling of the lower extremities.

The presence of IC and CLTI can cause considerable discomfort and should be managed vigilantly. Current literature reports that the application of an ibuprofen-foam (IBU) dressing may provide some local wound pain relief, as well as increase HRQoL.[174,175] However, there is no available evidence that recommends the routine use of these dressings to treat arterial ulcers,[162] or specifically for the purpose of pain management. More high-quality studies will have to be carried out before any conclusions can be made.[162]

Several studies have reported positive benefits of the use of statins to reduce IC pain.[176,177] A few small studies have demonstrated a benefit of statin therapy to optimize pain-free walking time in patients with IC, although the mechanism of action is not known.[8] However, a 2015 guideline suggests that prescribing ramipril 10 mg once daily should be considered to improve pain-free and maximal walking times in patients with IC.[8]

Pentoxifylline is a medication often prescribed for its action to reduce blood viscosity and platelet aggregation. A 2015 review concluded that there is currently insufficient high-quality data to support the benefits of pentoxifylline for IC.[178] Although pentoxifylline has not been shown to improve arterial ulcer healing,[80] a modest effect in increasing pain-free and maximal walking distance has been demonstrated. This is believed to be a result of improving blood flow and enhancing tissue oxygenation.[179,180]

Although the clinical effectiveness of pentoxifylline for the treatment of IC is not well established,[2] best practice guidelines recommend that pentoxifylline be considered for these patients to improve walking distances.[2]

The use of acetaminophen, in conjunction with opioids, should be considered for the management of pain associated with CLTI.[89] When pain is not adequately controlled, a referral to a specialist with expertise in pain management is recommended, and revascularization should be considered to augment wound healing and limb preservation.[49]

Nutrition

Nutritional counselling may be recommended for patients with PAD and CLTI to determine deficits that may impact the healing of the arterial ulcer.[80] The role of oral zinc to augment the healing of arterial ulcers is not well established.[170] Nutrition must be adequate to provide sufficient protein to support the growth of granulation tissue.[3,8,99,181]

For more information on nutrition, please see Chapter 4: Prevention and Management of Wounds: An Overview.[23]

Psychosocial Factors

Patients with CLTI who are not considered candidates for revascularization have lower reported HRQoL,[128] These lower scores relate specifically to physical pain and a reduction in physical functioning, as well as the ability to participate in activities of daily living. HRQoL scores are reportedly lower in females with CLTI, individuals with a higher body mass index (BMI) and/or reduced ABPI.[182] Social isolation, substance use (alcohol), lower socioeconomic status[1] and poor hygiene and nutrition have been implicated as psychosocial factors that contribute to the development of arterial ulcers. Securing the support of a social worker (medication funding, emotional support, transitions in care), outreach programs, food security and/or a spiritual care specialist may be beneficial to improving HRQoL.[183]

Offloading for Wound Prevention and Healing

As a preventative measure in persons with CLTI, an orthosis, shoe or other offloading device can minimize the pressure over vulnerable areas on the lower extremity. This is particularly important when peripheral neuropathy is present. It is essential that patients with PAD/CLTI receive a biomechanical assessment as soon as possible by a trained foot/footwear professional to ensure the appropriateness of footwear and other orthotic/prosthetic devices that may contribute to extrinsic pressures.[66] Every effort must be made to prevent pressure injury, particularly over boney prominences, and reduce the risk of wounds caused by trauma.[66]

When an arterial ulcer is present it may be necessary to modify the existing offloading device/orthotic to an alternative that will support wound healing and prevent further tissue breakdown.[80]

Consultation with a health-care clinician who is skilled at carrying out a biomechanical assessment of the lower limbs (pedorthist, chiropodist, podiatrist, orthotist) is recommended to determine the most appropriate offloading approach and/or device to use. For further information on offloading devices refer to Chapter 11: Best Practice Recommendations for the Prevention and Management of Diabetic Foot Ulcers.

Limb Amputation

Amputation for chronic ischemia may be performed as the result of a failed revascularization attempt, a lack of suitable conduit or target arteries, severe patient comorbidities, poor functional status or extensive gangrene or infection such that limb preservation is not possible.[184] The goals of amputation are to eliminate all infected, necrotic and painful tissue, to achieve uncomplicated wound healing and to have an appropriate remnant stump that can accommodate a prosthesis.[184]

Major amputation (above the ankle) in patients with CLTI is recommended when there is overwhelming infection that threatens the patient's life, rest pain cannot be controlled and there is extensive tissue loss.[53,185] Amputation should be considered for a patient with significant necrosis on the weight-bearing portions of the foot, non-correctable flexion contracture or very limited life expectancy as a result of comorbidities.[19,21]

Lower limb amputation (LLA) is a disabling and costly condition.[186] Cost estimates are not available for Canada; however, in the United States the costs associated with acute and post-acute care for LLAs exceeds $4 billion USD annually.[186]

A Canadian study on 20,062 patients in Ontario observed a significant increase in the rate of any amputation among patients with diabetes, peripheral arterial disease and both diabetes and periphery arterial disease.[187] In the study, 64% of patients underwent a major (above ankle) amputation. Diabetes was present in 82%, peripheral arterial disease in 94%, and both diabetes and peripheral artery disease in 76%.[187]

Liu et al. assessed whether or not there was a temporal trend in re-amputation rates. They reported higher incidence rates for reamputation to both limbs and to the contralateral limb only. At 12 months, the reamputation rate for all contralateral and ipsilateral reamputations was 19%, and at five years, 37.1%. At five years the contralateral reamputation rate was found to be 20.5%. They found no evidence of a trend in the reamputation rates over more than two decades.[188]

With the increase in the aging population and the expected growth in the number of individuals living with PAD leading to CLTI and lower limb amputation, it is imperative that adequate preventative, rehabilitation resources, lower limb and preventative foot screening and diabetes-management programs are available to this population and are allocated appropriately.[189] In a population-based descriptive study in Canada, Kayssi et al., found that there is variability in the delivery of lower-extremity amputations and postoperative hospital discharges among surgical specialists and regions.[190]

The length of the residual limb has important implications for rehabilitation.[184] Whether the patient has undergone a trans-met amputation (TMA), a below-knee amputation (BKA) or an above-knee amputation (AKA), they will require interventions related to ambulation and mobility, adjustment to new body image, management of phantom limb pain and social and environmental adaptations. A proper assessment is essential to determine whether an amputee is an appropriate candidate for a prosthetic device. Advanced prosthetic technology provides amputees with more choices and new functional designs, and ultralight materials help with independent living.[184] Measuring for and the fitting of a customized prosthetic device should be carried out by a trained professional who has expertise in the biomechanical assessment of the lower extremities, as well as other physiological considerations related to lower-limb amputation. Ulceration is an ongoing concern with the introduction of a prosthetic because the device can be a cause of external pressure injury and discomfort. The patient's overall safety is a priority.

Some important factors to consider in the choice of a prosthetic design are the patient's comfort and sense of safety, appearance of the device, functionality, social circumstances, user-friendliness, cost and maintenance. Collaboration among specialists is essential to support these patients following hospital discharge and to ensure regular servicing of the prosthetic. Regular reassessment may identify a change in the patient's level of function and mobility, weight changes and impact on the fitting of the device, or other concerns regarding safety and comfort.

Phantom Limb Pain (PLP)

Post amputation, the complication of PLP is prevalent (up to 80%) and difficult to manage.[117,191] Various therapies have been explored to determine the best approach to managing PLP; however, none has been found to be highly effective.[120]
Erlenwein et al. in a review explored the use of approaches focused on restoring body scheme and integration of senior-motor inputs. Technology-based applications such as virtual reality, offer options to supplement existing established approaches based on mirror therapy. As well, targeted muscle therapy and prosthesis aids in restoring limb function and reshaping one's body perception.[191]

Currently employed non-invasive and minimally invasive therapies for PLP include medications, exercises and relaxation techniques, transcutaneous electrical nerve stimulation (TENS) and acupuncture.[182,183] More-invasive options include anesthetic and steroid injections, spinal cord stimulation (SCS) and nerve blocks. Surgical stump revision and neurectomy are sometimes considered as a last resort.

Some evidence has been generated for the prevention of PLP before the amputation is performed with the use of pre-operative anesthetic.[120] An RCT by Brunelli et al. studied PLP management after amputation and concluded, "The use of a prolonged postoperative perineural infusion of anesthetic (ropivacaine 0.5%) seems to be an effective therapy for the treatment of phantom limb pain and sensations after lower extremity amputation."[193] Hunt et al. explored the use of perineural infusion of lefobupivaine (n=81) with minimal pain improvements.[194] More research is needed.

Psychological Considerations Following Lower Limb Amputation

Having one or more lower extremities amputated as a result of PAD/CLTI can result in a number of emotional responses, including grief (sense of loss), an alteration in body image and the need to adapt to a new way of life with self and others.[195] Supports are needed to manage associated anxiety and depression.[196] The presence of phantom pain can exacerbate mental health and wellness.[197] Patients are at risk of isolation and negative emotions associated with body image change, each affecting their ability to engage in and carry out activities of daily living.[197] Support is needed to help the patient self-manage and adapt to a new body image and a change in function; these are key to accepting the amputation and enhancing quality of life.[198-200]

Timely referrals to a mental health specialist, Indigenous support worker, psychologist or psychiatrist trained in dealing with amputation can help the patient explore their sense of grief and loss and transition to an acceptance of a new body image and level of functioning within their social, work and community life.[10,61]

Environmental adaptations in the home and place of employment, such as grab bars and modified bathrooms with appropriate signage, can optimize function and foster a greater sense of independence and self-care. This is particularly important when the patient is being considered for, or has been fitted with, a prosthetic limb or is required to mobilize with other devices such as a wheelchair, walker, scooter or vehicle. The support services of a PT and/or OT can optimize the amputee's physical strength, balance and co-ordination, as well as introduce skills and techniques related to transfer and mobilization.[198]

Social workers, psychologists and peer-based programs are helpful in accessing community-based resources and services for the patient to aid in the process of adapting to a new amputation. Supports should include social, psychological and spiritual care approaches relevant to the patient's beliefs and preferences. This includes mindfulness, cognitive behavioural therapy and short- and long-term counselling.[201]

4.2 Optimize the local wound environment

Strategies that are designed to manage the wound should reflect the goals of care for the patient, which have been made, in part by determining the healability of an arterial ulcer in the assessment phase. It is important to remember that healing a wound requires greater perfusion than is needed to maintain intact skin.[4,53]

An arterial wound that has adequate perfusion is considered healable and will need an aggressive approach if the goal is wound closure. The goals for non-healing and non-healable wounds, where blood perfusion is inadequate or factors that impact healing cannot be addressed, will focus on pain control and preventing infection.[4,83,202] Preventing re-ulceration and minimizing further tissue damage should always be a priority with patients who have PAD/CLTI.

It is recommended that dry gangrene or eschar be left dry until revascularization is successful;[79,138] therefore the cleansing of these arterial wounds should be carried out with the daily application of povidone iodine (10% PVP-I) to maintain a dry wound bed.[163,164,203]

4.2.1 Cleansing

For wounds that are considered to have adequate arterial perfusion, pH-balanced, non-cytotoxic skin and wound cleaners should be used to maintain the skin's moisture barrier and acid mantle and promote a moist wound healing environment.[80] Percival et al. state wound cleansers that contain surfactants may enhance wound closure, especially when microorganisms are present that delay wound healing. In wounds complicated by biofilms, persistent inflammation or slough, "The use of surfactants has been shown to aid in the removal of these barriers to wound healing. The use of concentrated surfactant (poloxamer) based wound dressings represent an important component of wound management".[204]

The cleansing of non-healable arterial ulcers that present with dry eschar or dry gangrene is not recommended.[79,88,138] Washing or cleaning a non-healable wound site before the application of 10% PVP-I is not recommended.[80] Gangrenous tissue, if not infected, can form an eschar cap that will progressively shrink as it dries and, eventually, 'mummify'.[53] Protective dressings are required throughout the mummification stage. If the circulation beneath or surrounding the wound is adequate (or improved by a revascularization procedure), a process of auto-amputation may follow.[53]

This process, however, may take considerable time, and pain management, education in bacterial burden, and maintaining a dry wound environment become the priorities.[53,174,203,205]

For further guidance on wound cleansing refer to Chapter 4: Prevention and Management of Wounds: An Overview[23] and Wounds Canada's Product Pickers https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/library/183-resources-industry-partner/288-product-picker

4.2.2 Debriding

Current literature on arterial ulcers is consistent with the practice of not debriding stable black eschar.[80,181,206] Debridement prior to revascularization in poorly perfused extremities should be performed only in a septic foot with or without ischemic signs.[79]

Autolytic and enzymatic debridement may be alternative approaches to consider in cases where sharp debridement may be contraindicated. However, autolytic and enzymatic debridement are contraindicated in the presence of significant PAD.[199] When employing these modalities with an ischemic wound, close monitoring is recommended.[80]

For further guidance on wound debridement refer to Chapter 4: Prevention and Management of Wounds: An Overview.[23]

Surgical debridement of nonviable and non-infected tissue is not recommended until adequate vascular status has been confirmed or restored.[79,207] Without adequate perfusion to heal the wound, debridement may exacerbate tissue ischemia by increasing metabolic demand, leading to increased risk of amputation.[79]

4.2.3 Managing bacterial balance

A progression of PAD often coincides with an increased risk of wound infection.[136] The probability of infection varies directly with increasing bacterial numbers and their relative ability to cause disease (known as virulence) while varying inversely with the host's ability to resist invasion.[136]

The application of topical antimicrobial dressings should be considered to minimize the proliferation of bacteria in the open wound.[136] Povidone iodine (10% PVP-I) is one of the most extensively used broad-spectrum topical antiseptics used to minimize the bacterial burden in long-standing wounds with an inadequate blood supply.[174,205] Hypersensitivity reactions may occur. PVP-I is available in an aqueous solution, as well as being impregnated into products that have a sustained-release delivery system. These newer technologies can support fiscal responsibility by reducing both the frequency of dressing changes and visits with a health-care professional.

However, it is important to consider that formulations of PVP-I, such as liposome hydrogel (3%) and cadexomer-iodine (0.9% iodine), may enhance moist wound healing and may not be appropriate for non-healing arterial ulcers.[205] When it is suspected that an arterial ulcer has become infected, the use of a topical antimicrobial dressing is not considered to be sufficient treatment.[80] Systemic antibiotic therapy is required in patients with CLTI who develop spreading or systemic infection.[53] Clinical signs of infection may be subtler because of the decrease in blood flow to the site of the arterial ulcer.[80] Clinical infection should be suspected when the ulcer becomes more painful, or the local wound site begins to deteriorate or fails to heal.[136] PAD/CLTI-related wound infection is a primary risk factor for major amputation.

For more on maintaining bacterial balance see Chapter 4: Prevention and Management of Wounds: An Overview.[23]

Antibiotic Selection

Rapid assessment and diagnosis of infection associated with PAD, including a consideration of extent and severity of tissue involvement, can facilitate timely intervention.[53] It is recommended that a patient with PAD and CLTI be referred promptly to a vascular surgeon when infection is suspected.[19,66,124] Best practice guidelines recommend that patients with CLTI, skin ulcerations and evidence of limb infection be promptly treated with systemic antibiotics.[64,66,124, 210]

A patient with an infected arterial ulcer should be evaluated as soon as possible by a clinician expert in determining the appropriate culture-guided antimicrobial treatment.[79] Wound cultures and tissue and bone biopsies can guide culture-specific treatment. Where no cultures are available, or prior to culture processing, empiric broad-spectrum antibiotics should be initiated in consultation with an infectious disease specialist whenever possible. Adjustment of antibiotics should be made once the causative micro-organisms and culture and sensitivity have been obtained.[136] Additional caution should be exercised when prescribing antibiotics to a patient with renal insufficiency to ensure effective clearance of these medications. In such cases, consultation with a nephrologist, or pharmacist for renal dose calculations, may be warranted to ensure patient safety. There is a growing practice of engaging a pharmacist for prescription of antimicrobials to treat infection.

Currently, this practice varies from region to region in Canada. The appropriateness of consulting a pharmacist depends on the scope of practice and expertise of individual pharmacists and should be carried out in collaboration with the specialist physician who attends the patient.

4.2.4 Managing moisture balance

Maintaining moisture balance in the local wound environment is recommended for arterial ulcers that are considered to have adequate perfusion to heal or after successful revascularization. Choosing an appropriate dressing can optimize the local wound environment throughout different phases of the wound healing process by helping maintain moisture balance.[4,23]

Careful monitoring is recommended when an arterial ulcer is being treated with a moisture-retentive dressing to ensure that tissues do not become boggy and vulnerable to bacterial growth.[80]

Current BPGs recommend the daily painting of non-healable arterial wounds with 10% PVP-I and covering with a gauze or breathable cover dressing to maintain a dry wound environment.[80,208,209] If sufficient perfusion can be restored through revascularization, the use of moist wound healing principles should be resumed.[80,208] If a dry eschar becomes moist or boggy clinicians should consider the possibility of wound infection.

The progression of infection may be inhibited through surgical wound debridement, and incision and drainage of an existing abscess, before revascularization is carried out.[79,138]

Maintaining a dry wound environment is recommended for non-healable and non-healing wounds, or until adequate blood flow has been re-established or the ischemic digit auto-amputates.[208]

Timely diagnosis and treatment of infection in peripheral arterial wounds is essential to reduce the risk of systemic infection and amputation.[79,138]

For further guidance on maintaining moisture balance refer to Chapter 4: Prevention and Management of Wounds An Overview.[23]

4.3 Select the appropriate dressings and/or advanced therapy

Having a good working knowledge of different classifications and of dressings can assist the clinician in making informed choices so that the wound environment can be optimized at various stages of the healing process.[4,79,136,138,208,210-214]

Currently, there is insufficient evidence to suggest that one particular dressing over another will significantly affect the healing of arterial ulcers.[162,211,215] The healability of the wound and the degree of tissue injury and the patient experience with dressings should always be taken into consideration when choosing the most appropriate dressing.[4]

Moist wound healing and occlusive dressings are not recommended for arterial wounds that do not have sufficient blood flow to heal.[105,216]

However, dressings that provide good ventilation and permit frequent wound inspection are recommended for arterial ulcers.[80]

For further guidance on the different classifications and selection of dressings refer to Chapter 4: Prevention and Management of Wounds An Overview.[23]

For more information about dressing selection, see Wounds Canada's Product Picker: Wound Dressing Formulary and Product Picker: Wound Dressing Selection Guide https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/library/183-resources-industry-partner/288-product-picker

When an ulcer is considered non-healable because of inadequate perfusion, it is strongly recommended that all sources of moisture, such as foot soaks, creams, ointments, saturated footwear/socks be avoided.[26,79,208]

Biologically Active Wound Dressings

Biologically active dressings are believed to influence the levels of proteases and growth factors in the wound environment. There is insufficient literature to support recommending biologically active dressings as a routine treatment for arterial ulcers.

More research is required in this area to determine the benefit that biologically active dressings may have on the healing of arterial ulcers.

Advanced Therapies

There is a lack of strong evidence to support the routine use of advanced therapies—such as electrical stimulation, hyperbaric oxygen therapy, intermittent pneumatic compression, negative pressure wound therapy, spinal cord stimulation, topic oxygen therapy and ultrasound therapy—for arterial ulcers (See Table 13). However, it is recommended that advanced therapies be considered to augment the wound healing progress for patients who are at a high risk for amputation.[80] In other words, advanced therapies should be considered in limited situations when the standard best practice approach to wound healing is not achieving satisfactory outcomes. Access to the advanced therapy, the availability of trained health professionals, cost and appropriateness of treatment are all considerations that should be made prior to the decision to use a particular advanced therapy. It is important to remember that although advanced therapies may support the healing of arterial ulcers, they do not correct the underlying disease. Whenever possible, adequate blood flow should be restored to sustain the healing unless contraindicated.[80] When combined with revascularization, the employment of advanced therapies may improve wound-healing outcomes.[80]

Table 13: Advanced Therapies for the Prevention and Management of Arterial Ulcers

Advanced Therapy	Current Evidence for Use
Electrical stimulation (E-STIM)	Does not replace the benefits or outcomes of revascularization[217-219] Further study specific to arterial wounds needs to be carried out to make any conclusions[220]
Hyperbaric oxygen therapy (HBOT)	Some evidence of benefit in selected patients with ischemic ulcers to augment the wound-healing process[53,79,138,217,221] Currently no evidence in literature to support or refute the use of HBOT to treat arterial ulcers[219,223] May be considered in selected patients with ischemic ulcers who have not responded to, or are not candidates for, revascularization[53] Further research is needed to clarify the benefit for patients without diabetes with arterial or other ischemic ulcers, or for wounds associated with surgical debridement, revascularization or amputation[217,219] Selection criteria should include wounds with hypoxia; tissue hypoxia can be determined with a transcutaneous oximetry measurement ($TcPO_2$) value of <40 mmHg, with reversibility and responsive to oxygen challenge[79,138,218] Some evidence to support consideration in cases of compromised grafts and flaps with concomitant hypoxia and impaired perfusion.[217]
Intermittent pneumatic compression (IPC)	The physiological effects include activating the skin's bioelectrical potential, attracting wound healing mediators, stimulating collagen and blood vessel formation, organizing collagen deposition, reducing tissue edema, improving blood flow and perfusion and generating an antibacterial effect[219,224,225] Thought to aid in the promotion of local circulation by increasing local collateral circulation, enhancing vasodilation, decreasing venous congestion and edema in the extremity[80]
Negative pressure wound therapy (NPWT)	Insufficient evidence to support the routine use for the management of arterial ulcers[226-228] Limited evidence has been obtained to recommend that NPWT may be safe to use on arterial ulcers; conclusions about other outcomes were not made[229] Frequent reassessment should be conducted to ensure ongoing appropriateness and safety of the therapy for a PAD/CLTI-related ulcer[226,227,229]

Spinal cord stimulation (SCS)	Study for the treatment of arterial ulcers is in its early stages[26] Stem cell/gene therapy is not recommended for patients with CLTI[26]
Topical oxygen therapy	Limited evidence to recommend the use of topical oxygen therapy to augment the healing of arterial ulcers. Further study is warranted to make any conclusions regarding its routine use[80]
Ultrasound therapy	No research currently available to recommend the routine use of therapeutic ultrasound to augment the healing of arterial ulcers[230] One limited RCT concluded that ultrasound therapy (MIST therapy) had a significantly higher rate of healing at 12 weeks specifically for ischemic (arterial ulcers[230]

Compression and Arterial Ulcers

There is limited evidence to recommend the cautious use of compression therapy to benefit the healing of ulcers that have been assessed to have mixed etiology (arterial and venous). In such cases, the presence of lower extremity edema is considered to be a barrier to wound healing.[79,138] When advanced CLTI is suspected, a decision to use compression is contraindicated until safe parameters can be determined for the patient, in collaboration with a vascular specialist. Accurate blood flow measures should be determined through appropriate investigations prior to applying compression. A lower level of compression may be appropriate for patients who have a documented ABPI >0.50 to <0.80, but should be avoided for those with an ABPI measure <0.50.[80]

Compression at higher levels may be appropriately used to manage lower limb edema after a successful revascularization procedure has been performed to restore adequate blood flow to the affected extremity.[62] In addition, the prescribing of a lower-level compression (18–30 mmHg) should be considered after lower extremity bypass surgery to manage edema.[80]

For further guidance on various types and indications for advance therapies refer to Chapter 4: Prevention and Management of Wounds: An Overview.[23]

4.4 Engage the team to ensure consistent implementation of the plan of care

A person who has been diagnosed with an arterial ulcer is living with a progressive chronic disease. Engaging the entire team, including the patient and their care partners, is an essential part of preventative care and chronic disease management.

Professional health-care team members who participate in plans of care for patients with CLTI should be actively engaged in educational strategies that teach and promote the prevention of ulceration, infection and amputation. Due to the complexity of PAD and its multiorgan involvement, an integrated team is needed.[231]

There is strong evidence to recommend the use of clinical pathways (structured multidisciplinary care plans) by health teams to optimize clinical outcomes, including a reduction in length of hospital stays, reduced in-hospital complications and costs.

Evans et al. developed an evidence based resource, The Foot Health Pathway for People Living with Diabetes. This pathway is based on population health principles by the Institute for Healthcare Improvement (IHI) and takes a risk-based approach focused on patient outcomes.[59] For more information see: https://www.woundscanada.ca/docman/public/1828-diabetic-foot-complications-b-ltr-1823e-final/file.

For further guidance on engaging the team for better patient outcomes refer to Chapter 4: Prevention and Management of Wounds An Overview[23] and Chapter 11: Prevention and Management of Diabetic Foot Ulcers.

Step 5: Evaluate Outcomes

Recommendations
5.1 Determine if the outcomes have met the goals of care

Regular evaluation of patient outcomes is an important aspect of care to determine whether the goals of care are being met. This should be an ongoing process carried out collaboratively with the patient and other members of the health-care team to ensure the goals of care are clearly understood and shared. When patients with arterial ulcers undergo treatment for PAD/CLTI, the goals of care may need to be modified, depending on the patient's response to treatment. The healability of the ulcer and the overall condition of the patient may change depending on the status of peripheral arterial blood flow and the effects of other comorbidities and other external modalities.

In cases of CLTI, achieving and sustaining optimal perfusion to the affected extremity through revascularization will significantly impact whether the original goals of care can be, or have been, met. When the original goals of care no longer seem achievable, setting new goals is an important step in supporting the patient's challenges in addressing the physical, psychological and emotional burden associated with the presence of CLTI. A conservative approach can be the best option at the terminal stage of CLTI. Patient-directed care that reflects a tailored approach is therefore essential.

5.2 Reassess patient, wound, environment and system if goals are partially met or unmet

When mutually agreed upon goals are not met through the process of arterial wound prevention or management, the team must return to Step 1 and reassess the factors that may be impacting the achievement of these goals. Careful attention should be made to any change in wound and vascular status, the degree and/or type of pain or progression of comorbidities and socio-economic changes in a patient's life that may increase stress and impact their ability to participate in any treatment plan.[79,138]

5.3 Ensure sustainability to support prevention and reduce risk of arterial ulcer recurrence

Ensuring access to ongoing vascular risk screening, foot care and primary health care will support the management of the associated risks for ulceration, recurrent ulceration or wound infection. Clinicians should review the patient's ability to participate in risk factor modification strategies (smoking cessation, medication therapy, appropriate nutrition, exercise programs), other medical therapies and activities that support mental health. Current best practice guidelines recommend that both smokers and ex-smokers be asked about smoking status at every visit with a health-care team member.[66] In addition, it is important to measure changes in the patient's overall condition and functional status in response to a therapeutic plan.

Sustaining adequate blood flow in the lower extremity in patients with CLTI is essential for managing the ongoing risk of arterial ulcers, infection, gangrene and amputation. Because there is a high incidence of re-stenosis when PAD is present, it is recommended that patients who have a prior history of CLTI, or have had a successful revascularization procedure, have scheduled follow-ups with a vascular specialist at least twice a year, or whenever wound progress stalls or deteriorates.[66] In addition, repeating blood flow measurements regularly is recommended after revascularization procedures to ensure ongoing patency of the vessel.[66] Yearly ABPI or TBPI testing may be valuable in providing a measure of disease progression.[49]

Patient and care partner education, in the form of both verbal and written instructions, is recommended to prepare the individual and their care partners on how to detect signs and symptoms of re-stenosis.[66]

Encouraging patients to be advocates for their own health will also enhance ongoing vigilance against recurrence of arterial ulcers. A simple measure of encouraging daily foot and leg inspections can be helpful in detecting early signs of complications associated with CLTI.

The goal of arterial wound care is not always to heal, but to protect from infection until arterial revascularization is achieved, if possible.[83]

Conclusion

The presence of arterial ulcers in the lower extremities can result in serious complications, including reduced quality of life, pain, infection, gangrene, amputation and death. Prevention of PAD that may lead to arterial ulcers and timely treatment of the underlying insufficiency in blood flow are essential. When blood flow cannot be adequately restored, aggressive preventative and management strategies must be employed.

Integrated teams managing the underlying disease process and employing preventative measures to optimize function and ensure the patient's ability to carry out activities of daily living are critical,[212] especially with older adults.[232] Reducing the incidence and recurrence of ulcers has been shown to reduce hospital admissions, the costs associated with treatment for wound infection, and community-based home visits, as well as having a significant impact on health-related quality of life.[233-236] The development of an integrated team is key in ensuring the patient's goals of care are met and through a comprehensive, evidence-based plan of care.

This chapter is intended to be a review and synthesis of the most current best practice guidelines specifically dedicated to the prevention and management of ulcers associated with PAD/CLTI. Currently, too few guidelines exist on this topic. However, the information contained in this and the introductory chapters can support health-care professionals, working in integrated teams, in the development and implementation of plans of care to prevent and manage arterial wounds and minimize unnecessary limb loss.

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Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 11

Prevention and Management of Diabetic Foot Ulcers

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INTRODUCTION

Diabetes mellitus (DM) is a complex, chronic metabolic disorder characterized by hyperglycemia that leads to microvascular, macrovascular and neuropathic complications.[1] Diabetes Canada states there were more than, "5.7 million Canadians living with diabetes (type 1 & type 2 diagnosed + type 2 undiagnosed), however there are 11.7 million Canadians living with diabetes or prediabetes a condition that, if left unmanaged, can develop into type 2 diabetes".[2] They further state that approximately $30 billion per year is spent on diabetes services. The high prevalence of diabetes and its overwhelming impact on patients, care partners, communities and the health-care system are a significant issue that require all levels of government to be engaged.[2]

In Canada, populations at higher risk for developing type 2 DM include those of African, Arab, Hispanic, Indigenous or South Asian descent.[3] Rates of DM are significantly higher in Indigenous populations, an issue compounded by unique barriers to care including, but not limited to, colonization effects, a lack of cultural competency among health-care providers, jurisdictional issues, limited access to care, geographical location, food security and language barriers.[4]

Ulcers and Lower Limb Amputations

The lifetime risk for foot ulceration in people with diabetes is higher, at 19–35%, compared with the general population, with a yearly incidence in higher income countries of 2.4%.[5] The Canadian Institute for Health Information (CIHI) states "diabetes accounts for about two-thirds of lower limb amputations in Canada"219 CIHI data from 2020 to 2023 indicates that there are approximately 7,720 hospitalizations each year related to diabetes-associated lower limb amputations, with 3,080 involving major leg amputations. These cases often result in extended hospital stays, averaging 19 days per admission, with each hospitalization costing around $47,000. Collectively, the healthcare costs associated with diabetic foot ulcers and amputations amount to $750 million annually.[219]

According to the International Diabetes Federation's *Atlas Reports,* persons with diabetes are 15 to 40 times more likely to require lower limb amputation compared with the general population.[6] Up to 25% of the nearly 5.7 million Canadians living with diabetes will develop a diabetic foot ulcer (DFU) in their lifetime. As well, approximately 85% of amputations are preceded by the development of a neuropathic foot ulcer[7] and are preventable.[219]

Lower limb amputations (LLAs) related to diabetes mellitus are increasing worldwide.[1] Diabetes Canada states 85% of diabetes-related amputations are preventable through risk screening for diabetes and peripheral arterial disease (PAD), as well as patient education focused on management of blood glucose, nutrition, physical activity, foot care, footwear and mental health.[8] Prevention initiatives must attend to patient health literacy, access to care (equity) and social determinants of health.[9] Of concern, a patient who develops a diabetic foot ulcer spends, on average, five days in the hospital if the ulcer heals as expected, yet, if the ulcer does not heal and progresses to an amputation the hospital length of stay increases to 70 days.[10] Diabetic foot ulcers incur inpatient hospital costs of $23,000 CDN (mean cost per patient) and costs more than double, up to $49,000 if amputation is required.[11] This is costly to the patient, care partners, families, employers, communities and the health-care system.[12]

Following a lower limb amputation, people with diabetes suffer psychological, spiritual, emotional and physical consequences of limb loss.[13] Armstrong et al. state the five-year mortality rates are as follow: Charcot (29%), diabetic foot ulcer (30.5%), minor (46.2%) and major amputations (56.6%) respectively. This is a higher mortality rate than is seen in breast cancer (9%).[5] As well, the foot ulcer recurrence rate is 60% at 12 months and 65% at 5 years; these are alarming statistics.[14]

Therefore, proactive and preventative risk screening and foot health initiatives (skin/nail care, footwear, pre-ulcer assessment) should be major considerations for people with diabetes, families and care partners, communities and health-care professionals who partner with patients and/or provide care. Foot complications in high-risk populations can lead to a cascade of negative diabetes-related foot complications, potentially resulting in decline in function, infection and loss of limb and life.[14] Armstrong et al. report the mortality rates for individuals with a foot ulcer is 231/1000 compared to 182/1000 deaths for persons with diabetes without foot ulcers.[14] McDermott et al. state, "Morbidity following incident ulceration is high, with recurrence rates of 65% at 3–5 years, lifetime lower-extremity amputation incidence of 20%, and 5-year mortality of 50–70%".[12]



Identifying and addressing the high-risk foot is cost saving to the health-care system and highly feasible, even in low-and middle-income countries.[15,16] Once an ulcer develops, timely access to care is required to prevent infection, amputation, changes to the patient's quality of life and strain on the health-care system.[17]

The International Working Group on the Diabetic Foot (IWGDF) identifies key elements to successful system-wide diabetes-related foot care. These are essential to the establishment of prevention, early detection, then treatment and long-term management. Plans of care and early detection should include: education, risk-detection systems, access to risk-reduction measures, prompt and effective ulcer and infection treatment, vascular and surgical expertise, offloading modalities, wound care access, and auditing of services.[1]

Canadian Perspective

Canada fares worse compared with the United Kingdom, where annual diabetic foot screening prevalence is 70–80%. In Canada, Patel et al. (2022) reported the current national frequency of annual diabetic foot screening is uncertain and may well be below 50%.[18]

Therefore, multidisciplinary teams must come together to continue to lower amputation rates.[14] In Canada, Hwang (2023) explored the referral times for patients (n=20) with high-risk wounds. Through early identification and treatment of patients identified at high-risk, the team was able to reduce (56.3%) average referral times, improve healing times, reduce the numbers of home care visits and suggest the potential for significant cost avoidance.[19]

The negative cascade of diabetic foot complications persists despite the many treatment modalities available for foot care of individuals with diabetes and its related conditions. In addition, public and professional awareness of optimal care is poor.[20] In response, Wounds Canada collaboratively developed and released the *Foot Health Pathway for People Living with Diabetes: Integrating a Population Health Approach*.[129] This pathway highlights the importance of, "upstream preventative care, timely detection and immediate intervention for pathology as well as the implementation of activities to prevent wound deterioration and recurrences".[17]

This chapter is written with the intent to encompass the quintuple aim for health-care improvement: to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity (See Table 1). The equity component is particularly important for patients living with skin issues, wounds and, specifically, diabetes-related foot ulcers. Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[20]



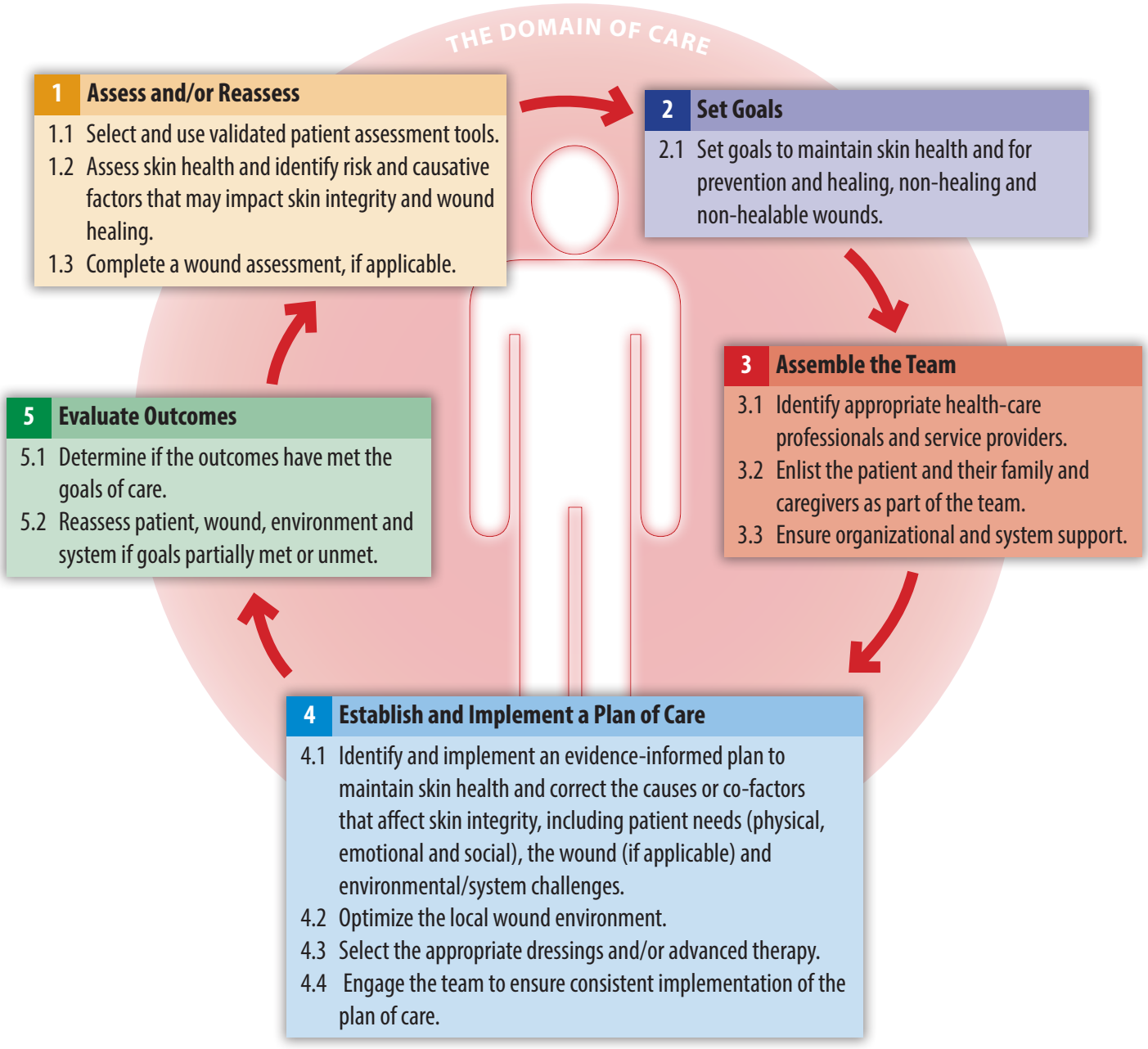
Table 1: Quintuple aim and management of Diabetic Related Foot Ulcers

5 Components	Applied to Diabetic Foot Ulcers
Improving population health	Through risk screening, prevention, education and self-management strategies Adopt Foot Health Pathway, focused on prevention and timely intervention[17] Establish care pathways for individuals with diabetic foot problems who need inpatient care[22]
Reducing costs	Application of best practice to ensure prevention and most effective treatment Appropriate use of resources such as foot care, footwear, nutrition, self-management, offloading, dressings
Advancing health equity	Provide, "care within 24 hours of a person with diabetic foot problems being admitted to hospital, or the detection of diabetic foot problems (if the person is already in hospital)"[22] Application of principles of equity to all those at risk for, or affected by, diabetes mellitus disease
Care team well-being	Provide clinically usable information for frontline clinicians Prevent morale injury by supporting frontline clinicians with best-practice-based policies
Enhancing the patient experience	Provide a supportive process of care for all those with diabetes-related foot ulcers

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide that incorporates the best available evidence. It outlines a process, or series of consecutive steps, that supports patient-centred care. This process, called the *Wound Prevention and Management Cycle* (See Figure 1) guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of complications and wounds from the initial assessment to a sustainable plan targeting self-management for the patient.

Figure 1: The Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence and are intended to support the clinician, patient, care partners, their family and health-care team in planning and delivering the best clinical practice. Two foundational chapters supplement this chapter with additional evidence, informed information and recommendations that are general to all wound types: Chapter 3: Skin: Anatomy, Physiology and Wound Healing[23] and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

There are three guiding principles within the best practice recommendations (BPRs) that support effective prevention and management of skin breakdown:

1. The use of the *Wound Prevention and Management Cycle*, regardless of the specifics, to prevent and manage skin breakdown
2. The constant, accurate and multidirectional flow of meaningful information within the team and across all care settings, and
3. The patient as the core of all decision making.

Step 1: Assess and/or Reassess

Discussion: A comprehensive patient assessment is essential to identify factors that may impact skin integrity and wound healing and should include: history and current health status (physical, emotional), head-to-toe skin assessment and wound assessment (if applicable). This also includes investigation of environmental factors such as socio-economic, cultural, health literacy, care setting, access to services (travel costs, web-based, and hybrid), and system factors such as diabetes-related policies, resources and programs.[25]

During the assessment phase, the clinician should obtain a medication list and identify medications that may interfere with skin health or wound healing (e.g., anticoagulants, nicotine, corticosteroids, immunosuppressants, non-steroidal anti-inflammatories, immunomodulators [e.g., infliximab, etanercept], tumor necrosis factors - TNF], colchicine, and chemotherapeutic agents).[26,27] In addition, clinicians should assess patients' risk of DM-related distress, depression, anxiety, and care adherence, as this may provide a more realistic care plan.[28,29]



Recommendations

1.1 Select and use validated screening and risk assessment tools

The use of validated and standardized patient and risk assessment tools is essential for identifying factors that may cause skin breakdown, impede healing and affect quality of life of individuals at risk for, or with, diabetic foot complications. They also provide direction for establishing a plan of care and carrying out preventative skin and foot care or foot complication management.

Discussion:

Foot-Risk Screening Tools

Clinicians should use validated foot screening tools in practice. Foot screening can be completed by trained primary care providers such as a nurse practitioner, family physician, podiatrist/chiropodist, foot care nurse, diabetes nurse, registered dietitian, physiotherapist or occupational therapist. Foot screening tools provide a uniform approach that helps ensure that a comprehensive foot exam is completed and that the results are clearly communicated to the patient and the integrated team.[1] There are several validated tools for clinicians to consider for use in their practice.[30,31] A risk screening tool is most effective when clinicians receive regular education and training and when organization and system supports (policies and procedures) are in place to communicate findings and to initiate timely interdisciplinary team referrals.[17] In this chapter we discuss Inlow's 60-second Diabetic Foot Screen: Update 2022.[32]

Patient Quality-of-life Screening Tools/Scales

Persons with diabetes are at risk of experiencing diabetes distress and depressive disorders.[33] The prevalence of depressive disorders in persons with diabetes is approximately 10% to 15%, twice as high as the prevalence of depression in persons without diabetes.[34] As well, individuals with diabetes may experience social changes in areas such as employment, driving, schooling, family role and responsibilities, and coping abilities.

Patient Quality-of-Life Screening Tools (See Appendix A)

- The Problem Areas in Diabetes Scale (PAID)[35]
- The Diabetes Distress Screening Scale[36,37]
- The World Health Organization – WHO-5 Well-being Index[38]
- The Hospital Anxiety and Depression Scale (HADS)[39]
- The Patient Health Questionnaire (PHQ-9)[40]
- The Center for Epidemiological Studies-Depression Scale (CES-D)[41]
- The Beck Depression Inventory[42]

Care partners' quality of life and stress

The care partners of the person with diabetes and/or with a foot ulcer is key to supporting the patient's care, short and long term.[13] Care partners may also experience feelings of stress and distress surrounding their diabetes-related caregiving activities.

Care Partner Stress Screening Tools (See Appendix B)

- Kingston Caregiver Stress Scale (KCSS)[43] Available at https://providencecare.ca/wp-content/uploads/2016/10/KCSS-Assessment-Form.pdf
- The University of Washington Center on Outcomes Research in Rehabilitation has developed several self-reported measures for consideration.[44]
  Available from: https://uwcorr.washington.edu/measures/
  · University of Washington Caregiver Stress Scale
  · University of Washington Caregiver Benefit Scale
  · University of Washington Self Efficacy Scale (UW-SES)
- The Behavioral Diabetes Institute offers tools for caregivers of teens, adults and partners of adults with diabetes.[45]
  Available from: https://behavioraldiabetes.org/scales-and-measures/

Quality of Life for Persons Undergoing Amputation

- The Trinity Amputation and Prosthesis Experience Scale (TAPES-R) – Revised[46]
- Amputee Mobility Predictor Assessment Tool – AMPnoPRO[47]
- Functional Assessment Questionnaire for Amputees (FMA)[48]

Quality-of-Life Tools and Scales for Persons Experiencing an Amputation and/or Prosthesis (See Appendix C)

1.2 Identify risk and causative factors that may impact skin health, skin integrity and wound healing

Discussion: Individuals with diabetes may have modifiable and/or non-modifiable risk factors[1,49] that can impact skin integrity and wound healing.[1] Prevention of foot complications is the cornerstone to improving patient outcomes, especially as diabetes rates continue to rise in Canada.[2]

The IWGDF (2023) guidelines outline five essential elements to identify risk and prevent diabetes-related foot ulcers, especially for patients without a current foot ulcer.

- First, it is essential to identify individuals with an 'at-risk foot' *before* complications arise. This involves assessing risk factors such as neuropathy, peripheral arterial disease and foot deformities. This includes the patient's ability to engage in self care activities.
- Second, regular examination of the feet in at-risk individuals is key for early detection of potential issues that could lead to ulceration.
- Third, structured, repeated education is emphasized, targeting patients, their care partners, family members and health-care professionals. Education focuses on raising awareness about diabetic foot risks, self-management, mental health, preventative care and the importance of early intervention.

- Fourth is the critical element of providing recommendations to patients about accessing and wearing appropriate footwear (seasonal). They should also be dissuaded from soaking their feet, as it causes maceration. Footwear protects feet (skin/nails), reduces pressure points and prevents injuries that could lead to pre-ulceration/ulceration.
- Finally, addressing risk factors for ulceration, such as blood glucose levels, skin and nail care, biomechanical abnormalities and footwear issues, forms a critical part of the prevention strategy. These combined efforts aim to significantly reduce the risk of foot ulceration in individuals with diabetes, thereby improving their overall health outcomes.[1]

See below the list of modifiable and non-modifiable risk factors the clinician might identify during the patient assessment.

Modifiable Risk Factors

- Glycemic level: hyperglycemia results in delayed wound healing and compromised chemotaxis and phagocytosis[50,51]
- Activity: patients may participate in activities that are not appropriate for their risk levels (e.g., running) because they can lead to injury and interfere with wound healing[52,53] Patients with an active ulcer should exercise under direction of health-care professionals
- Smoking/vaping compromises blood flow, increasing the risk of wounds and delaying healing
- Trauma: patients with diabetic neuropathy and loss of protective sensation (LOPS) are prone to injury/re-injury
- Footwear: ill-fitting and inappropriate footwear pressure increases the risk of skin breakdown and may interfere with healing
- Neuropathy: manifested in the sensory, autonomic and motor (SAM) components of the nervous system. Once neuropathy is established, it is not reversible and exacerbates the development of ulcerations, pain and poorer quality of life
- Bony deformity can result in areas of high pressure and skin breakdown
- Peripheral arterial disease increases the risk for the development of ulcers and impacts wound healing
- History of ulcers: healed wounds are more vulnerable to re-injury due to less resiliency and elasticity
- Amputation: abnormal biomechanics post partial foot amputation may lead to poor wound closure and/or new pressure injuries. Ill-fitting prosthetics may cause wounds on residual limbs from pressure or friction
- Vision changes such as retinopathy, cataracts, glaucoma and macular edema that change vision and may lead to blindness[54]
- Sleep patterns are affected by diabetes and thereby affect blood glucose control and quality of life[55]
- Increased body mass index (BMI) overweight or obesity (weight in the mid-girth area) may occur in relation to insulin and antihyperglycemic medication, increasing risk of complications. Managing weight is important.[56]

Non-Modifiable Risk Factors

- Gender
- Age
- Family history of diabetes, foot complications and amputation
- Ethnicity

Patient Quality of Life Screening

It is important to screen early in the assessment for a persons' risk of diabetes distress, depression and anxiety using reliable and validated tools that are diabetes-specific and measure quality of life.[28] Tegegne et al. report the prevalence of depression to be substantial, especially if the patient is older, not participating in formal education, living longer with diabetes and experiencing lower participation in diabetes self-management.[59] See Appendix A: Patient Quality-of-Life Screening Tools.

The importance of screening for risk of underlying mental health issues, in turn, supports patients and care partners to fully engage in preventive self-care and education.[28,60,61] Patients live with significant diabetes-related responsibilities. These multi-facted activities include daily monitoring requirements related to blood glucose and blood pressure management, medications, nutrition, activity, emotional balance, footwear/foot health and co-ordinating appointments and diagnostic tests. It is, therefore, important that mental health screening be completed regularly, and referrals and appropriate services be offered throughout a patient's care continuum.

Care Partner Quality-of-life

Clinicians are responsible for referring the care partner for support or to screen using credible tools.[43] Care partners of patients living with diabetes are at risk of burnout. See Appendix B: Care Partner Stress Screening Tools.

Quality of Life for Persons Undergoing Amputation and/or Prosthesis

For patients who undergo foot surgery and/or amputation (minor or major), their mental health and well-being should continue to be assessed at regular intervals.[62,63] After surgery many patients undergo further changes to their employment, mobility, self-esteem, body image and ability to cope.[64] See Appendix C: Quality-of-Life Tools and Scales for Persons Experiencing an Amputation and/or Prosthesis.

Foot Screening

The IWGDF recommends annual screenings for individuals with diabetes who are considered to be at very low risk of foot ulceration (IWGDF risk 0) with the goal of detecting potential risk factors for ulceration. Despite the absence of symptoms, people with diabetes can still suffer from foot diseases, such as asymptomatic neuropathy, PAD, pre-ulcerative signs or ulcers. Yearly foot exams confirms the level of risk.[1]

Assess for loss of protective sensation (LOPS) using techniques such as the Semmes-Weinstein 10 gram monofilament, a 128 Hz tuning fork, or tactile sensation tests when the above-mentioned tools are unavailable. Screening includes evaluating the vascular status by checking for symptoms of intermittent claudication (IC) and palpating pedal pulses. Identifying LOPS or PAD during these screenings indicates an increased risk of ulceration, necessitating further examination and interdisciplinary referrals.[1]

A consistent, uniform approach to diabetic foot risk screening ensures that all elements of the examination are completed. Risk factor recognition is vital in helping clinicians predict and prevent the occurrence of diabetic foot ulcers.[65] The most effective method for amputation prevention may simply be to have all health-care professionals teach patients to remove the shoes and socks and examine their feet and footwear.[66]

Risk Stratification

Inlow's 60-second Diabetic Foot Screen Risk Screening (2022) and Plan of Care tool aligns with the IWGDF risk stratification recommendations. This includes recommendations, actions and associated education with patients and care partners in efforts to support prevention and engagement in planning proactive, preventative care. To conduct the foot screen, work with the patient to complete the three steps. Remember this is an opportunity to build a trust-filled therapeutic relationship with the patient and care partner(s).

Inlow's 60-second Diabetic Foot Screen: Update 2022

- In **Step 1,** ask the patient (care partner(s)/family) about self-reported risk factors/comorbidities such as: retinopathy (vision), nephropathy (renal), poor glycemic control, cardiovascular disease, PAD and history of smoking.
- In **Step 2,** determine the risk for ulcerations and amputations using categories: Very low risk – category 0; Low risk – category 1; Moderate risk – category 2; High risk – category 3; Urgent risk.
- In **Step 3,** co-create a plan of care with the patient and/or care partner. The findings of the foot screen direct the care plan, frequency of future foot screening, prevention, patient-centred education and actions and referrals to be made to the interdisciplinary team members (See Figure 2: Inlow's 60-second Diabetic Foot Screen).

Figure 2: Inlow's 60-second Diabetic Foot Screen

Inlow's 60-second Diabetic Foot Screen

2022 RISK SCREENING AND PLAN OF CARE

WoundsCANADA.ca

Patient Name: **Clinician Signature:**

ID number: **Date:**

▶ Step 1: Complete Screen of the Right and Left Feet

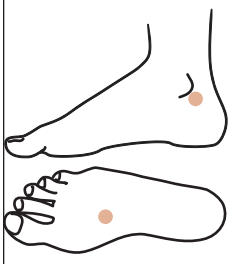
Instructions: Screen both feet using the parameters identified within Inlow's 60-second Diabetic Foot Screen[1] to identify clinical indicators and/or care concerns. Once each parameter has been assessed move on to Steps 2 and 3.

Self-Reported Risk Factors/Comorbidities

☐ Retinopathy ☐ Nephropathy ☐ Poor glycemic control ☐ Cardiovascular disease ☐ Peripheral Arterial Disease ☐ Smoking

RIGHT FOOT	1. Screen for Foot Skin and Nail Changes	LEFT FOOT	Risk Status and Care Planning
	**Skin:** ☐ Intact and healthy ☐ Dry with fungus or light callus ☐ Heavy callus build up ☐ Prior ulceration ☐ Existing ulceration (± warmth and erythema) ☐ Macerated web space **Nails:** ☐ Well-groomed and appropriate length ☐ Unkempt and ragged ☐ Thick, damaged, or infected		

RIGHT FOOT	2. Screen for Loss of Protective Sensation	LEFT FOOT	Risk Status and Care Planning
	**Foot Sensation – do they ever:** ☐ • feel numb? ☐ • tingle? ☐ • burn? ☐ • feel like insects are crawling on them? **Foot Sensation – monofilament testing:** ☐ No: Loss of protective sensation was not detected (sensation was present at all sites) ☐ Yes: Loss of protective sensation detected (sensation was missing at one or more sites)		

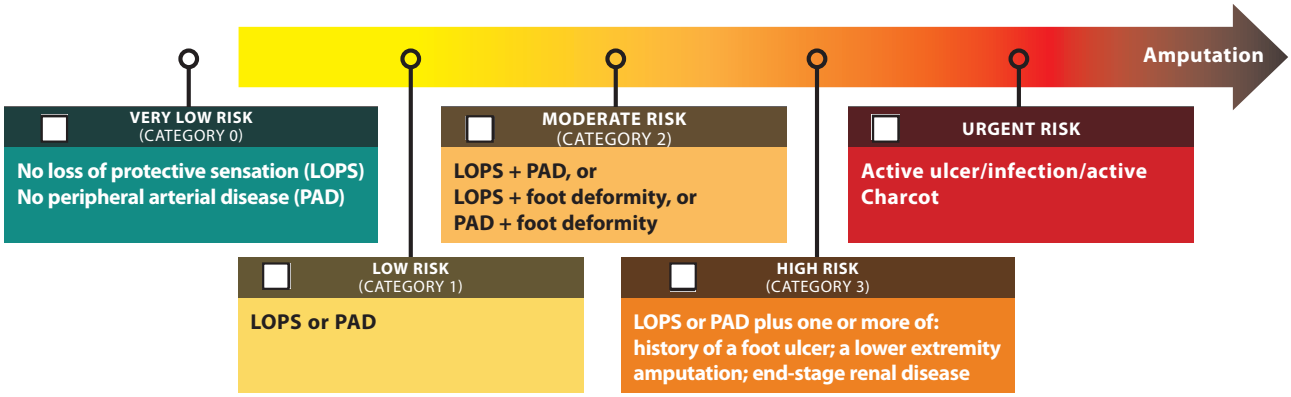
RIGHT FOOT	3. Screen for Peripheral Arterial Disease	LEFT FOOT	Risk Status and Care Planning
	**Pain:** ☐ Pain in the feet or legs when walking, limiting mobility **Dependent rubor:** ☐ No ☐ Yes **Cool foot:** ☐ No ☐ Yes **Pedal Pulses:** ☐ Present ☐ Absent		

RIGHT FOOT	4. Screen for Bony Deformity (and Footwear)	LEFT FOOT	Risk Status and Care Planning
	**Deformity:** ☐ No deformity ☐ Deformity (i.e. dropped metatarsal heads or bunion, chronic Charcot changes, hammertoes) ☐ Prior lower extremity amputation ☐ Acute Charcot (+ warmth and erythema) **Range of Motion:** ☐ Full range in hallux ☐ Limited range of motion in hallux ☐ Rigid hallux **Footwear:** ☐ Appropriate ☐ Inappropriate ☐ Causing trauma		

* Refer to Steps 2 and 3 before completing this area.

▶ Step 2: Determine the Risk for Ulceration and Amputation

Instructions: Review the results from Inlow's 60-second Diabetic Foot Screen to identify parameters that put the patient at risk. *Very low risk involves no loss of protective sensation, peripheral arterial disease or related comobidities/risk factors. If comorbidities exist, consider increasing to Category 1.



▶ Step 3: Create a Plan of Care with Your Patient Based on Identified Risks

Instructions: Based on the risk classification and clinical indicators develop a plan of care with your patient that best meets their needs.

Risk Category	Clinical Indicators	Screening Frequency	Recommendations and Actions**
Very Low Risk (Category 0)	No loss of protective sensation (LOPS) and no peripheral arterial disease (PAD)	Screen every 12 months	☐ Education on: risk factors; daily foot inspection; appropriate footwear and foot- and nail-care;† when/how to seek medical attention if needed ☐ Daily inspection of feet ☐ Appropriate foot and nail care ☐ Well-fitting footwear ☐ Exercise as able
Low Risk (Category 1)	LOPS or PAD	Screen every 6–12 months	☐ Education on: risk factors (including LOPS or PAD); daily foot inspection; appropriate footwear and foot- and nail-care; when/how to seek medical attention if needed ☐ Daily inspection of feet ☐ Professional foot and nail care, including treatment of onychomycosis and Tinea pedis if present ☐ Well-fitting, sensible footwear with custom, full-contact foot orthoses and diabetic socks ☐ Vascular studies ± referral to a vascular investigation +/- vascular surgeon ☐ Pain management for ischemic pain, if present ☐ Recommend non-weight bearing exercise program https://www.diabetes.ca/nutrition---fitness/exercise---activity
Moderate Risk (Category 2)	LOPS + PAD, or LOPS + foot deformity, or PAD + foot deformity	Screen every 3–6 months	☐ Education on: risk factors (including LOPS ± PAD ± foot deformity); daily foot inspection; appropriate footwear and foot- and nail-care; when/how to seek medical attention if needed ☐ Daily inspection of feet ☐ Professional foot and nail care, treatment of onychomycosis and Tinea pedis if present ☐ Well-fitting, orthopaedic footwear with custom full-contact total contact casted foot orthoses and diabetic socks. Footwear must accommodate any deformities present ☐ Vascular studies ± referral to a vascular surgeon ☐ Pain management for ischemic or neuropathic pain ☐ Referral to a general, orthopedic or foot surgeon, if indicated, surgically manage foot deformities ☐ Recommend non-weight bearing exercise program https://www.diabetes.ca/nutrition---fitness/exercise---activity
High Risk (Category 3)	LOPS or PAD plus one or more of: • history of a foot ulcer • a lower extremity amputation • end-stage renal disease	Screen every 1–3 months	☐ Education on: risk factors (including LOPS ± PAD ± foot deformity); risk of ulcer recurrence; daily foot inspection; appropriate footwear and foot- and nail-care; when/how to seek medical attention if needed ☐ Daily inspection of feet ☐ Professional foot and nail care, including treatment of onymycosis and Tinea pedis, if present ☐ Well-fitting, orthopedic footwear with custom full-contact total contact casted foot orthoses and diabetic socks. Footwear must accommodate any deformities present ☐ Modified footwear and/or prosthesis based on level of amputation ☐ Vascular studies ± referral to a vascular surgeon ☐ Pain management for ischemic or neuropathic pain ☐ Recommend non-weight bearing exercise program https://www.diabetes.ca/nutrition---fitness/exercise---activity
Urgent Risk	Active ulcer/infection/ active Charcot	Urgent care required	☐ Education on: signs of wound infection and wound care; risk factors (LOPS ± PAD ± foot deformity); risk of ulcer recurrence; daily foot inspection; appropriate footwear and foot- and nail-care; when/how to seek medical attention ☐ Daily inspection of feet ☐ Professional foot and nail care, including treatment of onymycosis and Tinea pedis, if present ☐ Offloading with total contact cast, removable cast walker or wound shoe to close ulcers and/or to immobilize Charcot foot ☐ Vascular studies ± referral to vascular surgeon or limb preservation clinic, as indicated ☐ Pain management for ischemic pain or neuropathic pain ☐ Referral to a general, orthopedic or foot surgeon, if indicated, to surgically manage foot deformities ☐ Referral to infectious diseases to manage infection, if indicated, and/or to a general, orthopedic or foot surgeon to debride infectious tissue ± bone, if indicated

** These recommendations and actions are not all-inclusive. Actions need to be customized to meet each patient's needs. Encourage patients (and caregivers) to manage their glycemic levels, triglycerides, weight, hypertension, and lifestyle choices such as smoking. Ensure the patient knows where to access professional assistance in the event of an urgent foot complication.

† Tools and educational materials are available online from Wounds Canada:
For patients (and caregivers): https://dhfy.ca/for-patients-public
For clinicians: https://dhfy.ca/for-clinicians

References:
1. Adapted from Inlow S. The 60-second foot exam for people with diabetes. Wound Care Canada. 2004;2(2):10–11.
2. Bus S, Lavery L, Monteiro-Soares M, Rasmussen A, Raspovic A, Sacco I et al. Guidelines on the prevention of foot ulcers in persons with diabetes (IWGDF 2019 update). Diabetes Metabo Res Rev. 2020;36(S1).
3. Botros M, Kuhnke J, Embil J, Goettl K, Morin C, Parsons L, et al. Best practice recommendations for the prevention and management of diabetic foot ulcers. In: Foundations of Best Practice for Skin and Wound Management. A supplement of Wound Care Canada; 2017. 68 pp. Retrieved from: www.woundscanada.ca/docman/ public/health-care-professional/bpr-workshop/895-wc-bpr-prevention-and- management-of-diabetic-foot-ulcers-1573r1e-final/file.

Assessing the Pathophysiology of the Diabetic Foot

Understanding the pathophysiology of diabetes is very important as it represents an awareness of the physiology of altered health. Pathophysiology deals with the structural and functional changes in the patient's cells, tissues and organs caused by diabetes.[67] The pathophysiology of diabetic foot complications is directly linked to amputation risk. Key factors contribute to this risk:

- Peripheral neuropathy (sensory, autonomic, motor) reduces protective foot sensation
- Peripheral arterial disease (PAD) and vascular problems hinder wound healing
- Foot and bony changes affect footwear fit and, along with neuropathy, lead to trauma. Unnoticed, untreated wounds may become infected, further weakened by impaired blood flow, ultimately causing tissue damage, infection, gangrene and, in severe cases, a necessity to amputate to prevent infection spread, other complications and death.[17] See **BOX** on Pathophysiology under Recommendation 1.2.

As mentioned in the introduction, understanding pathophysiology of the diabetic foot is critical for understanding patient risk, prevention of complications, treatment and management of lower limb/foot complications. Persons with diabetes (up to 25%) are at greater risk of developing foot ulcerations (wounds) in their lifetime. Ulcers lead to infection in the tissues, bone, tendon, and may lead to amputation (minor, major) and death. Therefore, understanding the pathophysiology of the disease is crucial to assessment approaches, diagnosis and treatment options. The components to consider in the development of a diabetic foot ulcer are as follows.

1. Peripheral neuropathy, to which persons with diabetes are prone, affects sensory, motor and autonomic nerves. Diabetic peripheral neuropathy may be asymptomatic in up to 50% of patients.[68] Diabetic sensory neuropathy classically presents as a distal symmetric sensorimotor neuropathy and is the leading cause of foot ulcers.[69] Other causes of neuropathy should be considered in patients with diabetes, as they may be treatable. Other causes of neuropathy to consider would be toxins (e.g., alcohol use, chemotherapy agents), vitamin B12 deficiency, hypothyroidism, renal disease, malignancy (e.g., multiple myeloma, bronchogenic carcinoma), infections (e.g., HIV), vasculitis and chronic demyelinating neuropathy.[70]

Sensory neuropathy relates to loss of protective sensation due to small and large fibre nerve changes. Large fibre function can be evaluated using the monofilament test (MFT), vibration perception or lower extremity reflexes. Evaluation of small fibres can be tested using pin prick or temperature. Early symptoms of neuropathy are described as burning or tingling as a result of small fibre changes. Loss of large fibres results in loss of protective sensation, and patients will often report numbness.[70]

Autonomic neuropathy in the foot leads to skin atrophy, dry or overly moist skin and brittle toenails. Skin changes due to autonomic neuropathy need to be distinguished from fungal infections.[70]

Motor neuropathy is characterized by intrinsic muscle atrophy and results in contracted digits and a displaced fat pad from the metatarsal heads to just below the toes. Consequently, metatarsal heads become prominent and close to the skin surface, leading to increased pressure and a potential ulceration site. Abnormal pressure over bony deformities can lead to callus formation and ulceration, particularly in the absence of protective sensation. A body of evidence has shown that elevated plantar pressure is a major risk factor for ulcer development. There is a direct relationship between elevated pressures and deformity.[70]

2. Peripheral artery disease (PAD) is present in about 50% of patients with diabetes and typically affects the distal lower limb. PAD is four times more common in people with diabetes than in those without diabetes.[71] Pain may be present in a small percentage of those with no neuropathy but significantly reduced blood flow to the extremity. The symptom of pain in patients with diabetes may be unreliable due to the presence of neuropathy. Pain with arterial claudication is described in a specific area of the lower limb that is brought on by exercise and relieved by rest. This nociceptive pain signal is often described as gnawing, aching, tender or throbbing (GATT). The location of the discomfort can be anywhere from the buttock to the calf, depending on where the blockage of blood flow occurs. More concerning is critical limb threatening ischemia (CLTI), defined as ischemic rest pain, tissue loss or gangrene that is present for a minimum of two weeks.[72] This should prompt an urgent vascular consultation. Risk factors for PAD are similar to other atherosclerotic vascular diseases; however previous cardiovascular history, diabetes, smoking and age are the strongest factors.[73] The impact of smoking on PAD is stronger than for coronary artery disease.[74] See PAD campaign Wounds Canada.

Figure 3: Peripheral Artery Disease – Wounds Canada



Source: https://www.woundscanada.ca/patient-or-caregiver/preventing-and-managing-wounds/293-patient-caregiver/wound-index/573-peripheral-arterial-disease

3. Foot deformity Foot deformity is a pivotal risk factor in the onset of diabetic foot ulcers (DFUs) and has been highlighted by the American Diabetes Association's Foot Care Interest Group as part of a critical triad alongside neuropathy and trauma.[75] This triad synergistically leads to ulceration, with deformities such as interphalangeal and metatarsophalangeal joint (MTPJ) deformities, pes cavus and pes equinus being particularly significant. MTPJ deformities, including hammer-and-claw toes and hallux valgus, are the most common in persons with diabetes.

The development of these foot deformities is linked to motor neuropathy, which causes muscle atrophy, reduced joint mobility and uneven pressure distribution on the foot. This leads to a degradation of musculoskeletal integrity, notably atrophy of foot muscles and fatty infiltration, undermining joint stability and foot functionality. As a result, there's an alteration in foot structure and mechanics, such as MTPJ hyperextension and hyper curvature of interphalangeal joints, which increase pressure on the metatarsal head and promote tissue damage through repetitive stress and ischemia-reperfusion injury.[76] See Figure 4 for how to examine for foot deformities in a person with diabetes.

Figure 4: How to Examine Foot Deformities in a Person with Diabetes

In a person with diabetes with LOPS or PAD (IWGDF risk 1–2), perform a comprehensive foot deformity examination:

A	B	C	D	E
Hallux abductus valgus	**Hammer toe**	**Claw toe**	**Metatarsal head prominence**	**Charcot-foot deformity**
				
Definition: lateral deviation from normal shape of the 1st MPJ	**Definition:** flexion contracture of the proximal IPJ and neutral flexion contracture of the distal IPJ (e.g., 2nd and 3rd toes)	**Definition:** plantar flexion of the proximal and distal IPJs and dorsiflexion of the MPJ (e.g., 2nd and 3rd toes)	**Definition:** bony prominence located beneath a metatarsal head (e.g., 3rd head)	**Definition:** mid-foot Charcot rocker-bottom deformity

IWGDF Definitions:
- **LOPS:** loss of protective sensation
- **PAD:** peripheral artery disease
- **MPJ:** metatarsophalangeal joint
- **IPJ:** interphalangeal joint

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In addition, hyperkeratosis (thickening and darkening of the skin) and pathological tendon changes exacerbate plantar pressure, restrict joint movement, and diminish ankle dorsiflexion, further heightening the risk of DFU development. Trauma can take many forms, but often is a result of repetitive impact causing callus formation, pressure from ill-fitting shoes, acute changes from sharp objects, blunt trauma or thermal injury.

Integrated teams should adopt *The Foot Health Pathway for People with Diabetes*.[17] Also, they should utilize a comprehensive approach to classify diabetic foot conditions, aimed at consistent, clear communication of findings among the team. The IWGDF recommends using the six items SINBAD (Site, Ischemia, Neuropathy, Bacterial infection, Area, and Depth) to classify the foot ulcer. This system requires detailed description of each variable rather than relying on a total score. An alternative is the WIfI (Wound, Ischemia, and foot Infection) system, recommended when the necessary equipment and expertise are available and feasible. These are discussed further in this document (IWGDF, 2023). Finally, the International Wound Infection Institute[77] discusses nine additional wound infection assessment tools in Wound Infection in Clinical Practice.

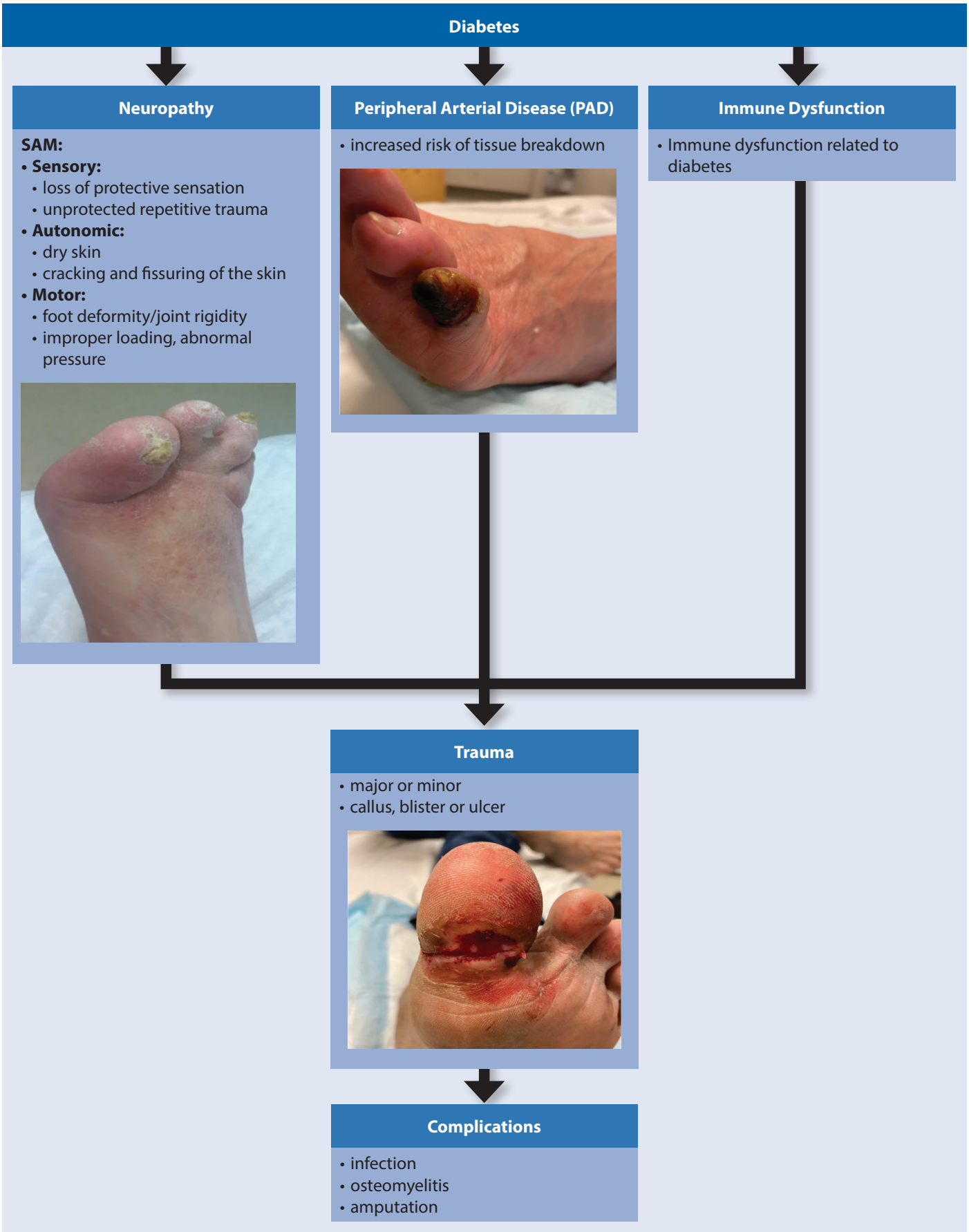
Pulling It Together: Identifying risk factors alongside the comprehensive patient assessment must be examined together to understand the health of the person's lower limbs/feet. Understanding the pathophysiology (peripheral neuropathy, arterial disease and foot deformity) blood glucose levels, hemoglobin A1c, history, lifestyle and footwear help create a focused assessment.

Diabetic foot infections remain the most frequent complication of diabetes requiring hospitalization and are the most common precipitating events for lower leg amputation(s).[1] Any form of trauma to the insensate foot (e.g., a sharp blow, thermal injury, pressure or friction) can result in disruption of the skin barrier and penetration of bacteria. The underlying immune disturbance and perfusion issues that are common in persons with diabetes allow for the inflammatory reaction to progress to infection. See Table 2 for an overview of factors that lead to neuropathy, the at-risk foot, foot ulcers, infections and amputations.

Table 2: Risk Factors for Neuropathy, at Risk Foot; Foot Ulcers, Infection and Amputation (Adapted from:[1,28,70,78,79])

Neuropathy	At-risk foot	Foot Ulcers	Infections	Amputation
Elevated blood glucose (and duration of diabetes)	Poor glycemic management	Peripheral neuropathy	Vascular complications	DFU patients, including the male sex
Elevated triglyceride (should be dyslipidemia)	Peripheral neuropathy/LOPS	Previous ulceration or amputation	Retinopathy	Smoking history
Body mass index (BMI) overweight, obese	PAD	Structural deformity	Number of ulcers, osteomyelitis	History of foot ulcers
Smoking	Foot deformities (bunions, hammertoes, Charcot joint, etc.)	Limited joint mobility	Diabetic nephropathy	Osteomyelitis, gangrene
Hypertension	Pre-ulcerative corns or calluses	PAD	Elevated HbA1c levels	Lower body mass index
	Prior ulceration	Onychomycosis	Higher Wagner grades	Higher white blood cell count (WBC)
	Prior amputation	High glycated hemoglobin (HbA1c) levels		
	Smoking			
	Retinopathy			
	Nephropathy (particularly in individuals on dialysis or posttransplant)			

Figure 5: Pathophysiology



Permission granted by Dr. Robyn Evans.

1.2.1 Patient: Physical, emotional and lifestyle

Discussion

Physical Assessment

A complete patient medical history is essential as it identifies undisclosed medical conditions or potential risks for wound development, delayed wound healing and risk for peripheral artery disease. A complete history should elicit any active and past medical conditions. The complications of diabetes include retinopathy, neuropathy, vasculopathy and mental health concerns. It is important to obtain a smoking history (all substances), as this represents a major risk for development of peripheral arterial disease (PAD). A patient's history may also identify barriers to self-management, care partner support and clinician-delivered care. This may include visual or auditory impairments and culture/language challenges that may prevent a patient or care partner from conducting preventative and effective foot assessments or receiving foot health instructions. By recognizing barriers early, patients and their team can co-create informed and effective plans of care.

HbA1C: This blood test reflects glycemic levels over the past three months and is critical in managing diabetes, preventing complications, and in wound healing. It is a convenient test as it can be measured any time of the day and helps predict microvascular complications.[28] Elevated HbA1c levels are linked to an increased risk of microvascular and macrovascular complications, such as cardiovascular disease, retinopathy and neuropathy. Clinical trials have shown that intensive glucose-lowering therapy reduces the incidence of these complications, with every one percent reduction in HbA1c translating to better health outcomes.[80] Clinicians will determine the most appropriate range of glycemic control for each person based on a full assessment (See Figure 6: Glycemic control: Targets for People with Diabetes).

Figure 6: Glycemic Control: Targets for People with Diabetes

Target	
<6.5%	To reduce risks of microvascular disease
<7.0%	Most adults with DM
7.1–8.5%	Frail elderly, functionally dependent, recurrent/severe risk of hypoglycemia

Clinicians can support patients by using the online calculator to individualize your patient's A1c target. (Diabetes Canada, 2024 February 1). https://www.diabetes.ca/managing-my-diabetes/tools---resources/individualizing-your-patient%E2%80%99s-a1c-target

Vascular Status: Peripheral Arterial Disease

For clinical assessment of individuals with diabetes, with or without foot ulcers, evaluating for PAD is critical.[1] A comprehensive examination should include a focused vascular history and physical examination, specifically by palpating pulses (femoral, popliteal, dorsalis pedis and posterior tibial) and noting signs of vascular compromise such as hair loss, nail thickening, delayed capillary refill and temperature differences.[1]

This approach highlights the critical role of specific diagnostic measures in managing the complex interplay between diabetes, foot health, foot ulcers and PAD. For individuals presenting with a foot ulcer and PAD, relying solely on signs and symptoms for ulcer healing prediction is deemed unreliable. Instead, the IWGDF recommends employing one of the following diagnostic tests to aid prognosis:

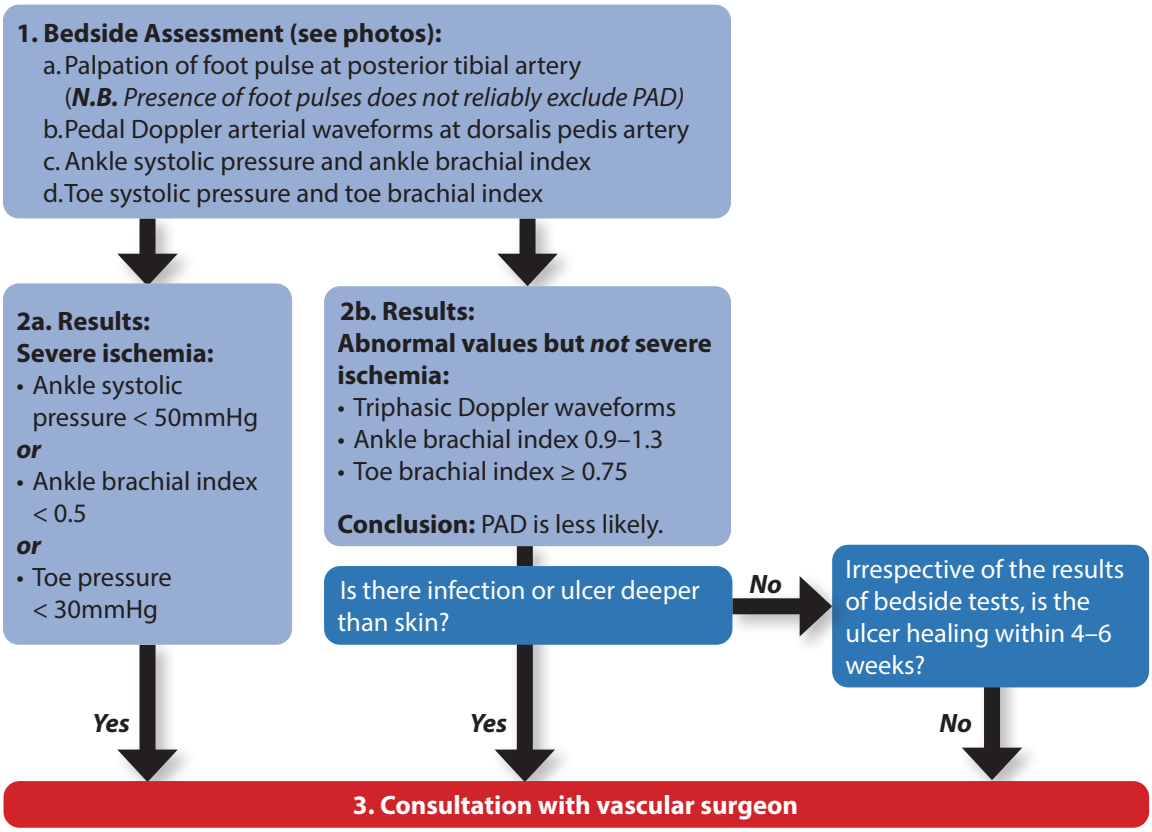
- a skin perfusion pressure of at least 40 mmHg
- a toe pressure of at least 30 mmHg
- a transcutaneous oxygen level ($TcPO_2$) of at least 25 mmHg, albeit other sources suggest a $TcPO_2$ threshold of55 mmHg for prognosis.[1]



Characteristics of the ulcer are also important; distal, punched-out ulcers with a pale base may indicate vascular compromise. Distal gangrene of the toes with a palpable pulse or adequate circulation

may indicate micro-emboli from proximal atheromatous plaques. Abnormal physical findings need to be confirmed with further diagnostic test.[81]

Figure 7: How to Perform a Vascular Assessment in a Person with Diabetes and a Foot Ulcer





a. Palpation of foot pulse at posterior tibial artery



b. Pedal Doppler arterial waveforms at dorsalis pedis artery



c. Ankle systolic pressure and ankle brachial index



d. Toe systolic pressure and toe brachial index

Note: Assess for claudication and critical limb ischemia
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For patients with diabetes, especially those with neuropathy, traditional signs of PAD may be absent or misleading, and the ankle-brachial pressure index (ABPI) might be inaccurately high due to arterial calcification.[82] Alternatives such as toe pressures and transcutaneous oxygen measurements are recommended for more accurate blood flow assessment.[1,25] Diagnosis of PAD may also utilize audible hand-held Doppler devices, with further confirmation by duplex Doppler in vascular labs if necessary.[83] There is no single modality that can reliably exclude PAD. The values listed in Table 3 indicating a normal ABPI, TBPI and triphasic/biphasic waves make PAD less likely. However, if an ulcer is present and not healing as expected, further evaluation with referral to a vascular surgeon should be considered. The presence of infection should also prompt a more urgent referral.

Table 3: Assessing Arterial Flow and Perfusion

Grade	Ankle-Brachial Pressure Index (ABPI)	Toe Brachial Pressure Index (TBPI)	Toe Pressure	Waveforms	Transcutaneous Oxygen Pressure ($TcPO_2$) - indicates perfusion
Non compressible	>1.40 Be aware of possible falsely elevated measures	Preferred when vessels are non-compressible	Preferred when vessels are non-compressible		Preferred when vessels are non-compressible or when localized perfusion may be altered due to previous insult (trauma or surgical repair)
Normal range	1.0–1.40	>0.7	>70 mmHg	Triphasic	>40 mmHg
Borderline	0.91–0.99	>0.6	>70 mmHg	Biphasic/ monophasic	>40 mmHg
Abnormal	<0.90	<0.6	<70 mmHg	Biphasic/ monophasic	<40 mmHg
Mild	0.7–0.9	>0.4	>50 mmHg	Biphasic/ monophasic	30–39 mmHg
Moderate	0.41–0.69	>0.2	>30 mmHg	Biphasic/ monophasic	20–29 mmHg
Severe	< 0.4 critical limb threatening ischemia (CLTI)	<0.2	<30 mmHg	Monophasic	<20 mmHg

The IWGDF emphasizes the significance of limb ischemia in foot ulcer healing rates and recommends cardiovascular risk reduction, potential pharmacological interventions for perfusion enhancement and consideration for revascularization based on specific diagnostic thresholds. Urgent vascular imaging and revascularization may be necessary for severe cases to improve healing prospects.[1]

Sensation

Patients with type 2 diabetes should undergo yearly diabetic peripheral neuropathy (DPN) screening at diagnosis, and those with type 1 diabetes should be evaluated five years after diagnosis, with yearly assessments following. These evaluations should include a detailed medical history, tests for small fibre (temperature or pinprick sensation) and large fibre (vibration sensation using a 128-Hz tuning fork) functions, and annual 10-g monofilament testing to check for LOPS. While up to half of diabetic neuropathies may be asymptomatic, emphasizing the importance of preventative care, current treatments focus on glycemic control rather than direct nerve repair. Regular assessments for DPN aim to manage symptoms early and improve quality of life, incorporating specific tests for both small and large fibre function, with electrophysiological tests or neurology referrals being exceptional measures.[70] Figure 8 demonstrates how to perform a sensory foot examination.

Figure 8: How to Perform a Sensory Foot Examination

1 10-g (5.07) Semmes-Weinstein monofilament

The test:
- Test for presence or absence of protective sensation
- Repeat this application twice at the same site but alternate this with at least one "mock" application in which no filament is applied (conduct a total of three questions per site).

Method:
- Apply perpendicular to the skin surface with sufficient force to cause the filament to bend or buckle
- Hold approximately 2 seconds
- Time necessary to perform this examination: 2 min for both feet
- Test these three sites:



Hallux



1st metatarsal head



5th metatarsal head

Results:
- Ask the patient if they feel the pressure:

Yes:
- Pressure sensation *present* at each site
- Two out of three answers are *correct*

No:
- Pressure sensation *absent* at each site; *OR*
- Two out of three answers are *incorrect*; *OR*
- Results *ambiguous*

No

2 128 Hz Tuning Fork

The test:
- Test for presence or absence of vibratory sensation
- Repeat this application twice at the same site but alternate this with at least one "mock" application in which the tuning fork is not vibrating.

Method:
- Time necessary to perform this examination: 3 to 5 min. for both feet
- Test on hallux; use another toe if hallux is absent



Dorsal hallux (distal phalanx)

Results:
- Ask the patient if they feel the vibration:

Yes:
- Vibration sensation *present* at each site
- Two out of three answers are *correct*

No:
- Vibration sensation *absent*
- Two out of three answers are *incorrect*

No

3 Ipswich Touch test

The test:
- Test for presence or absence of light touch sensation

Method:
- When touching do not push, tap or poke; touch lightly
- Hold 1 to 2 seconds
- Time necessary to perform this examination: 2 min. for both feet
- Test these three sites:



Hallux



3rd toe



5th toe

Results:
- Ask the patient if they feel the light touch:

Yes:
- Light touch sensation *present* at 2 or more sites

No:
- Light touch sensation *absent* at 2 or more sites

Permission granted by D-Foot International.

For additional information and steps to conducting sensation tests see Appendix D: Additional Information on Conducting Sensation Tests. Refer to this for details on using:

- The 10-gram monofilament sensation test
- The Ipswich Light Touch test
- The 128 Hz tuning fork.



Bony Structural Deformities

Foot deformities in patients with diabetes can result from neuropathic changes, stiffening of the joints (cheiroarthropathy) altered biomechanics, or previous surgeries.[84]

For a detailed discussion of Charcot foot see Appendix E: Charcot Neuro-osteoarthropathy (CNO or Charcot Foot).

The ability of the first toe joint to dorsiflex (lift upward) is essential to normal foot function. Limitation in the range of motion of the first metatarsophalangeal joint is called hallux limitus or, with complete immobility, hallux rigidus. With impaired joint mobility, gait is altered and pressure increases on the plantar surface of the first toe (hallux), potentially leading to ulceration. Gait examination, assessment of the range of motion, X-rays of the deformity and pressure mapping will enable the clinician to determine the extent of plantar pressures and any resulting forces on the foot. See Table 4 for examples of foot deformity.

Table 4: Foot Deformity

Deformity	Example	Deformity	Example
Claw toes		**Sausage toes**	
Motor Deformity			
Hallux valgus with plantar callus *(Image permission: K. Hansen)*		**Hammertoes** *(Image permission: K. Hansen)*	
			
Hammertoes with callous and blood-filled hematoma *(Image permission: K. Hansen)*			

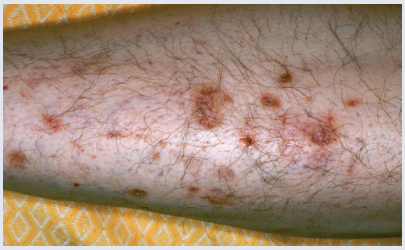
Skin and Nail Assessment

A complete head-to-toe skin assessment needs to occur, with special attention to legs and feet, including the toenails. Clinicians should identify and record any changes in skin colour, temperature, pigmentation, texture, turgor and odour, as well as assess between the toes, sole of foot and on the heels for dryness, cracks, fissures, maceration, scales or rashes (fungal infection).[1]

When examining the skin of a person with diabetes, assess for various conditions indicative of foot health status. Check for calluses (including location, size and colour [look for dark spots of dry blood in callus]), corns and non-bleeding or draining fissures or cracks, which could signal pressure points or areas of friction but are not immediately threatening. Normal, intact skin should appear healthy or dry. Particular attention should be paid to the spaces in between the toes for any hidden abnormalities. Inspection of toenails should investigate length, colour, thickness, subungual hematomas/debris, trauma, separation from the nail bed and pain. The appearance of the toenails can be a good indicator of self-care and foot health.[85,86]

A prior history of diabetic foot ulcers requires monitoring for signs of recurrence or ulcers in remission. Blisters or hemorrhagic calluses need careful evaluation for underlying issues. Fissures or cracks that are bleeding or draining indicate more severe skin integrity loss and require immediate attention. Diabetic foot ulcers, especially those not infected or covered with intact dry black eschar, highlight areas where the skin has broken down, necessitating further assessment for appropriate management to prevent infection or complications like wet gangrene.[85,86] See Table 5: Common Dermatological Conditions.

Table 5: Common Dermatological Conditions

Common dermatological condition	Example
Anyhdrosis	
Acanthosis Nigricans (AN): A condition marked by dark, velvety patches in body folds, signaling insulin resistance, often linked to obesity *(Image permission: Dr. J.L. Kuhnke)*	
Diabetic Dermopathy: Harmless, round red or brown patches on the shins, known as shin spots, resulting from blood vessel changes	 *Source: https://dermnetnz.org/imagedetail/2081-diabetic-dermopathy*

cont'd. . . .

Necrobiosis Lipoidica: Rare, painful, itchy patches, starting as bumps and worsening into swollen, hard skin	 *Source: https://dermnetnz.org/topics/necrobiosis-lipoidica*
Bullosis Diabeticorum: Blisters resembling burns on lower limbs, emerging without injury, associated with prolonged high blood sugar	
Fungal infection (person with DM) *(Image permission: Dr. R. Evans)*	
Callus *(Image permission: K. Hansen)*	 

cont'd. . . .

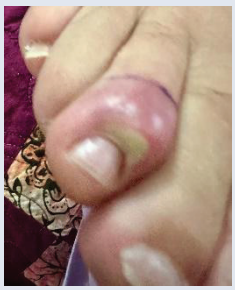
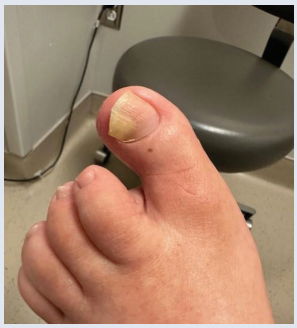
Eruptive Xanthomatosis: Tender, itchy, reddish-yellow bumps on extremities, caused by high blood fats	 *Source: https://dermnetnz.org/imagedetail/14914-eruptive-xanthoma*
Ischemia (gangrene)	

Changes in the nails of people with diabetes often stem from poor circulation, unnoticed trauma due to neuropathy and a general susceptibility to fungal infections caused by high blood glucose levels. Initial signs include discolouration, ranging from light yellow to canary yellow, often starting at the tip and moving toward the nail bed root. Dark toenails or black spots may indicate a subungual hematoma from trauma or, less commonly, a malignant melanoma, necessitating further examination to rule out cancer. See Table 6: Common Types of Nail Changes and Conditions in Persons with Diabetes.

Table 6: Common Types of Nail Changes and Conditions in Persons with Diabetes

Common nail changes	Example
Pincer Toenail: Curvature of the nail, causing potential skin breakdown and ulceration *(Image permission: K. Hansen)*	
Onychauxis: Nail thickening without deformity, often accompanied by discolouration *(Image permission: K. Hansen)*	

cont'd. . . .

Onychocryptosis (Ingrown Toenail): Nail grows into thesurrounding skin, potentially unnoticed due to neuropathy	
Onychogryphosis (Ram's Horn): Severe nail thickening and curvature *(Image permission: K. Hansen)*	
Paronychia: An infection causing redness, swelling, and tenderness around the nail *(Image permission: K. Hansen)*	
Onychomycosis: A fungal infection(deformity evident as well) *(Image permission: Wounds Canada)* *(Image permission:K. Hansen)*	 
Subungual hematoma: A collection of blood beneath the nail, often resulting from trauma. *(Image permission: K. Hansen)*	

Hand-held Infrared Skin Temperature Devices

Hand-held infrared skin temperature devices can be used to detect early signs of inflammation and tissue injury and have been validated in clinical wound assessment.[83,87-89] It has been reported that high temperature gradients between feet may predict the onset of neuropathic ulceration and that self-monitoring may reduce the risk of ulceration.[90] In a recent Canadian study, researchers reported that use of commercially available infrared thermometers (CAIT) could support patients with self-management and promote engagement in foot assessments.[91] Challenges using CAITs include how to embed their use in educational activities and choosing the most appropriate patients.[91]

It is important to note the IWGDF does not suggest using foot temperature for diagnosing diabetes-related soft tissue infection. More research is needed to address the need for well-defined and validated criteria to diagnose active Charcot neuro-osteoarthropathy.[1] The, "diagnostic accuracy of the (less than or equal to) ≤2˚C foot skin temperature measurement cutoff, that is frequently used, has not been demonstrated in a clinical study".[1] More research is needed. Also, we do not know which specific infrared thermometry device or protocol provides the most accurate method of measuring foot skin temperature. Future studies assessing the use of at-home monitoring with infrared thermometry devices to monitor disease activity would be beneficial. Daily temperature monitoring would allow the patient to liaise with the clinic without the need to attend clinic appointments as frequently and be able to identify changes in their foot condition rapidly and seek advice.[1]



Image permission: Dr. K. Stevens.

The IWGDF recommends "coaching a person with diabetes who is at moderate or high risk of foot ulceration (IWGDF risk 2-3) to self-monitor foot skin temperatures once per day to identify any early signs of foot inflammation and help prevent a foot ulcer. In case of an elevated temperature, ambulatory activity should be reduced and a member of the foot care team consulted".[1]

Footwear and Sock Assessment

Footwear, sock and orthotic assessments are key components of patient assessment, as ill-fitting footwear is a significant cause of ulcers and amputations. It is important to ensure that footwear, socks and orthotics match the person's function and activity level, address indoor and outdoor needs, are appropriate for each season and are not a source of pressure. As patients with neuropathy may not feel pain, daily foot and shoe examinations performed by patients or care partners are essential for preventing complications (pressure-related trauma, ulcers, amputations). For immersion foot please see: Chapter 5: Best Practice Recommendations for the Prevention and Management of Moisture-Associated Skin Damage.

The Self-Assessment Footwear Checklist for Patients (See Appendix F)

Patients with diabetes and their care partners should be taught about protective footwear and how to buy shoes.[92] The self-assessment footwear checklist is a tool to be completed by the patient to begin discussion about properly fitted footwear. During clinical visits, clinicians should assess the patient's shoes, socks and orthotics at every visit. Footwear that is causing harm should not be worn until reassessed by a trained foot specialist such as a podiatrist, chiropodist, orthotist or foot care nurse.[1] An area of callus build-up indicates that abnormal pressure is present, and if there is a blister, friction or shear is present. All persons with high-risk feet should be referred to a foot specialist (chiropody, podiatry, orthotics or the equivalent) if the health-care provider does not have the expertise to provide optimal plantar pressure redistribution.[93] See Figure 9 for images of ill-fitting footwear.

Figure 9: Examples of Ill-fitting Footwear



Too much wear *(Image Permission Dr. J. L. Kuhnke)*



Leather broken, too small for foot, damaged liner



Narrow toe box *(Image Permission: Dr. J. L. Kuhnke)*



Footwear too loose, heel not supported

The clinician should assess the following characteristics of each piece of footwear the patient wears (e.g., footwear for employment, leisure, walking).

- **Fit**: The toe box should be wide and long enough to prevent pressure on toes. The heel should be firm fitting but not too tight
- **Structure:** Footwear should have features that support the foot, including midtarsal support and solid heal counters. Footwear should have laces/Velcro to support the foot against the insole or liner. Footwear should not have seams or structures that could result in friction or pressure. Footwear should not have open toes or open heels
- **Cushioning**: Footwear needs enough cushioning to act as a shock absorber
- **General features**: Footwear should be made of breathable materials such as leather to allow moisture to dissipate
- **Motion control:** Footwear should limit overpronation (foot rolling inward and arch flattening)

In addition, clinicians should check inside all footwear for the presence of foreign objects, and for general wear and tear. This activity should be an 'educative moment'—explained and taught to the patient and care partner(s) so it becomes part of their daily exam activities. Footwear that is damaged should not be worn, and efforts should be made to replace it immediately.

The Care at Home Series: Caring for Your Feet: Safe Foot Care If You Have Diabetes provides steps to be followed by patients and their caregivers. Wounds Canada, Diabetes Care at Home Series.

1.2.2 Environmental: Socio-economic, care setting, potential for self-management

A significant risk factor for the development of diabetic foot complications may be the financial cost of managing diabetes. Purchasing protective footwear, prescribed offloading such as pressure redistributing devices (e.g., boots and footwear) for employment, seasonal and leisure activities is unachievable for some patients without financial support.[94-96] It is therefore essential that an environmental assessment be completed and communicated to the team to determine if the patient has the support in place to engage in a sustainable plan of care and self-management. Other determinants may include language, culture, education level, adequate housing, access to nutritious food and fluids,[97] social networks and access to services or equipment, as well as family knowledge, comfort or capacity in providing support or care.

1.2.3 Systems: Health-care support and communication

Discussion: The collective health of Canadians has a significant impact on economic performance and health-care systems. With increased chronic disease burden, including diabetes mellitus, health-care costs are increasing.[2,8] Diabetes-related care delivery is highly variable across provinces, regions, Indigenous populations and in different settings, leading to significant heterogeneity in outcomes.[3] Due to the variability, an assessment of regional services is required to determine the availability of services. To address the needs of the growing millions of Canadians living with type 1 and type 2 diabetes and pre-diabetes, an organized, interprofessional and collaborative approach to care is critical to improve diabetes-associated outcomes.[25,98]

1.3 Complete a wound assessment, if applicable

Discussion: The clinicians should identify the underlying **cause** of the wound and identify the person's **individual risk factors** and the wound should be **consistently** assessed using a validated tool and the findings communicated to the integrated team.[1] Wound assessment can help clinicians determine wound healing ability, plan treatment, facilitate communication, monitor treatment and predict and verify outcomes (e.g., healing and recurrence). It also helps identify additional complexity that may contribute to barriers to healing (e.g., depression, substance use, including smoking, access to services, care partner burnout, and health literacy).

Wound assessment tools

Assessment of skin, wound and periwound skin and documentation of findings requires a standardized approach.[99] Clinicians should use a comprehensive, validated and reliable wound assessment tool to provide a baseline and to assist with identifying any wound changes, as well as communicate with the team in a standardized manner. This information helps identify wound healing or deterioration and should guide ongoing treatment decisions. It also provides a consistent communication means among team members.[99]

For more on wound assessment tools, see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

Wound culture specimens

If infection is not suspected based on the clinical assessment, specimens for culture must not be collected and antibiotic treatment is not required.[77] Obtaining specimens for culture is recommended only for clinically infected wounds prior to initiation of antibiotic therapy.[77] The specimen for culture should be obtained following wound cleansing and debridement. Surface swabs most often do not reflect the microbiology of deeper tissues.[100]
The sample for microbiological assessment ideally should be obtained aseptically by curette or biopsy.[1] If bone is involved, the recommendation is to obtain a bone biopsy for culture based on the presentation and local resources.[1]

Probing to bone is indicative of bone involvement and suspect of osteomyelitis.

The IWGDF states that use of a universally recognized classification of the foot ulcer facilitates communication among teams, enhances research and improves patient outcomes by allowing for precise patient stratification, accurately characterizing DFUs and providing actionable treatment insights. Despite the lack of universally accepted systems, the existing ones play a crucial role in guiding clinical decisions.

SINBAD classification system[1]

The SINBAD (site, ischemia, neuropathy, bacterial infection, area and depth) classification system focuses on a methodical approach to thoroughly describe ulcer characteristics. It incorporates the following key elements:

- **Site**: Determine location of the ulcer,--forefoot, midfoot, or hindfoot.
- **Ischemia**: Assess if pedal blood flow is intact (at least one palpable pulse), or if there is clinical evidence of reduced blood flow. Examine the arterial pedal wave forms via ABPI or TBPI.
- **Neuropathy:** Assess if there is loss of protective sensation.
- **Bacterial infection**: Assess if clinical infection is present by assessing for the presence of at least two clinical signs or symptoms of inflammation (redness, warmth, induration, pain/tenderness) or purulent secretions. Note: these signs may be blunted by neuropathy or ischemia, and systemic findings (e.g., pain, fever, leukocytosis) are often absent in mild and moderate infections. Classify infection using the IWGDF/IDSA grading as mild (superficial ulcer with minimal cellulitis), moderate (ulcer deeper than skin or more extensive cellulitis, with or without abscess) or severe (accompanied by systemic signs of sepsis), with or without osteomyelitis.
- **Area:** Measure ulcer size (using a validated tool).
- **Depth:** Assess the ulcer depth and classify as: confined to skin and subcutaneous tissue; reaching muscle or tendon; or reaching bone. Determining depth can be difficult, especially in the presence of overlying callus or necrotic tissue. To aid assessment, debride any neuropathic or neuro-ischemic ulcer that is surrounded by callus or contains necrotic soft tissue at initial presentation, or as soon as possible. Do not, however, debride a non-infected ulcer that has signs of severe ischemia. Neuropathic ulcers can usually be debrided without the need for local anesthesia.[1]

The SINBAD classification system is graded on a binary scale (0 or 1 point), leading to a total possible score range from 0 to 5. This scoring system is designed to reflect the ulcer's severity incrementally. Its simplicity and reliance on standard clinical examination without the need for specialized equipment make the SINBAD system both accessible and practical for routine use. For example, patients with a higher SINBAD score have a lower chance of being alive and ulcer-free at 12 weeks and a higher risk of experiencing a major amputation at six months.[1] The SINBAD system has demonstrated moderate inter-observer and excellent intra-observer reproducibility, underscoring its reliability in tracking the progression of DFUs, including healing outcomes and the potential need for amputation.[1]

Wound, Ischemia, and Foot Infection (WIfI) classification system[1]

The WIfI classification system was introduced to evaluate three critical risk factors for lower limb amputation: wound, ischemia and foot infection. The WifI system assigns a score from 0 to 3 for each factor. Wounds are graded based on size, depth, severity and the anticipated difficulty of healing; ischemia is assessed through ABI gradations; and foot infections are evaluated by their scope and depth.[1]

This scoring system supports predicting the likelihood of major amputations in patients with diabetes-related ulcers and vascular disease, recommending its use for assessing perfusion and vascular function to facilitate timely revascularization and/or wound drainage interventions. However, due to the need for specialized vascular measurements, the WIfI system's application is more suited to settings with existing expertise in vascular interventions, indicating its limited utility in primary or community care contexts.[1]

The IWGDF/ISDA classification

The Infectious Disease Society of America and the IWGDF state that the diagnosis and classification of infection is based on clinical signs and symptoms,[1,101] The inflammatory response (erythema, warmth, tenderness, pain and induration, and loss of function) may be blunted in people with diabetes due to peripheral neuropathy, peripheral vascular disease and hyperglycemia. Secondary signs of infection, which may be useful in diagnosing infection, include the presence of necrotic tissue, friable granulation tissue, the type and amount of exudate and increased pain and odour. The severity of the infection should be defined based on the extent, depth and presence of systemic findings.[102-104]

For each classification system for diabetic foot ulcers there are advantages and disadvantages. See Table 7.

Table 7: Common Classification Systems for Diabetic Foot Ulcers[1]

System	Description	Comments
SINBAD	Site, Ischemia, Neuropathy, Bacterial infection, Area Ulcer, Depth	• Simple and quick to use • Requires only clinical examination • Contains necessary information to communicate for triaging purposes
WIfI	Wound Ischemia and Foot Infection Ischemia: based on ABPI or $TcPO_2$, Infection: based on the IWGDF criteria	• Estimates the risk of amputation and potential benefit of revascularization • Co-morbidities are not included • With confirmed infection and diagnosed peripheral artery disease, with vascular surgical expertise available this system should be considered
IWGDF/ IDSA	Classification system for the extent of infection and guide for management	• Assesses the severity of infection based on levels (1–4) • Diagnosis is based on local or systemic signs and symptoms of • inflammation • Adds the presence of bone infection to the level (e.g., 3 [O-osteomyelitis])

One aspect of assessment of diabetic foot ulcers is seeking the underlying cause/etiology. To create an optimal plan of care, the wound needs to be assessed and categorized as neuropathic, ischemic or neuroischemic.[1] Categories of diabetic foot ulcers outline some of the features most commonly associated with each of these etiologies. (See Table 8).

Table 8: Categories of Diabetic Foot Ulcers[105]

Feature/Etiology	Neuropathic	Ischemic	Neuroischemic
Sensation	sensory loss	pain	degree of sensory loss
Callus/necrosis	callus present and often thick	necrosis common	minimal callus; prone to necrosis
Wound bed	pink and granulating, surrounded by callus	pale and sloughy with poor granulation	poor granulation
Foot temperature and pulses	warm with bounding pulses	cool with absent pulses	cool with absent pulses
Other	dry skin and fissuring	delayed healing	high risk of infection
Typical location	weight-bearing areas of the foot, such as metatarsal heads, the heel and over the dorsum of clawed toes	tips of toes, nail edges and between the toes and lateral borders of the foot	margins of the foot and toes
Prevalence[90]	35%	15%	50%

Permission granted by Wounds International.

Mobile phone applications are being used to monitor wound size and characteristics with potential options to communicate with other care providers on the team. However, a pan-Canadian study[106-108] suggested challenges due to lack of organizational policy and procedure, cost of devices for clinicians, patients and care partners, access to stable internet services and standardized app education and use among teams and organizations. More research is needed.[109]

Diabetic Foot Osteomyelitis

Osteomyelitis is an infection in the bone(s) of the foot of a person with diabetes.[110] Osteomyelitis in the diabetic foot is a highly challenging diagnosis.[111] It can occur in 60% of hospitalized patients with diabetic foot infections and in up to 20% in outpatients with less severe infections.[102] Clinical presentations may vary greatly based on the involved site, extent of infection, perfusion, presence of surrounding infection and causative organism(s).[102] Osteomyelitis should be suspected when ulcers lie over a bony prominence and fail to heal in spite of offloading or when they have associated soft tissue induration ('sausage toe' appearance).[112,113]

Diabetic foot osteomyelitis commonly involves the forefoot and occurs by contiguous spread of infection from overlying soft tissues through to the underlying bone. A definitive diagnosis of diabetic foot osteomyelitis requires both histologic evidence of bone infection and isolation of a bacterial pathogen from a bone sample;[114] however, this is not always practical. In a 2021 review, researchers discussed a shift in surgery: major amputations were once common for osteomyelitis, but now, with improved diagnostic and surgical techniques, foot-sparking or conservative surgical approaches (resecting only the infected and necrotic bone) are becoming common, especially for forefoot infections.[111] In addition, antibiotic therapy, which has traditionally been administered predominantly intravenously and frequently over several months, is now being replaced by, "appropriately selected oral antibiotic regimens following only a brief (or even no) parenteral therapy, and given for no more than 6 weeks".[111]

Diagnostics

As bone biopsies are not routine in all clinical settings, diagnosis of osteomyelitis is made based on clinical assessment, laboratory and radiographic features. Diagnostic accuracy is critical to guide management. The IWGDF states that to diagnose osteomyelitis of the foot in a person with diabetes consider using a combination of plain X-rays, probe-to-bone test and lab tests (erythrocyte sedimentation rate, or C-reactive protein or procalcitonin) as the initial studies.[1] Probe to bone is a concern, and the patient must be evaluated for the possibility of osteomyelitis.

The probe-to-bone (PTB) test is a useful clinical tool when employed correctly for the diagnosis of osteomyelitis, "in combination with abnormalities on plain X-ray; high levels of ESR, CRP, or procalcitonin".[1] A sterile blunt metal probe is inserted through a wound and if bone is struck (hard, gritty end-feel), the likelihood of osteomyelitis is greatly increased in populations with high prevalence of osteomyelitis, such as persons with diabetes.[115-117] In 2016, Wrobel and Schmidt reviewed six PTB studies. The reported osteomyelitis prevalence varied from 22% (outpatient setting) to 55% for patients in the outpatient setting with infected ulcers and 70% in hospitalized patients. They state the PTB test provides important information where the, "likelihood of osteomyelitis is low after a negative test in the outpatient or low-risk setting. The likelihood is high after a positive test in a high-risk or inpatient setting".[118]

When considering radiographic evaluation, clinicians should be aware that plain X-rays are often adequate to evaluate the bone for established osteomyelitis.[1] They are also useful for assessing foot deformities, fractures, the presence of gas in the soft tissue and radiopaque foreign bodies. Bony changes seen on plain X-rays can be slower to develop, but X-rays are low-cost and readily available, and if there is any concern of osteomyelitis, serial plain X-rays may demonstrate the evolution of radiographic changes of osteomyelitis. Plain X-rays have sensitivity of 61.9% and specificity of 78.3%,[119] demonstrating that they should not be used in isolation, as they are not highly predictive of osteomyelitis regardless of the result. X-rays have poor positive predictive value, even when they are positive, unless subsequent radiographic evidence is positive.

Blood tests for inflammatory markers such as WBC, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), or procalcitonin (PCT) in a person with diabetes and a possible infected foot ulcer are often used but are not specific to the type of infection.[1] An ESR elevated to more than 70 mm/hr increases the likelihood of osteomyelitis and lower levels can decrease the likelihood.[1] An ESR may be a useful biochemical adjunctive test.[1] There is insufficient evidence, however, for routine use of these biochemical tests for diagnosis of diabetic foot osteomyelitis. Of these, as ESR drops more slowly with treatment, it may serve as a marker for treatment response.[1]

Magnetic resonance imaging (MRI) is considered the gold standard for diagnosing osteomyelitis as it gives a good review of soft tissue anatomy as well as joints and bones.[1] When MRI is contraindicated, or not available, a WBC labelled radionuclide scan, computed tomography or positron emission tomography may be considered.[102] While these techniques are helpful in diagnostic dilemmas, their availability may be limited and prior to requesting them it is important to discuss with a radiologist the most appropriate diagnostic imaging technique for the patient's specific clinical scenario.

Step 2: Set Goals

Discussion: Based on identified risk factors and complete patient, skin, wound and environmental assessments, goals of care (there may be several) need to be set in collaboration with the patient, family and/or care partner using the SMART principle. See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24] Identify the available options so that informed decisions can be made. Health-care providers must respect the individual's right to choose the interventions they prefer.[25]

Recommendations

2.1 Set goals for healthy skin, prevention of foot trauma, management of healing, non-healing and non-healable wounds

Discussion: From a long-term health perspective, a primary goal for those with diabetes should involve promotion of foot health and the prevention of diabetic foot ulcers. Therefore, factors that can cause skin breakdown or influence healing need to be identified so they can be addressed in the goal-setting stage.[25,120] Reducing the risk of neuropathy and peripheral arterial disease should also be considered.

2.1.1 Identify goals based on skin health and prevention or healability of wounds

Discussion: Promotion of skin health is key for persons with diabetes. Prevention of an initial wound or additional wounds on the contralateral limb or other parts of the foot is a goal that should be given paramount consideration. Ultimately, preservation of limbs and life may depend on it. In the presence of wounds, the health-care professional must identify whether the wound is healing, non-healing or non-healable. This decision is made based on the patient's modifiable and non-modifiable risk factors and is the only way to ensure that the goals are made in conjunction with, and are appropriate to, the patient.[5] See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for more on goal setting in general.

Diabetes Canada offers the ABCDEFSSS scheme for patients to improve communication with care providers and to support goal setting.[121]

A – A1c – Aim for a glucose control target of 7% or less, and link glucose levels to foot health. For example, set a target for one month.
B – Blood pressure – Aim for a blood pressure control target of less than 130/80 mmHg. For example, set a target for four to six weeks.
C – Cholesterol – Aim for an LDL target of 2.0 mmol/L or less. For example, set a target of 90 days.
D – Drugs – Protect against heart attack and stroke with appropriate medication. Drugs to decrease heart disease risk include: blood pressure pills (ACE inhibitors or ARBs), cholesterol-lowering pills (statins), medications that lower blood sugar with proven heart benefit, or ASA (Aspirin).
E – Exercise and healthy eating – Participate in regular physical activity and follow a healthy dietary pattern. Strive to complete at least 150 minutes of moderate-to-vigorous-intensity aerobic exercise each week (e.g., 30 minutes, five days a week) and resistance exercises (like lifting weights) two to three times a week. For example, set a target of 30 to 60 days.
F – Foot care and footwear for all seasons plus socks – Perform a daily examination. For example, set a target of 7 to 14 days.
S – Self-management support – Set goals and identify barriers that may prevent you from reaching your goals.
S – Screen and monitor for complications related to heart, feet, kidneys, eyes, and changes to mental health.
S – Smoking and stress – Stop smoking and manage stress effectively. For example, set a target date of 30 days.

Modified with permission from Diabetes Canada.

2.1.2 Identify quality-of-life and symptom-control goals

Discussion: Health-care professionals must remember the patient's goal(s) of care may be several and not necessarily aligned with those of the health-care providers. Goals related to healing wounds may take time and be complex. It is crucial that the team be well-organized, use a holistic health approach and include care partners and families.

Goals of care should be considered and established according to the SMART principle.[24]

Goals should be relevant to skin and foot health, mental health and wellbeing and, especially, urgency and timeliness to wound assessment and healing, pain reduction, odour, controlled infection, frequency of dressing changes and need for offloading.[25,120] Measuring patient outcomes using validated tools is important for research, education and to understand the need for system changes. This includes identifying patient-reported outcome measures (PROMS) that capture the experiences of patients while living with wounds.[122]

A special note on pain: Reducing painful diabetic neuropathy can be a key goal for patients living with diabetic foot complications. According to the Diabetes Canada guidelines, few patients have complete relief of painful symptoms with any treatment, and reduction of 30 to 50% in pain levels is clinically meaningful.[28] For example, a goal might be that neuropathic pain is controlled in three to seven days with regular reassessments of progress.

Many clinicians struggle with the decisions surrounding limb preservation and need support when exploring all goals of care with the team. It is important to note that some patients may elect to undergo amputation, as the wound may be interfering with their occupation, mental health, social and family support systems, access to care and financial resources.

Step 3: Assemble the Team

Discussion: Assessment, prevention and management of patients at risk for, or with, diabetic foot problems require the collaboration of an integrated team across all health-care sectors. The team must work closely and collaboratively to address the complex lifestyles, self-care strategies, emotional health, language and culture, as well as the social impacts of living with diabetes and being at risk for foot complications. Clinicians require clear protocols and clinical pathways that reflect the continued and integrated care needs of patients across all settings and that can be communicated among all team members.[17]

Recommendations

3.1 Identify appropriate health-care professionals and service providers

Discussion: The professional members of the team need to be trained and enabled to work with patients with diabetes and their care partners since the knowledge and skills necessary to assess and treat the person at risk for, or with, diabetic foot complications are not usually taught in an entry-level health-care professional curriculum. Caring for such individuals requires clinicians have the skills to address glycemic control (in relation to foot health), infection control, offloading of high-pressure areas, lower-extremity vascular status and local wound care, while supporting a self-management approach to care.[28] For more information visit Your Foot Care Team.

Patients and Their Care Partners First

The first team members are the patient, then their family or care partners. The next team member is usually the primary care provider, depending on the needs of the patient and allocation of resources within the community. We recognize this is a challenge across Canada as many individuals do not have a primary care provider,[123,124] potentially putting those with diabetes at greater risk.

Integrated teams may include: a diabetologist, specialist in internal medicine, diabetes nurse specialist, podiatrist/chiropodist, orthotist, pedorthist, nurse and rehabilitation professionals, a nurse specialized in wound care/foot care and pharmacist. In some cases, there should be contact with specialists in endocrinology, renal dialysis, dermatology, vascular surgery, microbiology, orthopedics and infectious diseases, as well as social workers, psychologists, cultural/ethnic health liaisons, registered dietitians, spiritual care providers, Indigenous elders and mental health workers.[24,25,120,125]

To manage diabetes-related health, foot health and foot complication issues, there may be a combination of face-to-face, virtual, web–based and/or hybrid strategies in place to promote access to care and communication.[126] Each strategy must be focused on patient and care partner needs and ensuring that effective collaboration and communication result.[120]

Patients with disabilities, including visual impairment and mental health issues, or those who are living unhoused, housebound or living in specialized care settings, may need further support.[120] Additional considerations for assembling the appropriate team are as follows.

- Specialized assessment equipment and training are required to assess the vasculature of a person with diabetes.[25,120] Appropriate referral for any patient diagnosed with, or suspected of, arterial insufficiency is essential for the prevention and treatment of diabetic neuropathic foot ulcers.
- If a person with diabetes is admitted to acute care where a diabetic foot problem is the dominant clinical factor for admission, acute care protocols and care pathways should be in place to support care delivery.[120] In the acute care setting, the patient needs to be assigned to a lead clinician who can ensure that timely care is provided.[120] In the United Kingdom, patients with diabetic foot complications access the multidisciplinary foot care team to enforce limb preservation strategies. This effective model needs to be considered in the Canadian health-care system.
- Clinicians and other professional team members involved in the assessment and treatment of diabetic feet should receive competency-based education and training.[1,127,128] Guidelines from the UK's National Institute for Health and Clinical Excellence (NICE) refer to engaging trained health-care professionals.[120] Since early detection and intervention may be the key to more successful outcomes, access to individuals with knowledge and training specific to diabetes and diabetic foot care will improve patient outcomes. In addition, professionals need to recognize the impact of living with neuropathy, which can reduce motivation to heal or prevent injury.[25,120]

Terminology

Multidisciplinary team refers to a team of health-care workers from a variety of disciplines. The IWGDF states a multidisciplinary team is a group of, "people from relevant clinical disciplines, whose interactions are guided by specific team functions and processes to achieve team- and person-defined favourable" outcome(s).[1]

Integrated team is the preferred term because it describes a team that includes the patient, care partners, family and a mixture of professional and paraprofessional providers.

Professional Team Members Guidelines (Modified from IWGDF, 2023).

Levels of care for diabetes-related foot disease	
Low Risk (Category 0)	Primary care provider (nurse practitioner, family physician), podiatrist, diabetes/foot care nurse, registered dietitian, physiotherapist, and occupational therapists who have been trained in diabetes foot screening
Moderate Risk (Category 1)	Diabetologist, surgeon (general, orthopedic, foot/ podiatric), vascular specialist (endovascular and open revascularization), infectious disease specialist or clinical microbiologist, podiatrist and diabetes nurse, in collaboration with a pedorthist, orthotist or prosthetist
High Risk (Category 2)	Foot centre specialized in care for diabetes-related foot disease, with multiple experts from several disciplines, each specialized in this area working together, that acts as a tertiary reference centre
Very High Risk (Category 3) or Urgent Risk	Specialized wound care team

3.2 Enlist the patient and their family and care partners as part of the team

Discussion: Patients with, or at risk for, diabetic foot complications and their care partners need to become part of a specialized, integrated diabetes team that is proactive, incorporates elements of the chronic care model (CCM) and is organized around them.[28] For pediatric patients, parents or legal guardians need to be part of the care-planning team.[129] Ideally, the patient and care partners are willing and able to set goals and participate in the development and implementation of any plan of care. Every attempt should be made to have meaningful communication with the patient and family—especially during transitions in care—regarding lifestyle choices that will result in the best possible long-term outcomes.[25,129]

To help ensure active participation, individuals with diabetes and their care partners should be offered timely, relevant diabetes information that is tailored to enhance self-care/management practices and behaviours.[130] Diabetes self-management, education and support (DSMES) is defined as a planned, co-created systematic intervention that involves

active patient and/or care partner participation in self-monitoring (physiological processes) and/or decision-making (managing). It includes a, "comprehensive blend of clinical, educational, psychosocial and behavioural aspects of care needed for daily self-management and provides the foundation to help all people with diabetes avigate their daily self-care with confidence and improved outcomes".[130]

A more informed patient is likely to be a more engaged team member. Wounds Canada has developed resources to help patients increase their knowledge of diabetes-related foot management. These include:

Care at Home Series: Caring for Your Feet: Safe Foot Care If You Have Diabetes, a simple guide that can be used by patients with diabetes and their care partners for caring for their feet at home. https://www.woundscanada.ca/docman/public/patient-or-caregiver/1728-home-safe-df-care-1942e/file

Care at Home Series: Diabetic Foot Complications When Is It An Emergency?, a guide to help patients with diabetes recognize causes and techniques for preventing foot complications and when to notify a health-care provider when changes occur. https://www.woundscanada.ca/docman/public/patient-or-caregiver/1727-home-emergency-df-care-1941e/file

Wounds Canada FIY series. Neuropathic/diabetic Foot Ulcer: What Is It? (2021). https://www.woundscanada.ca/patient-or-caregiver/resources/diy-series

Peer or lay educators may also increase diabetes-related knowledge and self-care behaviours.[28] The Diabetes, Healthy Feet and You program is an example of a peer-reviewed, peer-led, patient-focused program that provides supportive educational sessions on diabetic foot care. It is delivered to people with diabetes and their family members byfacilitators living with diabetes, alongside clinical experts. This approach gives patients the opportunity to ask clinical questions while also learning from the lived experience of peer educators.[131,132]

3.3 Ensure organizational and system support

Discussion: Management and prevention of diabetes-related foot disease necessitate a comprehensive, multidisciplinary approach, emphasizing the holistic treatment of foot complications as indicators of broader health issues. This approach requires an organized system with specific guidelines covering all standard care aspects, tailored to accommodate local resources and staffing variances. Essential elements of such care include extensive education for individuals with diabetes, their care partners and health-care professionals in both hospital and primary care settings. Moreover, it involves systematic screening to identify at-risk individuals, including mandatory annual foot examinations for everyone with diabetes, ensuring access to preventive measures like podiatric care and specialized footwear and providing timely, effective interventions for foot ulcers and infections.[1]

This organized care approach encompasses rapid access to revascularization procedures, techniques for ulcer off-loading and comprehensive wound care protocols, including regular inspections and appropriate dressings. Auditing services play a critical role in this framework, ensuring practices meet high standards of care and addressing any service shortcomings. The guidelines suggest that diabetes-related foot care should operate within a structure designed for chronic care management rather than being limited to responding to acute incidents. Ideally, a tiered foot-care management system should exist, involving interdisciplinary specialists at all levels to cater to the complex needs of individuals with diabetes, thereby reducing the risk of foot ulceration and improving overall patient outcomes.[1]

Successful diabetic foot care programs are designed and evaluated in collaboration with patients, care partners, clinical practice leaders, educators, researchers and administrators at the institutional, regional and provincial/territorial levels.[25] It is important to establish trust-filled relationships with patients and their care partners/family members to fully engage them in care.[1,25,120]

It is crucial that care be co-ordinated between health-care agencies and the community and promote a standardized approach to wound prevention and care to improve and measure patient outcomes and efficiency; this is especially important when patients transition between care settings.

- Successful programs involve formalized collaboration between the patient, care partners and acute, long-term, primary and community care to align best practices across the health care sectors.
- Teamwork and integration of services help to ensure clear, culturally safe, trauma-informed systems communication, reduce duplication of services and promote measurement of patient, care partner, clinicians and system

outcomes.[25,120] Organizations and leaders are encouraged to do the following, all of which are reinforced by Diabetes Canada.[25,28,120]

- Develop policies (federal, provincial/territorial, regional and local/institutional) that are relevant and acknowledge and designate human, material and financial resources to support the team in the prevention of diabetic foot complications and diabetic foot ulcer assessment, prevention and management.

Why Integrated Teams Are Important

Integrated teams and interprofessional teamwork are key to successful diabetes prevention, assessment, treatment and management.[25,28,120] Teams should:

- Establish a pathway for referral, from immediate, to 48 hours, to a multidisciplinary foot-care service of people with diabetes that supports risk stratification
- Work with community and other partners to develop a process to facilitate patient referral and access to local diabetes resources and health-care professionals with specialized knowledge in diabetes management (e.g., glycemic control, A1c)
- Work with community and other partners to advocate for strategies and funding for all aspects of preventative foot care, preventative and treatment footwear and glycemic control
- Ensure foot care services exist for the assessment, surveillance and treatment of preventative care
- Establish and support a multidisciplinary team composed of interested, skilled and knowledgeable individuals to address and monitor quality improvements in the promotion of skin health, and prevention and management of diabetes-related foot complications
- Use globally recognized risk classifications to help allocate resources such as therapeutic shoes, patient education and clinical visits
- Establish and sustain a communication network among the person with diabetes, care partners, health-care professionals and community systems
- Audit (measure outcomes) all aspects of the service to ensure that local practice meets accepted national and international standards of care
- Engage patients with diabetes to check their feet daily for cuts, cracks, bruises, blisters, sores, infection and unusual markings
- Advocate for your patients with diabetes to ensure they are supported by policies, practice, resources and support. Visit the Diabetes Canada advocacy web page for information and resources. https://www.diabetes.ca/advocacy---policies/advocate-for-diabetes-canada

Step 4: Establish and Implement a Plan of Care

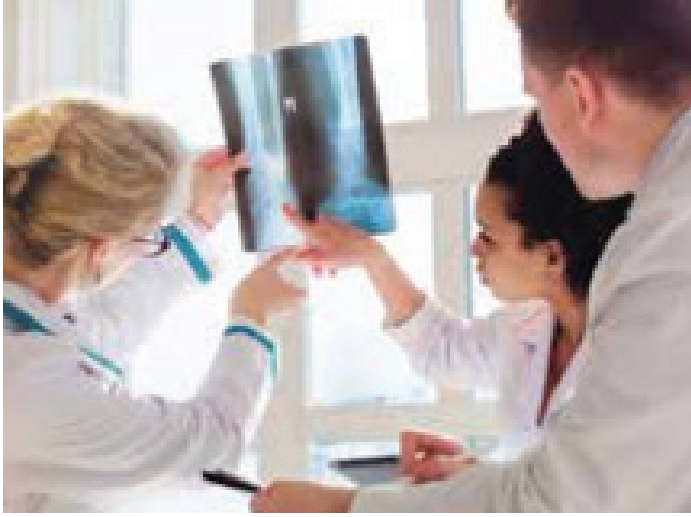
Discussion: Foot skin health, foot ulcer prevention and wound healing are challenging in individuals with diabetes, as the disease presents many complex prevention and management issues. The plan of care should incorporate the multiple factors identified during the assessment process.

Recommendations

4.1 Identify and implement an evidence-informed plan to support healthy skin, to correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional and social), the wound and offloading (if applicable) and environmental/system challenges

Discussion: Maintaining healthy feet and the prevention of diabetic foot complications is key. All individuals at risk for and living with diabetes need to receive at least annual foot screenings to identify whether they are at low, moderate, high, very high or urgent risk for the development of foot complications. Management strategies can then be developed that revolve around the prevention and/or management of diabetic foot risk as seen in Step 3 of the Inlow 60-second Diabetic Foot Screen.[32]

Whether or not the person with diabetes has an ulcer, the patient and health-provider team should work together to monitor and manage the factors that affect the patient's health and wellbeing, including smoking, glycemic control, weight-management, use of medications, level of physical activity, exercise and occupation, professional foot care and offloading and behaviours such as completion of daily foot self-examination, recognizing and managing foot injury, accessing care and acquiring and wearing appropriate footwear.[28,120]



There are critical times to offer regular and repeated education and diabetes self-management education and support.

- When engaging in promotion of health activities, nutrition and mental health and wellness[129]
- At diagnosis and during preventative foot-screening activities
- Annually, and/or when targets of treatment are not being met
- When complications arise
- When transitions in life and care occur[130]

For more information on Diabetes, Healthy Feet and You see: https://www.woundscanada.ca/for-patients-public/240-diabetic-healthy-feet-and-you/for-patients-and-public/267-information-about-diabetes-and-healthy-feet

The patient, care partner and family must work with the integrated team to ensure care plans are co-created, balanced and remain focused on the patient preferences and informed decisions. Care plans will include multiple topics such as: daily foot and skin checks, emotional wellbeing, smoking cessation, glycemic control, weight-management, medications[28] and physical activity.

When a wound is present, the care plan will include wound assessment, pain, vascular status, infection, and day-to-day management. Teams also need to include conversations about home life, financial responsibilities, employment (shift work), occupation(s), access to professional foot care and offloading and behavioural options.[25,129]

Care planning sessions take time, a commitment to listen to the patient's responses, a willingness to co-create and negotiate care and assessment of the person's ability to cope with the complexities of diabetes, skin health and/or a foot ulcer. Teams need to recognize early the need for timely and urgent care to manage a foot injury, accessing care and acquiring and wearing appropriate footwear for all activities, including employment, social, physical and at home.

Support for Self-managed Care/Education

- Support your patient in self-managing their care to prevent foot complications by having them do the following (accompanied by your activities in parentheses)
- Manage their blood glucose levels (discuss links to foot health)
- Stop smoking if they are a smoker (discuss links to vascular disease)
- Perform a daily foot exam (promote foot hygiene)
- Manage lower leg edema[133]
- Select professionally measured shoes, if they have neuropathy
- Perform high-quality foot and nail care and hygiene
- Seek professional foot care through podiatrist, chiropodist, or foot care nurse
- Seek help with urgent foot complications
- Ensure they receive an annual foot screen (train your relevant team members)[28]

Skin and nail care

Ensure that the person with diabetes has a skin- and nail-care routine that supports the maintenance of healthy feet. Skin should be assessed frequently for signs of impending injury. Callused areas require debridement and footwear adaptation/offloading as needed to prevent injury or recurrence of a wound. Heel cracks or fissures should be treated with debridement and appropriate dressings, as well as appropriate footwear, to reduce pressure and shear. Foot odour may indicate poor hygiene or a fungal infection, also known as athlete's foot, that requires treatment with antifungal therapy as well as attention to footwear to ensure it is breathable and hygienic. Ragged and unkempt nails may require professional and routine follow-up.[134]

Medication Management

Patient-centred care in diabetes management encompasses optimizing glycemic control with tailored oral antihyperglycemic medications, nutrition, and/or insulin therapy, addressing edema, malnutrition and cardiovascular risk factors,

while also recognizing and screening for and treating underlying psychosocial challenges such as diabetes distress[135] and depression and anxiety.[1]

Cardiovascular Management

Cardiovascular disease screening and management are crucial, as adults with diabetes have a two-four times increased risk compared with adults without diabetes,[136] and the risk rises with worsening glycemic control. Researchers report a 75% increase in mortality, with cardiovascular disease being a large contributor. Medication management should be focused on reduction of macro- and microvascular complications, coronary heart disease, strokes, heart failure, PAD, renal disease and vision changes.[136]

All patients with diabetes and an ischemic foot ulcer should receive aggressive cardiovascular risk management that may include support for cessation of smoking, treatment of hypertension and prescription of a statin as well as low-dose acetylsalicylic acid or clopidogrel.[1,137]

Glycemic Control

Appropriate glycemic control is essential for delaying complications of diabetes in adults and children, and for theprevention of foot complications and for wound healing.[138] The IWGDF emphasizes the relationship of glycemic management to wound healing by stating, "when the wound deteriorates or fails to significantly improve (e.g., a less than 50% reduction in wound area within four weeks) despite appropriate infection and glucose control, wound care, and offloading, reassess the vascular status and consult with a vascular specialist regarding possible revascularization."[1]

A glycated hemoglobin (A1c) test shows blood glucose levels over the previous three months.[139] Although glycemic targets must be individualized, most people with diabetes should aim for an HbA1c level of less than 6.5% to reduce the risk of micro- and macrovascular complications.[28] An increasing number of studies have, however, demonstrated significantly decreased healing times in individuals with lower A1c,[140] though not all researchers agree and more research is needed.[141]

Although it is clear from the literature that tight glycemic control prevents or delays the complications of diabetes, there is a growing body of literature discussing the A1c level as a good criterion for evaluating foot ulcer incidence, predicting the progression of foot ulcers and increased treatment duration and depth of the wound.[142] If poor glycemic control is suspected, the clinician should refer the patient to their primary care provider, diabetes educator or other specialist, as appropriate, for consideration of services, technologies or devices that could support glycemic control.[1]

Smoking Reduction/Cessation

The effects of smoking on health and when living with diabetes are well documented.[143] Every effort should be made to encourage and support smoking cessation in individuals living with diabetes and/or with a foot ulcer. Fu and colleagues showed that there is a significant risk for foot amputation when patients smoke. As well, they found an association between cigarette smoking and delayed diabetic foot healing.[144] Clinicians should refer patients and their care partner to smoking cessation programs to address this crucial modifiable risk factor.[1]

Pain Management

To support pain control, gabapentinoids, tricyclic antidepressants and serotonin-norepinephrine reuptake inhibitors are the first-line agents for treating neuropathic pain.[145] Tramadol and other opioids are recommended as second-line agents, while cannabinoids are newly recommended as third-line agents. Other anticonvulsants, methadone, tapentadol, topical lidocaine and botulinum toxin are recommended as fourthline agents.[145]
Opioids are avoided and only used when other treatments fail.[146] Other effective therapeutic options include topical nitrate sprays, topical capsaicin and transcutaneous electrical nerve stimulation.[28]

Footwear and Offloading

Prevention of ulceration or re-ulceration in the feet of individuals with diabetes is possible when pressure is taken off vulnerable plantar areas and friction is eliminated. This is achieved through proper fitting, use and inspection of insoles and footwear. Those with compromised sensation need the assistance of regular visual and hand inspection by themselves and their support team. Also, their footwear should always be professionally fitted. (See Table 9: Footwear for People with Diabetes).

It is important that the entire team be aware of the following footwear selection and wearing protocols for prevention of foot complications. Therapeutic footwear or orthotics must be worn at all times, both indoors and outdoors. Inappropriate footwear such as high-heeled or narrow-toed shoes should be avoided, as these can cause damage even if worn for only a few hours.[147]

Table 9: Footwear for People with Diabetes[148]

Risk Level	Low to Moderate Risk for Foot Ulceration	Moderate to High Risk for Foot Ulceration	Active Foot Ulcer(s)
Actions Required	Wear properly fitting and protective footwear that accommodates the shape of feet; wear socks to minimize shear and friction	Ensure proper fit, protection and accommodation of the foot's shape. Wear footwear at all times, both indoors and outdoors. Inspect footwear each time before use for foreign objects Examine feet after removing footwear for signs of pressure, trauma or ulcers For those with foot deformities or pre-ulcerative lesions, medical grade footwear, possibly including custom-made orthoses or insoles, is recommended Patients with healed plantar foot ulcers should use medical grade footwear with custom orthoses or insoles proven to reduce plantar pressure in high-risk areas. It's advised to review the effectiveness and fit of the prescribed footwear every three months to ensure ongoing protection and support	Prescribe appropriate offloading devices to heal ulcers. See: Product Picker: Offloading Plantar Pressures in Diabetes

Adapted from: van Netten JJ, Lazzarini PA, Armstrong DG, Bus SA, Fitridge R, Harding K, et al. Diabetic Foot Australia guideline on footwear for people with diabetes. J Foot Ankle Res. 2018 Jan 15;11:2.

Offloading is a fundamental treatment for foot ulcers caused by increased mechanical stress. Initial steps involve the use of non-removable knee-high devices, like total contact casts, to alleviate mechanical stress on neuropathic plantar ulcers. See Table 10 to identify factors to consider when offloading the foot of a person with diabetes.

In situations where such devices are not feasible, alternatives like removable offloading devices and felted foam, paired with appropriate footwear, are considered. Additionally, specific interventions such as digital flexor tenotomy are employed for ulcers resulting from toe deformities, with a careful approach adopted in the presence of infection or ischemia.

See Wound Canada's Offloading Plantar Pressures in Diabetes to understand the advantages and disadvantages of each. https://www.woundscanada.ca/docman/public/health-care-professional/1214-wc-product-picker-offloading-ltr-1703e/file

Table 10: Factors to Consider When Offloading the Foot of a Person with Diabetes

Factors	Description
Disease	• neuropathy • vision • PAD • inflammatory disorder
Pressure	Type of pressure • shear pressure • vertical pressure Intrinsic • structural modifications (deformity/limited range of motion/ tissue quality loss) • infection • malignancy Extrinsic • biomechanics • deformity • footwear
Foot ulcer recurrence	• presence of ulcer • type of ulcer/re-ulceration • location • dressing selection
Physical activity/ culture	• occupation with physical demands, footwear requirements • home lifestyle • sports/recreational activity • balance and exercise plan
Funding	• ability to pay for device, footwear etc. • third-party insurance
Psycho-social/spiritual care	• cognitive status (e.g., diabetes distress, depression, anxiety, delirium, dementia) • substance use disorders (e.g., tobacco, alcohol, marijuana) • spiritual care support(s)
Patient behaviour	• ability to adhere to co-created treatment plan • occupation and lifestyle

The IWGDF provides an algorithm to support clinical decision making related to selecting a proper offloading modality.[1] See Figure 10.

Figure 10: How to Select a Proper Offloading Modality

Diabetic foot ulcer (DFU) location

Non-plantar DFU

Proper modality:
- Removable ankle-high device
- Footwear modification
- Toe spacers or orthoses





Plantar forefoot or midfoot DFU

Is ischemia or infection present?

Yes

Severity:
- **Mild** infection

OR
- **Mild** ischemia

Proper modality:
- Non-removable knee-high offloading device

Yes

Severity:
- **Mild** infection + **Mild** ischemia

OR
- **Moderate** infection

OR
- **Moderate** ischemia

Proper modality:
- Consider using a removable knee-high offloading device

Yes

Severity:
- **Moderate** infection + **Moderate** ischemia

OR
- **Severe** infection

OR
- **Severe** ischemia

Proper modality:
- Address the infection and/or ischemia and consider using a removable offloading intervention

No

Proper modality:
- Non-removable knee-high offloading device



If the above modality is contraindicated or not tolerated:

Proper modality:
- Consider using a removable knee-high offloading device



If the above modality is contraindicated or not tolerated:

Proper modality:
- Use a removable ankle-high offloading device



If the above devices are not available:

Proper modality:
- Consider using felted foam with appropriately fitting footwear



If ulcer fails to heal:

Proper modality:
- Consider a surgical offloading intervention after reassessment of vascular status

Plantar Heel DFU

Proper modality:
- Consider using a removable knee-high offloading device





Permission granted from D-Foot International.

Hospitalization of patients with severe infection or moderate infection with other complicated issues may be required. See Table 11 for factors that should lead to considering hospitalization of the patient.

Table 11: Factors that Lead to Considering Hospitalization[1]

Factors that should lead to considering hospitalization[1]
• Severe infection (see findings suggesting a more serious diabetes-related foot infection above)
• Metabolic or hemodynamic instability
• Intravenous therapy needed (and not available/appropriate as an outpatient)
• Diagnostic tests needed that are not available as an outpatient
• Severe foot ischemia is present
• Surgical procedures (more than minor) required
• Failure of outpatient management
• Need for more complex dressing changes than patient/care partners can provide
• Need for careful, continuous observation

Psychological support

Diabetes and psychological issues are well documented. Co-occuring conditions such as diabetes distress,[129,135] depression, anxiety and sleep disorders require assessment, treatment and appropriate, timely interventions.[149,150] The complexity of living with diabetes contributes to changes in cognitive functioning in, "multiple domains such as attention, concentration, memory, executive function, and information processing speed".[150] This may be evident when persons with diabetes do not appear to engage in co-creating and updating care plans or education opportunities.

Clinicians need to screen for risk of mental health conditions and make timely referrals to health-care professionals trained in interventions. Treatment and intervention options may include the following: support to facilitate adaptation to diabetes, reduction of diabetes-related distress to improve outcomes, motivational interventions, stress-management strategies, coping skills training, family therapy and collaborative case management. Employment may be impacted, and the patient may need employment modification or time off, or to modify employment activities to support wound healing.[151]

Cognitive behaviour therapy and/or antidepressant medications may also be effective.[28] As well, it is important for persons and their care partners to collaboratively and proactively communicate with their pharmacist to optimize medication use.[152] Individuals taking psychiatric medications, particularly atypical antipsychotics, benefit from regular screening of metabolic parameters.[28] Self-management issues can be addressed in a one-on-one session or during diabetes self-management workshops given by peer leaders with diabetes.

Nutritional support

Clinicians can refer patients to credible resources to assist in decision-making regarding nutritional choices.[153] Nutrition recommendations for people with diabetes and foot ulcers should be individualized, taking into consideration co-morbidities, any previously documented abnormal laboratory test results, patient age, preferences, goals and medications.

Patients should be counselled regularly across the disease continuum by a registered dietitian[154] in a group or individually, preferably with their care partners present. It has been demonstrated that when dietitians collaborate with the patient in a meaningful exchange of information, A1c, quality of life and medication adherence is improved.

For more on nutrition and wound prevention and healing, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] and resources on the Wounds Canada website: https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/nutrition

Physical activity and exercise

Improved pressure management can be facilitated through patient participation in appropriate activities. Low-impact activities such as swimming, aqua-fit classes and bicycling are preferable to high-impact activities such as walking, jogging and aerobics.

Diabetes Canada states at least 150 minutes of exercise per week (aerobic) and at least two sessions per week of resistance exercise are recommended, though smaller amounts of activity still provide some health benefits. Appropriate levels of physical activity alongside healthy nutrition plans should be a cornerstone to promote skin health and wound healing.[28] Most people with diabetes, or those at risk for diabetes, do not meet the Diabetes Canada's guidelines for aerobic and resistance exercise, despite the following:

- patients have the power to improve their blood glucose control by actively exercising five days a week and engaging in resistance training and
- regular physical activity, in conjunction with healthy eating and weight control, can reduce diabetes incidence by 60%.[28]

Therefore, it is essential that physical activity be built into the plan of care for most patients. Aerobic and resistance (weights, weight machines) training are recommended.[153] Fitness level is one of the strongest predictors of all-cause mortality in people with diabetes. Poor physical fitness is as strong a risk factor for mortality as smoking.

Threatening Ischemia

The IWGDF guidelines highlight the increased risk of major limb amputation in patients with both diabetes and PAD, especially in the presence of infection. It is important that clinicians understand that the inflammatory response induced by infection results in fluid accumulation that causes pressure in the tissues that may further compromise perfusion. The guidelines emphasize the need for emergency/urgent treatment when these factors are present, underscoring the importance of optimizing vascular perfusion for diabetic patients with foot ulcers through a comprehensive vascular assessment and, if necessary, surgical consultation.[1]

For additional information see Chapter 10: Best Practice Recommendations for the Prevention and Management of Peripheral Arterial Ulcers.

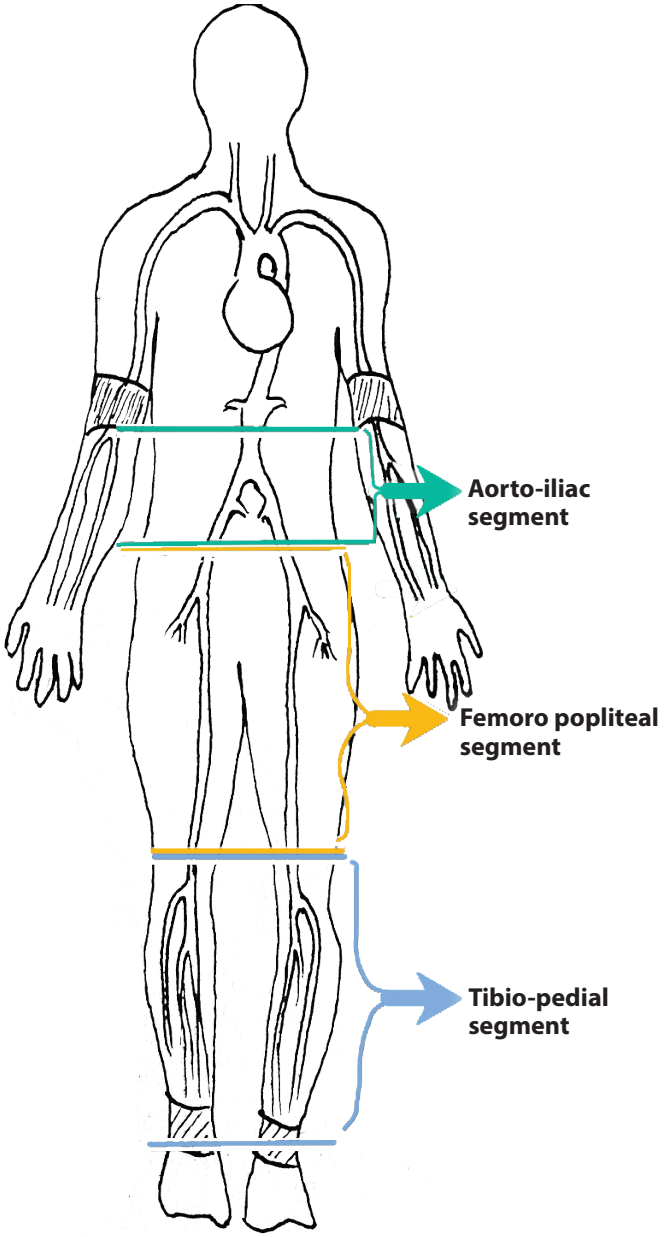
The most severe form of PAD is called chronic limb-threatening ischemia (CLTI). The term *CLTI* is preferred over *critical limb ischemia,* as the latter implies threshold values of impaired perfusion rather than a continuum. CLTI is a clinical syndrome defined by the presence of PAD in combination with pain at rest, gangrene or a lower limb ulceration over two weeks' duration.[155] Of concern is the presence of diabetes mellitus, as it increases the incidence of PAD, accelerates disease progression and worsens patient healing and overall outcomes.[156]

The IWGDF points out the significant negative impact of lower extremity ischemia on foot ulcer healing and stresses the importance of managing the increased cardiovascular risk associated with PAD. For patients presenting with specific diagnostic thresholds indicating severe ischemia, such as ankle pressure below 50 mmHg, ABPI less than 0.4, toe pressure below 30 mmHg, or $TcPO_2$ under 25 mmHg, immediate vascular imaging is advised to evaluate the need for revascularization.[1]

Revascularization is also considered for patients with significant tissue loss or infection, and when ulcers do not show healing within four to six weeks of optimal management. Before any major amputation, evaluating revascularization options to restore flow to foot arteries is essential, based on individual patient factors and local expertise. The effectiveness of revascularization should be objectively assessed post-procedure.

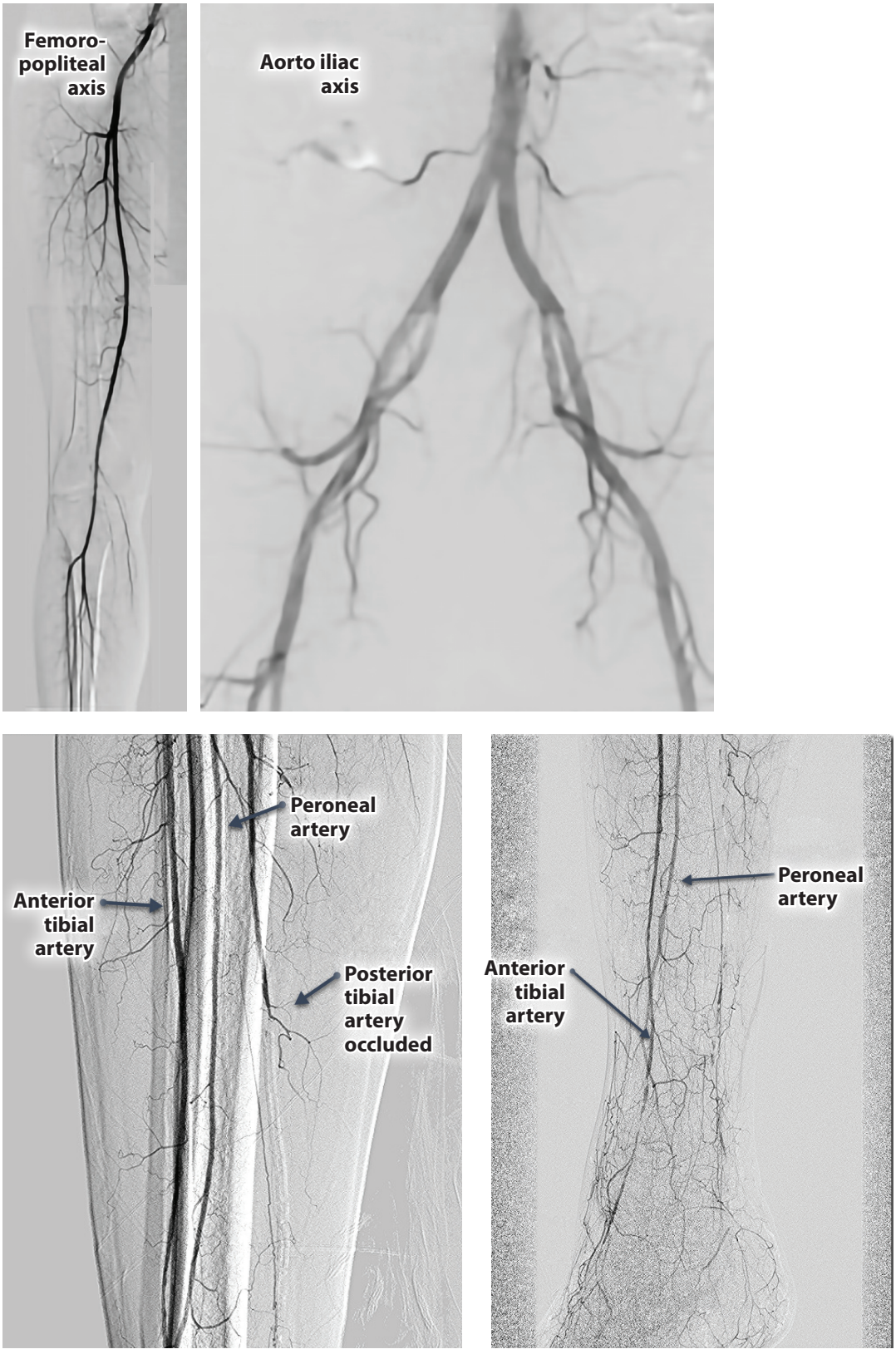
PAD is described anatomically by the level, or the arterial segment affected: aorto-iliac (AI) femoropopliteal (FP) or tibial/tibiopedial) (TBP).[157]

Figure 11: PAD Description. These descriptors are useful and are associated with clinical scenarios. For example, in smokers, atheromatous disease occurs more frequently in the AI and FP segments, whereas in individuals with diabetes, atheromatous disease involves the FP and TBP segments.



Permission from: Reeves I, Chaplain V, editors. Pratiques exemplaires en soins des plaies: de novice à expert. Presses de l'Université Laval; 2023.

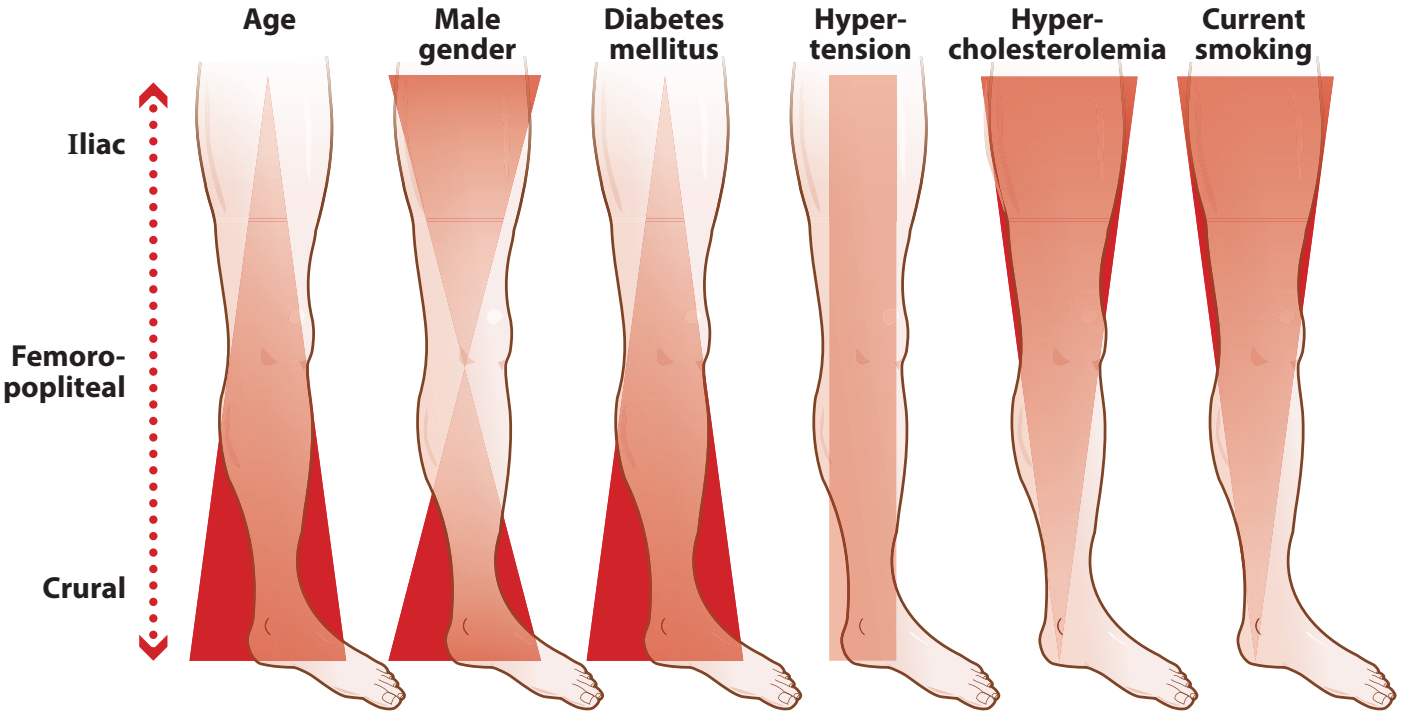
Figure 12: Example of an angiography in a patient with very distal peripheral arterial disease. In this case, the aorto-iliac and femoropopliteal axes are normal; however, only the anterior tibial artery and a portion of the peroneal artery are visualized. The vascularization of the foot is severely compromised.



Permission from: Reeves I, Chaplain V, editors. Pratiques exemplaires en soins des plaies: de novice à expert. Presses de l'Université Laval; 2023.

Patients with typical calf claudication usually present with disease in either the AI or FP segments, and often with only one arterial segment involved. In contrast, patients with severe arterial disease or critical ischemia will usually have two arterial segments involved of the three possible segments (AI, FP and TBP). Occasionally, only the TBP segment is severely affected, resulting in severe arterial disease or CLTI. This latter situation is more frequent in individuals with diabetes. Diehm et al. examined 2659 arteriograms of patients undergoing endovascular intervention. The AI disease was associated with younger age, cigarette smoking and male gender, whereas infragenicular disease was associated with diabetes and advanced age.[158] See Figure 13.

Figure 13: Association of Risk Factors with the Level of Atherosclerotic Target Lesions.
Red overlay on the anatomic figure illustrates the association of risk factor with pattern of atherosclerotic lesions.



Adapted from: Diehm N, Shang A, Silvestro A, Do DD, Dick F, Schmidli J, Mahler F, Baumgartner I. Association of cardiovascular risk factors with pattern of lower limb atherosclerosis in 2659 patients undergoing angioplasty. Eur J Vasc Endovasc Surg. 2006 Jan;31(1):59-63.

MVAP affects the iliac and femoral arteries with the same incidence in all patients, with diabetes or not. However, in individuals with diabetes, PAD occurs more frequently at the level below the knees, i.e., in the tibial arteries (anterior tibial, posterior tibial and peroneal arteries).[159] These arteries, although small, can be dilated percutaneously with balloons or perfused through a bypass surgery with good results. Pedal arteries have also been the target of revascularization. Small-vessel (microvascular) disease involvement is well described in the pathophysiology of other organs, such as the kidneys, heart, retina and peripheral nerves, but it does not affect the small arteries of the lower limb located distal to the tibial vessels, and certainly no more so than in a patient without diabetes but with PAD.[160,161] Capillary microangiopathy around nerves could, however, be one of the causes of peripheral neuropathy, but not of a decrease in peripheral tissue perfusion.[162,163]

For revascularization of the lower limb, procedures are classified according to their effect on blood flow: inflow or outflow. The disease involving inflow affects the aorta as well as the common, external and internal iliac arteries. The common femoral artery marks the transition point between inflow and outflow. Inflow interventions may include angioplasties with or without stenting, endarterectomies, and bypass surgeries. Disease affecting outflow involves stenosis or occlusion of the common femoral and its distal branches. The common femoral gives rise to two branches: the deep femoral and the superficial femoral. The superficial femoral artery becomes the popliteal artery at the knee, giving rise to the three tibial arteries (below the knee). Outflow interventions range from dilatations with or without stenting, to open angioplasty (with patch on the artery) or to bypass surgery using vein or synthetic conduits.

The primary aim of treatment for chronic critical ischemia is to reduce pain, prevent amputations and improve the patient's quality of life, including healing of arterial ulcers. To achieve this goal, many patients will require a revascularization procedure and an aggressive care plan to control cardiovascular risk factors. Occasionally, revascularization may not improve the patient's overall condition or mobility, and in certain circumstances, the risk-benefit ratio for the probability of success of the intervention is clearly unfavourable. This may happen if there is no realistic chance of healing or in a situation with a very large area of tissue destruction. When a functional foot is unlikely to be achieved, or if the patient is in a non-ambulatory state prior to the development of chronic critical ischemia, or if severe comorbidities can lead to poor prognosis, revascularization may not be in the best interest of the patient. Very frail patients with very short life expectancy, patients with poor functional status or patients with severe cognitive impairment may not be suitable for revascularization. Some situations will favour an arterial inflow procedure to improve the likelihood of healing a major limb amputation (below or above knee). The decision to adopt a palliative approach or proceed with a major amputation should be made in agreement with the person and their family and should involve a multidisciplinary team.[163,166]

Endovascular Treatment

Percutaneous endovascular treatment of arterial stenosis is a technique allowing balloon dilatation (or angioplasty) of arteries through a wire. The common femoral artery is punctured and percutaneous access to the vessel is established by working through valve introducer catheters. A wire is placed within the artery beyond the target lesion and then the inserted balloon is expanded with appropriate pressure. That leads to fracture of the lesion and stretching of the arterial wall. The evolution of endovascular therapy has introduced new technologies, including drug-eluting stents, self-expanding stents and cutting balloons (CBs).[164] These reduce post-treatment cell proliferation or restenosis, thereby improving patency. Pharmacologic treatment after angioplasty also has a role in preventing restenosis.

The endovascular approach is less invasive and therefore incurs less morbidity and mortality in the short term then an open surgical approach. On the other hand, it is less durable than the open approach.[165]

For short-distance stenoses in large vessels, the endovascular approach is excellent, with patency rates of 85% for common iliac and of 70% for external iliac at five years.[81,166]

Both the American College of Cardiology/American Heart Association (ACC/AHA) 2022 guidelines[164] and the European Society of Cardiology/European Society for Vascular Surgery (ESC/ESVS) 2017 guidelines[81] agree that hemodynamically significant upper inflow disease (aortoiliac) should be approached via an endovascular treatment if possible. In the case of outflow, they agree that endovascular and surgical revascularization procedures achieve similar outcomes.[167] However, the recent BEST-CLI trial may eventually influence these guidelines.[168]

Compared with the iliac angioplasties, the results of the superficial femoral arteries or popliteal arteries angioplasties are not as good and depending on the device (simple balloon angioplasty, drug-eluding angioplasty, drug-eluting stents, self-expanding stents), the permeability will vary but ranges from 50 to 70% at one year.[166] In fact, every three, six or twelve months, depending on the location and extent of the revascularization, radiological monitoring with ultrasound Doppler is needed to ensure vessel permeability and identify the appearance of early restenosis. As mentioned, the morbidity and mortality associated with endovascular procedures are low, such that multiple re-interventions,which may be required to keep the arterial tree open, are generally safe.[165]

Open surgical revascularization

Endarterectomy is a technique where atheromatous plaque is removed from the artery. The vessel is then often closed with a vein or prosthetic patch angioplasty to increase the diameter of the artery. Any specific artery can be treated with an endarterectomy if the lesion is localized to a segment of artery. The common femoral artery, the junction point between inflow and outflow, is the most frequent site treated with endarterectomy alone or in conjunction with a femoropopliteal bypass or an angioplasty of the proximal vessels (aortoiliac).

Aortoiliac (inflow) disease can be treated surgically with prosthetic bypasses, and they are associated with good patency rates (90% at five year for aortofemoral bypass).[169] Other types of bypasses called extra anatomical bypasses have lower but acceptable patencies (five years) such as femoral femoral bypasses (60-80%) or axillofemoral bypasses (80%),[170] and they are performed in situations when an aortofemoral bypass and an endovascular approach is impossi-

ble. All bypasses are associated with low but significant risk of perioperative wounds and grafts complication (hemorrhage and infection), some of which are avoided with endovascular approach.

The aortoiliac disease is generally treated with an endovascular technique with a stent but, when not possible, then a surgical bypass can be considered in patients with acceptable risks.[164]

Infrainguinal (ouflow) disease can be treated with a bypass originating in the common femoral artery and terminating in the popliteal artery above or below the knee, or even terminating in the tibial vessels or pedal vessels. These bypasses will be considered when one faces long segment occlusions that cannot be treated with an endovascular approach. The use of the saphenous vein is preferred, and the patency rate ranges from 60 to 80% at five years.[171] The more distal the bypass is taken the more the patency decreases.

Hybrid procedures

Hybrid procedures involve simultaneous use of surgery and endovascular techniques for revascularization. Often an endarterectomy and angioplasty of the common femoral artery will be combined with an endovascular angioplasty of the iliac vessels. This allows a more complete revascularization while optimizing the surgical time.

The choice of either endovascular, surgery or hybrid procedure depends on the patient anatomy and takes into consideration the feasibility and long-term durability of the procedure.

The choice of a revascularization procedure, either endovascular or open surgery, will be dictated by the location and distribution of arterial disease as well as the patient's comorbidities.[172]

To choose the best intervention, we must weigh the risk of the intervention against the benefit expected and the outcome of the intervention. The risks of the procedure must be low and the expected chances of revascularization high, restoring blood flow resulting in wound healing.

Chronic critical ischemia as opposed to claudication will often result in several segments of the arterial system involved—for example, an occlusion of inflow in the common or external iliac artery and a severe stenosis of the superficial femoral. Often an intervention on the inflow will be planned first. Following this, and depending on the importance of the outflow disease, an angioplasty of the superficial and popliteal arteries or a surgical bypass may be necessary to improve peripheral perfusion and heal an ulcer.

In a person with diabetes, PAD and a foot ulcer with an adequate segment of saphenous vein in whom infrainguinal revascularization is indicated and who would be suitable for both approaches, consider bypass in preference to endovascular therapy. Many studies identified in the systematic review on bypass surgery vs. endovascular therapy are observational and retrospective case reports.[173] The BEST-CLI trial is a large RCT comparing endovascular therapy first to open bypass surgery first. In the surgery group there are two parallel cohorts of patients: cohort 1 had a good segment of saphenous vein available for bypass and cohort 2 did not have a saphenous vein and required an alternate conduit.[173] The primary outcome was above-ankle amputation, or major reintervention, or death. Treatment with the GSV bypass surgery first was superior to endovascular therapy first for the primary outcome ($p<0,001$). In cohort 2 the primary outcome was similar between the two groups. 71% of patients in this trial were persons with diabetes.

Revascularization procedures should aim to restore in line blood flow to at least one of the foot arteries. Bypass surgery or endovascular angioplasty is ideally performed to an outflow vessel running into the foot. Pedal arch patency has been associated with improved wound healing and reduced risk of major amputation.[174]

Lower-limb Amputation

The decision to preserve or amputate a person's limb or foot is a difficult conversation to have with a patient, care partners and family members. Determining whether to amputate or not must be made on an individual basis and in discussion with care partners and family. It requires an in-depth evaluation of each patient's physical status, mental health, spiritual and cultural beliefs and socio-economic status. While amputation is often seen as the last resort and can elicit a sense of failure for both the patient and the clinician, for some it can be life-giving when there is sepsis from limb infections that would otherwise lead to death. For some it may be a relief from intractable odour, the burden of dressings and living with ischemic pain. Support of the individual and care partners pre- and post amputation is important and must be planned for the long term to support adaptation and increase coping skills.

The World Health Organization has stated that prostheses (artificial hands, legs) and orthoses (splints, braces) enable individuals to live healthier, dignified, more independent lives[175] and that prosthetics and orthotic services play a role in prevention and treatment of diabetes-related foot ulcers. When a limb is amputated, a prosthesis is offered. Yet, it is important to note that not all patients access or use prosthetics. Prosthetic candidacy is dependent upon strength, fitness, range of motion, skin integrity, cognition, functional goals and the level of the amputation. Though prosthetics can offer many benefits, abandonment of the prosthetics does occur.[176]

Post-amputation care is essential for health, function and mobility. With all lower-limb amputations, the use of compression in the form of compression socks, tubular bandages, elastic wrapping (not for above knee amputations) is essential to help shape the remaining limb—often to prepare the stump for a prosthetic or to reduce edema to promote wound healing.[177] Consideration needs to be given to stump edema and wound, periwound skin and prosthetic care for the prevention of further skin breakdown. The Canadian War Amps website provides tips to identify and correct minor problems.

Although not everyone will benefit from the provision of a lower-limb prosthesis and not all will master their device, patients should be offered this option.[178] Individuals living with diabetes and lower-limb amputation, and their care partners, should be encouraged to take ownership of their health and be introduced or reintroduced to foot-care strategies if there is a remaining limb. In one study, it was found that almost half of those living with diabetes who were admitted to an inpatient amputee rehabilitation program had never received information on preventative foot care.[179] Hopping on the remaining limb post operatively will increase plantar pressures and should be done cautiously and in consideration of the presence and severity of neuropathy. It should never be done in the presence of an actual or suspected Charcot deformity. Where there is significant loss of protective sensation and/or Charcot foot, safe transfers should be the main goal until prosthetic training is provided.

When contemplating a major amputation (above the ankle), it is advisable to explore the possibility of revascularization as a first option. The primary objective of revascularization is to restore inline flow to at least one foot artery, preferably the one supplying the wound's anatomical region.[1]

Lower-limb Amputation

The criteria to amputate can be:[180,181]

- clinical: peripheral arterial disease, tissue viability, progressing infection (sepsis)
- patient-focused: lifestyle, occupation, age, preferences, attitude, reliability, social support system, access to care, financial resources
- clinician-focused: policy and procedures, education, advanced skin and wound care system: regional/institutional policies may be in place to support or inhibit limb preservation versus amputation

Amputations can be divided into two broad categories.
Minor amputations:

- amputation of digits
- partial foot amputation
- ankle disarticulation

Major amputations:

- below-knee amputation, abbreviated as BKA
- knee disarticulation
- above-knee amputation, abbreviated as AKA (transfemoral)
- Van Nes rotation/rotationplasty (foot turned around and reattached to allow the ankle joint to be used as a knee)
- hip disarticulation
- hemipelvectomy/hindquarter amputation

4.2 Optimize the local wound environment

In the management and prevention of foot ulceration, treating the cause is crucial for devising effective treatment strategies and preventing recurrence.

Discussion: Local wound care needs to be based on healing potential and the goals that have been set by the patient and care partner as part of the team. The wound environment should be optimized. This involves cleansing, irrigation, debridement, ensuring bacterial balance and controlling moisture.

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for more on local wound care.

4.2.1 Cleansing

Discussion: Wound cleansing solutions vary and should be used at body temperature. Cleansing solutions should be nontoxic, hypoallergenic, readily available, cost-effective and easy to use. Wound cleansing solutions commonly used in management of diabetic foot ulcers include sterile normal saline, sterile water, potable tap water and liquid antiseptics.

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for details on cleansing the peri-ulcer and ulcer.

4.2.2 Debriding

Discussion: Debridement involves removing debris (biofilm), eschar and surrounding callus to promote wound healing. Debridement methods include sharp/surgical, mechanical, autolytic and biologic (larval) therapies.

Persons with diabetic ulcers are prone to heavy peri-ulcer callus development. Sharp surgical debridement is considered the gold standard for DFUs.[1] Debridement allows the clinician to do the following:[102]

- remove tissue that serves as a reservoir for bacteria
- disrupt surface biofilm
- appreciate the depth of the ulcer and evaluate for possible bony involvement
- reduce peak plantar pressure caused by calluses
- facilitate the collection of specimens for culture.

Sharp debridement using a scalpel or curette is considered the optimum method for rapidly debriding the wound.[102] However, only health-care professionals with the appropriate level of training (education, knowledge, skill, attitude and mentorship) should perform sharp or surgical debridement.[102,182] If there is inadequate blood supply to the wound, sharp debridement is contraindicated. Due to the presence of peripheral neuropathy, this is usually a painless procedure; however, pain may limit debridement in some patients. Evidence exists to support regular serial debridement of diabetic foot ulcers to improve healing rates.[102,182] The frequency of debridement depends on the needs of the individual patient.

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for specifics on debridement.

4.2.3 Managing bacterial balance

Discussion: Diabetic foot infections are common, and a comprehensive approach is required for the diagnosis, management and prevention of future events. Diagnosis is made on the basis of clinical symptoms and signs, with adjunctive microbiologic testing to guide therapeutic decisions. Once identified, the infection should be classified by severity. (See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24]).

To manage diabetic foot infections, clinicians are advised to follow these steps:

1. Evaluate signs and symptoms
2. Obtain appropriate specimens for culture
3. Select appropriate antibiotics (based on local epidemiology and antibiotic susceptibility patterns)
4. Determine effectiveness of antibiotics
5. Facilitate further testing
6. Refer to other specialties.

Antibiotic Selection

Antibiotic selection should be empiric and initially related to patient factors and the severity of the infection. In general, acute diabetic foot infections without prior antibiotic treatment are caused by aerobic Gram-positive organisms and most commonly by *Staphylococcus aureus* (including methicillin-resistant strains), alone or in conjunction with the β-haemolytic streptococci.[28] With time, the microbiology of the wound becomes polymicrobial and includes anaerobes. For more severe infections, the recommendation is to use antibiotics with broad-spectrum coverage until culture results and clinical response can be evaluated. Coverage for methicillin-resistant organisms (MRSA) should be considered based on local epidemiology and risk factors. The duration of therapy depends on the severity of infection, the involvement of bone and the patient's response to treatment.

In general, for mild soft tissue infections, one to two weeks of oral treatment is recommended.[77,102,183] For more severe soft-tissue infection or for larger necrotic wounds, a longer course may be required (three to four weeks).[183]

Osteomyelitis usually requires six weeks of treatment, which may be delivered orally or parenterally or combined parenteral and oral, based upon the patient's clinical presentation. Surgical consultation may be required.[102] Antibiotics should be discontinued with resolution of infection, which may be determined on the basis of clinical, biochemical and/or radiographic features, and are not required to continue until wound closure.[102] Following surgical management of osteomyelitis, consider three weeks of antibiotic therapy for minor amputations.[1] It is considered prudent to follow patients after treatment of osteomyelitis for six months to ensure resolution.

Empiric antibiotic options used to treat diabetic foot infections are listed in Table 12.

This serves as a guide only, and antibiotic decisions must be based on the type and severity of infection, culture result if available and patient factors such as comorbidities, allergies and drug interactions (sensitivities) along with local epidemiology and resistance patterns. Consultation with an infectious disease specialist may be required.

Table 12: Empiric Antibiotic Choice for Patients with Diabetic Foot Infections[1]

Severity of infection	Target Bacteria and Examples of Antibiotic Choices & Scenarios (Classes of antibiotic examples in notes below)	
Mild Treatment duration: 1–2 weeks	**Gram positive cocci: S. aureus, beta-hemolytic streptococci**	cephalexin[c], cloxicillin[g]
	Beta-lactam allergy	clindamycin, moxifloxacin[j], levofloxacin[j], trimethoprim-sulfamethoazole, doxycycline
	Gram positive cocci and Gram-negative rods – if recent antibiotic exposure	amoxicillin/clavulanate[b], ampicillin/sulbactam[b], trimethoprim-sulfamethoazole, levofloxacin[j], moxifloxacin[j].
	High risk for MRSA	trimethoprim-sulfamethoxazole, clindamycin, doxycycline, levofloxacin[j], moxifloxacin[j] (depends on sensitivities), linezolid
Moderate to Severe Treatment duration: 3–4 weeks; osteomyelitis: 6 weeks Oral antibiotic should not be used with severe infection, except to switch once infection has improved. Consider consult with infectious disease specialist Urgent surgical and vascular consult should be considered	**No complicating features: Gram positve cocci +/– Gram negative rods**	amoxicillin/clavulanate[b], ampicillin/sulbactam[b], cefuroxime, cefotaxime, ceftriaxone
	Recent antibiotic exposure: Gram positve cocci +/– Gram negative rods	Ticarcillin/clavulanate, pipercillin/tazobactam, cefuroxime[f], cefotaxime[d], ceftriaxone[e], ertapenem[h]
	Macerated ulcer or warm climate	Gram negative rods including Pseudomonas sp: Pipercillin/tazobactam[k], ticarcillin/clavulanate[k], Cloxicillin[g] + Ceftazidime or ciprofloxicin, meropenum[i] or imipenem[i]
	Ischemic/ Necrosis/ Gas forming: Gram positive cocci +/– Gram negative rods +/– strict anaerobes	amoxicillin/clavulanate[b], ampicillin/sulbactam[b], ticarcillin/clavulanate[k], pipercillin/tazobactam[k], ertapenem[h], meropenem[i], imipenem[i] Cefuroxime[f] or cefotaxime[d] or ceftriaxone[e] + clindamycin or metronidazole.
	MRSA risk – add or substitutes	vancomycin[l], linezolid, daptomycin, fusidic acid, trimethoprim-sulfamethoxazole, doxycycline, daptomycin
	Risk factors for resistant Gram negative rods: Extended-spectrum beta-lactamase	ertapenem[h], imipenem[i], meropenem[i], ciprofloxicin[j], amikacin[a], colistin.

Classes of antibiotics listed above:

a. Amikacin – aminoglycoside
b. Amoxicillin/clavulanate, ampicillin/sulbactam(not available in Canada) -ß-lactam-ß-lactamase inhibitor
c. Cephalexin – 1st generation cephalosporin
d. Cefotaxime -3rd generation cephalosporin(not available in Canada)
e. Ceftriaxone -3rd generation cephalosporin (only for iv use)
f. Cefuroxime -2nd generation cephalosporin
g. Cloxicillin – semisynthetic penicillinase-resistant penicillin
h. Ertapenum – group 1 carbapenem
i. Meropenem, imipenem - group 2 carbapenem
j. Moxifloxacin/Levofloxacin, ciprofloxicin – flouroquinolones
k. Pipercillin/tazobactam, ticarcillin/clavulanate - ß-lactam-ß-lactamase inhibitor 2
l. Vancomycin – glycopeptide

MRSA – methicillin-resistant Staphyloccus aureus (risk factors are
ESBL – extended-spectrum ß-lactamase

Adapted from the IWGDF, 2023[1]

Additional considerations

An integrated team approach is recommended for the treatment of complicated infections.[25,28,120] Assessment and appropriate referral to consultants in infectious diseases, and vascular surgery should be initiated early. Similarly, orthopedic surgery, plastic surgery or podiatry/chiropody should be involved to manage foot deformities, resect infected bone or surgically debride tissue. It is often necessary to consult with endocrinology and, certainly, pressure-offloading experts. Close clinical reassessment and follow up is required.

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for a general discussion on managing bacterial balance.

4.2.4 Managing moisture balance

Discussion: Ensure optimal local wound moisture balance to promote healing by choosing an appropriate dressing for the different phases of wound healing.[25] Appropriate wound care and dressing selection promote healing and reduce the risk of infection, so selecting the most appropriate dressing, at a frequency aimed at preventing periwound skin irritation and maceration while keeping the wound bed moist, is essential in managing moisture balance.[105,120]

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for more on managing moisture balance in wounds.

4.3 Select the appropriate dressings and/or advanced therapy

Discussion: The dressings selected may have a considerable effect on the outcome of a diabetic foot ulcer. However, there is insufficient evidence to recommend a specific dressing type for diabetic foot ulcers[184-187]

The general principles of wound management involve the provision of a moist wound environment, debridement of nonviable tissue (nonischemic wounds) and offloading of pressure areas.[28] It cannot be overstated that, for uncomplicated diabetic foot ulcers, dressing choice should always be secondary to correcting high plantar pressures and preventing repetitive trauma.[188] Dressings, however, are required to adequately manage moisture, minimize the risk of infection,[189,190] manage shear forces,[191] and help maintain optimal wound temperature.[192] Choice of dressing should be based on these factors as well as cost and patient preferences. It is important that clinicians and patients jointly select the right dressing and therapies after following the previous steps in the Wound Prevention and Management Cycle.

Specifically, one should consider that dressings with increased bulk may increase plantar pressures over the wound itself or on the contralateral plantar surface.[193,194] Although thicker dressings may initially be considered to pad the wound and protect it from trauma, the opposite is more likely to be true if, in fact, the thicker dressing decreases the space for the foot in the patient's shoe or offloading device. Although dressings can significantly reduce tissue shear forces, there is insufficient published data to assess one dressing's potential over another in reducing shear.[195] Instead, the clinician is left to clinically evaluate shear force reduction by looking for increased callusing of the periwound skin or by evaluating the presence of sub-keratotic hematoma or hemorrhage.[196]

Because of their plantar location, dressings generally are at high risk of saturation due to sweating or external moisture sources such as daily showering or bathing. For patients who prefer self-managed care, a simple non-adhesive dressing that can be changed daily is supported by the literature as a means of managing the moisture balance in the wound and increasing patient adherence to therapy.[197] The ongoing active treatment of diabetic foot ulcers and the presence of a dressing do not negate the need for daily foot inspection.

For further information on dressings, see See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] and the Wounds Canada Product Pickers: Wound Dressing Formulary and Wound Dressing Selection Guide.

Caution: Moist wound healing is a relative contraindication for ischemic ulcers. Consider any of the following adjunctive treatments in non-infected ulcers that fail to heal after four to six weeks despite optimal clinical care:

- A sucrose octasulfate impregnated dressing in neuro-ischemic ulcers (without severe ischemia)
- A multi-layered patch of autologous leukocytes, platelets and fibrin in ulcers with or without moderate ischemia
- Placental membrane allografts in ulcers with or without moderate ischemia
- Topical oxygen therapy
- Systemic hyperbaric oxygen therapy as an adjunctive treatment in ischemic ulcers
- Negative pressure wound therapy to help heal post-operative wounds.[1]

Dressing Protocol for Diabetic Foot Ulcers[184-187]

Prior to dressing/therapy selection the clinician needs to consider three components of care. First, whether best practice has been implemented, including the reduction of plantar pressures, management of blood glucose, control of arterial perfusion and infection, assessment of mental health and wellness, consideration of care partner, family and social supports and availability of funding for therapy. While selecting a dressing the clinician should also consider specific needs of the wound, including necrotic tissue and bacterial and moisture balance. Finally, the goals of care, such as wound healing, wound closure, pain management, exudate management, quality-of-life improvement and/or cost-effectiveness should be considered.

Once the dressing is selected, the clinician should plan the length of trial of the dressing/therapy and ensure it remains part of the assessment, treatment and evaluation processes.

For non-healing ulcers despite optimal care, adjunctive treatments such as sucrose octasulfate dressings for neuro-ischemic ulcers, multi-layered patches of autologous cells, placental membrane allografts and topical and systemic hyperbaric oxygen therapy may be considered, based on the ulcer's ischemic status and available resources. Conversely, the use of biologically active products, topical antiseptics and antimicrobial dressings lacks strong support for routine management.[1]

The following treatments are not well-supported for routine ulcer management:

- biologically active products (collagen, growth factors, bio-engineered tissue) in neuropathic ulcers; topical antiseptics and antimicrobial dressings or applications.[1]

4.4 Engage the team to ensure consistent implementation of the plan of care

Discussion: There is a need to acknowledge the ongoing and potentially escalating risk for skin breakdown in individuals with diabetes as well as the chronic nature of diabetic foot ulcers. Although individual ulcers may occur and reoccur, the relative risk for re-ulceration is high[198] and the team must understand that diabetic foot ulcers are a part of a chronic disease process that must be managed every day in the same way that blood sugars, blood pressures and mental health are managed. The patient's psychological adjustment to a chronic disease is important to disease outcomes, and the disease itself can challenge a patient's belief that they can live well with a chronic disease.[199] For some patients, psychological therapy may be required to support the consistent implementation of the elements of the care plan.

Diabetes-specific education and additional specialized training to help integrate new knowledge and transform old practices are essential for all team members. Investments must be made to ensure that health-care professionals receive specialized training in diabetes education and other chronic conditions relative to the population and cultural contexts in which they practise. In addition, patients, care partners and families need education on diabetes, mental health and wellbeing, preventative foot care, skin health and local wound care.[200]

Educational and academic institutions are encouraged to incorporate best practice guidelines and recommendations into undergraduate nursing, para-professional, medical and allied health-care professional (physical and occupational therapists, personal support workers, paramedics) curricula. These institutions also have an obligation to keep up to date with advances in diabetic foot skin health, promoting wound prevention, assessment and management strategies, and to develop standardized curricula to implement and evaluate these changes in practice settings.[25]

Key Interventions

- Support the patient and care partners in learning about skin health and prevention of foot complications. Engage in credible teaching websites such as: Wounds Canada. Do It Yourself (DIY) Skin Health Series. https://www.woundscanada.ca/patient-or-caregiv er/resources/diy-seriesWounds Canada. Care At Home Series. https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series
- Support the patient and care partners in learning about the chronic and complex nature of diabetic foot ulcers, including factors such as neuropathy, pressure, poor arterial flow and the implications of infection.
- Facilitate referral to mental health and well-being support resources and teams, including psychologist or social worker, and Indigenous support services as needed.
- Monitor high-risk patients.
- Support patient self-management to ensure daily foot examinations, appropriate footwear selection and use, injury recognition and accessing of the appropriate facility for care.

Patient and Care Partner Education

Patients with LOPS should be provided with education on ways to substitute other sensory modalities (palpation or visual inspection using an unbreakable mirror, hand-held thermometer) for surveillance of early foot problems.[70]

The IWGDF emphasizes the need for integrated teams to offer structured, organized and repetitive learning opportunities.[1] In recent Canadian studies, researchers noted that not all persons with diabetes attended education, were aware of credible resources or engaged their foot care partners in daily foot care.[95,201]

Specifically, the IWGDF reminds teams to provide education that focuses on self-care, increasing patients' knowledge and awareness and improved motivation to engage in protective behaviours.[1] They state patients at risk level 1 or higher should be taught to conduct daily foot exams and hygiene, and to identify early signs of pre-ulcerative issues (callus). Patients should learn how to protect skin, use emollients for dry skin and wear seasonally appropriate socks and footwear to protect their feet in all activities, both inside and outside.[1]

Teaching patients and care partners (if able) to trim and file nails has been demonstrated to promote discussions and engagement in self-care.[1]

Proactive education should be offered with the patient and care partner or in small groups. Education should be culturally sensitive, relevant and appropriate to the health literacy of the participants. Sessions should be repeated and creatively presented to better engage learners.[1]

Ensuring that the person with diabetes, and ideally their close family or caregivers, fully understands the information, is motivated to follow the guidance and possesses the necessary self-care skills is vital. Additionally, health-care providers should undergo regular training to enhance their proficiency in educating and caring for individuals at risk of foot ulceration.[1]

See more Canadian Wound Care Advocacy Resources at:

- Diabetes Advocacy. Diabetes Canada. (2023). Introducing diabetes advocacy. https://www.diabetes.ca/advocacy---policies/advocate-for-diabetes-canada
- Wounds Canada. (2023). Advocacy program. https://www.woundscanada.ca/leader-change-maker/11-patient-caregiver/8-advocacy-program
- Wounds Canada. (2023). Policy recommendations. https://www.woundscanada.ca/leader-change-maker/advocacy/policy-recommendations
- Registered Nurses' Association of Ontario. (RNAO, 2023). Policy and political action. https://rnao.ca/policy

Step 5: Evaluate Outcomes

Recommendations

5.1 Determine if the outcomes have met the goals of care

Discussion: Using validated and responsive skin and wound assessment tools and patient feedback, the clinician should determine if the goals of care have been met. Goals are patient-specific, may not involve complete closure of a

wound and may not be those the clinician would choose. If goals have been met, begin discharge planning by reviewing self-management strategies (see Section 5.3). If goals change, refer back to the Wound Prevention and Management Cycle to guide treatment based on new goals.

5.2 Reassess patient, wound, environment and system if goals are partially met or unmet

Discussion: If the goals are not met or only partially met, clinicians should re-evaluate the patient systemically. This includes general care such as blood glucose and A1c, blood pressure control, cholesterol, any medications that may impede healing, smoking cessation, exercise and healthy eating, mental health and wellness and engagement in screening for complications (lower limb, feet, heart, vision and renal).

Wound healing goals include measurement of wound progress, exudate, appearance, quality of life (suffering), undermining, and edge.[204] Paltry and colleagues demonstrated the, "best predictor of wound healing at three months was a 41.8% wound size reduction at four weeks".[205] If the wound is not healing, it requires a full reassessment to determine if all factors that affect healing have been managed. If healing still does not occur, a biopsy should be performed to rule out disease. If the wound is not healing at the expected rate, the clinician should consider the possibility of missed infection, vascular compromise, malignancy, inadequate offloading, lack of patient engagement in care or systemic, environmental or patient-centred obstacles to self-management (e.g., diabetes distress, anxiety, depression). According to the RNAO guidelines, these parameters can quickly change with a high risk of infection and amputation, so frequent monitoring is required.[25]

The most common reason for delayed healing is inadequate offloading.[25] Increasing evidence suggests that the majority of patients with diabetes are non-adherent to using offloading devices or footwear on a regular basis (NICE, 2023). In a study by Ababneh et al. (2023) patients with diabetic foot ulcers used the prescribed offloading treatment only 35% of the time during ambulation though they self-reported adherence of 90%.[206] To prevent and facilitate healing of foot ulcers, pressure redistribution must be addressed with an appropriate offloading device, use of technologies, and identification of barriers to patient adherence must be explored.

Table 13: Core Details for the Reporting of Intervention studies in the Management of Diabetic Foot Ulcer[207]

	Off-loading	Peripheral Artery Disease (PAD)	Infections
Population	No additional details	• Smoking status • Ambulatory status • Previous interventions for PAD, heart failure, cerebrovascular disease • Other relevant comorbidities (e.g., renal disease, depression) • Relevant cardiovascular drugs • Limb symptoms: none, atypical (weakness, limping), intermittent claudication, and rest pain • Toe systolic pressure, toe-brachial pressure index, or transcutaneous partial pressure of oxygen (TcPO2) • Arterial pulse waveform • Anatomical distribution of the vascular disease in the leg • Number of active ulcers • Site of index ulcer	• Preceding antimicrobial use (type, route, duration, and time before presentation) • Immunosuppression • Infection type (using Infections Disease Society of America (IDSA) or perfusion, extent, depth, infections, and sensation (PEDIS) grading: none, mild, moderate or severe • Involvement of bone or joint • Description of how samples were obtained for microbiological examination • Type of and results of microbiological examination (Gram stain and susceptibility)

cont'd. . . .

Interventions	• Details on non-surgical device, application method, material use and frequency of replacement • Specific design details of the foot-device interface • Person applying the device: the patient, a non-professional carer, or a health-care professional • Details of surgical intervention • Evidence of pressure-reducing efficacy if study is on plantar ulceration	No additional details	• Surgery undertaken before, or in association with, antimicrobial administration • Any other relevant intervention (including wound debridement, cleansing, and antiseptic use) undertaken before or in association with antimicrobial administration • Antimicrobial regime: route of delivery, agents and duration
Outcomes	• Ulcer healing • Adherence to the use of non-surgical removable interventions • Foot pressure (for footwear and surgical interventions) • Ambulatory activity level	• Number of participants alive with an intact foot • Description of outflow in the foot (in case of surgical or endovascular interventions) • Ulcer healing • Measures of the effectiveness of the vascular intervention (e.g., toe pressures and TcPO2) • Number of patients with minor and with major amputations	• Resolution of infection (which should be defined) at a prescribed time after stopping antimicrobial treatment • Clinical or laboratory signs of persistent infection at the end of antimicrobial treatment • Number and type of surgical procedures, including amputation (with level of amputation defined according to existing guideline) • Days of antimicrobial use, antimicrobial-free days, and days of hospital admission • Prevalence of antimicrobial resistance after treatment

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Discussion: One important component in sustainability is active patient engagement in managing their care and making choices that will optimize their health status. Studies evaluating diabetes-related education are growing. In a systematic review (14 studies) Abualula et al. discuss the importance of structured educational interventions with an indirect behavioural skills development in adolescents with type 1 diabetes may improve their quality of life.[206] Campbell et al. in a review (16 studies) focused on understanding the role of community health workers alongside diabetes specialities to promote better diabetes outcomes.[208] In an integrative review Colson et al. identified the need for more research to understand the effects of diabetes education for pediatric and adolescents.[209] Similarly, Drovandi et al. report the need for larger studies focused on evaluating the effectiveness of educational interventions focused on diabetic foot disease in adults. These researchers reported diabetes education programs increased diabetic foot disease knowledge and self-care behaviour scores.[210] In addition, the role of machine learning (ML) is growing in understanding the ML role in managing diabetic foot complications including to, "advance diagnostic accuracy and therapeutic approaches by leveraging developments in medical imaging, biomarker detection, and clinical biomechanics".[211]

Patients, care partners, and their families learn through different modalities partially due to learning styles, literacy, preferences (including technologies), and the individual's primary language. Written education material should be available in the relevant language and at a font size appropriate for the reader who may have impaired vision. The role of appropriate technologies in education is expanding. The importance of understanding the role of technology (phone, email, applications, artificial intelligence [AI]) is important when working with patients and their care partners.[212] There is a growing body of research exploring short messaging services[213] and technology that supports home foot monitoring.[214-216]

A role-modeling and real-life demonstration of recommended diabetic foot care techniques can have a positive influence in retention of information and does not require the ability to read.[179] Abrar et al. also remind us of the importance of culture and language.[217] In addition, a patient's trust in the deliverer of the information and the rapport established is also essential if education is to be effective.[216,218]

Whatever the method or methods used, patients should have the opportunity to take part in evidence-informed educational activities, including self-management programs that have specific aims and learning objectives, meet the needs of the patient and promote the patient's ability to manage their own health, if appropriate.[1,25,28] In addition to self-management, patients with diabetes need the continued support of their professional health-care team. An important component of this support is an annual foot inspection that includes monofilament testing, with more frequent testing if indicated by the results of a validated diabetic foot risk screening tool[1,25,28] as well as a foot inspection every time they visit their primary care provider.[1]

Conclusion

Promotion of foot health and prevention of foot complications must become a priority for diabetes care teams across all care settings.

For persons living with diabetes, and their care partners, the development of a diabetic foot ulcer can have devastating complications, multiple hospitalizations, strain on mental health and well-being, infection, amputation and even death. Therefore prevention should be the most important consideration for patients and health-care professionals on the team.

Patients and their care partners need regular, relevant information delivered using clear, effective communication techniques on how to protect their intact skin, prevent ulcers and care for wounds should they develop. They need routine reminders as to how to care for their feet, detect problems early and seek help in a timely manner when problems arise.[1,25,120,121]

If an ulcer develops, aggressive management involving a co-ordinated multidisciplinary team is required. Teams must recognize that the patient and their overall well-being are at the centre of care.

Moreover, integrated teams must recognize that their goals relate not only to management of the wound, but also to correction via the appropriate treatment pathway of the factors that have led, or may lead to, ulceration. Teams may then be successful at breaking the cycle of diabetic foot ulcer development and recurrence and thus preserve limbs.

Health-care organizations must support integrated teams to promote risk assessment and preventative strategies to prevent wounds and to promote wound healing when wounds do occur. This will reduce hospital admissions, infections, length of stay and amputations—thus reducing the financial and economic burden on health-care systems and improving the health outcomes and quality of life of patients.[1,28]

Developing and sustaining successful integrated teams that have a strong impact require standardized, relevant education, motivated health-care workers, supportive organizations and strong associations that engage community, regional, provincial/territorial and federal support.[25,28] The results will have not only a huge impact financially, but also socially, emotionally and psychologically for patients, care partners and their communities.

To diminish the detrimental consequences associated with diabetic foot complications, Canadians deserve an overall structure that is designed to meet the needs of patients requiring preventative and often chronic disease care, rather than simply responding to acute problems when they occur. Factors to consider include the following:

- well-defined treatment pathways and timely access to care in each community
- implementation of interprofessional guidelines for education, screening, risk reduction, treatment
- self-management education for patients care partners, family members
- establishment of services to detect individuals who are at risk, through annual foot examination of all patients and regular screening, with the frequency determined by level of risk
- universal preventative foot care services at the point of care for people living with diabetes
- public reimbursement for preventative footwear, socks and offloading devices for individuals who lack private insurance coverage

- establishment of integrated teams with specialized education to deliver timely and effective treatment if foot complications arise
- auditing of all aspects of the service to ensure that local practice meets accepted national and international standards of care.[1,25]

This chapter will serve as a guide to providing a systematic approach for the prevention and management of diabetic foot complications and assisting organizations in the successful development and implementation of programs to support patients and their teams.

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Appendix A: Patient Quality-of-Life Screening Tools

- The Problem Areas in Diabetes Scale (PAID).[1] http://care.diabetesjournals.org/content/20/5/760
- The Diabetes Distress Screening Scale.[2,3] www.diabetesed.net/page/_files/diabetes-distress.pdf
- The World Health Organization – WHO-5 Well-being Index.[4] www.ncbi.nlm.nih.gov/pubmed/11824831
- The Hospital Anxiety and Depression Scale (HADS).[5] https://academic.oup.com/occmed/article/64/5/393/1436876
- The Patient Health Questionnaire (PHQ-9).[6] https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bc-guidelines/depression_patient_health_questionnaire.pdf
- The Center for Epidemiological Studies-Depression Scale (CES-D).[7] https://www.apa.org/pi/about/publications/caregivers/practice-settings/assessment/tools/depression-scale
- The Beck Depression Inventory.[8] www.hr.ucdavis.edu/asap/pdf_files/Beck_Depression_Inventory.pdf

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Appendix B: Care Partner Stress Screening Tools

- Kingston Caregiver Stress Scale (KCSS).[1] https://providencecare.ca/wp-content/uploads/2016/10/KCSS-Assessment-Form.pdf
- The University of Washington Center on Outcomes Research in Rehabilitation has developed several self-reported measures for consideration.[2] https://uwcorr.washington.edu/measures/
- University of Washington Caregiver Stress Scale
- University of Washington Caregiver Benefit Scale
- University of Washington Self Efficacy Scale (UW-SES)
- The Behavioral Diabetes Institute offers tools for caregivers of teens, adults and partners of adults with diabetes.[3] https://behavioraldiabetes.org/scales-and-measures/

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Appendix C: Quality-of-Life Tools and Scales for Persons Experiencing an Amputation and/or Prosthesis

- The Trinity Amputation and Prosthesis Experience Scale (TAPES-R) - Revised.[1] https://www.physio-pedia.com/images/e/e7/TAPES_2011_Sept_2011.pdf
- Amputee Mobility Predictor Assessment Tool - AMPnoPRO.[2] https://www.physio-pedia.com/images/f/fa/AmpNoPro.pdf
- Functional Assessment Questionnaire for Amputees (FMA).[3]

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Appendix D: Additional Information on Conducting Sensation Tests (SWMT)

Monofilament pressure testing is part of a comprehensive lower limb assessment to screen for loss of protective sensation (LOPS). The inability to perceive the monofilament force is associated with large-fibre neuropathy.[1] Testing 10 points per foot is suggested to capture the largest proportion of patients with LOPS and identify the foot at risk for ulceration. The accuracy and durability of 10-gram Semmes-Weinstein monofilaments (SWM) varies commercially. Monofilaments have a, "short service life and should not be used when they have lost 10% or more of their initial bending force".[1] Some monofilaments, excluding single-use products, can evaluate approximately 70–90 patients (10 site testing) and the monofilament requires a 24-hour rest after assessing 10 patients.[1]

Figure 14: Monofilament Testing Sites

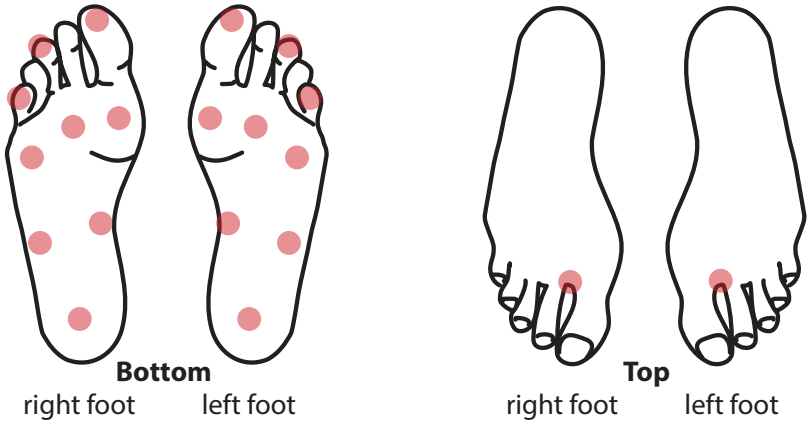
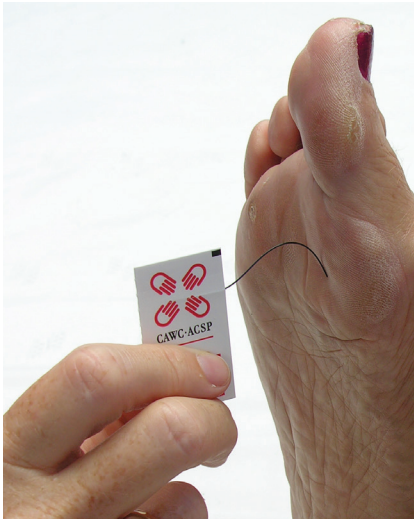


Figure 15: Application of the monofilament



The SWMT uses a 5.07 monofilament that exerts 10 grams of force when bowed into a C-shape against the skin for one second. The IWGDF details steps to correctly use the SWMT.

- First apply the SWMT on the patient's hands, elbow or forehead to demonstrate what the sensation feels like
- Test three different sites on both feet, selecting from those shown in Figure 14
- Ensure the patient cannot see whether or where you apply the filament
- Apply the monofilament perpendicular to the skin surface with sufficient force to cause the filament to bend or buckle (See Figure 15)
- The total duration of the approach -> skin contact -> and removal of the filament should be approximately two seconds
- Do not apply the filament directly on an ulcer, callus, scar or necrotic tissue
- Do not allow the filament to slide across the skin or make repetitive contact at the test site
- Press the filament to the skin and ask the patient whether they feel the pressure applied by having them answer Yes/No and where they feel the pressure (e.g., ball of left foot, right heel)
- Repeat this application twice at the same site but alternate this with at least one 'mock' application in which no filament is applied (a total of three questions per site)
- Protective sensation is present at each site if the patient correctly answers on two out of three applications; absent with two out of three incorrect answers
- Encourage the patient during testing by giving positive feedback.

The 128 Hz Tuning Fork Vibration Testing

The IWGDF (2023) details steps to use the 128 HZ tuning fork to do a sensory foot examination. The steps include:

- First, start the tuning fork vibrating by striking it with your hand. Then apply the tuning fork to the patient's wrist, elbow or clavicle to demonstrate what the sensation feels like
- When conducting the actual test, ensure the patient cannot see whether or where you apply the tuning fork
- Apply the tuning fork to a bony part on the dorsal side of the distal phalanx of the first toe (or another toe if the hallux is absent)
- Apply the tuning fork perpendicularly, with constant pressure (See Figure 16)

- Repeat this application twice but alternate this with at least one 'mock' application in which the tuning fork is not vibrating
- The test is positive if the patient correctly answers at least two out of three applications, and negative if two out of three answers are incorrect
- If the patient is unable to sense the vibrations on the toe, repeat the test more proximally (e.g., malleolus, tibial tuberosity)
- Encourage the patient during testing by giving positive feedback.

Neuropathy is also demonstrated by an inability to sense vibration from a standard tuning fork. A biothesiometer or neurothesiometer can also be used for assessing the perception of vibration.

Figure 16: Correct Application of Tuning Fork



Ipswich Touch Test (IpTT) (Light Touch Test)

The IWGDF states the IpTT has shown, "similar results to testing with the 10-gram monofilament."[2] The IpTT involves the clinician lightly touching or resting the tip on their index finger (See Figure 17) on six or eight sites. Steps to conduct the test include:

- Explain the procedure to the patient/care partner and ensure that everything is understood
- Instruct the patient to close their eyes and to say Yes when they feel the touch
- Test either six or eight sites:
- To test eight sites lightly touch sequentially with the tip of your index finger the tips of the 1st, 3rd, and 5th toes and the hallux of both feet for one to two seconds, **or**
- To test six sites lightly touch sequentially with the tip of your index finger the tips of the 1st, 3rd, and 5th toes and the hallux of both feet for one to two seconds
- When touching, do not push, tap or poke[3]
- LOPS is likely when light touch is not sensed in ≥ two sites whether testingsix or eight sites.

Figure 17: Ipswich Touch Test (IpTT)



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Appendix E: Charcot Neuro-osteoarthropathy (CNO or Charcot Foot)

Charcot foot is one of the major complications of diabetes mellitus.[1] There is no singular cause for the development of Charcot foot but well-recognized predisposing factors include diabetes, peripheral neuropathy, increases in local blood flow, excessive osteoclastic activity, unrecognized injury, continued repetitive stress and obesity. In industrialized countries the prevalence of CNO is high: 35% in persons with diabetes.[2-4]

Terminology: It is important to note the terms *neuro-osteoarthropathy* and *neuroarthropathy* are used interchangeably and mean the same thing.

Charcot- associated fractures (usually multiple) may result from normal activities of daily living—in contrast to those caused by overt trauma.

Charcot foot is characterized by sterile inflammation in individuals with neuropathy, leading to bone, joint, and soft tissue damage, potentially resulting in a deformed foot if left untreated (See Table 14). Charcot foot is a progressive condition characterized by four different disease stages:[5]

0 - Inflammation (acute phase): red, increased in temperature, swollen foot (bones, joints and soft tissue), pain minimal due to polyneuropathy
1 - Fragmentation (active phase): increasing bone fragility, collapse of the longitudinal foot arch, osteopenia leading to fractures, and joint destruction (Lisfranc's joint)
2 - Coalescence (less active): less redness of the foot; soft tissue and bone marrow edema may persist
3 - Remodeling, reconstruction or the consolidation phase: occurs when substantial joint and bone destruction followed by proliferations of the bone, the Charcot, rocker-bottom appearance of the foot emerges.

Table 14: Assessment of Charcot Foot[5]

Stage	Description or Characteristics	Image -
0 Inflammation (prodromal, acute phase)	• Dermal flush/redness • Warm, increased skin temperature(compared to other foot), with or without local edema (bones, joints, soft tissue) • Bounding pulses • Skin intact • Evidence of instability of the foot, plain X-ray (foot and ankle) evidence may or may not be seen. MRI may be needed if X-ray negative	
1 Fragmentation, destruction (developmental, active phase)	• Acute developments of CNO • This acute, destructive period is induced by minor trauma resulting in fragmentation of bone and joint dislocation and subluxation • Important stage for clinicians to recognize and where they can make the greatest difference in prevention of significant impairment for the patient	
2 Coalescence (coalescent, subacute, less active phase)	• The patient presents with lessening ofedema and healing of fractures	

cont'd. . . .

3 Remodeling (reconstruction, chronic phase)	• Healing of bone and remodeling on X-ray, plus evidence of deformity	

According to the IWGDF, an increase in skin temperature of 2° Celsius or 4° Fahrenheit (which is actually 2.2° Celsius) of the involved foot compared to the same location on the uninvolved foot has been used as a diagnostic threshold for active CNO. The IWGDF completed a systematic review and could not identify studies demonstrating the diagnostic accuracy of such measurement when using imaging as a comparator for the diagnosis of active CNO. However, there is evidence in regard to elevated temperature as a sensitive indicator of inflammation in diabetic feet and a precursor to ulceration.

In the absence of other signs and symptoms of inflammation (e.g., redness and swelling), an isolated increase in foot temperature may not always be indicative of active CNO and should be interpreted in the context of other clinical findings. Although an essential part of the diagnostic evaluation, isolated elevation of foot skin temperature is not sufficient to diagnose or rule out active CNO. Consequently, unilateral asymmetric temperature elevation is sensitive but not specific in diagnosis of active CNO. There is no evidence to define which method/protocol for infrared skin temperature measurement is most accurate to diagnose active CNO and where, for example on which anatomical locations, these measurements should be performed.[1]

Diagnosis hinges on clinical signs of inflammation and imaging abnormalities, with MRI recommended when plain X-rays are inconclusive.[1]

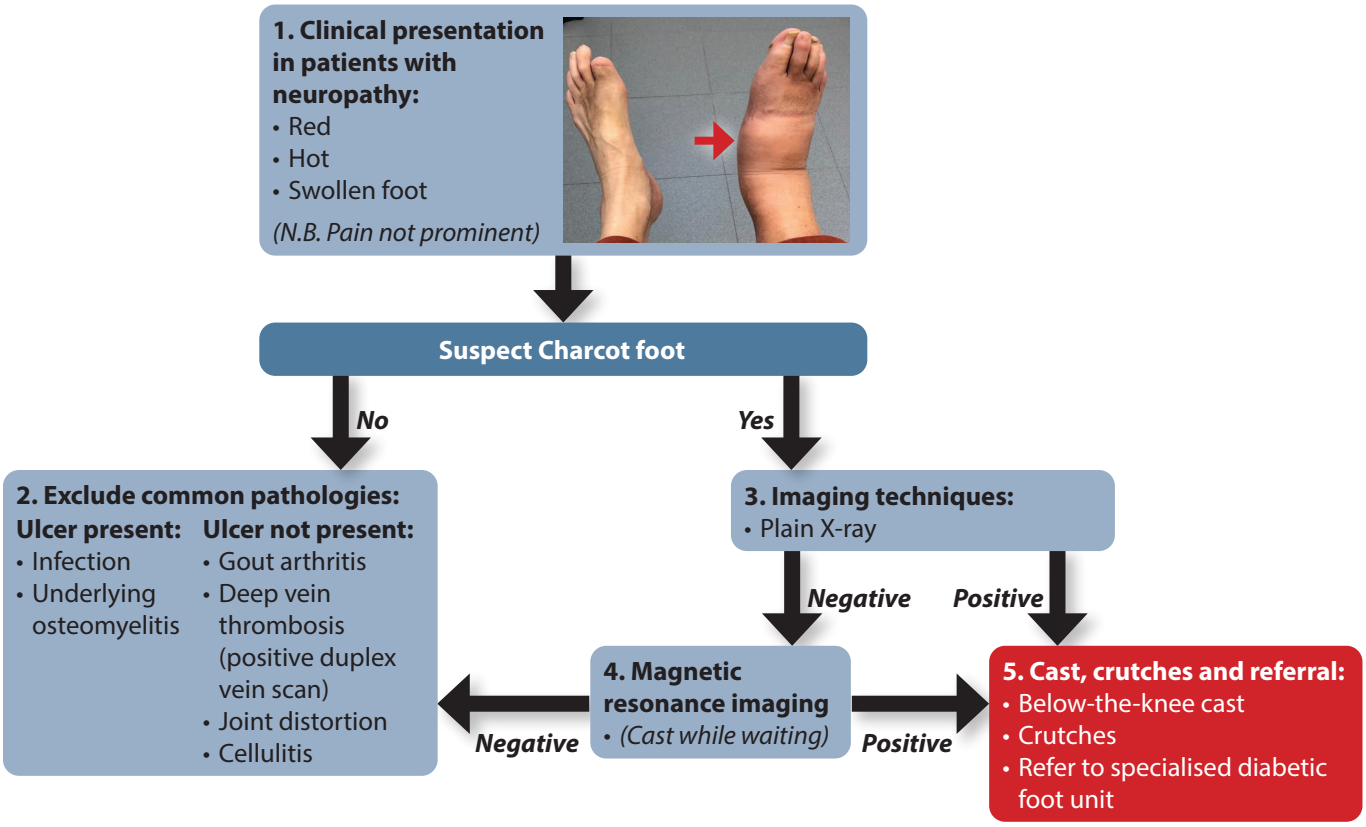
Management of Charcot Neuro-osteoarthropathy

Once a diagnosis of Charcot neuro-osteoarthropathy (CNO) has been made, interventions must be initiated immediately to prevent progression of deformity and subsequent risk for ulcers and amputation.[5] Treatment revolves around immediate plantar pressure management; in the chronic phase, it may require surgical intervention.

Stage of CNO	Charcot Osteo-neuroarthropathy Management[1,5,6]
0 (prodromal)	non-removable knee-high device minimum immobilization: 8–12 weeks
1 (developmental, acute)	non-removable knee-high device immobilization or graduation to removable cast walker
2 (coalescence, subacute)	patellar tendon-bearing brace (PTB) Charcot restraint orthotic walker (CROW walker)
3 (reconstruction, chronic)	custom-made shoes with or without a brace

Treatment emphasizes early offloading and immobilization of the affected extremity using total contact casts or non-removable knee-high walkers, with assistive devices as supplementary options. Offloading should persist until clinical remission with fracture consolidation is achieved, a process that may extend over several months, necessitating close monitoring to prevent complications and adverse effects. See Figure 18: Five steps to manage acute CNO.

Figure 18: Five Steps to Manage Acute Charcot Neuro-osteoarthropathy



Permission granted by D-Foot International.

Medical therapy has limited efficacy in shortening disease duration or preventing deformities, making such interventions not recommended. Supplementation of vitamin D and calcium is advised for individuals with elevated risk of deficiency. Infrared thermometry for skin temperature measurement is a valuable tool for objective disease activity monitoring, although an absolute cut-off value for remission is yet to be defined.

Charcot foot may also be in clinical remission or the, "absence of clinical signs of inflammation, with or without deformity, and radiographic consolidation of fractures, if present, on plain X-ray".[5] Remission is synonymous with the "inactive" stage of CNO.

Charcot foot can be reactivated. This occurs when CNO symptoms recur in the same foot. If active CNO develops in the opposite foot, this is considered a new CNO event. Remission is indicated when there are no clinical signs of inflammation and radiographic consolidation on plain X-rays. Custom-made footwear and orthoses are crucial post-remission to prevent CNO reactivation and optimize plantar pressure distribution. In cases of deformity and joint instability, below-the-knee customized devices may provide additional protection. Gradual foot loading after remission should be implemented, with prompt action in case of recurrence. This comprehensive approach to CNO management aims to improve outcomes and prevent long-term complications in diabetic patients.[5]

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Appendix F: The Self-Assessment Footwear Checklist for Patients[1]

Patients are to ask themselves and check boxes (√) that reflect their present footwear. The tool is to be used to start a conversation about footwear with the patient and/or care partner.	
❑	Are the heels of your shoes less than 2 cm high?
❑	Do your shoes have laces, buckles, elastic or other fasteners to hold them securely onto your feet?
❑	Do you have 1 cm (approximately thumbnail length) of space between your longest toe and the end of your shoes when standing?
❑	Do your shoes have well-padded soles?
❑	Are your shoes made from material that breathes, such as leather?
❑	Do your shoes protect your feet from injury, e.g., cover and protect your entire foot?
❑	Are your shoes safe (e.g., no seams, irregularities) to ensure they cannot cause injury?
❑	Are your shoes the same shape as your feet?
❑	Are the heel counters of your shoes firm?
❑	Are your shoes appropriate for each activity, such as standing for long hours, walking, shopping?
❑	Do they keep your feet dry and free from harm, trauma, injury?
❑	Are your socks made of breathable fabric?
❑	Are your socks smooth, without seams, repairs or rough spots?
Adapted from: Williams A. Footwear assessment and management. Podiatry Management. 2007 Oct; 165-175. Available from: https://podiatrym.com/cme/Oct07%20CME.pdf	

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Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 12

Prevention and Management of Venous Leg Ulcers

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Chapter 12
Prevention and Management of Venous Leg Ulcers

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INTRODUCTION

Physiology of the Lower Extremity Venous System

The lower extremity venous system comprises deep, superficial and communicating veins (See Figure 1a). Supporting returning venous blood flow are unidirectional valves in the 'deep and superficial venous systems and in the perforator veins' (See Figure 1b).[1] The contraction of the calf muscle helps propel venous blood from the superficial to the deep venous system via the communication veins (See Figure 1c). Properly functioning valves prevent the retrograde flow of blood to the superficial venous system.[2]

Figure 1a: The Lower Extremity Venous System

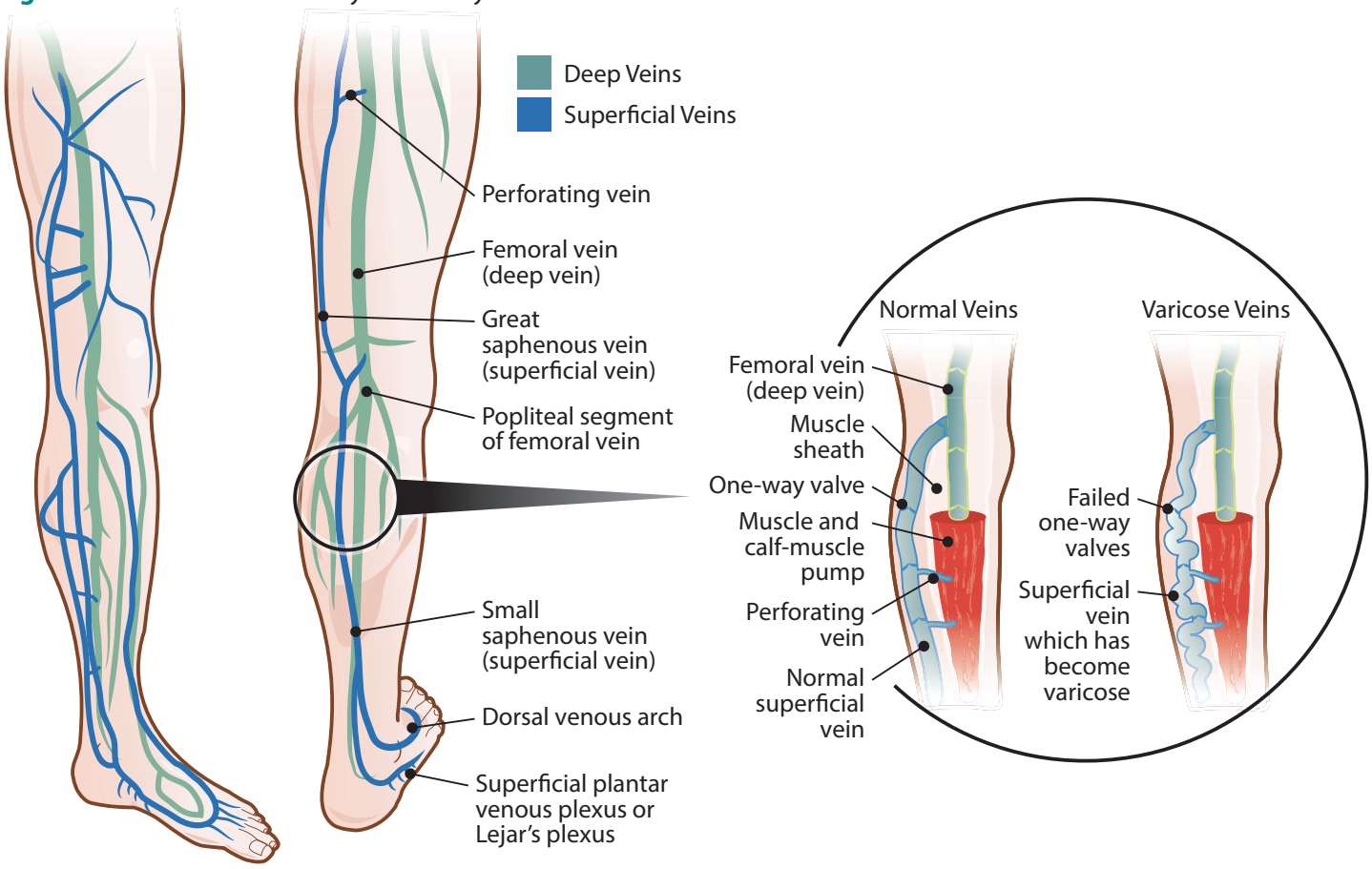

Figure 1b: Normal and Malfunctioning Valve

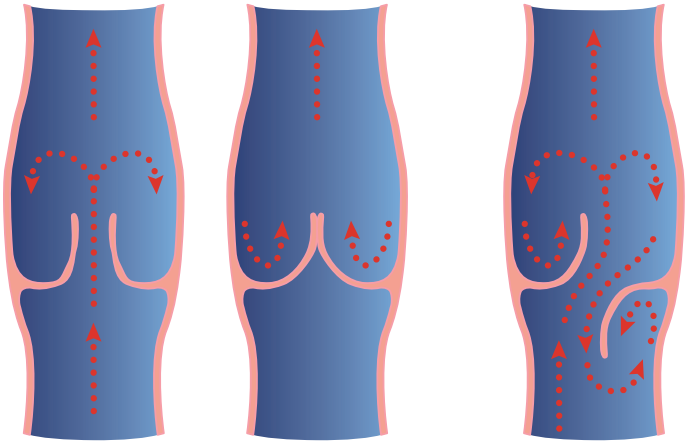

Figure 1c: Anatomy of the Lower Leg



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What is a Venous Leg Ulcer?

A venous leg ulcer (VLU) is an opening in the skin of the leg or foot in an area affected by sustained venous hypertension (high pressure of the blood in the leg veins) and chronic venous insufficiency (CVI).[3-6] Venous leg ulcers lead to approximately 60 to 80% of lower leg ulcers, with the challenge that only 60% heal on average by 12 weeks, and once healed, 75% will recur within three weeks.[7] The pathophysiology of lower leg ulcers is associated with sustained venous hypertension due to CVI, including failure of the calf-muscle pump (CMP), incompetent valves and reflux in the venous leg system.[8] Each of these underlying issues together or singularly could contribute to reduced healing.[9]

Leg changes associated with venous disease are present in 10 to 35% of adults in the United States. This can lead to venous leg ulcers, which affect approximately 1% of the population (prevalence 0.12 to 1.69%);[7] with age this prevalence increases to 4% in people older than 65 years.[10,11]

Venous leg ulcers are common and often recurrent and may result in significant economic and social burden to the patient, care partners, family and health-care system.[12] Patient quality of life is usually negatively affected.[13,14] The role of compression has become well-established as a first-line therapy.[15] Compression of the lower leg, "Is an effective intervention in prevention and treatment of venous and lymphatic diseases, with its effects largely dependent on the amount of compression applied during rest and while walking."[16] The American Venous Forum Research Committee also recommended a focus on topical treatments for VLU as there is a knowledge gap in this area.[17]

Unfortunately, VLUs have a long healing trajectory, with approximately 30% unhealed at 24 weeks.[18-21] In patients who do not fully participate or engage in wearing compression, recurrence of ulcers is two to 30 times greater.[22] Reasons patients may not wear compression include lack of education about VLUs and their recurrence, aesthetic and cosmetic factors, cost of therapy and lack of education for clinicians.[22]

Leading causes of VLU

Individuals at risk for VLU include those over the age over 55, with a history of blood flow changes in the legs, history of blood clots, bone or joint disease (arthritis) in legs or ankles, obesity, sitting or standing for long periods of time, lower limb surgery and multiple pregnancies.[1] Vascular risk factors should always be evaluated, and arterial flow should be quantified,[23] as mixed arterial-venous disease is common, occurring in up to 25% of leg ulcers.[24] Because venous insufficiency is a chronic disease, surveillance for CVI should begin based on an individual's risk factors *before* clinical evidence appears. Early interventions should be implemented to prevent CVI from developing. If the CVI is not prevented and VLUs develop, management of the condition and the wounds will require an interprofessional team who work in partnership with the patient and their care partners to address their specific concerns and to develop a plan for treatment.

When assessing lower limbs, it is important to consider the links between chronic lower leg edema/lymphedema and venous disease. Dean et al. state the four most common causes of lower extremity lymphedema were, "...CVI (41.8%), cancer-related lymphedema (33.9%), primary lymphedema (12.5%) and lipedema with secondary lymphedema (11.8%)."[25] Chronic venous insufficiency (e.g., post-thrombotic syndrome) in the lower limb is also a risk factor for lymphedema and may lead to secondary lymphedema.[26]

Edema which persists for more than three months and is minimally responsive to limb elevation and/or diuretics is defined as chronic edema. All chronic edema involves some lymphatic dysfunction and is appropriately classified as lymphedema (LE).[27] For more information specific to lymphedema, see Chapter 13: Prevention and Management of Wounds Related to Lower Limb Lymphedema.

Consult the Canadian Lymphedema Framework (CLF) at https://www.canadalymph.ca/.[8]

This chapter is written with the intent to encompass the quintuple aim for health-care improvement: to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity. This equity piece is particularly important for patients at risk for, or living with, skin issues, wounds and, specifically, venous leg ulcers (See Table 1). The need to ensure all patients receive care, supplies and ongoing preventative strategies should be recognized and communicated to policy makers.[29]

Table 1: Quintuple Aim and Management of Venous Leg Ulcers

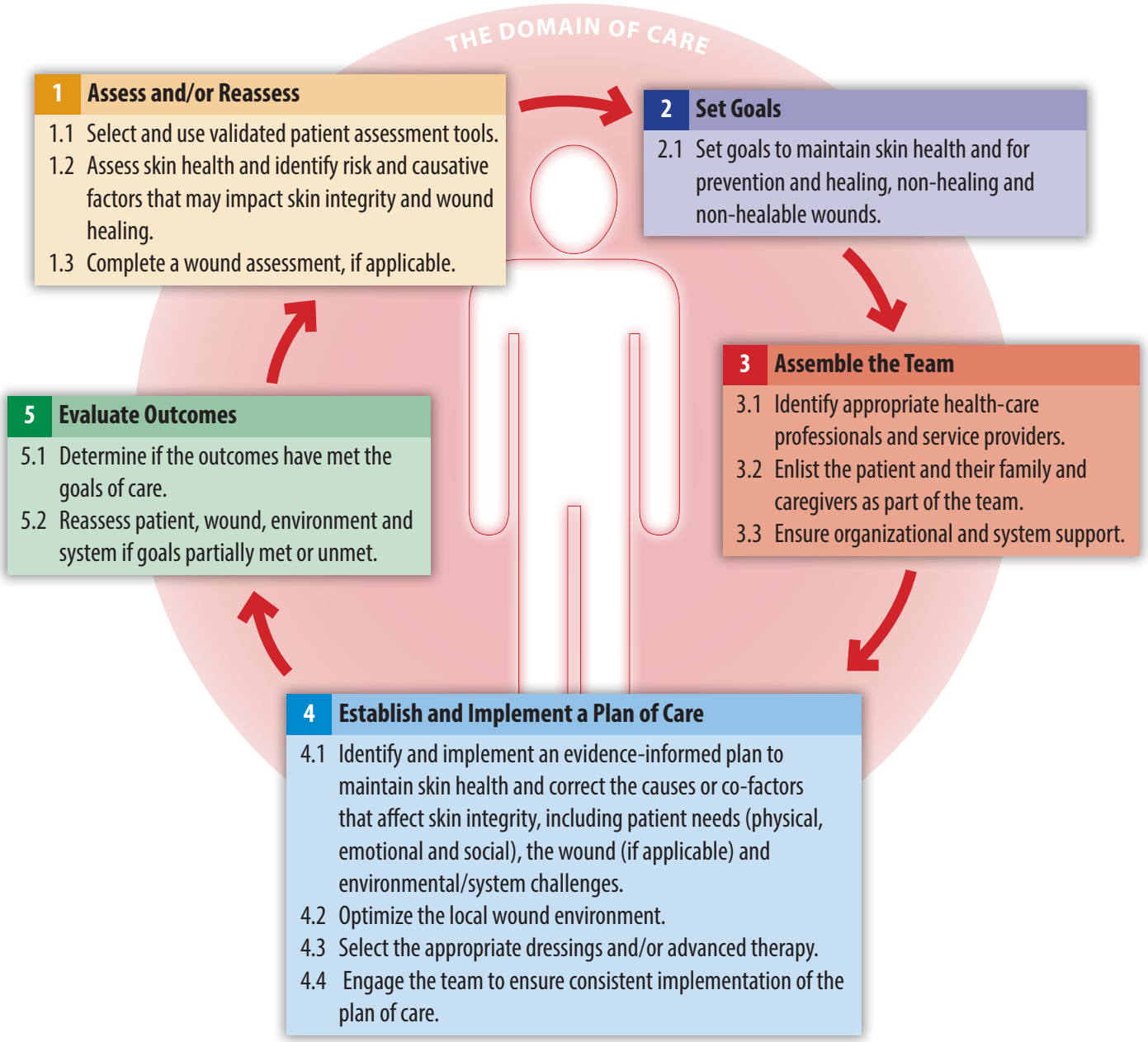
5 components	Applied to Venous Leg Ulcers
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practice guidelines to ensure most effective treatment Appropriate use of resources-examples compression, dressings, devices
Advancing health equity	Application of principles to all those at risk for, or affected by, venous disease
Care team wellbeing	Providing clinically usable information for frontline clinicians
Enhancing the patient experience	Providing a supportive process of care for all those with venous leg issues

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide that incorporates the best available evidence. It outlines a process, or series of consecutive steps, that supports patient-centred care. This process, called the Wound Prevention and Management Cycle (See Figure 2), guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of wounds, from the initial assessment to a sustainable plan targeting self-management for the patient.

The recommendations in this chapter are based on the best available evidence and the most current best practice guidelines available worldwide. They are intended to support the clinician, patient, care partner, family and health-care team in planning and delivering the best clinical practice.

Figure 2: The Wound Prevention and Management Cycle



Two foundational chapters supplement this chapter with additional evidence-informed information and recommendations that are general to all wound types They are Chapter 3: Skin: Anatomy, Physiology and Wound Healing[30] and Chapter 4: Prevention and Management of Wounds: An Overview.[31]

Three guiding principles within the best practice recommendation chapters (BPRs) support effective prevention and management of skin breakdown:

1. Use of the Wound Prevention and Management Cycle regardless of the specifics to prevent and manage skin breakdown
2. Constant, accurate and multidirectional flow of information within the team and across care settings, and
3. The patient as the core of all decision-making.

Step 1: Assess and/or Reassess

Recommendations

1.1 Select and use validated patient assessment tools

Risk Assessment Tools

Chronic venous insufficiency (CVI) is a prevalent disorder that includes impaired return of the blood from the lower extremities. The disorder includes, "lower extremity edema, trophic skin changes, and discomfort secondary to venous hypertension."[6] Risk factors for CVI include, "advanced age, history of deep vein thrombosis, sedentary lifestyle, use of oral contraceptives, leg injury, and hypertension."[6] When the disease is not treated it progresses to venous leg ulcer(s) and post-phlebitic syndrome and this leads to reduced quality of life (pain, itchiness, edema) and changes in employment.[6] In addition, the function of the calf-muscle pump is an important factor to consider in CVI and venous leg ulcer healing. Meulendijks et al., in a systematic review, identified calf-muscle dysfunction as a strong predictor of venous leg ulcer (VLU) severity and healing.[32]



Venous leg ulcer risk assessment tools can also assist in predicting ulcer healing and guide appropriate management, as risk factors for ulcer development are often the same factors that delay healing. Risk assessment tools that have been developed for VLUs are difficult to implement, as the variables to evaluate are not always present in the clinical setting.[33-35]

Two validated tools have been developed by Parker et al. that incorporate medical, physiological and psychosocial factors for understanding the delayed healing of VLUs.[34,35] In a recent validation study, the 10-item risk tool *Venous Leg Ulcer Risk Assessment tool* (VLURA) for delayed healing of Venous VLU was reported to be strong in supporting clinicians to help the patient realistically understand the time it will take to heal the VLU and to focus on what modifiable risk factors they can help mitigate to promote wound healing.[35]

Nutritional Status

It is important to assess the nutritional status of individuals at risk of, or with, VLUs using a validated tool.[36] Protein malnutrition and malabsorption from gastrointestinal distress can contribute to chronic leg edema associated with VLUs. As well, VLUs can be heavily exudating, making fluid and protein intake important to consider.[37]

More information on nutrition and wound healing and screening tools are available to support your practice . Visit the Wounds Canada – Nutrition page: https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/nutrition

Pain: Assessment of pain related to VLUs using a validated tool is important, as patients regularly report mild to moderate or severe pain and how it affects their life.[37] Clinicians have a range of tools that make it possible to evaluate the patient's pain pre-, during and post- procedure, dressing changes and at regular intervals. Pain affects patients' mental health and wellness, and therefore their behaviours and attitudes toward care planning.[38]

For more information on pain, please see Chapter 4: Prevention and Management of Wounds: An Overview.[31]

Clinicians can access validated pain screening tools from the Wounds Canada additional best practice resources. Available from: https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/28-publications/wound-care-canada/200-library-2

Quality of Life (QoL): A wide variety of quality of life (QoL) and health-related QoL assessment tools are available. To assess the patient's QoL generally, the 36-Item Short Form Health Survey (SF-36) is effective in clinical practice.[39] The Wound QoL tool can be used to measure quality of life in patients with non-healing wounds.[40] The Charing Cross Venous Leg Ulcer Questionnaire was found most appropriate for measuring health-related quality of life, as it is disease specific.[13]

For more information on quality of life, please see Chapter 4: Prevention and Management of Wounds: An Overview.[31]

For more information on quality of life and health-related quality of life tools see https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/28-publications/wound-care-canada/200-library-2

Spirituality: For patients living with VLUs and their families and care partners, spiritual activities may offer hope. A growing body of literature on spirituality and wounds indicates patients may benefit from discussing their spiritual care needs. Researchers (2015) using the Spirituality Self-Rating Scale (SSRS) and the Herth Hope Index (HHI) reported those with VLUs with exudate and odour, 20–39 years, retired, or having lived with the wound for one year or less reported the lowest HHI value.[41] Patients experience hope and benefit emotionally knowing clinicians holistically assess their needs, make appropriate referrals and offer advanced therapies.[42]

For more information on spirituality, please see Chapter 4: Prevention and Management of Wounds: An Overview.[31]

Assessment of Ability to Support Self-management and Treatment: As part of VLU care planning, it is important that clinicians assess the patient's ability to support self-management and treatment of leg edema and or VLUs. This assessment may include the ability to wash their legs, don and doff compression stockings and or bandaging, engage in physical activity programs and manage nutritional requirements. To support this need Kapp and Santamaria developed Part 1 of the self-treatment of Wounds for Venous Leg Ulcers checklist (STOW-V V1.0). In a reliability study-Part 2, Kapp and colleagues reported a high-level of agreement among raters and recommended that the STOW-V Checklist V1.0 be utilized when care is organized in a shared-care model involving patients and care partners.[43] More research is needed to fully understand self-management when living with leg edema and VLUs.

Wound Assessment Tools

There are several validated tools available for assessing wounds, but the Leg Ulcer Measurement Tool (LUMT) is one that consists of domains and parameters to systematically assess leg ulcers and aid in assessing changes in wound healing.[44] To describe the wound, the clinician can use the MEASURE mnemonic (measure, exudate, appearance, suffering, undermining, re-evaluate, edge) to assess the basic parameters of a venous leg ulcer (See Section 1.3). For more information on wound assessment tools, please see Chapter 4: Prevention and Management of Wounds: An Overview.[31]

For more information on wound assessment tools see https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/28-publications/wound-care-canada/200-library-2

1.2 Assess skin health and identify risk and causative factors that may impact skin integrity and wound healing

1.2.1. Patient: Physical, emotional and lifestyle

Following the full patient assessment (See Chapter 4), examination of the lower extremities should include a vascular assessment, identification of skin issues, evaluation of joint mobility, mobility aids and gait, including lower extremity strength, skin care regimen, compression garments and footwear. A focused examination of the wound and peri-wound skin condition should also be completed.[45,46] Laboratory and diagnostic tests should be considered based on the specific medical issues related to the patient's co-morbidities and the possibility of infection.

Three hemodynamic abnormalities and examples of risk factors result in venous disease:

1. Valvular reflux
   - Obesity
   - Multiple pregnancies
   - Prolonged sitting or standing (recreation or occupation)
   - History of varicose vein stripping
2. Obstruction
   - History of deep vein thrombosis (DVT)
   - May-Thurner syndrome (anatomic variant at the left iliac vein)
3. Failure of the calf-muscle pump (comerota)
   - Joint issues in the lower extremity (ankle and leg)
     · Arthritis, surgery, trauma
   - Walking
     · Shuffling gait due to medical conditions such as Parkinson's disease

Abnormalities might also result from medication- use (e.g., hydroxyurea, methotrexate), family history, gender (female > male) and or underlying genetic conditions (e.g., Ehlers-Danlos syndrome, Klippel-Trénaunay syndrome).

At the macrocirculation level, there are definite changes that occur in the vein wall and valves. Veins are a high-capacitance system that can accommodate an increased volume of blood. This blood is transported proximally to the heart by the actions of respiration and cardiac function, **but the largest volume is returned by the action of the calf-muscle pump**, sometimes referred to as the 'second heart'. Competent valves ensure one-way flow of blood, while incompetent valves allow blood to return into the tissues and further distend the veins; this is seen clinically as varicosities and edema (See Figure 2b). Within microcirculation, other perturbations occur—such as shear stress due to venous hypertension—causing disruption of the endothelial cells, which play a key role in hemostasis, coagulation and vascular tone.[3]

Venous Hypertension

Ambulatory venous hypertension is a key risk factor for the development of CVI, which in turn predisposes patients to VLU. For blood to circulate effectively throughout the lower extremity, several factors must work together:

- Central pump (the heart)
- Peripheral venous (calf-muscle) pump (the gastrocnemius and soleus muscles and to a lesser extent the other foot and thigh muscles, as well as the structure of the foot)
- Pressure gradient (related to respiration and the movement of the diaphragm)
- Competent veins and valves.

Under normal conditions, when the calf-muscle pump is activated, there is a decrease in pressure in the veins. Ambulatory hypertension is the failure to reduce these venous pressures.

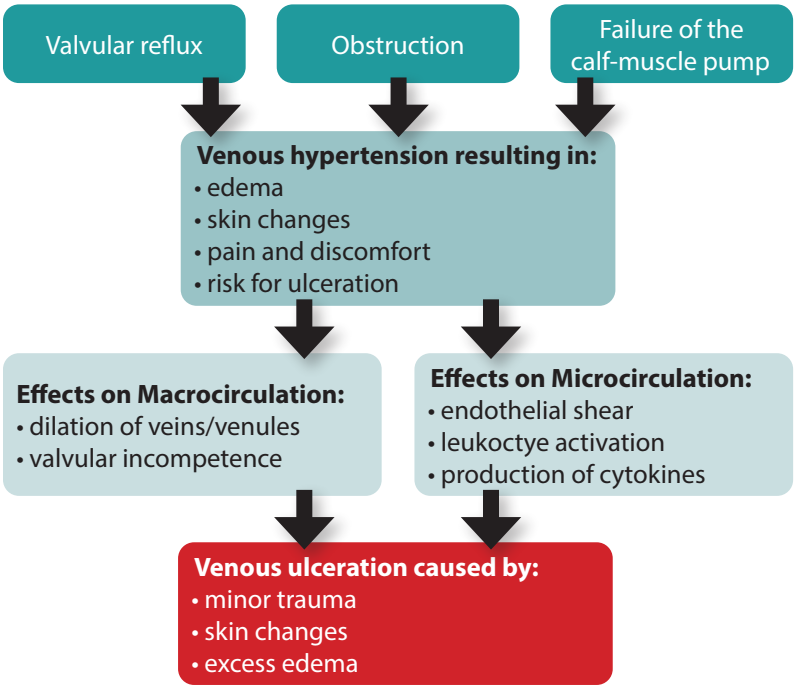
For the calf-muscle pump to function properly, the following are required:[47]

- A functional range of motion around the ankle joint into plantar and dorsiflexion
- Functional strength of the gastrocnemius and soleus muscles
- Proper heel-toe gait.

A correctly functioning calf-muscle pump results in heartbeat-like contractions that help to push blood back toward the heart. Maintaining the foot in proper position by using appropriate footwear when ambulating is also important to ensure that the calf-muscle pump can work optimally during gait. The skeletal and muscular components must be coupled with properly functioning valves within the venous system to ensure the blood does not flow in a retrograde fashion.[47]

The symptoms of venous disease are related to congestion in the venous system of the leg and skin changes including patient complaints of heaviness, fatigue, throbbing, cramping, burning/aching, itchiness of the skin and restlessness of the legs (See Figure 3).

Figure 3: Pathophysiology for the Development of a Venous Leg Ulcer



Physical Findings Associated with Venous Disease Peripheral Edema

Edema results in a palpable swelling in the extremity caused by fluid accumulation in the interstitium. The exchange of fluid in the tissues is tightly controlled and managed by hydrostatic pressure, oncotic pressure and the lymphatic system.

The original Starling's Principle stated: "Fluid movements between blood and tissues are determined by differences in hydrostatic and colloid osmotic (oncotic) pressures between plasma inside microvessels and fluid outside them."[48] Recent research has provided a new understanding of fluid shifts from the interstitium back to the circulation known as the Revised Starling Principle.[49] The endothelial glycocalx is made up of a gel-like layer coating the endothelium and hair-like layer projecting into the vessel lumen. It is composed of glycoproteins and proteogylcans. It is this layer that changes the understanding of fluid shifts and supports the lymphatic system as playing a more prominent role in removing interstitial fluid.[50]

Lower leg edema can be unilateral, bilateral, acute or chronic. A careful history is essential to understand the underlying process. Deep vein thrombosis should be considered with acute onset unilateral edema. The adjacent box lists some causes of edema by primary mechanism.

The biochemical pathway of ulcer formation involves several key factors, including chemical mediators that are released with subsequent leukocytes recruitment. Leukocyte migration into the tissues then initiates an inflammatory cascade with the production of matrix metalloproteinases (MMP), transforming growth factor (TGF-β1), tumor necrosis factor (TNF-α) and interleukin-1. This series of events results in skin changes and ultimately ulcer formation; imbalance in the MMPs is associated with poor wound healing outcomes.[51]

Causes of Edema by Primary Mechanism

Increase in plasma volume:
- Heart failure
- Renal disease
- Hepatic cirrhosis
- Medications (e.g., non-steroidal anti-inflammatory drugs, glucocorticoids, aromatase inhibitors, vasodilators, calcium channel blockers)
- Venous insufficiency or obstruction

Low protein states:
- Nephrotic syndrome
- Protein-losing enteropathy
- Liver disease
- Malnutrition

Increase in capillary permeability:
- Burns
- Trauma
- Inflammation
- Allergic reactions

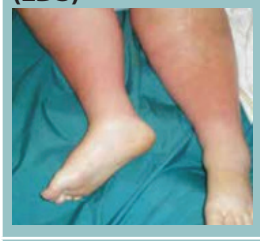
Lymphatic obstruction/damage:[28]
- Lymph node dissection
- Malignancy
- Trauma
- Venous disease
- Infection (e.g., lymphadenitis, filariasis)
- Inflammatory disease
- Immobility

Physical assessment includes identifying physical changes in both limbs for edema, stasis changes, hyperpigmentation of the skin or hemosiderin staining, corona phlebectatica and varicosities. Acute lipodermatosclerosis (LDS) and chronic LDS (a woody texture to the skin) are evidence of progressive changes over months to years. As well, the shape of the limb should be assessed; for example, with chronic LDS, an inverted champagne bottle deformity may be present (See Table 2).

Table 2: Physical Findings Associated with Venous Disease

Physical Changes and Presentation	Comments
Edema 	Edema is the perceptible increase in volume of fluid in skin and subcutaneous tissue, characteristically indented with pressure. Venous edema usually occurs in the ankle region but may extend to the leg and foot. Edema worsens with dependency and improves with leg elevation[52]
Stasis changes 	Eczematous changes make skin vulnerable, with redness and scaling often associated with pruritus. Management involves the use of emollients or topical corticosteroids. Contact dermatitis and allergies and or sensitivities may occur from the use of some topical agents[53]
Hemosiderin staining (hemosiderosis), hyperpigmentation 	When vein valves fail and red blood cells are forced out of capillaries, they break down and release the pigment hemosiderin. This results in grey-brown pigmentation of the skin in the gaiter area[52]
Corona phlebectatica 	This fan-shaped pattern of numerous small interdermal veins on medial or lateral aspects of the ankle or foot is commonly thought to be an early sign of advanced venous disease. Synonyms include *malleolar flare* or *ankle flare*. "The corona phlebectatica (CP) is classically described as the presence of abnormally visible cutaneous blood vessels at the ankle with four components: venous cups, blue and red telangiectases, and capillary stasis spots"[54]

cont'd. . . .

Retention Hyperkeratosis 	Common, benign skin condition related to reduction of edema and routing desquamation. Managed with skin hygiene protocols
Varicosities 	Usually tortuous, but tubular, saphenous veins with demonstrated reflux may be classified as varicose veins. Synonyms include *varix* (plural varices) and *varicosities* Varicose veins are blue, swollen, twisted veins that may be superficial or deep. Common locations include the ankle, back of the calf or medial aspect of the leg[52]
Acute lipodermatosclerosis (LDS) 	Acute lipodermatosclerosis presents with an extremely painful red to purple indurated warm area on the lower leg. It is often misdiagnosed as cellulitis, phlebitis or panniculitis. These changes progress over months to years to the chronic form[55]
Chronic lipodermatosclerosis (LDS) 	Localized chronic inflammation and fibrosis of skin and subcutaneous tissues of lower leg, sometimes associated with scarring or contracture of Achilles tendon. LDS may be proceeded by a diffuse inflammatory edema of the skin, which may be painful, referred to as hypodermatitis LDS, or acute LDS. The chronic form is recognized as a sign of severe venous disease or C4 in the CEAP classification[52]
Inverted champagne bottle deformity 	This is a form of lipodermatosclerosis with subcutaneous fibrosis, which leads to proximal leg swelling with skin tightening and a narrowing band at the distal leg or ankle

cont'd. . . .

Atrophie blanche 	Characterized by localized, often circular, whitish and atrophic areas surrounded by dilated capillaries and sometimes hyperpigmentation, often described as porcelain white scars Atrophie blanche is common, occurring in a third of patients with venous disease, but also may represent livedoid vasculopathy[56] This livedoid vasculopathy is associated with coagulation abnormalities in 50% of cases. The most common location for this is the medial malleolus extending to the dorsal aspect of the foot. Atrophie blanche is painful due to vascular occlusion[52,56]
Venous ulcer 	This full-thickness defect of the skin, most frequently in the ankle region, fails to heal spontaneously and is sustained by CVD

Patients with venous disease and associated leg edema often have stasis dermatitis and are prone to contact dermatitis.[57,58] Contact dermatitis must be differentiated from cellulitis (See Table 3). Breakdown of the epidermal barrier allows penetration of potential allergens and the development of sensitivities. Contact dermatitis is about 80% irritant and 20% allergic.[57,58] In the case of allergic dermatitis, activated Langerhans cells in the epidermis can migrate to regional lymph nodes, producing skin changes in sites distant from the original contact. Common allergens include balsam of Peru, neomycin, lanolin, latex and cetylsterol alcohol, preservatives (parabens, Quaternium[59] and components of adhesives such as rosin.[57,58]

Table 3: Differences between Dermatitis and Cellulitis[52]

Presentation	**Dermatitis** 	**Cellulitis** 
Symptoms	• Afebrile • Itching • Varicose veins/deep vein thrombosis	• Possible fever • Painful • No relevant history
Signs	• Normal temperature • Erythema, inflammation • May be tender • Vesicles and crusting • Lesions on other body parts (e.g., other leg, arms) • Unilateral or bilateral • The erythema may match the area where the product/ointment was used	• Elevated temperature • Erythema, inflammation • Tenderness • One or few bullae • No crusting • No lesions elsewhere • Unilateral
Portals of entry	• Stasis dermatitis with loss of the epidermal barrier allows allergens to penetrate	• Usually unknown; break in the skin, ulcers, trauma, tinea pedis, intertrigo implicated

Laboratory tests	• Often nothing is seen	• May have elevated neutrophils • Obtain skin swabs for *Staphylococcus aureus* or *Streptococcus* infections

Arterial Assessment

Ulcers due to arterial disease tend to be distally located and exhibit a 'punched out' appearance with a well-defined edge and a pale base. Characteristics of venous and arterial ulcers are described in Section 1.3.

Evaluation of the lower limb must include an arterial assessment. Knowledge of the arterial status is important for the safe application of compression and sharp debridement, as well as the expected healing potential of an ulcer if one is present. The most common risk factors associated with peripheral arterial disease (PAD) are smoking, diabetes and advanced age.[3,60] The prevalence of peripheral arterial disease is 14.5% in those older than 70 years.[3] Approximately 15 to 25% of patients with venous disease will also have some arterial insufficiency.[3] The term *CLTI* is preferred over *critical limb ischemia*, as the latter implies threshold values of impaired perfusion rather than a continuum. CLTI is a clinical syndrome defined by the presence of PAD in combination with rest pain, gangrene or a lower limb ulceration over two weeks' duration.[62]

See Chapter 10: Prevention and Management of Peripheral Arterial Ulcers for more on arterial assessment.
The Buerger's Test assesses whether there is sufficient arterial perfusion of the foot in the required range of > 60 mmHg. Controlled compression therapy is possible if a Doppler signal can be recorded from the ankle when the leg is elevated to a height of 77 cm.[63]

Buerger's test:

Figure 4: Buerger's test elevation for 30 seconds, pathological finding with noticeable pallor, loss of capillary refill, loss of venous filling.

Figure 5: Buerger's test sitting for 10 seconds, pathological findings on the left with persistent pallor and delayed reperfusion (compared with the right side).

Figure 6: Buerger's test sitting for 30 seconds, pathological findings on the left with notable reactive hyperaemia (compared with the right side).







Image permission: Cathy Burrows.

More extensive vascular testing or referral to a vascular surgeon may be necessary in high-risk patients when the ABPI is suggestive of arterial compromise or due to a falsely elevated ABPI. ABPI values over 1.4 indicate calcified, non-compressible vessels. This is a common finding in patients with diabetes. A vascular referral should be expedited in patients with symptoms suggestive of CLTI or an ABPI of less than 0.5.1.[64,65]

For more information on the science of an ABPI visit:[66] https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/wcc-2019-v17-no1/1403-wcc-spring-2019-v17n1-final-p-10-25-abpi-pdf/file

For more instruction on conducting an ABPI in practice visit:[67] How to assess blood flow using an ankle-brachial pressure index (ABPI) assessment

https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/wcc-2019-v17-no1/1404-wcc-spring-2019-v17n1-final-p-22-24-abpi-how-to-tool-pdf/file

Investigations for Venous Disease

While it is often possible to diagnose a VLU based on the patient's clinical history and physical examination, it is still necessary to definitively establish venous insufficiency to determine whether the patient would benefit from interventions to prevent skin breakdown, assist in venous ulcer healing (leg edema) or to prevent ulcer recurrence.[3]

Numerous hemodynamic modalities have been developed to investigate venous disease. One of the earliest was plethysmography, whereby a dorsal foot vein was cannulated, and a pressure probe was used to obtain direct measurements of venous pressures. Other less invasive approaches were subsequently developed and included impedance plethysmography, strain-gauge plethysmography, photoplethysmography (PPG) and air plethysmography. These investigations are not widely used today because the widespread availability and ease of use of duplex ultrasound has made them redundant. Duplex ultrasound is useful in assessing both the venous and arterial systems in the lower extremities. It can diagnose deep vein thrombosis and venous insufficiency, as well as arterial flow-limiting lesions and occlusions. The test is safe, non-invasive, cost-effective and reliable.[68-70] B-mode imaging permits accurate placement of the pulsed Doppler sample volume, and the addition of colour helps to establish obstruction, turbulence and the direction of venous and arterial flow.[71]

Duplex scanning is excellent for the evaluation of infrainguinal venous obstruction and valvular incompetence. It also differentiates between acute venous thrombosis and chronic venous changes. Valvular incompetence can be identified by Doppler using reflex time. Today, PPG is mostly of academic value, as it takes a long time to conduct and does not add particularly useful information. Quantifying pump power can be useful in certain circumstances, but it is expensive and limited in its application. An evaluation of the veins of the lower extremity includes visualizing the superficial and deep venous systems. Flow is assessed throughout the course of the deep venous system to rule out deep vein thrombosis and venous reflux; this can also be useful in ruling out reflux and phlebitis in superficial veins. In the deep veins, a reflux duration of one second or greater is diagnostic of venous insufficiency, whereas a reflux of 0.5 seconds or greater in the superficial or perforator veins is diagnostic of venous insufficiency.[3]

Classification of venous disease can occur after a thorough physical assessment using the CEAP (Clinical-Etiology-Anatomy-Pathophysiology) classification system. CEAP is an internationally accepted standard for describing patients with chronic venous disorders, and it has been used for reporting clinical research findings in scientific journals (See Table 4).[72,73] This classification system has not been correlated with outcomes, but does provide the clinician with a structured framework, with the clinical findings (C) being the most useful in practice. However, calf-muscle pump dysfunction is not considered under the etiological section. More research is needed to update this tool.

Table 4: The CEAP Classification for Venous Disease[72,73]

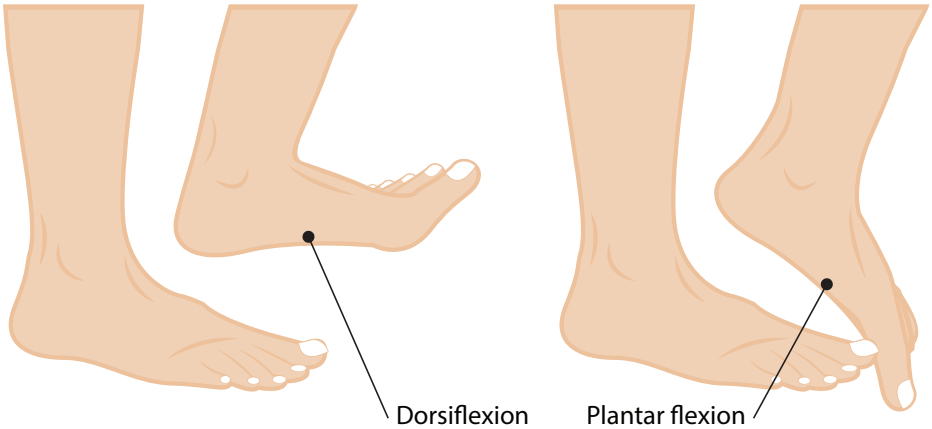
Clinical findings	C0	No visible or palpable signs of venous disease
	C1	Telangiectasias or reticular veins
	C2	Varicose veins; distinguished from reticular veins by a diameter of 3 mm or more
	C3	Presence of edema
	C4	Changes in skin and subcutaneous tissue secondary to CVD
	C4a Eczema or pigmentation	
	C4b Lipodermatosclerosis or atrophie blanche	
	C4c Corona phlebectatica[73]	
	C5	Evidence of a healed venous leg ulcer
	C6	Active venous leg ulcer symptoms
	S	Symptomatic
	A	Asymptomatic
Etiological factors	Ec	Congenital
	Ep	Primary
	Es	Secondary (post-thrombosis)
	En	No venous etiology
Anatomical site	As	Superficial veins (with venous segments) Telangiectasies or reticular veins Great saphenous vein above the knee Great saphenous vein below knee Small saphenous vein Nonsaphenous veins
	Ap	Perforating veins (with venous segments) Thigh Calf
	Ad	Deep veins (with venous segments) Inferior vena cava Common iliac vein Internal iliac vein External iliac vein Pelvic: gonadal, broad ligament veins, other Common femoral vein Deep femoral vein Femoral vein Popliteal vein Crural: anterior tibial, posterior tibial, peroneal veins (all paired) Muscular: gastrocnemius, soleal veins, other
	An	No venous location identified

cont'd. . . .

Patho-Physiological cause	Pr	Reflux
	Po	Obstruction
	Pr,o	Reflux and obstruction
	Pn	No venous pathophysiology identified

Investigation of the Calf-muscle Pump: Screening of the calf-muscle pump is an important part of an assessment of a person at risk of venous insufficiency and poor wound healing.[74] Calf-muscle pump failure is a key contributor to chronic venous insufficiency. The function of the calf-muscle pump is assessed by determining the range of motion around the ankle joint, strength of the calf muscles, gait pattern and if the patient is ambulatory, and with what devices. Normal function of the calf-muscle pump to support venous return requires a, "mobile ankle and routine dorsiflexion beyond 90 degrees".[52] At least 10 degrees of dorsiflexion is needed to fully activate the calf-muscle pump (See Figure 7).[75] Turner et al. state more research (randomized controlled trials) is needed on the role of exercise and wound healing.[76]

Figure 7: Dorsiflexion and Plantar Flexion



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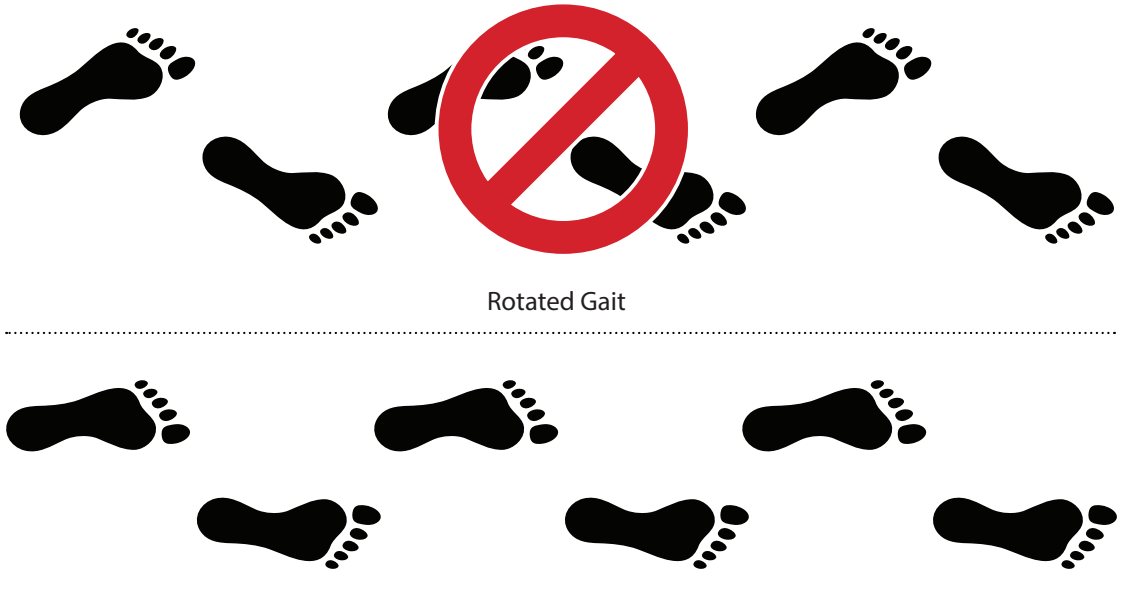
The calf muscle should have adequate strength to optimize proper gait. While standing, the person should be able to go up and down on their toes. The calf-muscle pump is best activated during proper heel-toe gait.[2] Gait pattern (See Figure 8) should be carefully noted, as many people with venous disease develop a 'shuffling' gait. Those exhibiting this gait should be referred to physiotherapy.[52]

Figure 8: Gait with Feet Rotated (top), Compared to Those with Feet Straight (bottom)



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A clinician should not only screen for issues with the calf-muscle pump, but also note the patient's activity patterns, as the potential for physical activation of the system is key. If deficits are noted in range of motion, strength, gait pattern and activity level, clinicians should consider the involvement of a physical therapist or other health-care professionals with knowledge of anatomy, exercise prescription and hands-on techniques that can address these areas to improve calf-muscle pump function. There should be exercise consideration for persons who live immobilized and may have calf muscle atrophy.

Pain

In venous disease pain is reported in about 64% of patients with VLUs.[77] Pain in VLUs is individualized and may be described as tender, dull aching or sharp. Pain may be exacerbated with dependency and improved with compression. It may be related to one or more of the following: edema, inflammation of woody fibrosis, bacterial infections, inflammation of the veins (superficial or deep phlebitis), atrophie blanche, arterial insufficiency or contact and or allergic dermatitis.[78] Pain, for some, can be all-consuming. The stress related to living in pain will negatively impact the wound healing process. Excess production of catecholamines and cortisol caused by stress can impact the immune system and lead to tissue hypoxia.[79] Pain due to arthritis in lower extremity joints limits mobility, which is known to contribute to leg edema and delay VLU healing.[47]

The clinician should assess using validated pain tools, address issues and treat the cause(s). For example, new or increasing pain may be related to local infection[80] or changes in the wound status. It is also important to consider deep vein thrombosis when there is new or increasing leg swelling. Pain that increases with application of compression should alert the clinician to ensure it is not related to (for example) arterial compromise, nerve pressure, or over bony prominences. Pain should be understood in terms of type and impact on the patient and underlying disease processes. Note that patients with diabetic neuropathy may have a reduced response to pain.

Pain is rated by the patient, assessed by the clinician and treated and reassessed on an ongoing basis.[81] Pain for individuals living with a VLU is a burden affecting activities of daily living (leisure, employment), sleep hygiene, mobility, footwear and the mental, emotional, social and spiritual domains.[82] Wound pain affects the patient's participation in care planning, re-assessment of care, wearing preventative stockings and engaging in care related to compression therapy.

For more information on pain, see Chapter 4: Prevention and Management of Wounds: An Overview.[31]

For more information about pain assessment tools, visit Additional Best Practice Resources: Pain Assessment Tools https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/28-publications/wound-care-canada/200-library-2

Patient Assessment Summary

Venous leg disease includes important laboratory and historical elements that should be considered in the patient-focused assessment. Table 5 summarizes key elements of the assessment.

Table 5: Key Components of the History and Physical Examination

History	• Risk factors for venous or arterial disease • Co-occuring conditions (diabetes mellitus, connective tissue diseases, inflammatory conditions), arterial risk factors • History of the ulcer(s) and recurrence and treatments used, tests conducted and effectiveness
Bedside examination	• Blood pressure (BP) • Examine lower leg and identify ulcer characteristics • Feel for pulses at the femoral, popliteal, dorsal pedis and posterior tibial • Ankle-brachial pressure index (ABPI) • Gait assessment, including walking aids/footwear/physical activity and ankle-joint range of motion

Laboratory	• Blood glucose level • Creatinine, CBC, AST, plus others depending on co-morbid issues, diagnostic considerations (thrombophilia screen if DVT or history)
Vascular laboratory	• Venous duplex Doppler • ABPI and more extensive arterial studies if indicated
Allergies and or sensitivities	• Medication(s) • Topical agents • Environmental
Self-care/ treatment abilities and psycho-social issues	• Ability to actively participate in skin health and wound care treatments/interventions[43] • Quality of life assessment • Continence status (urine, fecal or both, and associated devices) • Patient support systems (care partner, family)
Nutrition	• Weight • Use of validated nutrition tools
Medications	• Immunosuppressants • Possible drug interactions if adding antibiotics or other agents
Pain	• Procedural • Related to disease • Related to compression or dressings • Use of validated tools to evaluate

1.2.2. Environmental: Socio-economic, care setting, potential for self-management

The patient's ability to participate and engage in co-creating treatment goal(s) and care plan should be assessed. The clinician should determine the patient's ability to engage in preventive self-care skin and wound treatment measures, including consistent management of leg edema. Ulcer formation and changes to mobility may contribute to employment changes, job loss or changes in one's level of social engagement.[13] As well, leg edema may have an impact on patients' ability to toilet safely and in a timely manner. Issues specific to venous disease to consider include the amount of exudate, possible odour and pain that can affect the patient's activities of daily living (e.g., bathing, walking) and



instrumental activities of daily living (e.g., shopping, driving, computer use, taxi/transportation use and help with limbs). Managing appropriately fitted footwear can be a challenge due to leg edema and the bulk of some compression systems. As well, the frequency of dressing changes may vary, and large amounts of exudate can further challenge the patient and family supports.

Financial concerns may prohibit patients from taking time off work for appointments and impact their ability to purchase skin health supplies, preventative leg garments/devices, mobility aids and footwear. For some, transportation to and from appointments and parking costs may be prohibitive. The risk of altered skin integrity may change, as will the ability to participate in treatment plans. If patient needs are not met, the ability for wound prevention, wound healing, wound recurrence, and/or managing chronic venous insufficiency symptoms is diminished, potentially affecting the feasibility of a goal of wound prevention or healing.

Safety First: Remember to use good body mechanic techniques at all times when assessing and moving patients to protect yourself and your patients from injury. Edematous legs can be heavy!

1.2.3. Systems: Health-care support and communication

People at risk of developing VLUs, or recurrence, may live with multiple, chronic diseases, resulting in additional emotional, physical and psychosocial burdens.[83,84] Financial coverage of compression garments, venous leg dressings and other therapies varies within each health region, and many health-care systems do not financially support VLU treatment(s), leading to increased patient financial burden. For patients living in rural and remote areas, access to diagnostics and specialized care may be limited; this can be the case in urban areas as well. Assessing the health-care system in which the patient is involved will require the health-care professional to guide and refer the patient and family for financial support.

1.3 Complete a wound assessment, if applicable

Evaluation of VLUs requires careful consideration of the patient's history and a focused physical examination. The wound and periwound skin should be evaluated in terms of numerous parameters, including location (e.g., gaiter area, malleolar area), ulcer size and depth, amount and type of exudate (mild to severe), appearance of the ulcer (irregular in shape), condition of the wound edge (e.g., attached, rolled), signs of clinical infection (see bacterial burden, section 4.2.3) and condition of the periwound skin (See Table 6).

Table 6: Example of the MEASURE Mnemonic Used with a Person with a VLU[85]

Parameter	VLU assessment includes the following:
Measure	Measure the VLU longest length with the widest width at right angle and the depth
Exudate	Record the exudate amount (none, scant, moderate or heavy), and characteristics (serous, sanguineous, purulent or combination of exudates) Comment on the odour after cleansing
Appearance	Consider the type of tissue in the wound (necrotic, fibrin, slough, friable, granulating, hypergranulating) Assess periwound skin and note skin changes
Suffering	Assess pain and quantify (pain 0–10, quality, timing) Record the relationship to daily living Record the relationship to dressings, skin and wound care and application and use of compression garments
Undermining	Determine location, often described using the hands of a clock, and measurement
Re-evaluate	Do so at regular intervals related to wound dressing changes
Edge	Determine whether the wound edge is normal, attached, hyperkeratotic, macerated or rolled

Differential Diagnosis

When the observed venous leg ulcer findings do not fit the classic characteristics, clinicians need to be aware that additional categories of leg ulcers exist, such as those identified in Tables 7 and 8.

Table 7: Differential Diagnosis of Leg Ulcers[3]

Categories	Examples
Vascular	Venous disease, mixed arterial venous, Martorell hypertensive ulcer
Inflammatory	Pyoderma gangrenosum, polyarteritis nodosa, necrobiosis lipoidica
Hematologic	Sickle cell disease, polycythemia vera
Autoimmune	Rheumatoid arthritis, leukocytoclastic vasculitis, Sjörgren's syndrome, cryoglobulinemia
Malignancy	Basal cell, squamous cell, melanoma, cutaneous lymphoma
Infectious	Bacterial, viral, fungal
Metabolic	Diabetes mellitus, calciphylaxis
Medication	Hydroxyurea, methotrexate
Genetic defect	Klinefelter syndrome
Exogenous	Trauma, radiation, pressure

Table 8: Differences Between Venous and Arterial Ulcers[5,86,87]

Assessment	Venous Ulcer	Arterial Ulcer
Health history	Deep vein thrombosis, vein surgery, venous disease, leg trauma, failure of the calf-muscle pump	Cardiovascular disease, stroke, peripheral arterial disease (PAD), advanced age
Lifestyle	Sedentary, obesity, immobile or working in occupations requiring prolonged standing or sitting	Smoking, malnutrition, obesity
Anatomical location	Gaiter region of the leg (malleolar)	Below ankle, tips of toes
Measurement (size)	Shallow, irregular, larger in size	Deep, smaller size
Exudate	Moderate to large amount	None to minimal amount
Appearance	Often covered in slough, granulation or fibrin	Black and dry tissue
Suffering	Discomfort at the end of the day, heaviness in legs	Pain with elevation of the legs or with activity
Edge	Attached edge, may be sloping	Unattached edges
Surrounding skin	Dry, scaly or macerated skin	Dry, shiny; loss of hair
Pedal pulses	Present	Weak or absent
Leg characteristics/ conditions	Edema limb, Varicose veins, hemosiderin staining; may also have lipodermatosclerosis, atrophie blanche and stasis dermatitis	Edema not common Pallor, dependent rubor, poor capillary refill, changes to nails, possible gangrene of toes

Infection

Wound infection develops as a result of micro-organisms invading the tissues, causing damage and invoking a local or systemic response in patients with VLU. Certain factors make VLUs unique in terms of infection, including large size or multiple ulcers, significant exudate and edema, stasis changes of the skin and arterial insufficiency, which coexists in about 25% of ulcers.[24] Edema and stasis changes predispose patients to small breaks in the skin, allowing microbes to en-

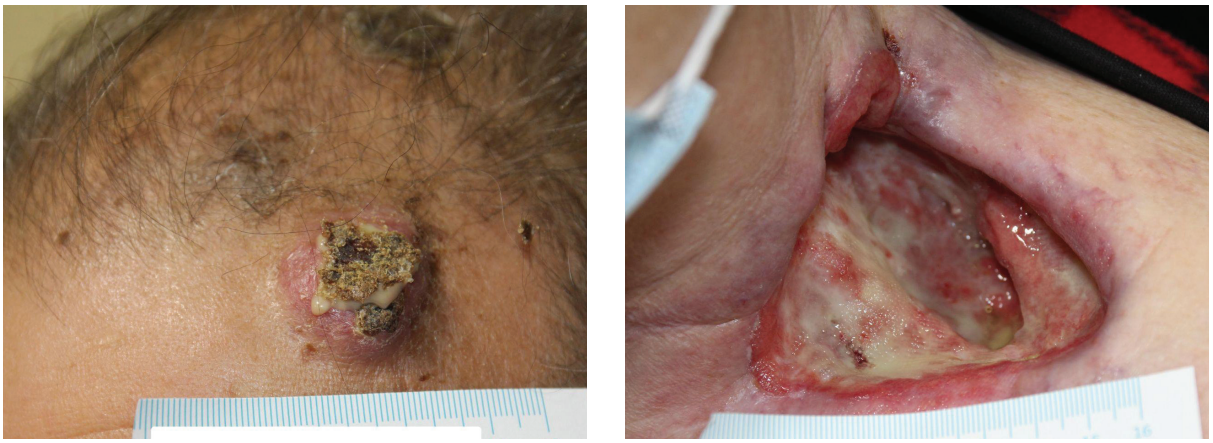
ter. Edema fluid also neutralizes the fatty acids of sebum, reducing the inherent bactericidal properties of the skin.[81] Clinical evaluation of infection involves assessment of wound characteristics, as well as the patient's symptoms and wound bed microbiological cultures. Swab cultures should only be obtained in the presence of clinical signs of infection.

For more on infection, please see Chapter 4: Prevention and Management of Wounds: An Overview.[31]

Malignancies

Non-healing VLUs can be a risk factor for the development of malignancies. Characteristics associated with malignancy include friable surface tissue, raised borders, abnormal granulation tissue and failure to respond to treatment. A squamous cell carcinoma arising from a non-healing wound is known as Marjolin's ulcer.[88,89] Basal cell carcinomas are the most common presenting malignant ulcer in the leg. Biopsy is recommended when there are atypical features or failure to improve after four to six weeks with appropriate management, including compression.[3] It may be necessary to do multiple biopsies to exclude malignancy if clinical suspicion is high. The patient history is important, as malignancies are more common in patients on immunosuppressants, and in areas of a scar or previous areas of radiation. Malignancy is also more common with advanced age and ulcers on the anterior shin (See Figure 9).[90]

Figure 9: Malignancy



Step 2: Set Goals

Recommendations

2.1 Set goals for healthy skin, prevention of trauma, healing, non-healing and non-healable wounds

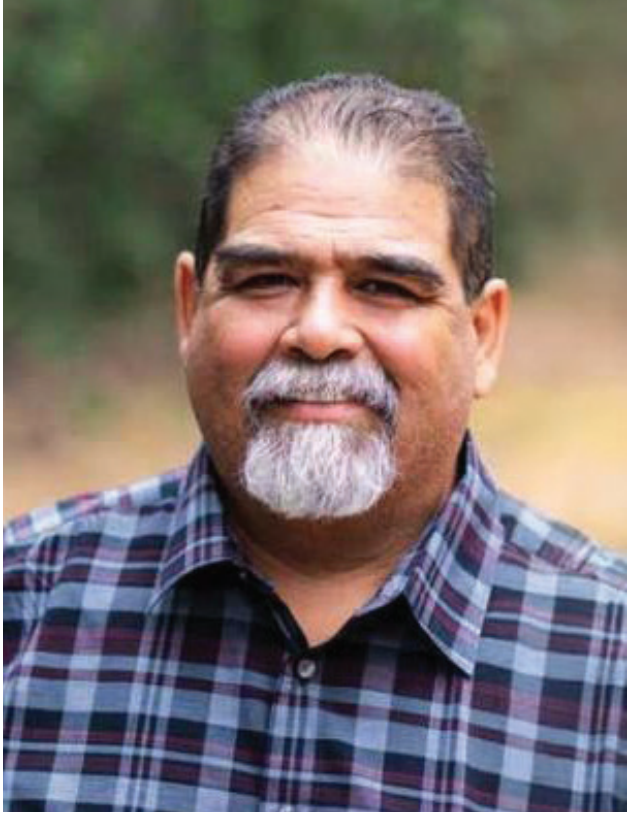
Patient-driven SMART goals are based on comprehensive patient, environmental and support system assessments and are co-developed in collaboration with the patient and care partners. Goals to promote and protect intact skin are a priority. For more information on SMART goal development see Chapter 4: Prevention and Management of Wounds: An Overview.[31]

2.1.1 Identify goals based on prevention or healability of wounds

Goals should be developed to support the management of skin care, leg edema and the prevention, healing or recurrence of VLUs. Goals change over the course of care and should regularly be reviewed and reassessed with the patient and/or care partners.

Examples of Preventative Skin and VLU Goals

- Skin care regimen in place within one day
- Foot care and footwear plan established, with a focus on prevention of trauma to skin
- Leg edema reduced by elevating the affected limb above heart level for 30 minutes, three times per day
- Leg edema reduced through continuous use of compression therapy (wraps or pumps) within two weeks; including care and management of wraps
- Leg edema prevented through long-term use of garments once edema is reduced
- Calf muscle and calf-muscle pump activation exercises using elastic bands 10 times, three times per day
- Walking using heel-toe gait for 20 minutes two times per day
- The risk of injury reduced through the reduction of environmental hazards within two days
- Activities of daily living modified in two weeks to renew activity and full ADLs resumed within one month



Wound Healing Goals

The designation of the VLU as healing, non-healing or non-healable or recurring, may change over time and affect goal setting. This is most obvious if arterial flow can be improved to the extremity through vascular surgery; in this case, the wound may transition from a non-healing to a healing wound. Responsible use of resources is necessary, and this is an important consideration in venous disease management. The type and re-usability of compression wraps will be a consideration if the wound is not considered healable.

Examples of Goals for Patient with a Healing VLU

These goals may be appropriate where there is sufficient vascular supply, underlying causes have been corrected and health is optimized.

- Leg edema management goals, as in prevention
- Wound closure within three months
- Infection managed with antimicrobials within two days
- Exudate managed through dressing selection within two days
- Pain managed though analgesia within one day
- Awareness of signs and symptoms of infection learned within one day
- Planning purchase of lower leg compression stockings and application device to don stockings within seven days
- Hand hygiene education to reduce infection (cellulitis) within one day
- Proper hand-washing, hanging to dry of stockings and or garments within two days. (Note daily washing helps the elastic in the garment return to its original shape and may increase the life of the garments)
- Mental health screening for distress, depression, anxiety and supports within two weeks.

Examples of Goals for Patient with a Non-healing VLU

These goals may be appropriate where there is potential to heal, but where wide-ranging patient or health-care system factors are limiting wound healing. This includes the patient's inability to accept or consistently wear compression therapy as prescribed. These issues may take weeks or months to address.

- Leg edema managed (e.g., identify specific approach patient and care partner is able to achieve and maintain)
- Independence established with dressing changes using clean technique
- Drainage, itchiness and odour managed with recommended dressings
- Pain managed using analgesia
- Awareness confirmed of signs and symptoms of infection and/or deterioration, and to whom to report concerns
- Infection prevented and/or treated with antimicrobial dressings
- Mental health screening done for distress, depression, anxiety and hope, and referrals made to appropriate supports
- Lower leg compression stockings and donning application device purchased and appropriate education provided
- Hand hygiene to reduce risk of infection (cellulitis)
- Proper hand-washing and hanging to dry the compression stockings and garments supports the elastic in the garment to return to its original shape (this may extend the life of the garment).

Continue to reassess to identify if wound status moves to healable.

Examples of Goals for Patient with a Non-healable VLU

These goals may be considered when there is no ability to heal due to untreatable co-morbidities such as severe PAD/CLTI, malignancy and/or an end-of-life illness:

- Same as for non-healing VLUs
- Attendance at a chronic disease-management support group, as able
- Attendance at smoking cessation session(s), as able
- Continue to reassess to identify if wound status moves to non-healing or healable.

For more information on healable, non-healing and non-healable see Chapter 4: Prevention and Management of Wounds: An Overview.[31]

2.1.2 Identify quality-of-life and symptom-control goals

Quality-of-life and symptom-control goal setting requires co-ordination and communication to ensure patient involvement and effective management of venous disease. It is essential that the integrated team set realistic goals around smoking cessation, appropriate garments and footwear, and medication management, as well as ADLs such as exercise and physical activity. If patients experience an exacerbation of their disease, goals may need to be revisited and modified.

Step 3: Assemble the Team

By connecting health-care professionals with the patient, family members, care partners and service providers, health care becomes the responsibility of an integrated team. Respectful team communication is essential, especially when not all team members are in the same clinical setting.

Recommendations

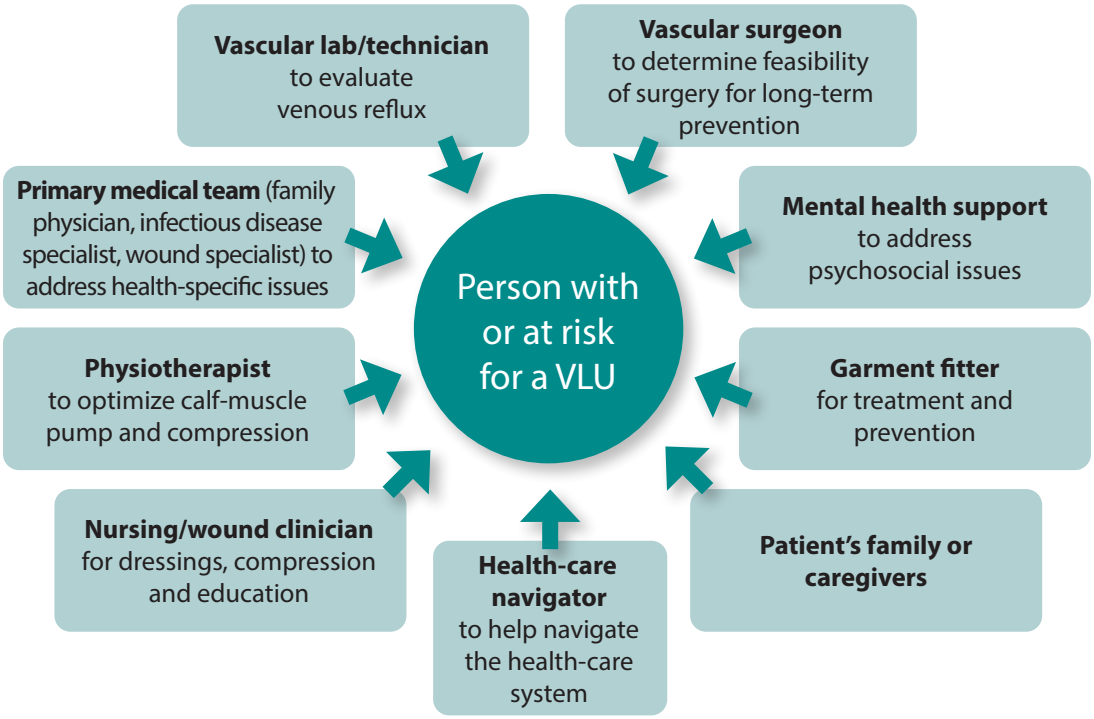
3.1 Identify appropriate health-care professionals and service providers

Completing a comprehensive assessment of physical, psychological, spiritual and socio-economic needs will help determine which health-care members and service providers must be part of the care plan.

Patients with wounds, chronic venous insufficiency or venous leg ulcers may require the skill of numerous health-care disciplines, depending on the patient's needs and availability in the community of team members. The team will likely change over time depending on risk, the presence of a leg edema, a wound, patient factors and the wound healing process. Team members might include nurses, physicians (general, specialized), pharmacists, social workers, psychologists and spiritual advisers, vascular technicians and surgeons, physiotherapists, occupational therapists, pharmacists, mental health and chronic disease self-management groups, registered dietitians, diabetic educators and garment fitters.

Some team members need to be in place to help the patient navigate the health-care system in which they are operating, specifically in areas such as accessing and using equipment, funding, activities and instrumental activities of daily living and travel (OTs), as well as mental health screening, counselling, accessing medical benefits and insurance coverage for garments, devices or therapies (social worker) (See Figure 10).

Figure 10: Example of an Integrated VLU Team



3.2 Enlist the patient, their family and care partners as part of the team



Enlisting the patient and their care partners within the health-care team is a critical component to the success of VLU prevention and treatment outcomes.[91,92] Compression therapy and calf-muscle pump exercises are the mainstay in VLU therapy. Education and support are needed about the role of compression and the rationale for wearing life-long compression. Patients and care partners must receive appropriate and regular instructions focused on the mechanics of wearing compression therapy daily and why it is essential to do so.

Clinicians can be challenged when patients discontinue wearing compression garments once the VLU is closed. In addition to providing ongoing education to the patient, the team must find the most appropriate compression for the patient situation in order to achieve successful long-term prevention and management of VLU and to prevent recurrence. The patient and their care partners must be involved in deciding which compression is the most suitable based on comfort, ease of application and cost (or availability of funding). Team members should be committed to regular contact with the patient and care partners to assess their progress and management instead of waiting until after a VLU recurs.

As team members, patients can commit to an activity program that promotes an active calf-muscle pump.

3.3 Ensure organizational and system support

Organizational and system support requires that policy and decision-makers, and those who oversee financial budgets, understand the importance of providing evidence-informed, cost-effective care for the prevention and management of VLUs. Often, due to limited budgets and resources, clinicians are challenged and can be strained to provide appropriate VLU prevention and treatments.

It is imperative that systems support the use of the most appropriate care provider to deliver VLU prevention and management interventions within the designated scope of practice. As well, decision-makers on a macro level (administrators, managers, local and regional governments) must understand the value of research, adjunctive therapies and best practices ,and support continued education for patient, care partners and other team members, as these translate to improved, cost-effective patient outcomes.

Organizational issues that need to be considered specifically for venous disease are:

- Adequate funding for preventative skin health and compression garments or the newer self-adjustable hook-and-loop fastener systems
- The role of self-management for venous disease for patients and care partners
- The role of clinician education and access to compression garments and hook-and-loop fastener systems
- Funding for footwear and foot care while the patient is wearing lower-limb devices and garments (compression)
- Economic evaluation of therapies used in prevention, treatment and long-term management.

Step 4: Establish and Implement a Plan of Care

Recommendations

4.1 Identify and implement an evidence-informed plan to maintain skin health and correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional and social), the wound (if applicable) and environmental/system challenges

Prevention of, and early intervention in, venous disease remains key for physical and mental quality of life. Venous leg skin care, leg elevation to manage edema and wearing of compression socks are considered proactive, preventative care.

Figure 11: How to Correctly Position Lower Limbs





Basic skin care for persons with venous hypertension

Maintaining healthy skin for people living with venous leg disease is essential. Whether they have an ulcer or not, lower leg skin and the skin surrounding venous leg ulcers requires impeccable skin care and hygiene, as it is at risk for breakdown due to dermatitis and moisture-associated skin damage.[93]

Leg Hygiene and Cleansing: In provision of care for patients living with venous leg edema, routine skin care as well as wound cleansing is part of care planning. When compression bandages and garments are removed from the patient's leg, it is essential that the full leg receive a careful cleansing; many patients describe appreciating having their, "leg washed and report that the presence of exudate is distressing to them."[15]

Routine skin care regimens include washing the leg with a pH-appropriate skin cleanser.[37] To ensure that the skin pH is optimal, the clinician should avoid solutions that are too alkaline or contain allergens, such as perfumes. To complete the leg hygiene, a moisturizer should be applied to the skin for hydration and maintenance of healthy skin. Routine skin care regimens aid in the removal of scaly skin and allows for a careful examination of the leg tissues. Due to the use of compression wraps, retention hyperkeratosis results and gently washing and bathing the limb must be done to manage this. Use a non-sensitizing moisturizing cream and emollients applied in a downward motion to moisturize the skin. Refer to manufacturers' product information sheets to ensure creams and emollients are compatible with leg compression bandaging, wraps, stockings and or garments.[94]

Compression Therapy

Patients with venous insufficiency, VLUs, and/or lymphedema require the life-long use of therapeutic compression that may include compression bandaging systems, compression garments (stockings or hook-and-loop fastener systems) or compression devices.[91] Compression improves calf-muscle pump function and decreases reflux in incompetent veins.[90] Compression must be applied safely and with the goal of providing effective patient-centred therapy.

In general, **bandages** and **compression devices** are most commonly used for the treatment of active VLUs and the reduction of lower-leg edema.

Compression garments are generally then measured and prescribed once the leg edema is reduced, to prevent recurrence of VLUs.

> **Safety First**: When patients have leg compression as part of their care plan, safety issues may arise for clinicians, care partners and home support workers. These include the physical strain of bending, lifting limbs and stretching while managing skin hygiene and applying bandaging systems, especially if the patient is less mobile, obese, morbidly obese, chair-bound or physically infirm. It is important that health-care providers and care partners communicate safety needs to the patient, care providers, team leaders and managers.[95] It is important to maintain safe transfer and movement techniques throughout all care.

Compression garments may also be used in the early stages of chronic venous disease, including thrombotic disease (e.g., deep vein thrombosis [DVT]), to help prevent disease progression. High compression is the treatment of choice, but this needs to be reduced if there are concerns about arterial insufficiency or patients' ability to manage.
Before applying any compression, the practitioner should consider the patient's physical status (vascular, cardiac and renal function) and any patient-centred concerns. Contraindications include severe peripheral arterial disease, compression of epifascial arterial bypass, severe cardiac insufficiency and true allergy to compression material.[96]

In 2017, Andreissen et al. evaluated the literature to clarify the contraindications, risk factors and adverse events resulting from the application of compression.[97] This review of 20 papers on compression therapy for venous leg ulcers indicated consensus for absolute contraindications when there is arterial occlusive disease, heart failure and an ABPI of less than 0.5. There was conflicting information on relative contraindications and adverse events for patients. Other patient factors that were identified as issues that would need to be taken into consideration in using compression were neuropathy, thrombosis, serious non-controlled hypertension, skin issues and intolerance to materials. Patient education and factoring in patient issues are important to the successful use of compression (See Table 9).

Table 9: Considerations when applying compression therapy: Risks and complications[96]

Concern	Clinical	Comments	Incidence
Skin irritation	Itching, dry skin	May be a component of existing venous congestion. Often self-limiting	Common
Allergic skin reaction	Itching, erythema	Most are related to rubber-based products or latex	Very rare
Discomfort or pain	Feeling 'too tight', usually around the ankle or foot	Ensure correct sizing, bandaging technique Give choice to patient	Common
Forefoot edema and lymphedema	Compression devices provide low pressure over the dorsum of the foot and toes Lower leg compression may cause swelling of the knee region.	Consider forefoot and toe compression pieces Ensure proper bandaging technique	Rare
Mechanical tissue and nerve damage	Areas with small radius and bony prominences are prone to more pressure (Laplace's Law) Concern occurs where there is less subcutaneous fat (older, malnourished) Reduced ABPI is contributory Areas of concern: • Tibialis anterior tendon • Achilles tendon • Anterior border of the tibia • Malleoli • Head of the fibula In patients with neuropathy or atrophic skin ensure regular re-assessment	Ensure adequate perfusion Padding to the areas of concern Proper fitting of compression devices (sizing) Using lower pressure systems Educate patients to recognize symptoms of nerve or tissue damage	Very rare
Peripheral artery disease	Important to do a thorough evaluation of the arterial systems through history, physical and support with vascular testing In severe PAD, compression is contraindicated (ABPI <0.6, systolic ankle pressure <60 mmHg, toe pressure <30 mmHg)	Inelastic compression provides lower resting pressures	Very rare
After arterial bypass or stunting	If the bypass is located deep below the muscular fascia compression is unlikely to affect the arterial flow For more superficial procedures or more distal procedures standard compression should be avoided	Published data is limited in this area; more research is needed Communication with the vascular surgeon should occur in these cases	Very rare
Venous thromboembolism	Not a contraindication for compression. Studies indicate that in patients with varicose veins, where compression causes a tourniquet effect, there is a small risk of superficial thromboembolism	Proper application of compression systems is necessary	Very rare

cont'd. . . .

Cardiac insufficiency	Decompensated cardiac insufficiency is considered a contraindication for compression No compression is advised for NYHA III, IV*	Appropriate compression is possible with NYHA I and II* Stages III and IV* would require careful consideration with attention to compression pressures	Very rare

*NYHA=New York Heart Association. Classes and Stages of Heart Failure 98 (American Heart Associations, 2024).
Class – Patient Symptoms
I – No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation or shortness of breath.
II – Slight limitation of physical activity. Comfortable at rest. Ordinary physical activity results in fatigue, palpitation, shortness of breath or chest pain.
III – Marked limitation of physical activity. Comfortable at rest. Less than ordinary activity causes fatigue, palpitation, shortness of breath or chest pain.
IV – Symptoms of heart failure at rest. Any physical activity causes further discomfort.

The Underlying Principle of Compression Therapy

Compression therapy helps to reduce ambulatory venous pressure. The pressure measured at the ankle when standing is about 80 to 100 mmHg. When the calf-muscle pump is activated during walking, pressure drops to about 30 mmHg. This pressure does not drop appropriately when the legs are dependent, or if there is valvular disease or obstruction. Therefore understanding Pascal's equation is important.

Pascal's Equation: $\Delta P = \rho g\ (\Delta h)$

P= F/A where; P= pressure, F= force, A= area
Vowden et al. define Pascal's Law as: "external static pressure exerted on a confined fluid (the limb) is distributed evenly."[91]

Two physical laws are used to understand how compression works to improve venous return:

Pascal's Law states that, "Pressure applied to an enclosed system of an incompressible fluid is distributed evenly. This can be demonstrated using a capped tube of toothpaste in which several equally sized holes have been punched. When pressure is applied to the tube at one point, toothpaste will extrude from all the holes at the same rate, no matter how far they are from the point of applied pressure".[99] Pascal's Law applies to rigid or short-stretch (inelastic) compression systems. With muscle movement against the rigid system, pressure is generated and distributed equally along the lower leg.

The variables defined by Laplace's Law are related to the size of the limb, the bandage width, the degree of overlap or numbers of layers and the degree of tension applied. In the lower leg with compression applied at the same tension, pressure is higher at the ankle and lower in the calf.

Compression therapy affects the blood vessels, lymphatic system and fluid content in the tissues.[100] By decongesting the venous and lymphatic system, arterial blood flow can be improved.[101] The compression pressure should not exceed the arterial perfusion pressure. An ABPI less than 0.5 is a contraindication to compression. Use of compression in patients with mixed arterial-venous disease should only be considered following a comprehensive vascular assessment by appropriate personnel, such as a vascular surgeon. Inelastic compression systems would be recommended in patients with mixed arterial-venous disease. Caution: clinicians must remember that patients with calcified pedal vessels can have a normal ABPI.

These principles are important to consider in applying compression to patients with narrow limbs or over bony prominences. Irregularly shaped legs can be challenging and may require padding.

Compression Bandaging Systems

Several bandaging systems are available for edema and VLU management. Compression therapy systems are divided into **short stretch** and **long stretch** and, further, by the number of component layers in the bandaging system (See Table 10).

A 2021 Cochrane review by Shi et al. looked at randomized controlled trials that compared types of compression bandages or stockings with no compression in participants with VLUs (14 studies, n=1391 participants). Compression bandages or stockings applied included:

- short-stretch bandage,
- four-layer compression bandage and

- Unna's boot (a type of inelastic gauze bandage impregnated with zinc oxide).[102]

Comparison patient groups used 'usual care,' pharmacological treatment, a variety of dressings and a variety of other treatments. Ten of the studies (71.4%) presented findings that were considered to have high overall risk of bias. There is moderate certainty evidence (downgraded once for risk of bias) that there is probably a shorter time to complete healing of VLUs in people wearing compression bandages or stockings when compared to patients not wearing compression. As well, people treated using compression bandages or stockings are more likely to experience complete ulcer healing within 12 months compared with people not wearing compression.[102]

Multi-layers bandaging systems are more effective than single-layer systems. Multi-layer systems containing elastic bandage appear to be more effective than those composed mainly of inelastic constituents. Two-layer bandaging systems appear to perform as well as four-layer bandaging (4LB) systems. Patients receiving the 4LB system heal faster than those allocated to the short-stretch bandages (SSB). More VLUs heal while wearing high compression systems than with SSB. Additional data are required before the difference between high-compression garments and the 4LB system can be established.[103]

Table 10: Types of Compression Bandages

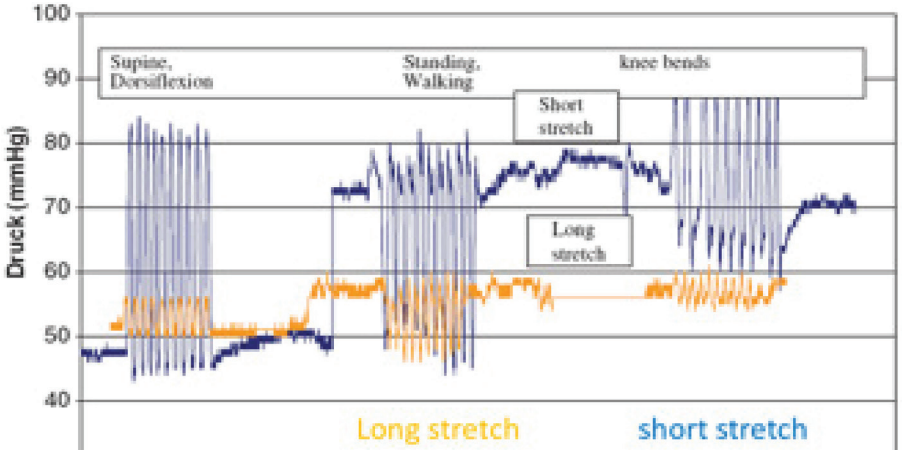
Type of bandaging	Alternate Name	Static Stiffness	Compression	
			Resting	With Activity
Long Stretch Bandaging (LSB)	Elastic	Low	High	Lower
Short Stretch Bandaging (SSB)	Inelastic	High	Low (support)	Higher

The compression therapy system chosen will depend on patient preferences and concerns. If pain is a problem, inelastic compression systems may be more comfortable. The increase in pressure exerted by the compression therapy system in going from a lying position to standing is termed the *static stiffness index*.[100]

This is an important characteristic of the inelastic system, where the static stiffness is high, causing a massaging effect during walking. Elastic systems have a low static stiffness index and maintain a constant high pressure, and therefore would have a lower margin of safety. In addition, the bulk of some compression systems that assist in reducing ambulatory venous hypertension can actually decrease range of motion around the ankle joint, further adding to the problem of calf-muscle pump failure.[104]

Figure 13 illustrates an example of the resting and working pressures of a patient when they are supine (lying) and standing/walking and with knee bends. The orange lines demonstrates the effect (pressure mmHg) of the long stretch bandage. The blue lines demonstrates the effect (pressure mmHg) of the short stretch bandage.[16]

Figure 12: Comparison of Long and Short Compression



Permission: *Partsch H, Clark M, Bassez S, Benigni JP, Becker F, Blazek V, et al. Measurement of lower leg compression in vivo: recommendations for the performance of measurements of interface pressure and stiffness: consensus statement. Dermatol Surg. 2006 Feb;32(2):224-32.*

Compression Garments

Compression garments are the standard of care for the long-term management of patients with edema and VLUs (classified as C3 to C6 using the CEAP system [See Table 4]). Prescribing graduated compression garments requires that clinicians have a full understanding of the principles of this therapy. These require appropriate measurements of the area of the leg to be compressed, as well as prescription if pressure over 20 mmHg is required (See Table 11).

Compression garments are to be fitted only after leg edema has been reduced. Limb edema needs to be reduced through compression wraps or pumps, after which legs can be measured and fitted for compression garments. Education for the patient and care partner during this time is crucial, emphasizing the message that compression is a life-long commitment.

Table 11: Compression Garments for Maintenance and Prevention of Leg Edema

Class	Pressure	Indication(s) for Use
	15–20 mmHg	Tired, achy feet and legs; slight edema; for airline travel Spider veins, early varicose veins
I	20–30 mmHg	Varicose veins, mild edema Deep vein thrombosis (DVT) prevention
II	30–40 mmHg	Moderate varicose veins, mild edema Prevention of venous leg ulcer recurrence Lymphedema (but higher pressure is better)
III	40–50 mmHg	Severe varicose veins Prevention and treatment of venous leg ulcers Lymphedema Post-phlebitic limb Chronic venous insufficiency
IV	50–60 mmHg	Lymphedema

It is important that patients and their care partners focus on exercise of the calf-muscle pump when wearing compression.

For more information on reducing edema through the use of compression, calf-muscle pump activation and other strategies visit Wounds Canada Product Picker: Control of Venous Leg Edema. https://www.woundscanada.ca/docman/public/health-care-professional/1182-wc-product-picker-control-of-venous-leg-edema-ltr-1691r2e-2pg-copy/file

Patients and care partners must be provided with education to become aware that VLU recurrence rates can be higher when they do not participate in, and fully adhere to, wearing their garments. A Cochrane Review by Nelson and Bell-Syer examined four trials (n=979) to determine the effect of compression (socks, garments, tights, bandages) in preventing recurrence of VLUs.[105] They concluded that there is evidence from one trial that compression hosiery reduces rates of VLU recurrence compared with no compression.[106]

The Shi et al. review concluded that people with venous leg ulcers using compression bandages or stockings probably experience complete wound healing more quickly, and more people have wounds completely healed. The use of compression bandages or stockings probably reduces pain and may improve disease-specific quality of life. There is uncertainty about adverse effects and cost effectiveness.[102]

Caution: High compression therapy should be applied only in the absence of arterial disease, with an ABPI = >0.9. High compression therapy should be handled by trained and skilled practitioners.

A 2016 Cochrane review conducted by Weller et al. looked at the literature to determine if specific interventions would improve adherence to compression, improve healing outcomes and reduce recurrence.[107] Their summation was, "It is unclear

whether interventions designed to help people adhere to compression therapy improve venous ulcer healing and reduce recurrence. There is a lack of trials of interventions that promote adherence to compression therapy for venous ulcers."[107]

Donners and Doffers

Compression garment application may require the patient to obtain a donner to aid in the application of socks or stockings. There are various devices available commercially, and patients and their care partner should be encouraged to obtain one and be instructed on how to prevent damage to the garment or skin during application and removal. Consistent education with patients and care providers is necessary. Maintenance of the device is needed and periodically may need to be updated or replaced.

Compression Devices

Intermittent pneumatic compression (IPC) has been used to reduce lower limb edema in the treatment and management of VLUs and lymphedema (See Figure 14). In 2014, Nelson and colleagues conducted a Cochrane Review of the effect of IPC and its impact on healing and health-related quality of life for patients with VLUs (9 RCTs, n= 489).[106] The RCTs compared the effects of IPC with control (sham IPC or no IPC) in VLU management. The authors concluded that IPC may increase healing compared with no compression, but it remains unclear whether it can be used instead of compression bandages.[106]

Figure 13: Intermittent Pneumatic Compression



Permission: Dr. Robyn Evans.

Young et al. examined the use of IPC in the home of one female patient. They concluded that IPC in the home setting is anticipated to improve patient involvement, concordance, patient outcomes and reduce risk to staff applying conventional compression bandaging systems, particularly for obese patients with limited mobility.[108]

Williams et al. explored the comparison of venous hemodynamics and the effect of a neuromuscular stimulation (NMS) device to IPC in healthy subjects (n = 10).[109] Baseline measurements were taken of superficial femoral venous velocity and volume flow. Subjects received bilateral therapy for 30 minutes with both devices. The measurements were repeated and then the devices swapped for another 30 minutes. The results showed a peak velocity of 19% with IPC versus 42% with NMS. Time averaged peak velocity was 12% with IPC compared with 27% with NMS. Volume flow was 7% with IPC versus 46% with NMS.

Calf-muscle Pump Activation

The impact of calf-muscle pump failure cannot be overestimated when addressing the treatment of venous ambulatory hypertension. Research by Meulendijks et al. has identified calf-muscle dysfunction as a strong predictor of venous leg ulcer (VLU) severity and healing.[110]

A treatment program that addresses the range of motion around the ankle joint, muscle strength and gait training is integral to the overall care plan for the patient at risk for, or currently living with, a VLU, if the patient is ambulatory.[111] Exercise programs tailored to address venous hypertension need to include stretches and strengthening for the gastrocnemius/soleus muscle complex in preferably weight-bearing positions but may also be of benefit when done in the non-weight-bearing position. It is of benefit for the exercises to be monitored by someone specifically trained in exercise prescription, but the intervention can be successful when incorporated in a self-management program. Exercises are particularly beneficial when done while wearing compression.[112,113]

Ideally, a clinician should prescribe supervised and safe exercise to patients with, and at risk of, VLU to promote overall wellbeing and decrease the risks associated with a sedentary lifestyle, including cardiovascular events and metabolic syndromes.

A study by Klonizakis et al. looked at 39 patients with VLUs. Patients were randomized to a 12-week supervised exercise program three times/week with compression (n=18) and for compression alone (n=21). They reported the supervised exercise group showed a median healing time of 13 weeks compared with 34.7 weeks for the compression alone group.[114]

Orr et al. performed a meta-analysis (eight studies) and found a significant increase in calf-muscle pump function (as measured by ejection fraction) in favour of the exercise group compared with the control ($p < 0.001$) in 83 participants. Ankle range of motion was higher in the exercise group (116 participants) but was not found to be significant when compared with the control group.[115]

There is strong emerging evidence for the importance of exercise directed at improving calf-muscle pump strength, range of motion and function, including a recent systematic review and meta-analysis that found exercise manifested positive effects on VLU healing and range of ankle mobility compared with the control group. In addition, patients' adherence to the exercise regimens was favourable.[116]

Pharmacologic Management

Based on the pathophysiology of VLU development there is a significant inflammatory component. While compression remains the gold standard to improve the healing of these ulcers, the search has been for medications that will target more of the inflammatory nature of this disorder. The medications that have been considered are pentoxifylline, sulodexide glycosaminoglycan, micronized purified flavonoid fraction (MPFF) and fibrinolytic enhancers such as aspirin and doxycycline.



Pentoxifylline is a methylxanthine derivative similar in structure to caffeine taken orally three times daily. This medication is thought to improve erythrocyte deformability, inhibit neutrophil and platelet activation as well as tumor necrosis factor (TNF), formerly known as TNF-α.[117] It is reported to increase microcirculatory blood flow.[118] Pentoxifylline is supported by randomized controlled trials as well as the Cochrane reviews when used with compression.[118-120]

The Cochrane review[119] also indicates pentoxifylline should be considered for patients who are unable to tolerate compression.

The Society for Vascular Surgery/American Venous Forum recommends the use of pentoxifylline or MPFF together with compression for long-standing venous leg ulcers.[3,121]

Pentoxifylline is contraindicated with severe hemorrhages, acute myocardial infarction and liver and kidney disease.

Flavonoids are a diverse group of naturally occurring compounds found in food supplements. MPFF consists of 90% diosmin and 10% hesperidin. There is a formulation available over the counter in Canada indicated for venous disease and hemorrhoid symptoms. MPFF are reported to support venous drainage, inhibit the activation of leukocytes to reduce inflammatory mediators.[117] The Cochrane review found improved healing rates; however the quality of the studies was considered poor.[122]

Suloxdexide is a glycosaminoglycan purified from porcine intestinal mucosa. Reported biologic effects include anti-inflammatory and endothelial protection.[123] Studies have evaluated its effectiveness for chronic venous disease as well as prevention of venous thromboembolism. Sulodexide is used more in Europe and South America.[118] To date, there is no strong evidence to support its use; a Cochrane review reports low quality evidence.[124]

Aspirin inhibits platelet aggregation and subsequent inflammatory mediators. The largest trial done in 2017[120] did not show an improvement of healing. The Cochrane review[125] also indicated a lack of evidence for oral aspirin, and that more research is needed to study higher doses for potential impact.

Doxycycline is an antibiotic that is known to inhibit pro-inflammatory cytokines. There is no strong evidence to support the use currently.[118]

Diuretics are indicated for intravascular volume overload due to conditions such as congestive heart failure, hepatic failure and renal failure. They are not indicted for the treatment of peripheral edema that is due to pure venous disease. The underlying problem with venous insufficiency and edema is related to venous reflux and valvular incompetence, resulting in fluid in the interstitial spaces. If diuretics are used for a short duration to reduce massive edema, electrolytes need to be monitored.[126]

Pain

Management strategies should be targeted to the cause of pain specific to venous disease. Patients must be given the opportunity to talk about pain management strategies, co-create and reassess care plans. Pain is a critical element to assess, as four of five persons with VLUs experience mild to moderate pain.[127]

Topical agents or dressings aimed at reducing wound pain are also available. In a recent systematic review, researchers state that, for patients living with painful venous ulcers, there is some evidence to suggest ibuprofen dressings provide relief, and topical lidocaine/prilocaine (5%) appears to aid in pain relief during debridement.[128] Again, more research is required.

Table 12 lists the causes and various options for management.

Table 12: Venous Disease-related Pain[127,129]

Pain Related To:	Pain Management
Edema	Sufficient compression, exercise to improve the calf-muscle pump
Deep vein thrombosis	Essential to evaluate with venous Doppler and treat with appropriate anticoagulant; this requires urgent evaluation
Superficial thrombophlebitis	Pain localized over a vein with associated inflammation and palpable tenderness; non-steroidal anti-inflammatory medications and compression
Acute lipodermatosclerosis	Compression bandages, analgesics
Chronic lipodermatosclerosis	Compression bandages/garments, oral medication (e.g., pentoxifylline)
Atrophie blanche	Analgesics
Cellulitis/infection	Topical antimicrobial or oral antibiotic depending on the extent of infection and patient's co-morbidities
Acute contact dermatitis	Removal of the offending agent; treatment with topical agents such as corticosteroid creams

Managing VLU pain can be challenging, and it is therefore important to regularly reassess the management plan with the patient. Pain can be chronic, related to ulcer factors or related to dressing changes, cleansing or debridement procedures. Pain in VLUs is ranked as the most severe when compared with other wounds, and removal of dressings causes the greatest pain.[78] Having too dry a wound will cause discomfort in dressing removal. Conversely, the exces-

sive moisture common to VLUs can cause periwound maceration and further tissue breakdown, increasing pain and discomfort. If sharp debridement is considered and pain is a concern, lidocaine/prilocaine (eutectic mixture of local anesthetics, consisting of 2.5% lidocaine and 2.5% pilocarpaine) is an option.[128] As well, certain topical agents or dressings can be used to reduce pain. For patients with painful venous ulcers, some evidence suggests ibuprofen dressings provide relief,[128] but more research is needed. Table 13 lists the various treatment options for pain caused by a VLU. Pain related to venous disease can persist even after the ulcer has resolved.[129]

Table 13: Venous Leg Ulcer-related Pain Management

Pain Related To:	Pain Management
Dressings	Choose a product that absorbs enough fluid to protect the periwound area. If dressing changes are uncomfortable, choosing a dressing that can be left on longer may be helpful
Debridement	Use topical analgesia such as lidocaine/prilocaine or use topical 1–4% solutions prior to debridement Consider using autolytic debridement if sharp is too painful
Bacterial balance	Some antimicrobial dressings may cause burning in certain patients, and changes may be necessary More extensive infection requires oral or intravenous antibiotics
Compression	Ideally, high compression systems are recommended if there is normal arterial blood flow Inelastic systems do not exert pressure at rest and may be preferred when pain is an issue. If compression is not available, elevation of legs is an option

A therapeutic relationship between the health-care provider and the patient and care partner is required to enhance pain management outcomes and ensure an improved quality of life for the patient. Pain should be evaluated at each visit to determine the type of pain the patient is experiencing, thus guiding the treatment strategy.

4.2 Optimize the local wound environment

4.2.1 Cleansing

Wound Care

Cleansing the wound and periwound skin should be done at each dressing change, wound assessment and prior to the application of a new dressing and/or compression product. Wound and periwound cleansing reduces the odour that is very common in highly exudative venous ulcers. There are various methods of cleansing the wound, with the most common being the use of saline irrigation. Irrigation of the wound can be performed using a syringe (30 or 35 ml) and an 18- to 19-gauge needle. Saline also comes in prepared proprietary containers. It is also recommended to use water, as long as it is potable.

Patients who are physically capable of showering may cleanse the wound during this time. Showering may be beneficial to the patient's overall wellbeing, as it reduces odour and provides improved personal hygiene. Showering is done in consultation and communication with the care team, patient and care partners.

For more information on wound cleansing, refer to Chapter 4: Prevention and Management of Wounds: An Overview.[31] and Wounds Canada's Product Picker: Skin and Wound Clean-up https://www.woundscanada.ca/dhfy-doc-man/public/health-care-professional/1307-product-picker-skin-and-wound-clean-ip/file

4.2.2 Debriding

Evidence for the benefit of debridement of VLUs is limited. A study of 10 RCTs failed to show benefit; however, this study did not include sharp surgical debridement, nor did it compare debridement with no debridement.[130] The choice of debridement method depends on the expertise of the clinician, availability of resources and patient and wound factors. Pain is often an important consideration.[131]

Arterial flow should always be evaluated before proceeding with debridement.

Debridement of the venous leg ulcer is important to accomplish the following:
- Prepare the wound bed to receive treatment
- Remove any necrotic and nonviable wound tissues to manage infection
- Disrupt the biofilm
- Identify the extent of the wound.

Cardinal et al. evaluated serial debridement in 310 patients with venous disease and found a significantly higher closure rate following surgical debridement versus no debridement. Established wound care principles do recommend debridement.[132]

Larval therapy

Greene et al. conducted a systematic review (6 RCTs, n=531) of people living with VLUs and reported larval therapy removed similar amounts of sloughy necrotic tissue as sharp debridement and produced greater debridement when combined with compression therapy versus compression alone. While pain after debridement was significantly less with larval therapy when compared with standard sharp debridement techniques, there was no significant improvement in the rate of wound healing of the VLUs treated with larvae in these studies. The authors concluded larval therapy was an effective method of producing faster wound debridement.[133]

Ultrasonic debridement

Murphy et al. examined the effect of debridement using low-frequency contact ultrasound treatment (LFCUD/ ultrasonic debridement) on patients with significant vasculopathy and lower-extremity wounds. Weekly LFCUD treatments, administered via an advanced nurse in a multi-disciplinary tertiary vascular service, was well tolerated by patients and associated with a greater number of healed wounds and fewer instances of wound deterioration when compared with continued control subjects who received standard care including conservative sharp debridement.[134]

For more information on debridement, refer to Chapter 4: Prevention and Management of Wounds: An Overview.[31] and Wounds Canada's Product Picker: Skin and Wound Clean-up https://www.woundscanada.ca/dhfy-doc-man/public/health-care-professional/1307-product-picker-skin-and-wound-clean-ip/file

4.2.3 Managing bacterial balance

It is recommended that infected ulcers be treated with topical agents if local infection is evident, and systemic agents with spreading or more systemic infection.[3,80,135,136] Beta-hemolytic *streptococci* is known to cause extensive tissue destruction and should be treated if identified at any level.[81,137]

Debridement is also important for successful eradication of infection and disruption of surface biofilm. In evaluations of the evidence for use of topical antimicrobial agents, only cadexomer iodine has been shown to promote healing in venous leg ulcers with excessive bacterial burden.[37,64] Honey has shown no benefit over standard care in locally infected venous leg ulcers.[64]

Systemic therapy for infection should be limited to two weeks unless clinical signs and symptoms persist.[3] There is no evidence for the routine use of antibiotics to promote the healing of venous leg ulcers.[138]

The choice of antibiotics will depend on the patient's co-morbidities, allergies and drug interactions. Non-healing wounds are more likely to be polymicrobial and have gram-negative bacteria and anaerobes in addition to gram-positive bacteria.[139,140] The semi-quantitative swab is useful for ensuring the chosen antibiotic covers the bacteria grown and identifying resistant organisms. Oral antibiotics are usually sufficient unless deeper infection or patient co-morbidities warrant the use of intravenous antibiotics. If atypical infections are a consideration, a tissue biopsy should be obtained.

Topical antimicrobials may be used to aid in wound healing when evidence of clinical infection is evident, but not for bacterial colonization. Some evidence shows that cadexomer iodine is effective,[141] and more research is needed to support routine use of honey or silver-based products.[138]

Biofilm is a concern in slow- and non-healing VLUs. It has been shown that 60% of non-healing wounds and only 6% of wounds healing at a normal rate contain biofilm structures.[117] Disruption of a biofilm within a wound is an area of active research. The use of surfactant-containing antimicrobial cleansers has been shown to be useful for disrupting biofilm.[142] Various antimicrobial wound dressings have been evaluated in terms of effectiveness against biofilm. There is no clear recommendation, but there is evidence that time-release silver gel and cadexomer iodine are more effective than other dressings.[143]

For more on maintaining bacterial balance see Chapter 4: Prevention and Management of Wounds: An Overview.[31]

For more on wound hygiene and cleansing, see Wounds Canada. Product Picker: Skin and Wound Clean-up.

https://www.woundscanada.ca/dhfy-doc-man/public/health-care-professional/1307-product-picker-skin-and-wound-clean-ip/file

4.2.4 Managing moisture balance

Managing moisture balance, odour, puritus and overall quality of life, can be challenging in patients with edema and/or VLUs.[144] Wounds may be large with excessive exudate that may be the result of inflammation/infection or edema. Excessive drainage should be managed to prevent periwound maceration, wound extension or hypergranulation. The management of moisture can be achieved by using appropriate products and absorbent and superabsorbent dressings, along with compression, to control edema. Moffatt identifies key mechanisms that aid in obtaining proper moisture balance when compression is effectively used:

- by reducing venous hypertension and enhancing venous return,
- by enhancing local tissue perfusion,
- by reducing (edema) formation and promoting removal through the venous and lymphatic system,
- by reducing overall exudate production and [periwound] maceration and
- by providing absorption of excess exudate away from the wound bed.[144]

Some wounds may have a lack of moisture, which may be a result of inappropriate dressing selection or systemic problems such as dehydration, or be indicative of an ischemic ulcer. The objective of care is to ensure an adequate quantity of moisture to facilitate the wound healing process but not so much that it will impede healing and cause additional skin breakdown. Therefore, the moisture level should be assessed at each dressing change, as exudate/moisture may indicate a change in the wound status.[145] This also includes the patient and care partners ability to manage wound care treatment.[146]

Dressings that provide exudate management support wound healing by managing moisture amounts in and around the wound. Foam dressings may assist in venous ulcer healing but are not considered more effective than other wound dressing treatments.[147] In a recent meta-analysis of five RCTs, the evidence did not suggest that alginate dressings are more or less effective in the healing of venous leg ulcers than hydrocolloid or plain non-adherent dressings, and there is no evidence to indicate a difference between different proprietary alginate dressings.[148]

For more information on managing moisture balance, refer to Chapter 4: Prevention and Management of Wounds: An Overview.[31]

Surgical Management Numerous studies have examined the role of surgical intervention for the treatment of VLUs. The role of surgery is to remove the incompetent superficial vein and divert venous flow to the deep system, thereby mitigating the effect of venous hypertension on the ulcerated skin. Surgical interventions include ligation and stripping, endovenous laser or radiofrequency ablation, and injection with foam or cyanoacrylate glue to chemically ablate the superficial veins. In patients with deep venous occlusive disease, surgical interventions may include stenting of the deep veins or creation of a venous bypass.

A significant study to assess the role of superficial venous stripping was the ESCHAR study, which compared surgery and compression with compression alone for the treatment of venous leg ulcers.[149] In this multicentre study, 500 patients with isolated superficial venous reflux and mixed superficial and deep reflux were randomized to either compression treatment alone or in combination with superficial venous surgery. The authors reported that, while the healing rates were similar between patients who underwent venous stripping and those who received only compression therapy, the recurrence rates of venous ulcers were lower in patients who underwent venous stripping procedures. A randomized trial by Viarengo et al. found that endovenous laser ablation with laser therapy was associated with a shorter time to healing and a greater median reduction in ulcer size compared with compression therapy alone.[150] O'Hare et al. also compared injecting the saphenous vein with foam with compression therapy alone, but found no statistically significant difference in wound healing between the two groups.[151] This study, however, was not adequately powered to detect small differences in healing rates. To date, there is a lack of well-powered, prospective randomized trials to definitively investigate the role of endovenous therapies for the treatment of venous leg ulcers.[152]

Currently, Canadian provincial health insurance plans will pay for saphenous vein ligation and stripping procedures for patients with venous ulcers. Endovenous technologies such as laser, radiofrequency ablation or chemical ablation are not covered by Canadian public insurance plans. Most vascular surgeons will consider offering the patient a venous intervention if the pathology is limited to the superficial system without involving the deep veins and after the ulcer has healed

to prevent recurrence. Some patients have been able to privately obtain endovenous interventions for their venous leg ulcers, but this approach is not currently considered the standard of care in the absence of Level I evidence for its efficacy.

4.3. Select the appropriate dressings and/or advanced therapy

Dressing Selection

Dressings play an important supportive role in compression therapy. Once the wound is cleansed, leg hygiene is conducted and the wound assessed, the decision is made as to what dressing to use. Dressings are chosen for a variety of reasons, including wound bed and periwound protection, exudate absorption and management, pain reduction and management, infection and odour control and patient preference.[153] A recent study emphasized the importance of the use of superabsorbent dressings versus foam dressings for patients with moderate to high exudating wounds.[154]

It is important to understand that dressings may be worn without compression, or beneath compression bandages or garments. Dressings are most often held in place by compression therapy; however, dressings worn without compression therapy must be attached with a device such as a roller gauze or tube netting, so no harm is caused to surrounding skin. Dressings held in place with tube netting or gauze help to prevent further skin damage to the periwound skin from adhesives. Dressings applied when compression hosiery is used require patient and clinician skill and knowledge to ensure the dressing is not forced or moved out of position when the hosiery is applied.

Treatments for VLUs may include protease-modulating matrix (PMM) therapy, especially for wounds that do not follow the normal trajectory toward closure. In a recent systematic review, Westby and colleagues determined that it was unclear whether PMM dressing treatments influenced VLU healing relative to dressing regimens without PMM activity.[155] Testing and treating for elevated wound protease activity for healing in venous leg ulcers requires further research.[156]

For more information on dressing types and their attributes, refer to Wounds Canada's Product Picker for Dressing Selection https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/library/183-resources-industry-partner/288-product-picker

Advanced Wound Therapies

For VLUs that fail to progress toward healing despite optimal treatment and certainty of the diagnosis, advanced wound therapies should be considered. These advanced therapies include electrical stimulation (ES), muscle pump activator devices (MPA), negative pressure wound therapy (NPWT), hyperbaric oxygen therapy, biologic skin equivalents and topical wound oxygen (TWO2) therapy. In the literature, there is evidence for electrical stimulation and biologic skin equivalents. Hyperbaric oxygen therapy and negative pressure wound therapy continue to be controversial, as there is not enough information to support their use in treating venous leg ulcers.[3]

Table 14 lists the potential advanced therapies to consider, along with the evidence for their clinical use. Most of these advanced therapies do not have strong scientific evidence or are in the early stages of scientific evaluation.[159]

Table 14: Advanced Therapies

Therapy	Comments
Hyperbaric Oxygen Therapy	Hyperbaric oxygen does have a role in treating arterial disease, and this can often be an issue in mixed arterial-venous-disease-type ulcers.[157] The effect of HbOT administered by pressurized chamber has been examined in two systematic reviews. Bai et al. (2022) identified seven RCTs (n=419) where HbOT added to endovascular surgery was associated with shorter ulcer healing time and lower pain scores.[160] Keohane et al. (2023) identified six RCTs (n=146) that evaluated the effects of HbOT on VLU healing and a significant reduction in wound size after HbOT treatments compared to continued standard wound care, however there was no significant effect on the likelihood of complete ulcer healing[161]
Ultrasound	Therapeutic US is another modality that is sometimes used to promote wound healing in stalled wounds, including VLUs. High frequency (1 or 3MHz) therapeutic US administered either directly to periulcer skin or via a water bath has been evaluated in 12 clinical trials (n=994), and all but 2 of the 12 RCTs reported a significant improvement in various healing outcomes compared to standard wound care. Two RCTs (n=150) recorded VLU healing rates with US treatment that were similar to those that occurred after vein stripping surgery. There was no further improvement in VLU healing outcomes when US treatment and surgery were combined. Chen and colleagues (2023) identified 8 RCTs (n=317) and reported a pooled effect that showed significantly fewer non healed VLUs and significantly smaller VLU wound size after treatment with low frequency US applied in contact (i.e., ultrasonic debridement) or administered via a fine mist spray (non-contact) compared standard wound care including compression therapy.[179] In a Cochrane review, Cullum and Liu (2017) concluded that "it is uncertain whether therapeutic ultrasound (either high or low frequency) improves the healing of venous leg ulcers"[158] There is no strong evidence to suggest that the US speeds ulcer healing in this patient population. There was weak evidence, according to one study included in this review, to support the use of high-frequency US to speed wound healing
Shock Wave Therapy	Shock wave therapy uses mechanical waves to activate healing processes. A Cochrane review (2018) found no RCTs that examined the effect of extracorporeal shock wave therapy on healing outcomes of VLUs[162] Dolibog et al. (2018) compared healing effects of radial and focused shock wave in a controlled clinical trial involving 50 people with VLUs. The proportion of completely healed ulcers were similar for both types of shock wave therapy and both were significantly higher than control subjects that received standard wound care[180]
Direct Wound Bed Electrical Stimulation	Electrical stimulation applied to the wound and/or periulcer skin is believed to reduce bacterial load and improve wound healing by activating tissue repair processes and improving profusion to the area.[181] There is also some evidence that pain is diminished with ES.[182] In a review Houghton (2017) identified and appraised studies (n=62) that evaluated the effect of ES on healing of various wound types.[183] Houghton reported that ES applied at therapeutic doses to locations around the wound consistently produced faster wound size reduction and/or a greater number of closed wounds. This review included nine clinical trials (n=361) involving persons with leg ulcers primarily due to venous insufficiency. A wide range of ES protocols and many different manufactured devices have been used to electrically stimulate wound healing[184]
	Researchers (2017) found six RCTs support the benefit of pulsed current including high voltage pulsed current (HVPC) over conservative management of leg wounds. They concluded further research is required to determine optimal treatment parameters that will promote healing. Novel forms of ES that automatically deliver direct current at ultra-low levels (microcurrent) to the wound bed or stimulate nerves outside the wound area have not produced improved healing outcomes.[185,186] These findings are consistent with other researchers who showed improved healing outcomes are associated with applying pulsed current directly to the wound area at an intensity sufficient to produce sensory nerve stimulation (250–500uCi)[181,186,187]

cont'd. . . .

Biologic Skin Equivalents	These are monoclonal antibodies that target specific parts of the immune system. Chronic wounds have higher levels of TNF-alpha. Auto-antibodies, such as adalimumab, etanercept and infliximab, target TNF-alpha. There are early studies using adalimumab sc as well as agents used topically. Other studies are directed at inhibiting proinflammatory cytokines in chronic wounds[167]
Negative Pressure Wound Therapy	A Cochrane review (2015) found only one RCT that provided low quality evidence that adding NPWT to standard wound care including compression therapy could improve time to heal of lower leg ulcers.[188] A review of published literature since 2017 did not reveal additional research examining the effect of NPWT on VLU healing
Pulsed Electro-magnetic Fields	A Cochrane review (2015) found 3 RCTs (n=94). While all three RCTs reported better healing outcomes after PEMF treatment compared to control, because included studies were very small, there was no clear evidence to support the use of PEMFs to stimulate VLU healing.[189] A review of clinical research literature published since 2017 did not reveal new research examining the effect of this technology on wound healing outcomes
Laser Therapy	A RCT (n=82) patients with VLUs present for 1-5 years, reported a significant decrease in the time to heal and improvement in the number of healed VLU treated with low laser light therapy (LLLT)[190]
Growth Factors and Platelet Rich Plasma Injections	Researchers (2022) identified 13 studies in people (n=991) with VLU and meta-analysis revealed a statistically significant difference in complete healing and greater wound size reduction between placebo treatments and different growth factors including (KGf-2, EGF, TGF-β2, and autologous concentrated growth factor (CGF), and granulocyte macrophage-colony stimulating factor (GM-CSF).[190] Two meta analysis examined the effect of platelet rich plasma (PRP) on healing of lower extremity venous ulcers. Pooling results of 6 RCTs (n=294) and eight RCTs (n=451) revealed platelet rich plasma injections into the wound and/or peri-ulcer skin resulted in improved healing rate and reduced wound size compared to control[191,192]
Stem Cells	Elsharkawi and colleagues (2023) identified one RCT and three non-randomized controlled studies that examined the effects of adipose derived stem cells (ADSCs) on the healing rate of recalcitrant VLUs. The rate of completely healed VLUs was 75% with ADSC compared to 50% in controls suggesting this type of stem cell therapy may be enhance ulcer healing in people with VLUs[167]

cont'd. . . .

Low Frequency Nerve Stimulation[196] (in Canada this is referred to as Muscle Pump Activator (MPA))	MPA is a small electrical device that delivers low frequency electrical nerve stimulation (60 pulses per minute at 1hz). The MPA is used to activate peroneal nerve and stimulate repetitive muscle twitches of the peroneal muscle, and lateral gastrocnemius muscles which activate the calf and foot muscle pumps. This action mimics the natural muscle contractions equivalent to 60% of walking[194] This technology has been reported to improve limb circulation, prevent post- operative DVTs, and increase the healing rate of lower extremity wounds.[169,195-198] NICE (2016) completed a comprehensive review of published and unpublished research on MPA device and recommended the use of MPA device on people who have a high risk of venous thromboembolism and for whom other mechanical or pharmacological methods of prophylaxis were impractical or contraindicated[199] This limited recommendation was because most research that examined the effect of the MPA device on arterial/venous circulation was performed on healthy human subjects who received relatively short treatment times (5-30 minutes). In 2016, an eight-week case series evaluation at the Welsh Wound Innovation Centre using Speckle Spectroscopy imaging determined that this technology increases venous, arterial and microcirculatory blood flow in the lower limb in patients with chronic venous insufficiency and intermittent claudication[168,200] Improved healing outcomes were reported after use of the MPA device on venous leg ulceration in two small case series involving 12 and four patients with VLU, respectively[201,202] In addition, a recent 'self-controlled study' involving 60 patients with VLUs were studied. All 60 participants were on standard of care for a four week run-in period. At week five, patients were randomized to SOC or SOC and MPA. Of the 60 patients, nine patients were withdrawn due to post-randomization criteria failure. From weeks five to eight, 22 patients were in the SOC arm, and 29 patients were in the SOC and MPA arm. The results showed a significant two-fold increase in the rate of wound healing, both in terms of wound margin advance and percentage area reduction[170]
Topical Wound Oxygen Therapy (TWO2)	TWO2 is an innovative technology that is showing promise in its early trials and evaluations to treat non-healing wounds, in particular refractory VLUs. Oxygen is required in cellular and molecular metabolism. It promotes angiogenesis, granulation and collagen deposition. Sultan et al. (2016) conducted a study with 67 limbs with 67 ulcers—who were managed using TWO2 therapy —while 65 limbs with 65 ulcers were managed using conventional compression dressings (CCD). The study found that the proportion of ulcers that healed completely and the mean reduction in ulcer surface area were greater in patients managed with TWO2. This group also saw a shorter median healing time than the group managed with CCD[171] Further research involving properly designed, controlled clinical trials are needed to determine if healing outcomes can be significantly improved when these new innovative electrical devices are added to standard wound care programs

4.4 Engage the team to ensure consistent implementation of the plan of care

Health-care professionals providing care for individuals living with venous leg disease and VLUs must understand their roles and responsibilities in communication and collaboration and in the provision of prevention, treatment and management of care. Prevention of lower leg ulcers requires all team members to encourage and support patients to participate in smoking cessation, physical activity, wearing of compression garments and use of appropriate, professionally fitted footwear. During all phases of care, team members must communicate patient status and collaborate around current treatment and compression options.

Patients, as the key team members, require assessment for distress, depression and anxiety symptoms and suffering to ensure they can participate in care planning and decision-making.[82] Reporting patients as non-participatory does not contribute to care planning and patient concordance and engagement; more research is needed on this important topic.[173]

To engage the patient as the key team member, health-care professionals can employ effective communication strategies, including the following:

- Provide education and engage the patient in the care plan process

- Screen for mental health and well-being, hopelessness, depression, anxiety
- Plan footwear and clothing changes ahead of initiating compression
- Refer patient to physiotherapy to assess gait and equipment needs ahead of initiating compression
- Provide effective education about the benefits of compression and leg hygiene
- Where possible, have consistent, well-trained nurses wrapping and caring for this patient group. This builds trust on which health-care planning can be more effectively built.[82]

Self-Management with Venous Leg Disease and Ulcers

Self-care is the ability of people with venous leg disease to care for themselves. Building self-care capacity is done with the patient, care partner, family and health-care professional(s). This may be done one-on-one, or in a small group. Managing preventative skin care, associated socking and garments, medications (oral, topical) and wound care and associated compression puts demands on the patient and care partner.

Kerr and colleagues provide a toolkit: https://wounds-uk.com/best-practice-statements/personalised-self-care-for-people-with-venous-leg-ulcers-a-toolkit-for-change/ for change focused on personalized self-care for people with VLUs.[174]

Step 5: Evaluate Outcomes

Recommendations

5.1 Determine if the outcomes of the goals of care have been met

Using validated and responsive tools and feedback from the team, clinicians should determine if all goals previously set have been met. If goals have been met, the team should continue with discharge planning and ensuring proactive, preventative self-management strategies are effective and in place.

5.2 Reassess patient, patient's skin, wound, environment and system, if goals of care are partially met or unmet

If the goals and response to the current management have been only partially met or unmet, the team needs to return to Step 1 and reassess. The specific activities required will depend on any factors that may be interfering and could involve further assessment of the original treatment plan to see if it was carried out as intended or if further specific investigations are required, including blood work, more in-depth evaluation of circulation, a wound biopsy or the involvement of other clinicians. Benchmark data show that, when compression is optimized, a VLU healing rate of 11 weeks is possible.[175] Goals may need adjustment once reassessment is completed. As well, clinicians should include patient-reported outcome measures (PROMS) that focus on quality of life.[176]

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Recurrence rates of venous ulcers have been reported as high as 70%. The ongoing use of compression is required to prevent venous leg ulcer recurrence. Compression can be underutilized due to the lack of clinician knowledge, unavailability of bandages/hosiery and patient resistance to its use. To support sustainability the ideal compression system should be:[177]

- Affordable
- Comfortable
- Easy to apply
- Non-allergenic
- Able to fit into the patient's footwear (seasonal).

The treating clinician needs to be sensitive to, and address, these issues. Unfortunately, a recent Cochrane Review identified only two studies looking at educational intervention for prevention of recurrence, and neither study showed a difference in long-term healing, recurrence rates or adherence to compression between the control and the intervention group.[107] This area requires more research.

As this condition requires a life-long commitment to garments, the patient's arterial supply should be regularly assessed. Unfortunately, there is no evidence for the optimal frequency of this assessment.[178] As well, consistent efforts to manage activity and mobility (walking) are essential. Collaborative care is necessary to support the patient's efforts to improve and manage their health, as it has the potential to reverse underlying causes. Ultimately, strengthened system support is required to ensure patient access to the resources necessary for preventing and managing venous ulcers.

Conclusion

This chapter presents a systematic approach to the prevention and management of venous leg ulcers. It is incumbent on the clinician to make the correct diagnosis by evaluating the patient's risks and knowing the characteristics and pathophysiology of venous disease. Assessment of the lower leg can be complex, and it is essential to ensure arterial disease has been fully evaluated by physical exam and supported by quantitative vascular means, starting with an ankle-brachial pressure index (ABPI) test.

The most important consideration and the gold standard for treatment is the use of compression. This requires considerable knowledge on the part of the health-care provider in co-operation with the patient, and needs to be done in a timely manner to prevent lengthy treatment times. This may require referral to a multidisciplinary wound clinic, if available in the care setting, or other subspecialties.

The important role of the calf-muscle pump in supporting edema management is well established, and exercises and activity to promote its function are necessary components of all treatment plans. Exercise and activity are ways that the patient can be actively engaged and empowered to take control of their care. The role of a muscle pump activation device can improve calf muscle pump function, reduce edema, and improve blood flow.

Surgical management of venous disease is an important consideration that should be carefully evaluated. A wound biopsy is necessary for atypical-looking ulcers or when healing is not evident despite appropriate ulcer management. Venous legs ulcers are unique and challenging because of the large amount of exudate that must be managed. Skin issues need to be addressed along with assessment of infection and pain.

The quality of life for patients with VLUs is impacted significantly and needs to be considered throughout the treatment cycle. These issues are unique to each patient but must be evaluated by the treating health-care providers in a successful treatment plan.

Recognizing the early stages of venous changes is significant, and those who see these patients in a primary care setting have an opportunity to provide education about venous disease and the prevention of venous ulceration. Intervening early on with strategies to improve the function of the calf-muscle pump would be ideal.

Recurrence of venous ulcers is known to be common. Patients leaving care should know that compression therapy is a lifelong commitment.

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Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 13

Prevention and Management of Wounds Related to Lower Limb Lymphedema

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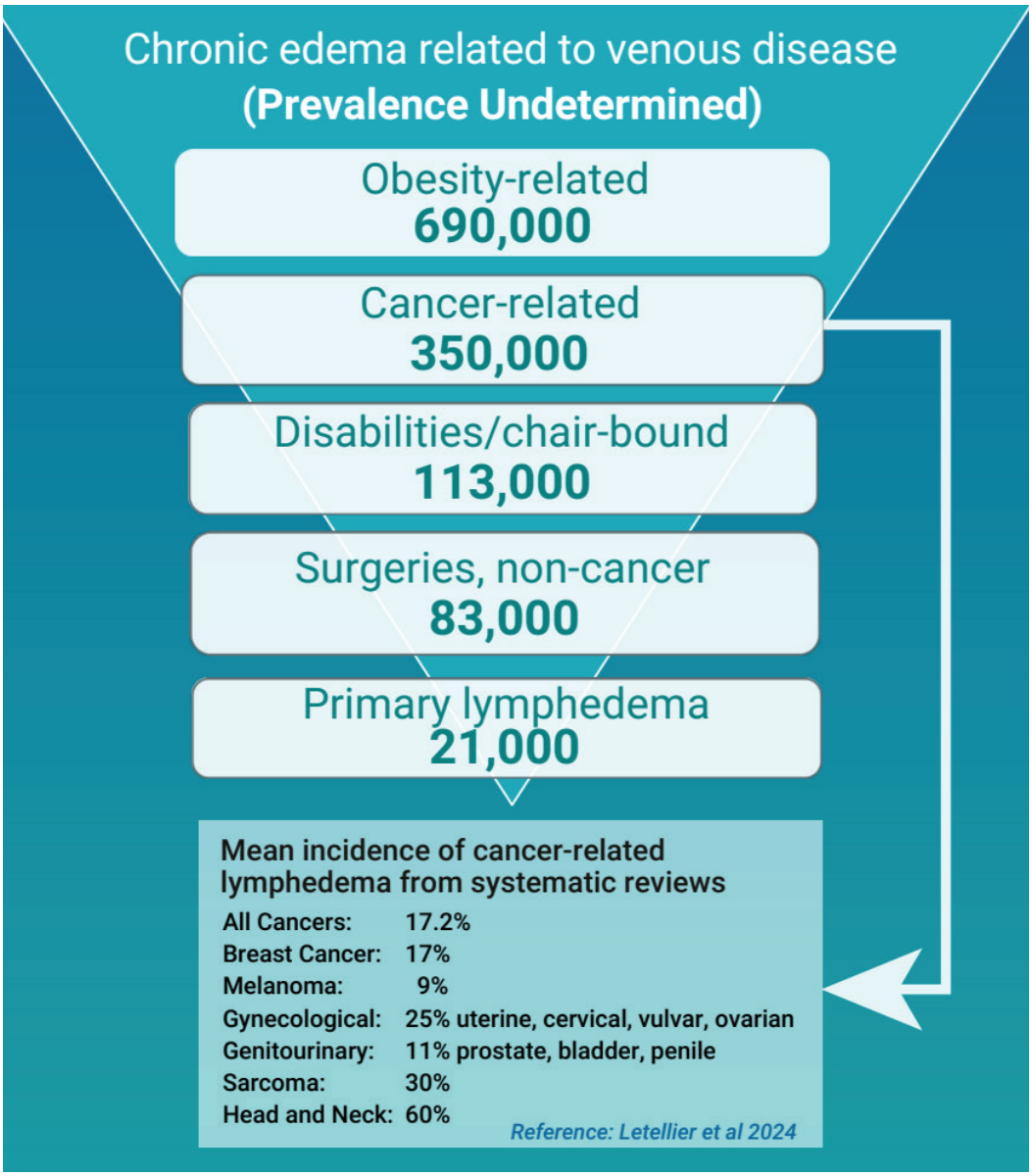
INTRODUCTION

Lymphedema, often termed a hidden disease, is generally under-assessed and under-appreciated by health-care providers.[1,2]

Edema that persists for more than three months and is minimally responsive to limb elevation and/or diuretics is defined as chronic edema. All chronic edema involves lymphatic dysfunction and is appropriately classified as lymphedema (LE).

Lymphedema affects more than 200 million people worldwide.[3] In the United States, it is estimated that 35 million individuals have the condition.[4,5] The prevalence of LE in Canada is approximately 1.25 million (based on 41.5 million population), but the condition is underdiagnosed and undertreated.[146] LE is associated with obesity, the rates of which are increasing in Canada.[6,7,146] Because of these factors it is important that patients receive timely assessment, diagnosis and referrals for activation of treatment, with an important focus on skin health and the prevention and management of wounds related to LE. This is crucial, as wound care is a costly concern to the health-care system and more research is needed to fully appreciate the impact of LE on this issue.[8,9] Figure 1 presents information on potential prevalence of LE and its associations with other health conditions.

Figure 1: Lymphedema and Chronic Edema Potential Prevalence, Canada 2024



What is Lymphedema?

Lymphedema, whether congenital or secondary, is a serious, debilitating and progressive condition that develops when protein-rich fluid accumulates because the ability of the lymphatic system is inadequate to transport the excessive interstitial fluid. The fluid accumulation is most commonly seen in the extremities.[4,10] The condition may range from mild to serious and affect patients of all ages, impacting quality of life, employment/employability, mobility and social and emotional wellness. Individuals who develop LE live with chronic, progressive swelling, skin changes, risk of infection, emotional distress and pain. Therefore, a holistic approach to lifelong care is required, including multiple referrals and reports from an interprofessional team whose members may represent lymphology, rheumatology, dermatology, endocrinology (diabetes mellitus), orthopedics and internal medicine (renal, cardiac, respiratory, bariatric) to determine causality.

Early diagnosis of LE is critical, as the disease is progressive. In the past, chronic leg edema (over three months) was not identified as LE. Recently, international experts have determined that though the pathology of chronic edema and LE may differ, the disorder is to be considered similar, as the overload or impairment of the lymphatics is the constant factor.[11]

Patients diagnosed with lower limb LE often live with other co-occurring diseases/disorders such as obesity.[1] To understand the state of LE in Canada, Wang and Keast (2016) reviewed 326 LE patients and found an average of 7.3 comorbid conditions that were potentially related to the development of chronic edema; hence the term *complex* lower extremity edema.[11] Of importance is that they reported that 45% of patients were found to be morbidly obese. They state, "it is conservatively estimated that over half those with a BMI ≥ 40 will have lymphedema and if BMI ≥ 50 the risk increases to 100%."[6]

Other causes of lower extremity LE include phlebo-lymphedema, most commonly known as chronic venous insufficiency (CVI) (41.8%), cancer-related lymphedema (33.9%), primary lymphedema (12.5%) and lipedema with secondary LE (11.8%).[12]

Lipedema versus Lymphedema: One of the challenges for clinicians is understanding the differences between lipedema and LE. Lipedema is an, "abnormal fat accumulation [and] is not a lymphatic-related disease (at least in the early states), and conventional imaging results demonstrate normal lymphatic functioning".[13] Based on the patient's lipedema history, hormone changes and genetics, secondary LE may develop as a complication.

The Canadian Lymphedema Framework states lipedema, "is caused when higher than normal fat deposits build up on the buttocks, legs, ankles and feet. This is not obesity and weight control makes no difference. Like LE, lipedema is a lifelong condition. But, they are different conditions and lipedema is often misdiagnosed as lymphedema."[14] Lipedema tissue is very painful, as is often noted on assessment.[15]

For more information on lipedema, see Appendix A: Lipedema.

Quere et al. explored the prevalence of patients with LE or chronic edema in acute care hospitals internationally. In the study of participants (n=1905), LE or chronic edema was identified in 723 (38%) of patients. Risk factors associated with chronic edema were age, morbid obesity, heart failure, immobility (chair bound) and neurological issues. Patient history of cellulitis was more frequent in patients with chronic edema and wounds (24.8%) and in those with chronic edema alone (14.1%), when compared with the 1.5% prevalence in patients without chronic edema.[16]

When reviewing the studies for LE prevalence it is important to note the methodology used to collect data.[17] Keast notes that in Canada, we are dependent on self-reported census data, of which obesity rates may not be accurate.[6] More research is needed to accurately understand the LE incidence.[18]

The focus of this chapter is on adults with LE, therefore the specific challenges of pediatric LE are beyond its scope.

Pathophysiology

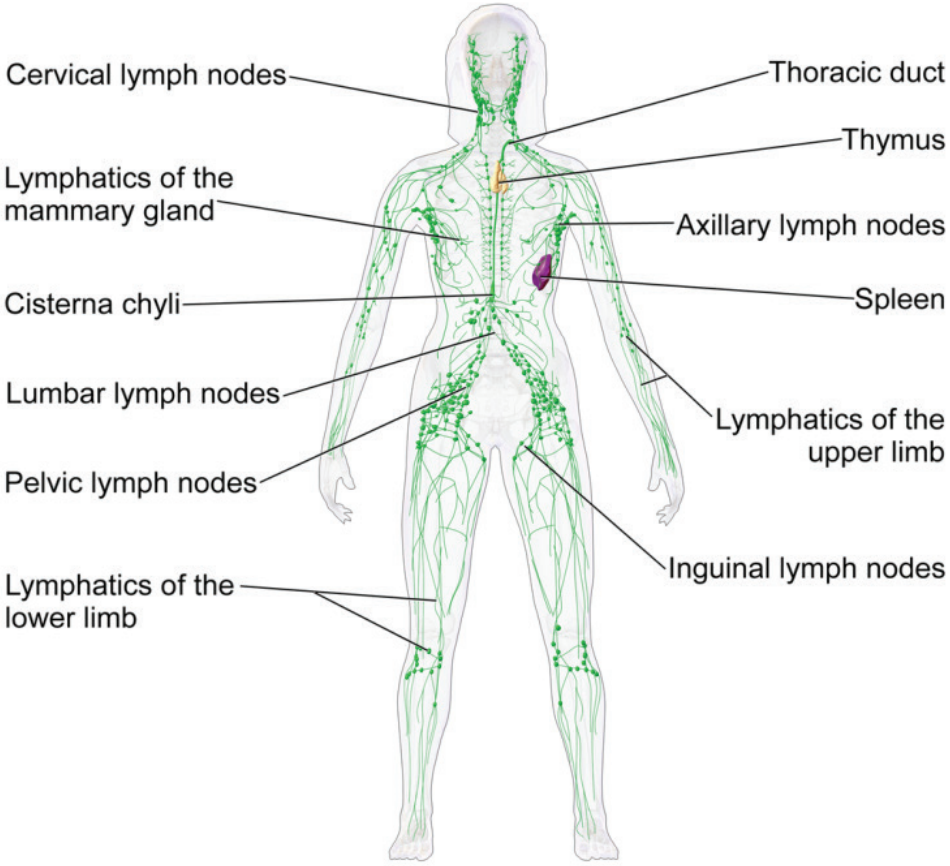
Understanding the pathophysiology of LE is important for successful assessment and management of the disease. It is important to consider the lymphatics, arteries and veins together.[6] The lymphatics are responsible to, "mobilize all

excess tissue fluid…have an immune function and a key role in fat metabolism. Lymphatics absorb fat from the digestive system and transport it as chyle to the circulatory system. It is known that LE and fat metabolism are linked".[6]

The lymphatic system consists of lymph vessels, lymph nodes, spleen, thymus, tonsils and Peyer's patches. The lymphatic system has a major role in the functioning of the immune system. It is now recognized that the vascular capillaries, the extracellular matrix and the lymphatics act as a co-ordinated unit and play a key role in regulating fluid and molecular transport.[19] The lymphatic system also plays a role in regulating the function of such organs as the brain, kidneys and liver. See Chapter 3: Skin: Anatomy, Physiology and Wound Healing[25] for additional information on the lymphatic system.

The lymphatic capillaries connect to common lymphatic collectors that merge into a single lymph vessel (lymphangion). Smooth muscle in the lymphangion contracts once distended to propel lymphatic fluid through the valves in a peristaltic manner. Normal lymph propulsion is aided by adjacent arterial pulsations, muscle contractions, body movements, respiration and skin distention. The lymph vessels ultimately connect to the thoracic duct, which empties into the subclavian vein (See Figure 2).

Figure 2: The Lymphatic System



Source: Medical gallery of Blausen Medical 2014. Blausen 0623. Lymphatic system in the female - English labels. At AnatomyTOOL.org by Blausen.com staff (2014), license: Creative Commons Attribution. Available at: https://en.wikiversity.org/wiki/WikiJournal_of_Medicine/Medical_gallery_of_Blausen_Medical_2014

Water, glucose, amino acids and oxygen filter out of the capillaries into the interstitial space, nourishing the cells and supporting metabolism, thereby creating waste products. Large molecules such as proteins do not easily cross the semipermeable membranes of the walls of the capillaries. Filtration and reabsorption by the capillaries are dynamic processes, and proteins may be partially reabsorbed. However, lymphatic capillaries have a unique structure that allows the absorption of these large protein molecules and waste products. The cells of the lymphatic capillaries have anchoring filaments and are able to separate from one another to create an opening through which fluids, proteins and macromolecules can flow into the lymphatic capillary. The resulting fluid is known as lymph. Lymphatic fluid

also may include lipids (that are absorbed in the intestine), waste products of metabolism, matrix metalloproteinases (MMPs), cytokines, polysaccharides and fibronectin.

There is no net reabsorption by the capillaries, and all residual tissue fluid is handled by the lymphatics. While lymphatics have significant reserve capacity they can be blocked, absent or overwhelmed. When there is an imbalance between filtration and absorption, fluid will accumulate in the interstitial space and is assessed clinically as edema. All chronic edema lasting more than three months is defined as LE.

Lymphedema and the Development of Wounds

Slow- and non-healing wounds associated with LE are more likely to be identified in the lower extremity than upper limbs (most upper limb LE is related to breast cancer treatment). The higher intravascular hydrostatic pressure related to gravitational forces, chronic dependency and failed calf-muscle pump action in the lower limb result in higher filtration rates. This then leads to accumulation of tissue fluid, overwhelms the lymphatic capacity and results in subsequent inflammatory lymphatic dysfunction.

In a review of international studies, the prevalence of persons with LE (n= 2,200) and chronic wounds mostly involved persons in developed countries.[1] Approximately half of all individuals with LE in acute care, long-term care or community nursing settings develop slow- or non-healing wounds.[1]

When the lymphatic system is impaired, blocked or overloaded the skin is affected, making it more susceptible to breakdown.[19] Immune system involvement leads to a triggered inflammatory response.[20] Risk for repeated episodes of acute and chronic cellulitis increases.[21] The "stagnant, protein-rich lymph initiates an inflammatory response that leads to adipocyte proliferation, fibrous tissue deposition, and increased susceptibility to infections."[22]

The Quintuple Aim for Health-care Improvement

This chapter is written with the intent to encompass the quintuple aim for health-care improvement (See Table 1) to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity. The health equity element is particularly important for patients living with skin issues and wounds related to LE. Ensuring all patients receive care, appropriate supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[23]

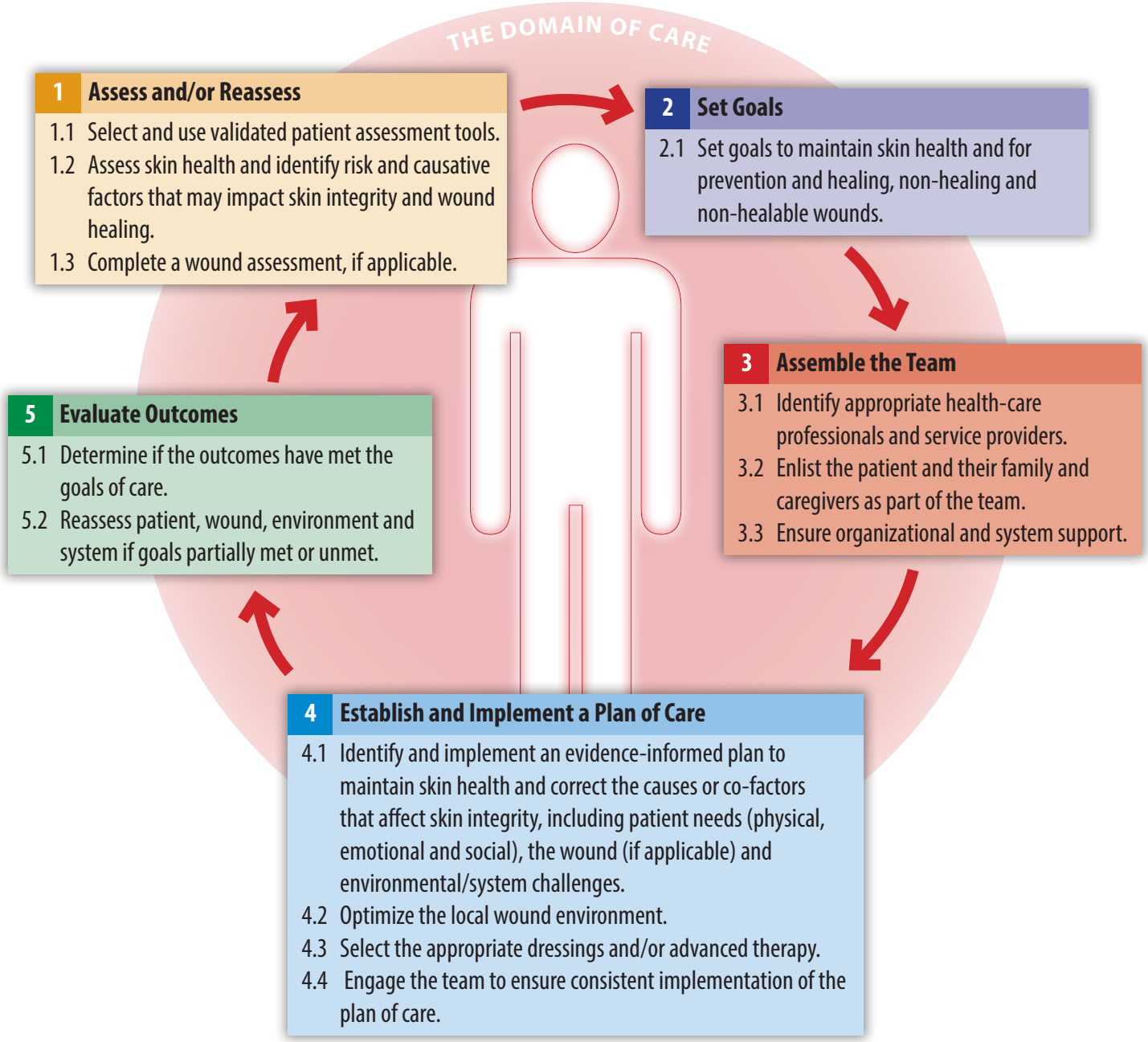
Table 1: Quintuple Aim and Management of Lymphedema

Five Components	Application to Lymphedema
Improving population health	Prevention, education and self-management strategies
Reducing costs	Application of best practice to ensure most effective treatment Appropriate use of resources: examples include compression therapy designed for each individual, bandaging, dressings, exercise and weight management programs
Advancing health equity	Application of principles to all those at risk for or affected by LE
Care team wellbeing	Provision of clinically usable information for frontline clinicians
Enhancing the patient experience	Provide a supportive process of care for all those with LE and associated skin and wound issues

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide that incorporates the best available evidence. It outlines a process, or series of consecutive steps, that supports patient-centred care. This process, called the Wound Prevention and Management Cycle (See Figure 3), guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of wounds from the initial assessment to a sustainable plan targeting self-management for the patient.

Figure 3: The Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence and are intended to support the clinician, the patient, their care partners and family and the health-care team in planning and delivering the best clinical practice. Two foundational chapters supplement this chapter with additional evidence-informed information and recommendations that are general to all wound types: Chapter 3: Skin: Anatomy, Physiology and Wound Healing[25] and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

Three guiding principles within the best practice recommendations (BPRs) chapters support effective prevention and management of skin breakdown:

1. The use of the Wound Prevention and Management Cycle, regardless of the specifics, to prevent and manage skin breakdown
2. The constant, accurate and multidirectional flow of meaningful information within the team and across all care settings, and
3. The patient as the core of all decision making.

Step 1: Assess and/or Reassess

Recommendations

1.1 Select and use validated patient assessment tools

Discussion: Complete a comprehensive patient assessment as outlined in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24] The use of validated and standardized risk assessment tools is essential for skin health and wound management. Currently, there are no specific validated assessment tools for identifying LE risk factors that may affect intact skin; therefore clinicians should use general skin and wound assessment tools. Circumferential (limb) measurements are used to monitor progress in reducing chronic edema. The most common method is to measure with a tape measure at the ankle, knee and at a defined distance in centimeters above and below the knee. The points used depend on the areas of the limb that are most edematous.

For general skin assessment tools, see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

Quality of Life

There are validated health-related quality of life (HR-QoL) tools focused on LE (upper and lower limb). It is important to use validated tools to screen for depressive symptoms, depression, anxiety, feelings of worthlessness, change in sexual function (e.g., hydrocele, genital LE) and reduced hope. Cermal et al. conducted a review exploring quality of life for persons with LE secondary to cancer. They reported the need for high-quality research and for clinicians to screen for risk of mental health changes.[26] Mental health factors are important to consider as they impact the patient's ability to engage in complete decongestive therapy and other therapeutic modalities and potentially burden the care partner and family.[27,28]

In a 2022 review, researchers identified 12 health-related quality of life (HRQoL) tools focused on LE arm and leg.[29] Out of the HR-QoL tools available, the Lymphoedema Quality of Life Tool (LYMQOL) is the tool most commonly used.[30] (Keeley, 2007). The Lymphedema Life Impact Scale may also be used to assess for LE impact on a patient's life.[31] For a full description of lymphedema-related quality of life tools and further information, see Lim et al. 2022 at https://rees-france.com/wp-content/uploads/2022/05/Health_related_Quality_of_Life_Measurement_Tools.pdf

In addition to the above assessment, continence status (fecal, urinary and/or both) should be assessed using validated tools. There is an association between lower limb LE and pelvic floor surgery (e.g., gynecological), continence and changes to the patient's body image and quality of life.[32,33]

Evidence supports the use of validated venous-disease-specific quality-of-life indicators, which can be found at https://www.woundscanada.ca/health-care-professional/resources-health-care-pros

For disease-specific assessment tools that focus on health-related quality of life while living with a chronic lower limb wound, see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

Wound assessment tools: Assessment of any wound and documentation of findings also require a standardized approach using a comprehensive, validated and reliable wound assessment tool. Such tools not only provide a baseline of wound characteristics, but also identify wound change over time, which helps determine if a wound is progressing toward closure or is deteriorating. See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for more on wound assessment tools.

Pain assessment tools: Pain assessment tools for persons living with LE provide a systematic approach for assessing and documenting pain, as well as the factors that are causing or exacerbating wound-related pain. The accurate and regular assessment of pain is essential to ensure patients experience effective pain management. Clinicians should use validated pain assessment tools, such as the visual analogue scale, the numeric rating scale, non-verbal pain scales and verbal rating scale, the Brief Pain Inventory and the McGill pain questionnaire. See Chapter 4: Best Practice ecommendations for the Prevention and Management of Wounds: An Overview[24] for more on pain assessment tools.

Nutrition and activity screening: Nutritional screening tools provide a standardized approach for identifying patients with LE who are at risk of compromised nutrition and who require further nutritional assessment and

intervention. For patients with LE, nutritional assessment may focus on anti-inflammatory and anti-edema diets and weight management alongside physical activity.[34] As part of an integrated team, the registered dietitian and physiotherapist work closely with the patient to co-develop life-long nutritional support and activity plans.[34] More research to fully understand links between nutrition and LE is required.

For more information on nutrition screening tools see Appendix 1: Nutrition for Skin Health, Wound Prevention and Wound Healing in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

1.2 Assess skin health and identify risk and causative factors that may impact skin integrity and wound healing

Discussion: Given the complex nature of LE there are many risk factors that impact the health of the patient that clinicians considered while conducting the holistic patient assessment.[1]

1.2.1 Patient: Physical, emotional and lifestyle

Discussion: Lower limb LE requires early diagnosis to support goal setting, care planning and the implementation of preventative strategies that include patient education focused on risk factors.

A comprehensive physical and lower limb assessment should be completed and communicated to the team members. For steps on completing a lower limb assessment see Chapter 12: Best Practice Recommendations for the Prevention and Management of Venous Leg Ulcers.

Independent risk factors to consider are outlined in Table 2.

It is important to have an appropriate examination table, blankets, gowns and assessment tools (blood pressure cuffs) appropriate for the person's size. A second clinician may need to be present to support patient comfort, turning and positioning during the physical examination.

Table 2: Assessment and Impact of Risk Factors

Assessment	Factor(s)	Considerations
Complete a detailed history	Congenital predisposition	Inherited or congenital condition, e.g., Milroy's disease
	Volume overload (e.g., heart failure)	Volume overload must be managed to reduce filtration pressure
	Diabetes mellitus (duration)	Uncontrolled blood sugars delay healing
	Trauma (e.g., sprains, musculoskeletal abnormality; veni-punctures, injections, wound and drainage complications; breast/ lymph node dissection or surgery)	May have removed or damaged lymphatics
	Venous leg disease, varicose vein surgery (e.g., vein stripping, vein harvesting)	May have damaged lymphatics Chronic venous insufficiency with associated leg edema
	Abdominal or lower extremity surgery	May have damaged lymphatics (seroma) Consider continence status (urine, fecal)
	Hip or knee surgery (e.g., implants, hardware)	Increases risk in some patients Ruptured Baker's cysts[35]
	Chronic inflammatory diseases	Chronic inflammation my affect lymphatic function Löfgren syndrome
	Malignancy, melanoma (e.g., pelvic and abdominal surgery)	Surgery, radiation or drugs may affect lymphatics
	Infections (e.g., cellulitis, lymphangitis)	Rule out infectious causes. Cellulitis history[13,36]
	Neurological problems	May alter gait May lead to chronic limb dependency
	Osteoarthritis (e.g., mobility, gait pattern, devices used)	May alter calf-muscle-pump function
	Mental health and wellness	Depression, anxiety, history of engaging in health activities[37, 38]

cont'd. . . .

Medications (prescribed, over the counter, other)	Edema-causing medications (list not inclusive)	Anti-hypertensive: • Calcium channel blockers e.g., amlodipine • Beta-blockers • Clonidine • Hydralazine • Minoxidil • Methyldopa[35] Nonsteroidal anti-inflammatory drugs (NSAIDS), e.g., ibuprofen Corticosteroids, e.g., prednisone Alpha blockers, e.g., doxazosin Hormones and related compounds, e.g., tamoxifen[39,40] **Additional drugs that often cause peripheral edema:** Anticonvulsants for pain management, e.g., pregabalin Opioids, e.g., analgesics, fentanyl, hydromorphone, morphine oxycodone, tramadol, replacement therapy methadone[41] Antidepressants, e.g., trazodone[39]; escitalopram, mirtazapine, paroxetine, venlafaxine[41] Anti-diabetes, e.g., rosiglitazone; insulin[41] Antipsychotics, e.g., risperidone Bisphosphonates, e.g., zoledronic acid[39]
	Chemotherapeutic treatment and agents	May suppress wound healing: e.g., docetaxel[39] Targeted cancer therapies: mitogen activated protein kinase inhibitors[39, 41] Anti-cancer agents, e.g., rapamycin inhibitors[39]; Gemcitabine, pemetrexed, cyclophosphamide, clofarabine ATRA/taxanes[41]
	Radiotherapy	May develop radiodermatitis, scarring Radiotherapy in the regions of the lymph nodes, mammary glands or pelvis (postoperative)
	Immunosuppressive drugs	May suppress wound healing (e.g., sirolimus)[39] ; calcineurin inhibitors, ciclosporin, tacrolimus[41]
Social history	Substance use	Smoking (cigarette, other), alcohol, recreational drug use may delay wound healing; contaminated illicit/illegal drugs (e.g., xylazine)
	Living conditions/travel	Availability of formal/informal care partners Challenges in living conditions, space, safety Travelling to regions with filariasis Insect/animal bites[35]
	Access to services	Barriers to accessing services or treatments (e.g., travel costs, finances, employment)
Employment	Ability to work or be employed	Assess ability to work, adapt and maintain employability[42] Clothing, footwear[43]

cont'd. . . .

Examination	Height, weight, body mass index (BMI)	BMI >40 associated with 50–60% increased risk BMI >60: 100% lymphatic dysfunction[44]
	Blood pressure	Uncontrolled hypertension may increase filtration
	Joint mobility, fixed ankles, gait	All may decrease calf-muscle pump function Hip and knee surgery increase risk
	Arterial/vascular assessment	Cardiovascular risk factors identified Ankle brachial pressure index (APBI) must be done to rule out significant peripheral arterial disease[45]
	Limb skin assessment	Acute cellulitis, erythema, chronic infections Look for positive Stemmer's sign and pitting test, skin creases, papillomatosis and fibrosis (See Figure 4) Presence of hemosiderin staining Presence of dermatitis and loss of barrier function Consider biopsy if suspicious for skin malignancy Hyperkeratosis (scaly, thicker)
	Nail/foot assessment	As per limb skin assessment Nail/foot condition(s) including footwear
	Wound assessment	Refer to Chapter 4[24]
	Compression therapy	History of compression therapy, garments, device use Self-bandaging method and products used Present compression being used (day and nighttime) Barriers to access due to funding/insurance Donning/doffing devices used
Laboratory	Screening laboratory	Anemia, poor nutritional status, hyperglycemia may affect healing
Pain assessment		Type of pain (nighttime rest pain, intermittent claudication)[46] Does pain interfere with adherence to care plans? Strategies used to manage

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Pain: Patients with lower limb LE describe heaviness, pain and a feeling of tightness and swelling in their limbs and feet.[47] This may be related to peripheral arterial disease (PAD) and associated intermittent claudication, chronic and acute ischemic pain, neuropathic and/or musculoskeletal pain.[47] In addition, patients may describe numbness, stiffness, tightness, tenderness due to compression therapy that leads to dysesthesia and tingling in the lower limbs.[48] Patients with LE in the genital region—a rarer form of LE—may experience pain and swelling that may interrupt sexual functioning, lead to incontinence and affect quality of life.[49]

Ankle Brachial Pressure Index (APBI)

The British Lymphology Society published a position paper to support clinician understanding of the role of ankle brachial pressure index (APBI) when planning application of compression therapy for patients living with LE.47 Obtaining an accurate ABPI may be challenging because of the presence of edema, hyperkeratosis and tissue thickening.45,47 An APBI is needed to rule out PAD, which is a contraindication for use or level of compression therapy. Clinical assessment skills must be added to any APBI assessment to prevent inaccurate readings from affecting care planning decisions.45,47 It is important to note that clinicians conducting an APBI must be conscious of selecting the correct size of blood pressure cuff to ensure tolerance in patients with LE.

Elwell and Snodden discuss the challenges of obtaining a satisfactory vascular assessment. They state the following: "Unfortunately, the presence of peripheral edema may render a reading impossible or grossly inaccurate. Relying solely on ABPI assessment is potentially harmful to patients, who may be denied appropriate treatment or experience complications and deterioration of their condition due to delayed treatment. The BLS recognizes a need to focus more on clinical assessment skills to determine vascular status, rather than relying on ABPI alone."[45]

Factors that May Affect Obtaining an ABP[147]

Available from: https://lymphoedemaeducation.com.au/wp-content/uploads/2018/10/BLS-ABPI-A4.pdf

- Inadequate preparation, e.g., room temperature
- Inexperience of the practitioner
- Patient anxiety
- Repeated inflation of the cuff moving Doppler probe during the procedure
- Poor patient positioning
- Prolonged inflation of the cuff or re-inflation mid procedure
- Inappropriate gel
- Releasing sphygmomanometer cuff too rapidly
- Incorrect size of sphygmomanometer cuff
- Excessive pressure on a vessel during the procedure
- Wrong size of doppler probe
- Miscalculation of reading
- Incorrect positioning of the doppler probe over the vessel.

See Chapter 10: Best Practice Recommendations for the Prevention and Management of Peripheral Arterial Ulcers for further information on arterial diagnostics.

Diagnostic Testing

Researchers state 90% of LEs can be accurately diagnosed with a comprehensive physical examination and detailed history.[50] This process requires time and may take several hours or patient visits to fully complete. The assessment should include an ABPI[46] or clinical vascular assessment (see above) and baseline blood tests that include: complete blood count, metabolic panel, white count for infection, atrial natriuretic peptide, albumin level and thyroid panel. In addition, a routine urinalysis may be completed to rule out other causes of the lower extremity edema.[2,50] Liver function and blood urea nitrogen (BUN/creatinine) levels and liver function tests may be checked as well as neoplastic markers, if required.[50]

Diagnostic imaging may be completed with the goal of understanding what is causing the lymphatic blockage, compression or dysfunction.[51,52] These may include:

- Ultrasound (US) to rule out deep vein thrombosis (DVT); also useful to exclude other etiologies such as venous insufficiency. In addition, the US may help in identifying tissue changes and masses that might be the cause of lymphatic compression[50,53]
- Magnetic resonance imaging (MRI) and computerized tomography (CT) scan can help investigate causes of soft tissue edema, hematomas, cellulitis and cysts[54]
- Magnetic resonance lymphoscintigraphy (MRL) involves intradermal injection of radiolabeled colloid and subsequent imaging of the lymphatic system, with the goal of visualizing lymphatic function, anatomy and as a step in determining if tumor cells are present.[54,55] MRL can also aid in diagnosing certain diseases or conditions, such as lymphoma or LE[55]
- Indocyanine green (ICG) test and fluorescence imaging more commonly assist with LE diagnosis by analyzing the functional and anatomic lymphatics. This test involves the, "activation of molecules in tissue to generate high-resolution images. The short half-life of the ICG not only makes it safe for patients but also allows for repetitive application preoperatively, intraoperatively, and postoperatively".[54]

Note: these diagnostic tests are most commonly used to determine outcomes of treatment through reduction of limb volume particularly in upper extremity LE. Bioimpedance spectroscopy (BIS), bioimpedance analysis (BIA), tissue dielectric constant (TDC) and additional measuring devices may assist with early assessment of tissue fluid accumulation.[13]

Perometry (perometer software) and three-dimensional techniques may be used to measure limb volume;[56] each has limitations.[57] In a specialized clinic, these two tests may be completed using advanced technological devices.

Risk Considerations Specific to the Pediatric Populations

Though not the focus of this chapter, in the pediatric population (infant and child), primary LE (congenital) and secondary (caused by an injury or event) LE are considered relatively rare, yet it is still a progressive and chronic

condition.[58-60] Lymphedema carries with it the lifelong burden of aiming to manage LE swelling and the risk of secondary complication.[61] In this population, LE may or may not be visible and the swelling may only, "develop later in childhood or adolescence; others still will first develop symptoms of LE as an adult, usually after some aggravating lymphatic event such as weight gain, injury or infection".[61]

Lymphedema is usually associated with surgery and various syndromes; therefore, genetic testing for certain cases should be considered.[13,60] Recent research has implicated specific abnormalities in the genes that control development of lymphatic valves. All pediatric lymphedemas should be referred to a pediatric LE specialist, certified lymphedema therapist and a garment fitter trained in the support of pediatric populations.

Risk Considerations Specific to the Population with Cancer

Patients who have cancer and are undergoing cancer-related treatments (e.g., chemotherapy, radiation, surgery) may be at risk of developing LE. Cancer tumors that grow in size not only impair organ function but also impair the lymphatic system, including lymph nodes and vessels. Chemotherapy treatments and anti-cancer medications may also contribute to the development of LE (See Table 2). For example, one of the greatest concerns with melanoma cancer along with the extensive surgical excision required, is the patient may have already developed underlying metastatic disease with lymphatic involvement. When advanced-stage melanomas occur, they require sentinel lymph node biopsy (SLNB) and occasionally lymph node dissections (LND).[62] Researchers report that after an inguinal SLNB is completed, LE may occur, and when inguinal LND is done the rates of lower limb LE increases. What is interesting in this study is the growing role of lymphatic reconstructive surgery. The researchers discuss the importance of pre-operative diagnostics (Indocyanine green lymphography) and the role of super-microsurgical lymphaticovenular anastomosis (LVA) with the goal of maintaining the lymphatic flow throughout the body.[62] Chen et al. studied patients (n=85) undergoing inguinal lymphadenectomy (greater than 10 nodes), and this significantly increased LE in patients, especially women, who were at greater risk.[62]

Cibul et al. explored the risk of developing lower limb LE after SLNB in patients diagnosed with cervical cancer.[63] In this study, patients (n=150) underwent preoperative lower limb LE assessments using both limb volume measurements and asking patients their perception of limb swelling. The study results revealed that at 24 months the incidence of LE was 17.3% for mild LE, 9.2% for moderate LE, and only one patient developed severe LE.[63] They concluded that the, "replacement of standard pelvic lymph node dissection (PLND) by bilateral SLN biopsy in the surgical treatment of cervical cancer does not eliminate the risk of mild to moderate LE, which develops irrespective of the number of SLN removed".[63]

Patients with cancers of the abdomen, including gynecologic malignancies vulvar, cervical, endometrial and ovarian, are at risk of developing lower limb LE; up to 70% in select populations.[64] These study results remind us of the importance of understanding the pathophysiology and risk factors, especially when the patient is undergoing cancer treatments before and after surgery and the need for long-term follow-up. There is a need for more research to follow these populations long-term to determine the best post-operative lower limb LE supports and measures.[64]

LIfestyle Considerations: In Canada we have the challenge of understanding the role of recreational drugs such as cannabis and the associated risk of cerebrovascular and neurological (neurovascular) perspectives.[65] Researchers in a narrative literature review reported recreational use of cannabinoids is related to, "both cardio and cerebrovascular events such as ischemic and hemorrhagic stroke…and neurological diseases that result from structural and functional changes in the brain, cognitive dysfunction and behavioral disorders".[65] More research is needed, especially related to LE and cannabinoids as they interact with skin, the immune system, bone marrow and liver.

1.2.2 Environmental: Socio-economic, care setting and potential for self-management

Discussion: Health-care professionals must have knowledge about the environmental factors that can impact the skin health of a person living with LE. These factors include the ability for self-care, socio-economic conditions (employment type, income and benefits to fund bandaging system or compression garment design), living situation and environmental factors.[1,9] The understanding of self-management specific to LE is growing, but more research is needed to focus on patient-centred outcomes and the impact of clinicians and systems.[1,66] The key challenge with self-care approaches is how much the patient and the care partner can manage without it leading to emotional, physical and financial burden overload.

1.2.3 Systems: Health-care support and communication

Discussion: Health ministries and health-care professionals are responsible for addressing the prevalence of LE, its association with multiple chronic illness and the burden to the health-care system.[1] Yet not all provinces/territories capture the diagnosis consistently using the International Statistical Classification of Diseases and Related Health Problems (ICD codes).[67] For example, some provinces/territories use different billing codes or have no billing codes for lymphedema (assessment and management). As a result, data for research may not be fully available, and prevalence and incidence rates may be significantly underreported.

Note: ICD is a system of codes that classify medical diagnoses. The current version is ICD-10. The current main code is 457, but there are subcodes and other vascular codes that can apply.

To improve the care of patients with LE, awareness programs, early screening and assessment are necessary at the individual, community and population health levels. In a recent review (12 studies) Yarmohammadi et al. explored health-care providers' knowledge of LE. Overall, practitioner knowledge was low, including their understanding of pathophysiology, signs and symptoms, management and referral support.[68] Manrique et al. state LE education is limited or minimized in clinical practice and academic programs and needs to be improved.[54] See Appendix C: Lymphedema/Chronic Edema Clinician Certification and Education for a list of courses in Canada focused on LE assessment and management.

1.3 Complete a skin and wound assessment, if applicable

Discussion: Complete a baseline skin/wound assessment as part of the comprehensive lower limb assessment.

Skin Assessment: In a systematic review, Fife et al. identified skin disorders related to LE[19]

- Directly caused by LE:
  - LE-related inflammatory processes leading to disfigurement of the associated limb or affected limb, and/or
  - Lymphorrhea – lymphatic fluid that drains directly through the skin that leads to tissue maceration and breakdown
- Indirectly related to LE:
  - Pressure ulceration from the weight of the limb(s)
  - Venous leg ulcers with a mixed venous/lymphatic origin, such as venous stasis
- Associated with the diseases causing LE, such as cancer
- Associated with LE treatment, such as poorly wrapped bandaging and ill-filling compression garments and/or devices.[19]

Figure 4 presents some of the key lower limb findings that aid in LE diagnosis: pitting edema, and positive Stemmer's sign.

Figure 4: Diagnosis of Chronic Edema/Lymphedema



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Table 3 outlines examples of skin changes that may be seen as the protein-rich fluid accumulates and initiates the inflammatory response that often leads to adipocyte proliferation, fibrous tissue deposition and increases the risk of infections.[22]

Table 3: Skin Changes Associated with Lymphedema[19]

Skin Change	Description	Cause	Image
Cellulitis	Acute onset, increase in swelling and pain; tenderness, erythema, fever, malaise **Note of caution**: Bacterial cellulitis is often over diagnosed and over treated with antibiotics. It is usually unilateral, shows a deeper erythema and it progresses quickly. Bacterial cellulitis has an acute onset (measured in hours rather than many days). It is often accompanied by general malaise, fever and occasionally by GI symptoms. The neutrophil count would be elevated on a blood test. Chronic accumulation of edema fluid will cause chronic inflammation. It is often bilateral and diffusely erythematous. Neutrophil counts are usually not elevated	Acute bacterial infection often caused by *Streptococcus pyogenes* or *Staphylococcus aureus*	 *Used with permission from Dr. D. H. Keast.*

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Dermal fibrosis	Thickened plaques within the area of lymphedema, usually associated with Stage ll or beyond	Fibrosis is a consequence of the longstanding protein-rich fluid and associated inflammation	 *Used with permission from Dr. D. H. Keast.*
Hyperkeratosis and nodular fibrosis	A large fibrotic nodule within the area of lymphedema	Directly related to the ongoing fibrosis in lymphedema	 *Used with permission from Dr. L. Parsons.*  *Used with permission from Dr. D. H. Keast.*
Necrobiosis lipoidica	Occurs in the skin of persons with type 1 and 2 diabetes Collagen degeneration leads to skin lesions on anterior shin Carries a risk of ulceration	Cause unknown. May include changes to blood vessel walls, collagen deterioration, formation of granulomas and deposition of fat	 *Used with permission from Dr. D. H. Keast.*

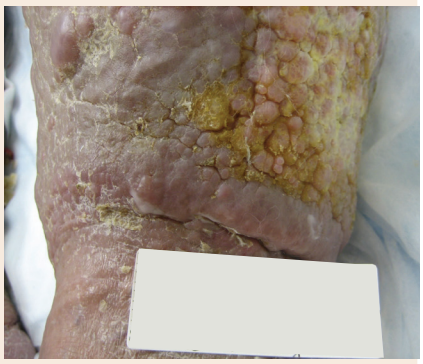
cont'd. . . .

Lymphoceles or lymphectasia	Dilated lymphatics that form dome-shaped papules on the skin	Directly related to areas of chronically dilated lymphatics	Acquired lymphectasia  https://dermnetnz.org/topics/acquired-lymphangiectasia
Massive localized lymphedema	Pendulous nodules, polyps or tumours found within the areas of lymphedema (this patient probably has lipedema with secondary LE; note cuffing at the ankle)	Gravity and fibrosis +/– compressible fluid	 *Used with permission from Wounds Canada*  *Used with permission from Dr. L. Parsons.*

cont'd. . . .

Lymphorrhea	Clear fluid that seems to seep spontaneously from skin affected by lymphedema	Microscopic skin defects leak fluid under pressure	Lymphorrhea  *Used with permission from Dr. R. Evans.*  *Used with permission from Dr. D. H. Keast.*
Lymphagio-sarcoma (Stewart-Treves syndrome)	A rare, aggressive malignant tumour associated with longstanding lymphedema. Probably more common in untreated lymphedema	Chronic inflammation can lead to malignant transformation	 Early stage *Used with permission from Dr. D. H. Keast.*  Late stage (post radiation treatment) Images taken from the lateral thigh *Used with permission from Dr. D. H. Keast.*

cont'd. . . .

Elephantiasis (usually stage III)	Extreme or end stage lymphedema with enlargement of the affected limb and often with one or more of the above-mentioned skin changes, seen in conjunction with the increase in size	End stage of chronic, untreated lymphedema Almost exclusive to lower limb lymphedema	Stage 3 elephantiasis nostras verruciformis (ENV)  *Used with permission from Dr. D. H. Keast.*
Papillomatosis			 *Used with permission from Dr. D. H. Keast.*

Lymphedema Classification: Lymphedema can be classified in several ways, with the goal of identifying the disease progression and severity.[13] Two staging systems are available for use: The International Society of Lymphology (ISL)[13] and the National Lymphedema Network (NLN). See Appendix B: National Lymphedema Network (NLN) Staging of Lymphedema. In this best practice recommendations chapter we discuss the ISL staging system. See Figure 5.

Figure 5: Staging of Lymphedema

Stages of Chronic Lymphedema (Severity)		
Stage 1	**Stage 2**	**Stage 3**
		
Moderate stage: • Edema is pitting • Edema is soft and reduces with elevation	**Moderate stage:** • Pitting is manifested • Edema rarely reduced by elevation • Inlater stages: development of fat tissue and fibrosis	**Severe stage:** • Tissue is fibrotic and pitting is absent • Significant skin changes: · fat deposition · warty skin (papillomatosis) · hyperkeratosis · hyperpigmentation · increases skin folds

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According to the International Society of Lymphology, it is important to note that patients may, "exhibit more than one stage, which may reflect alterations in different lymphatic territories."[13] See Table 4 for the specifics of staging.

Table 4: Clinical Stages of Lymphedema[13]

Stage	Symptoms	Protein-rich fluid accumulation	Pitting edema	Non-pitting edema	Scar tissue formation	Hardening of dermal tissues	Skin papillomas
Stage 0: Refers to a latent or subclinical condition where swelling is not yet evident despite impaired lymph transport, subtle alterations in tissue fluid/composition and changes in subjective symptoms. It can be transitory and may exist months or years before overt edema occurs (Stages 1 – 3). Assessment of early fluid changes can be accomplished using BIS, BIA or TDC analysis	Yes	No	No	No	No	No	No
Stage 1: Represents an early accumulation of fluid relatively high in protein content (e.g., in comparison with "venous" edema), which subsides with limb elevation. Pitting may occur. An increase in various types of proliferating cells may also be seen	Yes	Yes	Yes	No	No	No	No
Stage 2: Stage 2 involves more changes in solid structures. Limb elevation alone rarely reduces tissue swelling, and pitting is manifest	Yes	Yes	Yes	No	Yes	No	No
Late Stage 2: The limb may not pit as excess subcutaneous fat and fibrosis develop	Yes	Yes	No	Yes	Yes	No	No
Stage 3: Encompasses lymphostatic elephantiasis where pitting can be absent and trophic skin changes, such as acanthosis, alterations in skin character and thickness, further deposition of fat and fibrosis and warty overgrowths have developed	Yes	Yes	No	Yes	Yes	Yes	Yes

Adapted from: Manrique OJ, Bustos SS, Ciudad P, Adabi K, Chen WF, Forte AJ, Cheville AL, Jakub JW, McLaughlin SA, Chen HC. Overview of Lymphedema for Physicians and Other Clinicians: A Review of Fundamental Concepts. Mayo Clin Proc. 2022 Oct;97(10):1920-1935. DOI: 0.1016/j.mayocp.2020.01.006

Wound Assessment

When completing a comprehensive wound assessment it is important to know the underlying LE causes and factors and know the other co-morbidities with which the patient has been diagnosed. To accurately assess all wounds, plan assessment when compression bandaging and garments are being applied as part of the patient's routine. Document wound(s) using validated tools to promote clear communication among team members. Monthly photography (approved by your organization) assists with the documentation of the full scope of the lower limb LE and associated wound issues.[69] Burian et al. recently studied wounds and chronic leg edema. Of the 7077 patients studied with leg edema, 12.7% had wounds. Independent factors included, "PAD, cellulitis within the past 12 months, secondary LE, being male, being over 85 years of age, underweight, bed bound, chair bound, diabetes, and walking with an aid".[70] Of importance is that 43.22% of those with wounds had clinically defined well-controlled edema and that hard/fibrotic tissue and a positive Stemmer's sign were associated with wounds.[70] This study reminds clinicians of the importance of initiating interventions to control edema because well-controlled edema was shown to result in a 50% lower risk for the development of wounds.[70]

Determine if the wound is healing or non-healing, healable or unhealable.

A healing wound is progressing through the normal stages of healing on an appropriate timeline.

A wound is considered healable if the LE-related cellulitis of the lower limb is localized and has sufficient vascular supply, underlying causes such as infection can be corrected and overall skin health and compression therapy can be optimized.

A wound is considered to be non-healing if the cellulitis is extensive, healing has stalled and the wound has healing potential, but various factors—such as smoking, high body weight and/or uncontrolled edema—are compromising skin health and wound healing. The patient may not tolerate the compression therapy or compression bandaging or devices may not be available to, or affordable for, the patient.

A wound is considered non-healable when it has no ability to heal due to untreatable causes such as terminal disease, significant peripheral arterial disease, smoking, obesity (morbid) that cannot be treated surgically, end stage malignant disease (such as extensive, inoperable tumours) or end-of-life status.[71,72] If the wound is deemed to be non-healable, goals should be set that reflect management strategies for activities that prevent infection, protect the fragile periwound and other skin to prevent further skin breakdown and provide comfort for the patient.

For more information on wound assessment tools see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

Step 2: Set Goals

Recommendations

2.1 Set goals for skin health and for prevention, healing, non-healing and non-healable wounds

Discussion: Prior to, or in the presence of, diagnosed LE, the primary goal for the integrated team is to promote skin health, prevent the progression of LE and support patient engagement in compression therapy, medical management of underlying co-morbid diseases, physical exercise, weight and medication management and mental health. Though LE is not fully preventable, progression can be slowed.[1] Holistic goal setting with patients who have LE must involve the integrated team and be based on consistent and effective communication. Goals must be developed according to the SMART principle[73] in collaboration with the patient, family and/or care partner, and adjusted as needs change over time. For more information on SMART goal setting, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

2.1.1 Identify goals based on skin health, prevention or healability of wounds
Discussion: Goals should be developed to support the management of skin, edema reduction and the prevention, healing or prevention of recurrence of wounds. Due to the risk of infection (e.g., cellulitis, infection, sepsis) and hospitalization, it is a priority to promote skin health and hand hygiene.[13] Wound-specific goals are determined by healability. See Table 5 for examples of goals.

Table 5: Examples of Goals for Patients with Lymphedema

Area of Focus	Examples of Goals
Underlying co-morbidites	• Manage volume overload conditions such as heart failure within 2–3 weeks • Manage glycemic levels in persons with diabetes within 2 weeks • Vascular consult within 2 months
Complete Decongestive Therapy (CDT)	• Vascular status assessed to permit compression therapy within 2 weeks • Implement compression bandaging to reduce edema once vascular status is assessed (show patient edema reduction using measurement tape) • Once edema is reduced, implement wearing of garments to maintain/control edema within 3 days; Intermittent pneumatic compression can supplement bandaging in some cases; Reusable (hook and loop) systems (wraps) that are adjustable can be worn
Medication	• Have edema-related drugs reviewed by physician/pharmacy within 3 days
Skin care	• Establish skin care routine within 2 days • Perform hand hygiene instruction on first visit • Reduce and manage wound-related pruritus within 5 days • Provide instruction within 2 days to patients with diabetes and/or neuropathy to frequently inspect skin at pressure points from footwear, bandaging, garments;[13] attention must be paid to the toe and forefoot regions[74]
Wound care	• Healing: Provide optimal wound care and compression therapy within 7–14 days • Non-healing: Control pain and skin sensitivity within 2 days • Non-healable: Manage odour and drainage within 7–10 days and review ongoing
Exercise/mobility	• Refer to physiotherapist (PT) to promote calf-muscle pump/ankle activity within 7 days • Promote education of appropriate exercise within 7–14 days • Support donning and doffing of day and nighttime compression within 7 days[13]
Lifestyle change/ choices	• Make smoking cessation program referral within 7 days • Refer for diabetes mellitus management within 7 days • Review substance use (e.g., alcohol) within 14 days • Refer to a registered dietitian within 14 days for weight management
Pain management	• Pain is managed (nociceptive and neuropathic pain) within 5 days • Adjunct pain management strategies are discussed within 30 days
Social/ employment	• Refer to occupational therapist (OT) to promote independence (restore, modify) within 30–40 days • Return to/modify employment, home, school, leisure activities within 30–60 days • Support access to clothing and footwear
Offloading	• Refer for offloading footwear (for diabetic foot ulcers and pressure injuries) within 7 days
Psychological/ spiritual	• Refer for psychosocial and spiritual support in place within 30 days • Engage in mental health and wellness promotion such peer as support, web-based support, counselling and therapy as appropriate within 14 days[75]

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2.1.2 Identify quality-of-life and symptom-control goals

Discussion: Quality-of-life and symptom-control goal setting requires that the integrated team set realistic goals around smoking cessation, appropriate garment use, medication management, ADLs such as exercise and physical activity and the impact of skin changes and CDT on the patient's daily life.[75] See Table 5 for examples.

Step 3: Assemble the Team

Recommendations

3.1 Identify appropriate health-care professionals and service providers

Discussion: Health-care providers working with patients and their caregivers need to be trained in LE assessment and management. When caring for patients living with LE, clinicians need to understand anatomy and physiology, pathophysiology, multi-organ systems (skin, cardiac, renal, respiratory), mental health, mobility and exercise and collaborative care.[13]

Ideally, clinicians would all be in a specialized centre, but in reality patients will be assessed by individual clinicians and specialists using in-person, online, web-based and tele-medicine approaches. Through use of technology and strong communication skills, clinicians specialized in LE can create a community of practice in which the patient and care partner are the centre. Table 6 lists team members and describes their roles.

It is important to note that certified lymphedema therapists[76] come from various disciplines and can be registered massage therapists, nurses, physicians, physiotherapists and occupational therapists. For information on clinician-focused LE certification, education and training see Appendix C: Lymphedema/Chronic Edema Clinician Certification and Education.

Table 6: Team Members and their Roles in Managing Lymphedema

Team member	Roles
Certified lymphedema therapist (CLT)[76]	• Assess for stage of LE (stages may be overlapping) • Co-create goals for treatment and maintenance with patient • Assess strengths and ability to conduct self-care such as manual lymph drainage (MLD), exercise, nutrition, skin care • Monitor compression therapy progress • Assess for LE compression therapy for day/night wear • Provide education on hand hygiene, skin care and hygiene, anatomy and physiology, garment management
Primary care provider, physician, nurse practitioner, specialists such as clinical lymphologist, infectious disease[13]	• Diagnosis of LE (within scope of practice) supports access to funding for compression garments (in some provinces/territories); may be a specialist or designated primary care physician • Provide care based on their specialty (dermatology, cardiac, respirology, vascular and diagnostic) based on patient need • Assist with management of edema, pain, infection • Provide referrals and support
Garment fitter (certified to authorize and order garments)	• Assess compression therapy (most appropriate) and reassess long term • Assesses funding/insurance support • Assess comfort of compression for day/nighttime • Refer for adaptive clothing and footwear • Communicate with care partners and provide education

cont'd. . . .

Physiotherapist (PT), physiotherapy assistant (PTA)	• Provide education on prevention, anatomy, physiology • Assess compression therapy (most appropriate) and reassess long term • Assess functional status and provide exercise plans • Support deep breathing exercises • Prescribe and facilitate exercise and motion exercise • Evaluate strength and administer treatment • Prescribe gait aids/devices • Communicate with family members and provide education
Pharmacist	• Educate the patient and their care partners, family members about medications that contribute to LE and the use of diuretics for underlying co-morbidities • Assist with management of edema, pain, infection • Provide medication reconciliation, information, education or teaching, monitoring for medication interactions that cause edema • Communicate with care partners and provide education
Occupational therapist (OT), occupational therapy assistant (OTA)	• Provide education on functional activities of living • Assess for adaptive clothing and footwear • Assesses activities of daily living (ADLs) and instrumental activities of daily living (IADLs) • Prescribe adaptive devices/equipment • Support vocational/employment goals and activities • Communicate with care partners and provide education
Pedorthist, chiropodist, foot care nurse	• Educate patient and care partners on prevention of foot complications • Assess for appropriate footwear • Provide hand and foot nail care and promote skin health
Registered dietitian; nutrition, weight management clinics	• Assess baseline health • Monitor dietary needs and provide nutritional support • Provide nutritional education to the patient and their care partner – this may include education on anti-inflammatory and anti-edema nutritional approaches • Communicate with care partners and provide education
Respiratory therapist	• Assess baseline respiratory status • Support activity/exercise in partnership with physiotherapy • Provide rehabilitation therapy • Communicate with care partners and provide education
Counselor, social worker, psychologist, psychiatrist	• Address anxiety and/or psychological stress • Contribute to understanding cause of LE (health choices) • Support the patient to develop and/or enhance coping skills • Assist with social and financial supports (funders, insurance) • Support sexual health discussion • Link patient to peer support groups (local, online, web-based) • Communicate with care partners and provide education
Wound care nurse/ specialist	• Co-ordinate in-patient care and transitions in care • Provide skin and wound care and positioning, complete and assist with wounds assessment and dressing changes • Support patient and care partners to access compression donning/doffing devices as needed • Do monthly review of photography • Communicate and assist to co-ordinate care activities with health-care providers (e.g., timing of bathing and bandaging/compression therapy) • Deliver patient, care partner and family education

cont'd. . . .

Spiritual care professional	• Support and counsel those with LE and slow-to-heal, non-healing and non-healable wounds • Link patients' to their spiritual, faith-based community of support • Provide palliative support if required
Specialized physician, surgery	• Discuss surgical options with patient and care partners – and other team members as needed

3.2. Enlist the patient and their family and care partners as part of the team

Proactive skin health should be a priority for patients living with lower limb LE. For patients who develop skin complications and wounds, healing is often a complex process because of related underlying co-morbidities. Providing early encouragement and education to patients and their care partners enhances their engagement and understanding of how they can participate effectively in the LE care process.

It's important to note that some patients who have had a delay in diagnosis may be frustrated when clinicians try to engage them in efforts to improve their quality of life through education and resources.[10]

Khong et al. explored perspectives of patients (n=6) diagnosed with morbid obesity who were identified as being disengaged in LE care. *Disengagement* was defined as the patients not attending more than 50% of appointments, living with LE for more than 90 days, and clinicians reporting low engagement in compression therapy. In this study, patients reported social, psychological and physical factors as barriers to being involved in care, overlapping with the burden of daily management of LE, especially as the person progressed to being house-bound with increased disability.[77] In a 2022 study (n=81), patients expressed that their needs and expectations must be heard by the team and that they should be an active part of care decisions.[78] They emphasized the importance of an accurate LE diagnosis and treatment options.[78]

To help ensure active participation, patients living with LE and their care partners should be offered consistent information that is tailored to enhance self-care strategies and management practices and behaviours. In all cases, the information should be delivered in an individualized and sensitive manner to ensure effective, trusting relationships among patients, care providers and the rest of the integrated team.

3.3 Ensure organizational and system support

Discussion: Successful LE programs are patient-centred and include an integrated team of clinical practice leaders, educators, researchers, policy makers and administrators at a local, regional, provincial/territorial and national level.[13] Organization and system support is required to ensure patients receive co-ordinated transition of care through community and health-care agencies. This level of collaboration and co-operation is essential as patients' needs will change as their LE progresses and as they live with other co-morbidities.[13] Patients with LE require relevant home and community care services focused on improving and maintaining their quality of life,[42] along with adapting and modifying their work and engagement in life.[79]

Organizations must support the education of staff so they obtain and maintain the required knowledge and skills to be effective members of the lymphedema care team. It is essential that LE health-care provider education includes a needs assessment to identify knowledge, skill and attitude gaps. Education should address the identified short and long-term gaps and be provided using the principles of adult learning.

The Canadian Lymphedema Framework lists several private schools that provide LE education and training that meet the Lymphology Association of North America[76] requirements.

Step 4: Establish and Implement a Plan of Care

Discussion: The development and implementation of a sustainable plan of care must be based on the identified goals and be collaboratively created with the patient, their family and care partners and relevant health-care team members.

Recommendations

4.1 Identify and implement an evidence-informed plan to maintain skin health and correct the causes or cofactors that affect skin integrity, including individual needs (physical, emotional and social), the wound (if applicable) and environmental/system challenges

Discussion: Standard prevention and treatment of LE involves patient-centred Complete Decongestive Therapy (CDT) with the overarching principles of promoting and supporting patient engagement in daily activities.[80,81] The patient and care partner should receive skin health education related to handwashing and meticulous skin care to prevent skin breakdown, as well as information on the anatomy and physiology of the skin and other relevant areas of the body, management and wearing of individualized compression garments, proper footwear, exercises and management of wounds. They should also receive mental health and wellbeing support.[13]

There is a range of therapies to support patients living with LE. O'Donnell et al. state that firstline conservative LE therapy includes a singular or a bundle of care elements that might include manual lymphatic drainage (MLD), multi-layer bandaging, psychosocial support, skin care and LE garments.[5] Additional therapies include intermittent pneumatic compression devices (several are available from various manufacturers) and programmable compression devices.[5]

Manual Lymphatic Drainage mobilizes lymphatic fluid and is most effective when combined with compression therapy.[13]

The current international standard for conservative LE management is manual complete decongestive therapy (CDT) that includes skin health regimens, exercise, bandaging and manual lymphatic drainage.[13,82] These specific care components require attention to daily care, which can sometimes be fatiguing for the patient and care partner. Yet these routines are important. A review stated that patient hygiene-centred self-care approaches reduced acute episodes in patients living with filariasis-related LE.[66] As well, in Italy, as part of the LIMPRINT (Lymphedema IMpact and PRevalence INTernational) study, Cestari et al. reported that education was essential to the development of strong self-care patterns. However, in their study (1419 outpatients and 218 inpatients) only 32.4% patients received skin care instruction.and only 23 received psychological support, thereby adding to the patients' emotional burden.[83] Lack of education may lead to less engagement in self-care routines.

Jones et al. explored the self-management abilities required to consistently attend to one's skin, self-bandaging, garment application and care and day-to-day demands of managing LE. They report the intersection of daily hand hygiene, bandaging and LE skin care to lead to psychosocial, financial and physical burdens.[84] It is important for clinicians to heed the risk of over-burdening the patient and care partners. This reality is an important reminder for health-care professionals to review and reinforce self-care maintenance for life. Leard and Barrett explored unilateral lower limb LE in a 42-year-old patient with morbid obesity. Using a physiotherapy-LE approach in an out-patient setting with transportation and bandaging supports, the patient's limb was reduced to the same size as the unaffected limb by 23 weeks.[85] This is a strong example of the role of education, bandaging and interprofessional collaboration.

The ISL recommends treatment begin with physical therapy and adjuvants (for adults and children). Three terms are commonly used to describe LE therapy: *Complete Decongestive Therapy* (CDT), *Combined Physical Therapy* (CPT) or *Complex Decongestive Physiotherapy* (CDP), as well as others.[13] The ISI notes, "even widely used treatment methods have yet to undergo sufficient meta-analysis of multiple studies which have been rigorous, well controlled and with sufficient follow up".[13] More studies are needed to compare treatment approaches. In this chapter we use CDT.

Based on a comprehensive assessment, care approaches begin with phase 1. Treatments may include:

- Meticulous skin care using pH-balanced soaps and unscented emollients (moisturizers)

- Routine nail care[86]
- Education focused on using, managing and daily washing of garments
- Specific light manual massage – manual lymphatic drainage (MLD) with a therapist or taught to the patient (termed self-MLD)
- Limb elevation, range of motion and calf-muscle- and ankle-pumping exercises
- Deep-breathing exercises
- Compression therapy typically applied with multilayer wrapping (short-stretch) and hook-and-loop devices, taught by a trained therapist.[13,87]

Wounds Canada: Care at Home Series provides additional information for the prevention and care of wounds at home. https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series

For more information on short short-stretch compression bandaging see Appendix D: Parkwood Wound Clinic Protocol for Application of Short-Stretch Compression Bandages.

Phase 2 treatments, may include:
- Continuing phase 1 activities and optimizing education
- Compression therapy: low-stretch elastic stocking or sleeves and reusable, adjustable or fastened devices may be used once taught by a trained therapist[13,87]
- It is important to note that compression garments or massage therapy alone may not be effective. These approaches require further research.[13]

The management of patients with LE primarily occurs in the home, community and outpatient hospital settings.[13] When patients experience severe infections, they may need to be hospitalized. The treating team should be notified to ensure compression therapy and specific care parameters are communicated between care teams (e.g., hospital and rehabilitation providers), and particularly during transitions of care between health-care settings. Care planning and implementation for LE requires an engaged team that has a comprehensive understanding of the patient's clinical status.

The Canadian Lymphedema Framework offers tips https://www.canadalymph.ca/hints-and-tips/ for patients and care partners to plan and improve their experiences in the areas of travel, clothing and fashion, caring for compression garments, and skin care to reduce risk of infection. There is also information on how to improve or maintain communication with health-care providers and therapists.

Skin Care

Patients or their care partners will be doing most of the basic skin care at home, so they need to be confident about their knowledge and skills related to hand hygiene, meticulous leg skin care, lotion application (medicated, non-medicated), identifying new skin changes, completing nail and foot care and managing compression garments, including daily washing of compression (circular and flat) garments, resetting the elastic and returning the garment to its original shape.[87] Patients wearing reusable (hook and loop) systems need to know the 'under stocking' requires daily washing for cleanliness.

Many patients with LE stage 2 or 3 frequently have deep skin tissue folds in the lower extremity and may have loss of the normal space between their toes. Therefore, care must be taken to clean skin folds daily with a mild pH-balanced cleanser, and ensure folds are carefully dried to prevent skin breakdown. Daily inspection of these folds is necessary to prevent local and deep tissue infections as a result of disruption to the normal skin barrier function. Patients may need mirrors and personal assistance to conduct their daily lower limb inspection.

Deep skin folds, creases or interdigital toe spaces may require wicking with a moisture-wicking cloth or antimicrobial gauze strips woven between the toes.

Monthly photography of skin is encouraged to monitor for changes.[69] Care partners can assume some of this responsibility but should not be the sole provider due to partner fatigue and burnout.

Skin-related prevention strategies must be regularly reassessed to ensure they remain appropriate.

Wounds Canada: Caring for Your Swollen Legs at Home is an excellent patient resource that is part of the Care at Home Series: https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series. It can be used as a teaching tool and left with patients and care partners to refer to when needed.

More patient information can be found at The Canadian Lymphedema Framework:
Hints and Tips https://www.canadalymph.ca/hints-and-tips/ and
Skin Care https://www.canadalymph.ca/skin-care/

For an expanded list of provincial/territorial patient-centred resources see Appendix E: Patient-centred Lymphedema Resources

Manual Lymphatic Drainage

Manual lymphatic drainage (MLD), also called lymphatic drainage massage, is a gentle massage done to stimulate the lymphatic vessels and to relieve or reduce the swelling in the limb. This can be done by a trained therapist or the patient or care partner with training. Massage helps to move lymph into an area of the body that is less or not affected by LE. Patients and care partners should be taught by a trained therapist and monitored ongoing. The University Health Network provides a resource for patients and care partners focused on how to do lymphatic self-massage on the lower body. https://www.uhn.ca/PatientsFamilies/Health_Information/Health_Topics/Documents/How_to_Do_Self_Lymphatic_Massage_Lower_Body.pdf

In addition, the University of Michigan offers patient education for manual lymphatic drainage for legs.
https://www.med.umich.edu/1libr/PMR/Lymphedema/BilatLEMLD.pdf

Exercise

Exercise programs should be part of a long-term commitment for a patient living with LE.[13] The programs should be relevant to the patient's underlying co-morbidities and stage of LE and should engage care partners and family members, as appropriate. Exercise programs should be individualized by a physical therapist and may be unsupervised or supervised, depending on the patient's health status and co-morbidities.[13] Although there is low-quality evidence on the direct role of exercise on LE reduction, consistent engagement in exercise is associated with improved physical and mental health outcomes (quality of life, daily functioning and wellness).[13]

Activating the calf-muscle pump is done through walking and exercise programs. Efforts should focus on activating the calf-muscle pump and ensuring the ankle joint is being fully mobilized for lower extremity involvement. For more information see Chapter 12: Best Practice Recommendations for the Prevention and Management of Venous Leg Ulcers.

Swimming has been identified as being a benefit, as the water acts as natural compression on the limbs.[13] Swimming is not appropriate for persons with open wounds.[13]

Compression Therapy

Prompt application of compression therapy is the cornerstone of LE treatment and lifelong edema management.[45] As stated in Step 1 (1.2.1 Patient: Physical, emotional and lifestyle), it is essential that the clinician obtain an ankle-brachial pressure index (APBI) prior to application of compression therapy to the lower limb(s). In cases where obtaining an APBI is challenging, vascular studies should be considered in collaboration with the team and patient.

After a holistic assessment, and if vascular status permits, discuss compression therapy with the patient as one of the essential components for the treatment and management of lymphedema. If the patient agrees, compression therapy can be initiated.[13,69]

Lymphedema needs continuous compression (See Table 7). If compression therapy is interrupted, edema will recur. When edema reduction is optimized by using a disposable compression bandage, therapy needs to be continued, using a reusable compression garment. To effectively achieve goals, choose compression garments depending on the LE stage.

Table 7: Selection of Compression[69]

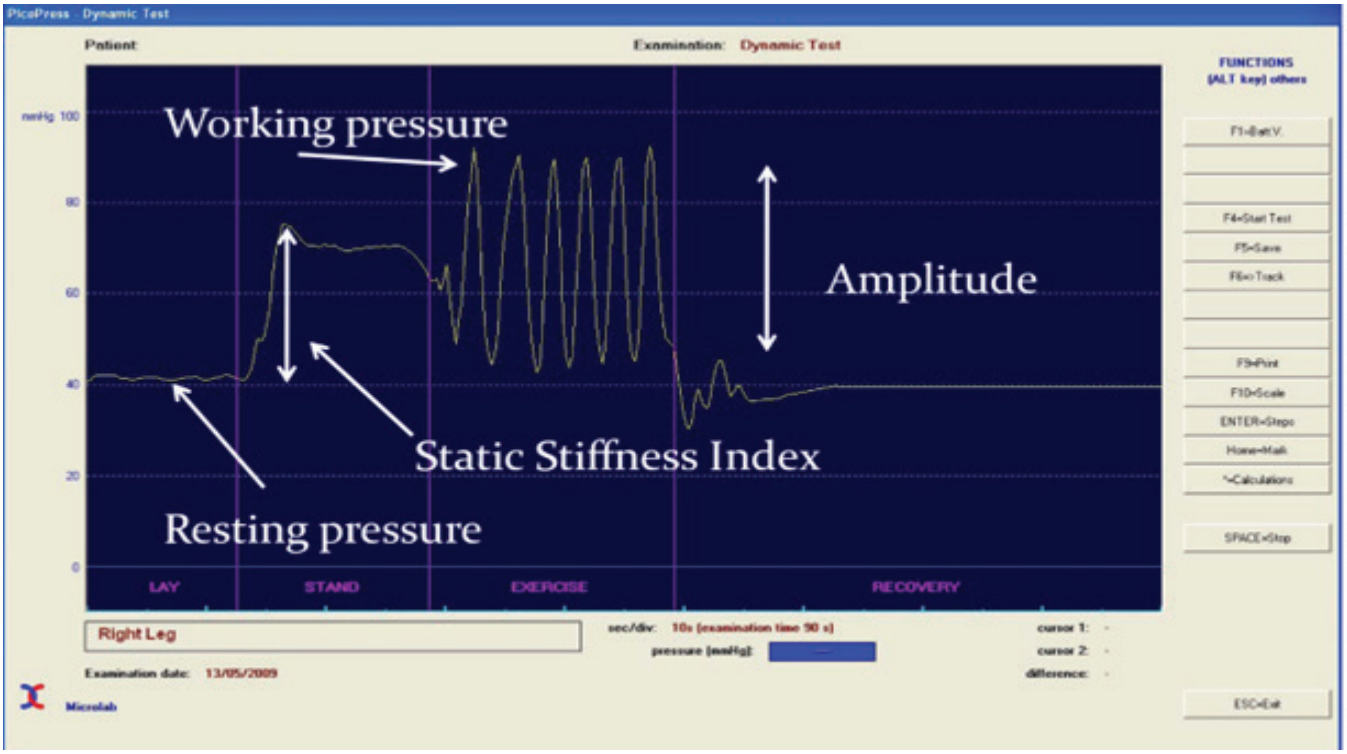
Stage	Compression and Clinical Considerations
1	Limb elevation can reduce edema. ABOVE the heart! Circular knit compression garments are usually sufficient
2	Substantial compression products are required, such as: • flat knit custom-designed compression garments, and/or • inelastic adjustable wrap/garment These are preferred to circular knit, ready-to-wear compression as they are stiffer and provide better containment and hemodynamic effect
3	Due to the fibrosis and fat deposition that have occurred in this stage, elevation does not reduce the edema; there may be shape changes in the limb, with formation of lobules and/or ankle cuffs
	Substantial compression products are required, such as flat knit custom compression garments or inelastic adjustable wrap This type of compression is needed due to the skin thickening with additional development of fibrosis and fat deposition and/or development of skin papillomas and warty (verrucous) overgrowth

Source: Hettrick H, Ehmann S, McKeown B, Bender D, Blebea J. Selecting appropriate compression for lymphedema patients: American Vein and Lymphatic Society position statement. Phlebology. 2023 Mar;38(2):115-8.

Key Points

- Compression therapy needs to be designed specifically for each patient.
- The team must be aware that compression is essential for managing LE in the long term.
- Compression therapy should be assessed for, prescribed and applied by the patient, care partner, knowledgeable clinician or certified lymphedema therapist.
- Education and training with the patient and/or care partner must be relevant and repeated to reinforce the proper use of compression therapy.
- Education for the patient must include identified risks and complications and to whom the patient and care partner should communicate any changes.

Figure 6: Illustrates key terminology used in compression therapy



Used with permission from Dr. D. H. Keast.

Terminology:

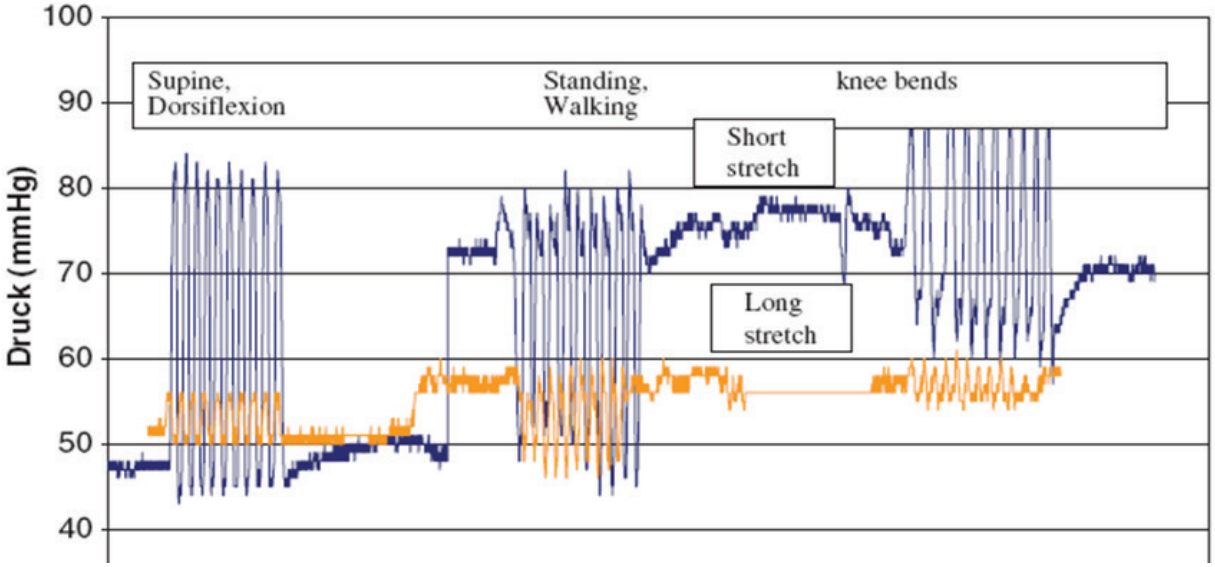
- *Sub bandage pressure* on a lower leg measured at a standard location.
- *Resting pressure* occurs when the patient is in a recumbent (lying down) position.
- *Static stiffness index*. Occurs when the patient stands. The sub bandage pressure increases due to the influence of gravity on the fluid in the leg. The stiffer the bandage the higher the sub bandage pressure because the leg cannot expand against the rigid barrier.
- *Working pressure or peak pressure*. Occurs when the patient walks. The contraction and relaxation of the calf muscle create pressure waves in the sub bandage tissue, enhancing the action of the calf-muscle pump.
- *Amplitude* is the size of the pressure wave.

Figure 7 illustrates the relative effectiveness of short-stretch versus long-stretch bandages in mobilizing edema fluid and the sub bandage pressures on a patient's leg.

The blue tracing represents a short-stretch (inelastic) bandage, and the orange tracing a long-stretch (elastic) bandage. Starting from the left side this figure demonstrates that the resting pressure of the short-stretch bandage is less than that of the long-stretch bandage, which is actively squeezing the leg. This reading was obtained with the subject lying down.

This explains the greater comfort at rest using a short-stretch bandage. The patient is then asked to repeatedly flex their foot at the ankle, generating pressure waves with the contraction and relaxation of the calf muscles. The long-stretch bandage expands to accommodate the muscle, generating much smaller pressure waves. The subject is now asked to stand. Immediately the sub bandage pressure increases. The stiffer the bandage the higher the sub bandage rises and the larger the Static Stiffness Index. The subject is now asked to walk. The contraction and relaxation of the calf muscles again create pressure waves. The pressure waves generated by the short-stretch bandage have a much larger amplitude and significantly create greater enhancement of the calf-muscle-pump function. Finally, the subject is asked to do deep knee bends, further increasing the pressure waves generated.

Figure 7: The Relative Effectiveness of Short-Stretch Versus Long-Stretch Bandages in Mobilizing Edema Fluid



Source: Partsch H, Clark M, Bassez S, Benigni JP, Becker F, Blazek V, et al. Measurement of lower leg compression in vivo: recommendations for the performance of measurements of interface pressure and stiffness. Dermatologic surgery. 2006 Feb 1;32(2):224-32.

Key Points Regarding Short-stretch Compression

Short-stretch bandages:

- Are more comfortable at rest
- Do not squeeze the leg, but rather support the leg
- Work by enhancing calf-muscle-pump function, increasing venous return and lymphatic mobilization of tissue fluid.[89]

Compression Bandaging: The disposable compression bandage is commonly employed during the initial phase of LE management. Its primary objective is to decrease edema to ensure an optimal fit of compression garments for long-term maintenance. Inelastic disposable systems should be administered by trained health-care professionals.

Adjustable Compression Garments/Wraps: Adjustable or modifiable garments/wraps are also available to help reduce edema. As the volume of the limb reduces throughout the day, the garment can be modified and readjusted to provide a better fit and comfort, bringing the patient closer to a permanently fitted garment.
For more information about adjustable compression wraps see the Canadian Society for Vascular Surgery resource Adjustable Compression Wraps: Applications & Benefits.[90]
https://canadianvascular.ca/resources/Documents/Sponsor-Showcase/MOHFocus_Wraps.pdf

Self-bandaging by Patients: Self-bandaging with compression bandages, adjustable wraps or garments may be done by some patients and their care partners after they have been taught how to safely wrap by a trained team member (See Table 7). Patients need to be taught the signs and symptoms of an infection and not to wrap until they have been assessed by a health-care provider. Self-bandaging supports the patient's independence, enhances their self-management abilities, reduces the number of therapist visits and generally increases their knowledge about LE treatment and management.[91,92]

Teaching a patient to self-bandage takes preparation and time, and the provider must use a teaching technique most appropriate for the person. The University Health Network provides an example of a visual and written teaching tool: How to Self-Bandage Your Legs and Feet to Reduce Lymphedema (Swelling). https://www.uhn.ca/PatientsFamilies/Health_Information/Health_Topics/Documents/How_to_Self-bandage_legs_feet_to_Reduce_Lymphedema.pdf

See the Wounds Canada Product Picker Control of Venous Leg Edema
https://www.woundscanada.ca/docman/public/health-care-professional/1182-wc-product-picker-control-of-venous-leg-edema-ltr-1691r2e-2pg-copy/file for information on compression options.

Compression Garments: A standard guideline for selecting LE compression garments includes having the affected limb measured and fitted by a professional garment fitter when the limb is in a decongested (baseline) state. There is no straightforward answer when it comes to choosing a compression garment for LE management. Various options are available in the consumer market, including circular knit, firmer circular knit, flat knit, adjustable wraps, night garments and decongestive garments.[93]

Key Points about Compression: Meticulous skin care, daily exercises and consistent application of compression garments are more important than choosing a garment with high pressure and stiffness.[94]

The best compression garment is the one that CONTROLS THE EDEMA and that THE PATIENT WILL WEAR daily.

Compression has been shown to have a positive impact on both lymphatic and venous function because it:

- Decreases accumulation of excess interstitial fluid by counteracting fluid filtration from blood capillaries into the tissue, consequently lowering the lymphatic burden
- Redirects lymphatic reuptake and promotes lymphangion contractions
- Enhances calf-muscle-pump activity, leading to heightened frequency and intensity of lymphatic movement.[95]

Daily Care of Compression Garments: Proper care includes washing by hand, hanging to dry, folding and storage of LE compression garments daily. Daily washing helps return the elastic in the garment to its original shape and may increase the life of the garment. The Canadian Lymphedema Framework outlines key teaching points for the handwashing, drying, storing and replacement of garments at https://www.canadalymph.ca/hints-and-tips/ They also discuss how to protect the garments in warm weather and when travelling.

Compression garment design can be divided by technologies.[69] See Table 8.

Table 8: Compression Garment Design

Type	Properties
Circular knit garment	Ready to wear (stocking, arm sleeves) Manufactured in a cylindrical form Supplied with compression gradients of 15–20 mmHg, 20–30 mmHg and 30–40 mmHg in standardized sizes for average-shaped limbs Due to their elastic nature, pressure variations under circular knit garments are minimal with movement
Flat knit garment	Custom measured and designed to fit the patient's specific anatomical extremity dimensions Elastic, and the knit design provides significantly higher resistance to stretch, providing more containment of edema under the garment Options for compression levels for flat knit garments are similar to circular knit; however, because the garment is custom engineered specifically to accommodate the size and shape of the limb, there is a more predictable pressure distribution. The stiffer construction results in slightly larger pressure variations with movement Flat knit garments are typically easier to apply as they are form fitting and specific to the patient
Inelastic adjustable wraps (hook-and-loop technology)	Designed to provide patients with adjustable compression levels along the length of the leg The adjustable design, often with hook-and-loop inelastic adjustable bindings, allows for easier application of the garment by the patient or care partner and permits adjustments throughout the day as needed These compression devices provide the stiffest construction, producing larger pressure variations with movement. Inelastic adjustable wraps can be worn during the day and nighttime hours
Nighttime garments	Designed for use when the patient is supine or sleeping Garments are designed to provide containment of the edema with lower compression levels during sleep They are specifically engineered with textured fabrics to soften fibrotic tissue

Adapted from: Hettrick H, Ehmann S, McKeown B, Bender D, Blebea J. Selecting appropriate compression for lymphedema patients: American Vein and Lymphatic Society position statement. Phlebology. 2023 Mar;38(2):115-8.

Note: In Canada cohesive and inelastic bandages are regularly used to reduce edema, especially when dealing with leg ulcers. While the inelastic adjustable wraps will reduce edema, stockings will not. Stockings are prescribed for prevention and long-term maintenance once the edema is reduced to a relatively stable state to enable fitting.

Intermittent Pneumatic Compression (IPC) Therapy: The role of IPC is usually a two-phase program that can be part of a patient's daily care.[13] IPC mimics the principles of manual lymph drainage and may be used by the patient at home after being taught by a trained therapist. During the therapy the patient usually remains immobile. External compression therapy may be used with a sequential gradient pump, form-fitting low-stretch elastic stockings or sleeves to maintain LE reduction.[13] Some devices are available that aim to support the patient to be more independent in their LE self-care. For example, there are electronic devices that simulate manual massage with varying limb coverage.[13] More research is needed to fully understand the effects of combining manual lymphatic drainage (MLD) and IPC.[96] Funding for IPC varies across most provinces/territories. For example, in Ontario IPC is funded for primary LE only and the patient pays a portion (25%).

Non-pneumatic Compression Device

Recent research is exploring the role of a novel non-pneumatic compression device (NPCD) for lower limb LE in which the patient remains physically active during the compression treatment. In one study, once the NPCD was applied, the patients' (n=24) QOL was measured using the LYMQOL scale. There was statistically significant improvement in their QOL, and the average reduction in the affected limb was 39.4%.[97]

More research is needed to explore the role of laser therapy, ultrasound/shockwaves, thermal heat in LE prevention and therapeutic treatment.[13]

Nutrition

The patient's nutrition and nutritional status are important elements of LE treatment. There is no specific diet for patients living with LE. Early referral of patients with LE to a registered dietitian is encouraged. Patients may describe a roller-coaster life of weight loss and weight gain and the associated emotions that result. Of great concern is if the patient's weight increases. Added weight increases LE risk and burden of disease and co-morbidities, decreases mobility and adds extra challenges to self-management, particularly in the areas of self-bandaging and exercise.[44] Patients may have had negative or traumatic experiences related to weight management programs, and this needs to be acknowledged to create a new path moving forward. Consider psychosocial support when patients are having challenges with engaging with or adhering to nutrition and/or weight management plans.

The patient's nutritional plan should be individualized and continually modified throughout their lifespan taking into consideration cultural perspectives and patient preferences. Weight management is a key focus of nutritional planning for patients with LE. In a review of dietary supplements by LE Bonetti et al., the authors identified obesity as a, "comorbidity that exacerbates the risk for secondary lymphedema and constitutes a negative prognostic factor".[98] They suggested that weight management must be a consistent conversation with patients and their care partners.[98] Recent research has focused on the role of anti-edemagenic and anti-inflammatory foods and their effects on limb LE, seeking to understand the possible therapeutic role of specific diets in the long-term management of LE.[34,98] For more information on nutrition see Appendix 1: Nutrition for Skin Health, Wound Prevention and Wound Healing in Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

As discussed in Step 1, obesity is an identified risk factor for LE.[99]

Medications

As noted in Table 3, medications play an important role in managing the patients' comorbidities. However, some medications may contribute to the development of LE. In the initial stages of LE, diuretics have limited use and should be prescribed only if indicated for a comorbidity such as congestive heart failure.[13] (ISL, 2020). Pharmacists can assist with medication reconciliation and monitoring for drug interactions and side effects. Regular assessment for the indications and risk/benefit profiles for medications should be done by the primary care team.

Quality of Life

Psychosocial support is emphasized as an important component of success in long-term LE management.[13] Once issues such as distress, anxiety, depression and fatigue are identified, appropriate referrals and education are needed long-term, as patients living with LE require consistent psychosocial support. The level of engagement and service will vary depending on the patient's communication, coping skills and their ability to adapt to living with LE.[13] For patients with LE related to an underlying cancer, Bowman et al. developed a novel model for LE care that includes an integrated team with physical and psychosocial support.[100]

Surgical Considerations

Surgical options to alleviate lower limb LE and improve lymph return are currently being researched and are gaining use in clinical settings.[13,101] For specific patient populations, micro-surgical and super-microsurgical (connecting vessels less than 0.8mm) approaches may be considered as an adjunct to complete decongestive therapy (CDT).[13] Recently, supermicrosurgery has advanced enough to present a viable option for the treatment of lymphedema. Specific techniques include lymphovenous bypass and vascularized lymph node transplant.[101] Ciudad et al., in a review focused on surgical management of lower limb LE, emphasized the importance of an accurate and early LE diagnosis to enable specialized LE teams to consider proactive rather than reactive surgical approaches. At present interventions

are focused on slowing the LE disease progression.[22] Recent procedures may also include lymphovenous anastomosis and vascularized lymph node transfer.[22] In an algorithmic approach, Ciudad et al. outline when surgery might be considered depending on a holistic assessment, ISL LE stage and patient history. For more information see: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6664851/

4.2 Optimize the local wound environment

This section focuses on management of LE when a wound is present. Some aspects may be applicable to overall LE management.

Discussion: Local skin health and wound management strategies need to be part of the plan of care and fit within the context of the overall healability of the identified skin issue or wound. To optimize the local skin and/or wound environment, clinicians must consider periwound skin, wound cleansing and debridement, management of bacterial burden and moisture control to support prevention and healing goals.

Care at Home Series on Wound Management
https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series

4.2.1 Cleansing

Discussion: Skin care can be particularly challenging in LE due to the presence of edema and altered limb/foot shapes, creases and contours.[102] Patients with LE are at risk of infections such as cellulitis, which can exacerbate lymphatic dysfunction and lead to greater edema, sepsis and increased mortality.[103] Therefore, it is important to daily cleanse and moisturize (unscented, non-allergic) the skin of the affected areas, or more often, depending on the plan of care.[88]

Skin care regimes should be updated regularly depending on the skin condition(s) and when treatments (creams, ointments) need to be applied. Skin care should be done before donning garments and the skin checked upon removal of garments.

Areas with new onset of pain should be examined for evidence of deep fissures and assessed clinically for the possibility of infection.[104] To minimize the bacterial burden, cleanse the wound with the aim of flushing away soluble debris, surface microbes, foreign bodies and non-viable tissue. Cleanse the periwound skin and assess the limb and foot and toes (creases) for any skin changes and document findings.

Considerations When Cleansing

- For patients with LE and skin and wound issues, cleansing may involve the complete limb and multiple skin folds on the limb, foot and toes.
- Showering is a way to cleanse skin and may be considered in partnership with the medical team, wound care nurse, occupational therapy for equipment and safety and physiotherapy for mobility assessment.
- Some patients may need limb/foot/toe wound care conducted in their bed/chair based on mobility, safety and overall goals.
- When needed, clinicians must keep their managers and leaders apprised of the need for more than one health-care provider to be present to provide skin and wound care.

Cleansing solutions commonly used in wound management include sterile normal saline, sterile water, potable tap water, commercial wound cleansers and liquid antiseptics. Regardless of the type of cleanser chosen, solutions at room temperature should be applied in sufficient quantities to ensure the area is adequately cleaned. Safe irrigation (4–15 psi) is preferred to help flush away surface microbes, foreign bodies, soluble debris and non-viable tissue.

For more information on cleansing please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

The Wounds Canada Skin and Wound Clean-up Product Picker https://www.woundscanada.ca/dhfy-doc-man/public/health-care-professional/1307-product-picker-skin-and-wound-clean-ip/file is a useful tool to help clinicians choose the most appropriate type of wound cleanser.

4.2.2 Debriding

Discussion: Debridement serves to remove microbes, foreign bodies, debris and non-viable tissue from a wound to promote wound closure. As with wound cleansing, the appropriate method of debridement should be determined based on the patient's needs and vascular status. This includes consideration of the periwound condition, wound, the environment, available resources and the scope of practice of the health-care clinician completing the debridement.

For more information on wound debridement please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

The Wounds Canada Skin and Wound Clean-up Product Picker is a useful tool to help clinicians choose the most appropriate form of wound debridement. Product Picker: Skin and Wound Clean-Up.

4.2.3 Managing bacterial balance

Discussion: Patients living with LE are at specific risk of soft tissue infections, which may include erysipelas, lymphangitis or cellulitis in the affected areas.[13,105] The stagnation of lymph limits bacterial clearance and may impair host immunity to bacteria due to limited lymphatic flow. Although these three entities (erysipelas, lymphangitis, cellulitis) have some clinical differences, they are treated similarly with directed antibiotics against usual skin bacteria of *Staphylococcus aureus* (including MRSA) and *Streptococcus* species (e.g., *S. pyogenes*). Soft tissue infections most commonly affect the limbs, but in some cases may occur in other areas affected by LE (e.g., genitals, groin area). In those cases, other bacteria may need to be considered and will guide treatment decisions.

Cellulitis is the most studied infection in the context of LE. As with other soft tissue infections, cellulitis is characterized by acute onset of new or increased pain, swelling, redness and functional loss (e.g., unable to bear weight in the affected limb/foot).[106] When patients present with subacute or chronic progression of symptoms such as pain, erythema or swelling or an isolated change in one of these symptoms, an alternate non-infectious diagnosis is likely. With lymphedema, patients can experience more severe infections (including with pre-sepsis/sepsis symptoms)[107] and may have recurrent episodes.[108] These infections can further damage the lymphatic system due to their extension into the dermis (erysipelas) and/or subcutaneous tissues (lymphangitis, cellulitis), setting up a vicious cycle.

Up to 50% of patients who develop cellulitis will experience repeat episodes.[36] Secondary prophylaxis with antibiotics can be considered in patients with recurrent lower extremity cellulitis to decrease future risk. A Cochrane review of five trials identified that antibiotic prophylaxis decreased future episodes by 69% and reduced the rate significantly until the next attack. However, the protective effect appeared to wane following therapy stoppage.[109] The antibiotic prophylaxis strategy appears to be helpful in people with at least two past episodes of cellulitis in a three-year timeframe. Of the agents used, penicillin was the most common. Notably, none of these studies looked at the effects of additional interventions such as protective skin care or compression. However, in specific patients, and in particular where other care strategies such as CDT have been optimized, prophylactic antibiotics may be considered.[13]

Patients with LE are also at risk for developing fungal (dermatophyte) infections. Fungi thrive in the moist environments that can be present in skin folds and creases common in patients with lymphedema and can be exacerbated by factors such as stasis, immobility and the patient's clinical status. This is particularly common in the lower limb. Fungal infections may be treated with antimycotic drugs.[13] The washing and proper drying of the skin are important steps. Other treatments may include adjunctive antihistamines or steroids in selected patients.[13]

For more detailed information on managing bacterial balance see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

4.2.4 Managing moisture balance

Discussion: Managing moisture on the skin and in a wound is an important aspect of care. Lymphatic fluid can drain directly onto the skin through microscopic skin defects known as lymphorrhea.[110] Lymphorrhea drainage will collect in skin folds, especially if deep and in gravity-dependent areas, such as feet and toes, leading to skin irritation and excoriation. This results in moisture-associated skin damage (MASD). For more information on MASD see Chapter 5: Best Practice Recommendations for the Prevention and Management of Moisture-Associated Skin Damage.

Lymphorrhea drainage often saturates the patient's clothing, footwear, bedding and surfaces,[110] increasing the amount of laundry, bedding and clothing changes. This adds to the burden of daily LE management in the home setting, leading to additional physical and financial burdens for the care partners and family members.[111]

The combination of fluid and pressure (weight of the tissue) puts patients at greater risk for the development of skin and wound complications (e.g., cellulitis, infection) and may require escalation of management strategies, including hospitalization.[13,36]

Wound dressings that support exudate management should be selected for patients with heavily draining skin/wounds and, whenever possible, be non-adhesive. They need to be worn under the compression therapy (bandaging, garments) and used in alignment with the manufacturers' recommendations. Wound dressing changes can coincide with compression therapy changes and be done in partnership with the patient and other team members.

For more detailed information on managing moisture see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

4.3 Select the appropriate dressings, and/or advanced therapy

Discussion: Advancements in technology and innovation are rapidly evolving within the wound care sector. When choosing suitable dressings for LE-related wound care, it is crucial to ensure that the wound contact layer is compatible with the compression therapy being used and that the secondary dressing has the capacity to absorb and retain significant volumes of lymphorrhea to preserve periwound skin integrity.

For further guidance on dressings refer to Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

For more information about dressing selection, see Wounds Canada's Product Picker: Wound Dressing Formulary https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/library/183-resources-industry-partner/288-product-picker and Product Picker: Wound Dressing Selection Guide www.woundscanada.ca/docman/public/health-care-professional/1114-product-picker-2017-selection-guide-1/file

4.4 Engage the team to ensure consistent implementation of the plan of care

Discussion: An individual who has been diagnosed with LE is living with a progressive condition that will require their entire team, including the patient themselves and their care partners, to be engaged in the plan of care. Trust, communication and collaboration among team members are essential for ensuring the success of any care plan. The team will need to encourage the patient to participate in management of underlying conditions, compression therapy, skin care, weight management, physical activity and other self-care activities while supporting their mental health throughout their lifelong journey with the LE. See Table 9 for a summary of key components of a care plan for patients with leg wounds and LE.

Table 9: Summary of Key Components of a Care Plan for Patients with Leg Wounds and LE

Component	Discussion
Manage underlying conditions	• Volume overload conditions such as congestive heart failure require management and may require diuretics; otherwise, diuretics do NOT help to reduce edema • Manage glycemic control in persons with diabetes mellitus • Consider referral to vascular surgery in arterial or venous insufficiency; ligation of veins may increase wound healing and reduce risk of recurrence in eligible patients with venous leg ulcers (VLU)[112] - low threshold for referral in peripheral arterial disease (PAD)
Compression therapy	• Vascular status permits compression therapy and is the key intervention to reduce edema, improve the skin condition, and stimulate wound healing; in general, modified compression can be used up to the point of critical ischemia, in trained hands[113] • Risks of compression therapy primarily includes skin irritation, discomfort and pain[114] - severe adverse events are rarely seen if compression is applied correctly, but use caution in severe cardiac heart failure (risk of decompensation), severe neuropathy and ischemia (risk of pressure injuries and/or compromised arterial function)[114] • Modified/reduced compression in ABPI 0.5–0.8[115] - bandaging usually contraindicated ≤0.5 (critical ischemia). Multi-component bandage and hosiery systems are more effective than single (for VLU)[116] • Garments are essential to prevent new edema formation and wounds; life-long treatment usually necessary; patient encouragement and education; renewal of garments necessary due to wear
Other edema management	• Edema-related drugs: consider change of medication (risk-benefit) • Intermittent pneumatic compression can supplement compression bandaging in selected cases
Wound care	• Debridement • Removal of non-viable tissue/slough at every dressing change where possible by clinicians with the skill and appropriate scope of practice can help prevention of overwhelming bioburden and biofilm • Therapeutic cleansing at every dressing change with appropriate solutions (tap water, saline, antiseptics, depending on the care setting, home, community, rehabilitation)
Microbial management	• Control of bioburden usually satisfactory with debridement and irrigation • In high bacterial colonization or wound infection, local dressings/products are added containing antiseptics (e.g. silver, cadexomer iodine, PHMB, vinegar); antibiotics appropriate only in presence of cellulitis or wound infection that cannot be controlled by local antiseptics; treatment supported by cultures and antibiotic resistance[104]
Exudate control	• Main reduction of exudate production is through compression—treat infection if this is the reason for excessive exudate • Manage exudate through appropriate choice of dressings and frequency of dressing changes, usually from once weekly to daily
Skin care	• Proactive hand hygiene • Prevention of broken skin and development of cellulitis • Use of pH balanced soaps, cleaning and drying between toes and in all crevices to prevent fissures/ mycosis that can lead to cellulitis[88] • Gentle emollients to restore skin barrier function; if the skin is dry ointments are preferably used, otherwise a cream—carbamid or salicylic acid products can be used in hyperkeratosis • Control excessive inflammation/dermatitis (e.g., by topical corticosteroids, zinc or tar); steroids to be applied before usage of emollients • Barrier films to protect periwound skin from exudate • Diabetics and patients with neuropathy are encouraged to frequently inspect skin at pressure points from footwear, bandaging, garments, especially between toes.

cont'd. . . .

Promote exercise/ mobility	• Physiotherapy consult may help to maximize calf muscle pump activity; otherwise, pamphlets and discussion of appropriate exercises can be provided • Support donning and doffing of day and nighttime compression[69]
Promote life-style change/ choices	• Smoking cessation program • Diabetes mellitus management • Control substance use (e.g., alcohol) • Adherence encouragement with compression, mobilization, exercise, weight control, nutrition, and offloading footwear • Weight loss, especially in obesity-induced LE[44] • Sexual health[49]
Pain manage-ment	• Nociceptive and neuropathic pain important to distinguish from each other to initiate proper treatment (See Table 2: Medications)
Offloading pressure	• Proper offloading footwear mandatory for diabetic foot ulcers, and pressure injuries - encouragement, and education are important • Empowerment strategies[81]
Psychological and spiritual impact	• Psychosocial and spiritual care and referrals made in collaboration with the patient[75]

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Step 5: Evaluate the Outcomes

Recommendations

5.1 Determine if the outcomes of the goals of care have been met

Clinicians need to determine if the skin health, limb volume, skin thickness, compression therapy and wound goals have been met, using general and specific validated tools accompanied by patient/care partners and team communications.[52,117-119] Where possible, practitioners should aim to co-develop and document goals of care with the patient (and/or caregiver or family member) early in the patient-health-care-professional encounter.[120]

It is important to remember that continued support of the patient with long-term compression therapy and psychosocial, physical activity and relevant therapies, proactive skin care and self-management strategies must take place and needs to be part of the determination of outcomes of the goals that have been set. Due to the progressive nature of LE, clinicians need to monitor care partner and family fatigue and provide ongoing support to patients and their care partners and family members.

5.2 Reassess patient's skin, wound, environment and system, if goals of care are partially met or unmet

If the LE goals and response to the current therapies have been partially met or unmet, the team needs to return to Step 1 to reassess. The specific activities will depend on the skin status, wound factors and the impact on the patient's ability to manage daily activities (employment, social and home).[121] Re-assessment should include a holistic review that includes reviewing underlying disease processes. Further assessment may include repeating diagnostic tests and laboratory tests relevant to the patient's co-morbidities, arterial/vascular assessment and psychosocial assessment. The latter may include the patient and/or care partner, as burnout may be occurring.

For some patients, wound healing may not be the goal of care. In this case, quality of life, pain control, fewer episodes of cellulitis or wound infection or fewer hospitalizations may become the outcomes measured to determine quality of care. In 2019, 713 Canadians took part in an international survey conducted for the International Lymphoedema Framework that was distributed through the Canadian Lymphedema Framework. 64.7% of the respondents were patients and 35.7% were health professionals.[122] Commonly used outcome measures employed by health professionals are outlined in Table 10.

Table 10: Outcome Measures Most Commonly Used in Everyday Practice by Health Professionals

Measure	Percentage
Circumference measurements	70.23
Mobility	66.51
Pain	64.19
Quality of life	60.00
Patient adherence	57.21
Photography	43.72
Episodes of cellulitis	43.26
Weight/BMI	34.88
Circumference only without volume	33.95
Wound size	30.70
Complications of treatment	26.51
Wound type	24.19
Hospital admissions linked to chronic edema	22.79

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According to the survey's results, the LE outcome measures currently used focused on limb size, mobility and patient quality of life.[122] Interestingly, the ability to self-manage is also rated highly, whereas wound healing was rated as important by only 12% of participants.[122] The participants in this survey were largely patients and health professionals who were members of provincial advocacy organizations. The LIMPRINT survey of specialized lymphedema services found that less than 10% of patients with chronic edema/lymphedema had wounds.[83] The recent research on wounds and lymphedema clearly showed wound prevalence in upper extremity LE was about 10% while in lower extremity ranged from 50 to 75%.

5.2.1 Determine if the outcomes have met the care goals of care

Discussion: Evaluation of patient outcomes should take into consideration factors originally set in patient goals. Goals may need change over time based on management of LE, environmental factors, access to bandaging and compression therapies and overall health status (e.g., mobility, employment). Frequent reassessment of outcomes and their intersection with patient goals of care is recommended to develop a longitudinal understanding of the patient's care context and trajectory.

Although several quantitative tools exist to aid in the assessment of whether goals have been met (See Recommendation 5.2),[29, 52,117,122,123] health-care professionals should also integrate patients' subjective reports to better determine whether outcomes have met the goals of care.

5.2 Reassess patient, wound, environment and system if goals are partially met or unmet

Discussion: Consider several factors when reassessing the patient, wound, environment and system. Identify whether acute physical management goals have been met through thorough reassessment of limb volume (tape measurements) and related measures using validated tools (See Figure 4).[30, 31,124-126] Also assess lymphorrhagia, wound exudate, allergic reaction/sensitivity to dressings, skin integrity and levels of wound comfort.[29,52,117,122,123]

Health-care professionals may refer for additional support regarding the patient's physical symptoms and functional status. Using quality-of-life tools will assist in reassessment of specific or general health status.[29,126-136] It is critical to acknowledge and adjust care to each patient's unique experience and potential wound or LE-related stressors.

These ongoing LE-related stressors may include the psychosocial burden of functional impact, social/relational factors, financial burden associated with chronic wound or lymphedema care, identity changes, cultural aspects of wellbeing and perceived physical appearance changes due to complex wounds or lymphedema.[123,137,138] These stressors may be

worsened by the health-care system. Patients with LE reported a relative lack of LE interest or knowledge when interacting with the medical system, which may result in delays in assessment and testing to support an accurate, timely diagnosis. It is important clinicians acknowledge this experiential context as a reminder to offer a patient-centred and tailored approach to reassessment in addition to quantitative assessments (See Figure 4).[137,139]

If goals of care are not met, return to Step 1 and complete the cycle. If care goals are met, proceed to Recommendation 5.3 prior to discharge or transition to another setting.

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Discussion: Early discharge planning communications and integrated team collaboration are key in building a sustainable maintenance plan to reduce the risk of recurrence.[140] A detailed discharge or transition in care (setting or unit) plan should be co-designed (with the initial plan of care) to accommodate the patient's unique physical, financial, social and accessibility needs. Ensure community-based care plans and referrals for follow-up have been established prior to discharge to promote smooth transitions in care and prevent patients from returning to hospital.[140]

Patient education on compression therapy, manual lymphatic massage, exercise and physical activity, meticulous skin care, infection prevention practices (hand hygiene) and patient-clinical support and networks in the community should be introduced before the immediate clinical encounter is completed, and repeated often.[141]

Health-care providers need to recognize that certain lymphedema care practices are not covered by provincial/territorial health-care funding.[11] Familiarizing yourself and your patient with up-to-date local care financial coverage is important in ensuring accessible, patient-centred longitudinal care is provided. Ensuring timely referrals to support services that understand funding of LE bandaging and garments is essential. Furthermore, certain maintenance therapies, such as specialized exercises, skin care (products, prescriptions) and manual lymphatic drainage, can be tailored and introduced to patients as self-care practices in order to balance co-morbidity management and financial sustainability.

Health-care providers need to stay up to date on LE, skin and wound-related knowledge. They need to practice compression therapy, ABPI, CDT and other LE-related skills.

Leaders and organizations need to support LE education and training for health-care professionals. This includes the provision of health assessment tools and education for LE (appropriately sized blood pressure cuffs, assessment tables, Doppler assessment equipment). As well, health-care professionals require appropriate blocks of appointment time to complete complex LE assessments and, in some cases, the team may need the services of a second health-care professional to support assessment and patient positioning as diagnostic testing may cause the patient pain and discomfort.

Conclusion

Outcome evaluation is a stepwise process that engages the patient and care team across several aspects of the health continuum. Health-care professionals must be mindful of the many tools that can be used in the assessment of LE and corresponding wounds, while tailoring care to the unique needs and goals of the patients they encounter. Research is needed to develop assessment tools that integrate aspects of both lymphatic health and wound care in order to optimize the wellbeing of patients living with complex, combined presentation of lymphedema and wounds.

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Appendix A: Lipedema

Lipedema is a distinct entity from lymphedema (LE) and often occurs bilaterally and symmetrically Lipedema is a disproportionate accumulation of fat in the lower body. A familial association has been suggested with X-linked dominant or autosomal dominant with a predilection for female sex, so it is predominantly found in women. It progresses over time.[142,143]

Lipedema is often misdiagnosed as obesity or LE; however, the fat deposition in lipedema has sparing of the foot at the ankle, sometimes known as the cuff sign (late sign). In lipedema, the swelling is non-compressible. It is often associated with pain with touch to the skin and easy bruising.[144]

Appendix B: National Lymphedema Network (NLN) Staging of Lymphedema[145]

Lymphedema develops in a progressive manner, from mild to severe, making early identification of the condition important. The stages of lymphedema are:	
Stage 0 (Latency)	Lymphedema begins to develop deep within the tissues and can progress very slowly. Early changes happen without obvious, noticeable swelling; however, the fluid congestion causes sensations such as tightness, heaviness, or diffuse tingling in the at-risk limb. Despite the normal appearance of the limb, there may be subclinical changes occurring that can be measured and identified. Responding to changes in this early stage can help to prevent the onset of the condition. Special imaging or other lymphatic technology is required for diagnosis in this stage.
Stage 1 (Spontaneously Reversible)	In this early stage, swelling may or may not be present all the time. Swelling may come and go intermittently. When swelling is present, the skin will 'pit', meaning the area indents with pressure and holds the indentation. Elevation of the swollen limb provides relief and reduction in the swelling. It is important to seek out treatment for lymphedema management at this early stage to help to prevent the condition from becoming progressively more swollen.
Stage 2 (Spontaneously Irreversible)	In this stage, the tissue now has obvious signs of stagnant swelling that do not go away with elevation. The tissue will be firmer and show signs of less pitting. The tissue consistency change is caused by the formation of fibrosis. Fibrosis is the scarring of the tissue due to the prolonged presence of stagnant lymph. This marks the beginning of the hardening of the limb and progressively more aggressive swelling. Seeking treatment at this stage will help to reduce limb volume and improve tissue. The treatment will be more intensive and will require more vigilant follow up to maintain the swelling.
Stage 3 (Lymphostatic Elephantiasis)	At this stage, the tissue becomes very hard (fibrotic) and may begin to develop thickening on the surface of the skin. Excess skin forms on the limb and there is greater potential for open, seeping areas. Due to the high concentration of lymph fluid, the swollen limb(s) becomes an ideal culture medium for bacteria to thrive and recurrent infections may be common. Moreover, untreated lymphedema can lead into decrease or loss of functioning of the limb(s), skin breakdown, chronic infections and, sometimes, irreversible complications. Treatment is still beneficial at this stage and can have a remarkable impact on tissue softening and decongestion of the swelling.
These stages represent the natural progression of lymphedema when the condition is left untreated. At any stage, lymphedema can be treated and the progression halted and, in some instances, reversed. The importance of early identification and early management should be stressed. *Source: National Lymphedema Network. Available from: https://lymphnet.org/stages-of-lymphedema*	

Appendix C: Lymphedema/Chronic Edema Clinician Certification and Education

Organization	Link
Atlantic Clinical Lymphedema Network (ACLN)	The ACLN is an interprovincial network of skilled LE clinicians committed to the exploration and implementation of best practice and effective service delivery in education and management of lymphedema https://atlanticlymph.ca/en/
Canadian Lymphedema Framework	Home page. Lists all provincial lymphedema associations https://www.canadalymph.ca/ Offers list of schools that offer certification and education for lymphedema https://www.canadalymph.ca/health-professionals/schools/
Casley-Smith International	https://www.casleysmithinternational.com/
Chikly Lymphedema therapy Certification	https://chiklyinstitute.com/Class/LDT/CLTC
Guardian EMR	Manual lymph activation course https://www.e-his.ca/mla/
Lymphatic Education & Research Network	https://lymphaticnetwork.org/living-with-lymphedema/find-a-lymphedema-therapist
International Society of Lymphology (ISL)	https://isl.arizona.edu/
International Lymphedema Framework (ILF)	https://www.lympho.org/national-frameworks
Klose Training Lymphedema Certification	https://klosetraining.com/course/in-classroom/lymphedema-certification/
National Lymphedema Network (NLN)	https://lymphnet.org/stages-of-lymphedema
Niagara College, St. Catharines, Ontario	Lymphedema management course https://www.niagaracollege.ca/parttimestudies/courses/SMNR/1580/
University of Alberta	Lymphedema and chronic edema management https://www.ualberta.ca/en/rehabilitation/programs/professional-development/micro-courses/lymphedema-and-chronic-edema.html
Vodder School International	https://www.vodderschool.com/manual_lymph_drainage_overview2
Welsh Lymphedema Framework	https://lohmann-rauscher.co.uk/wales-lymphoedema-framework

Appendix D: Parkwood Wound Clinic Protocol for Application of Short Stretch Compression Bandages

Note: This is an example of multi-layer bandaging (MLB) which is part of many recommendations for treating LE. This approach is particularly useful in heavily exudating legs as the bandaging system is washable and reusable (follow manufacturers instructions).

STEP 1: Washing and Preparing to Wrap

- After removing dressings, please wash lower legs and feet using mild soap or plain warm water and washcloth. Pat skin dry and dry well between toes with a clean, dry washcloth
- Apply recommended moisturizer or steroid ointment as directed. Do not apply moisturizer between toes unless otherwise indicated.
- Have patient exercise ankles, knees and feet at this time

NOTE: Legs must not go without compression for more than 1 hour. Edema will accumulate and you will be starting all over

STEP 2: Wound Assessment and Dressing Application

- Inspect skin for any new open areas or new red itchy areas
- Assess the wound if present and record your assessment
- Apply dressings as directed

STEP 3: Applying Skin Protection Layer

- Starting at the base of the great toe, on the dorsum of the foot, apply cast padding once around the foot, to lock the first go-round, then continue wrapping by overlapping 50% in a spiral fashion up toward the knee to two finger breadths below the bend of the knee
- THIS STEP MUST NOT BE OMITTED as it distributes the pressure and prevents breakdown at pressure points
- You may require extra padding to protect bony prominences (pretibial, malleolus)

STEP 4: Applying Bolster on Dorsum of Foot if Required

- If a patient has a large amount of edema on the dorsum of foot/feet, you may add foam or abdominal pads to create a bolster. You may also 'figure 8' over the foot

STEP 5: Applying First Layer of Short-Stretch Bandage

- Use a 6 cm, 8 cm or 10 cm bandage
- Discard clips provided
- Start at the base of the great toe on the dorsum and lock the first layer around the foot. Apply at full stretch, wrapping in spiral fashion with two-thirds or more overlap up as far up leg as it goes
- DO NOT CUT THE BANDAGE
- Secure with tape

STEP 6: Applying Second Layer of Short Stretch Bandage

- Discard clips provided
- Start at just above the malleolus (ankle bone), overlapping the first layer as much as required
- Apply at full stretch, wrapping in spiral fashion with 2/3 overlap up the leg to 2 finger breadths below the bend of the knee. You may need to adjust the amount of overlap to end at the knee
- You may require a second wrap on larger legs to reach the knee
- DO NOT CUT THE BANDAGE
- Secure with tape
- Use an 0.8 cm, 0.10 cm or 0.12 cm bandage (one size larger than the first layer)

STEP 7: Securing the Bandage

- Use tubular bandage or a knee-high nylon over the short-stretch wrap bandages to help hold up

STEP 8: Follow-up

- Assess the patient for comfort
- Rewrap legs as necessary, every day initially, then q 2–3 days
- Encourage rest periods of 1–2 hours daily with legs elevated above the level of the heart as tolerated
- Short-stretch bandages can be washed up to 20 times in cool water by hand or in the gentle cycle of a washing machine. Squeeze in a dry towel to remove excess moisture and drape over a towel rack to dry

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Appendix E: Patient-centred Lymphedema Resources

Organization	Resource and Link
Alberta Lymphedema Association	A voice for lymphedema https://albertalymphedema.com/
BC Cancer Library	Lymphedema resources available from the BC Cancer Library system https://bccancer.libguides.com/pathfinder-lymphedema
Canadian Lymphedema Framework	Hints and Tips https://www.canadalymph.ca/hints-and-tips/
Canadian Cancer Survivor Network	Lymphedema https://survivornet.ca/learn/issues-affecting-cancer-survivors/survivorship-issues/lymphedema/
Lymphedema Association of Saskatchewan (LAS)	Focus on resources and support for persons at risk of or who live with LE https://www.sasklymph.ca/
Lymphedema Association of Manitoba (LAM)	Resources for those affected or at risk of primary and secondary LE https://lymphmanitoba.ca/
Lymphedema Association of Ontario	Resources: https://www.lymphontario.ca/LE-Resources
Lymphedema Association of Quebec	Resources in French and English to support patients and care partners with the goal of lessening the burden https://infolympho.ca/en/
Lymphedema Association of Newfoundland & Labrador	What is lymphedema? Patient stories included on the website https://lymphnl.com/
Lymphedema Association of New Brunswick	Resources and support offering hope for persons living with LE through meetings and social media https://atlanticlymph.ca/en/find-a-therapist/new-brunswick/
Lymphology Associaton of North America (LANA)	https://clt-lana.org/
Lymphedema Association of Nova Scotia	Offers support for persons living with LE https://lymphedemanovascotia.com/
Lymphedema Association of Prince Edward Island	Resources and support offering hope for persons living with LE through meetings and social media https://atlanticlymph.ca/en/find-a-therapist/pei/
Wounds Canada	Caring for Your Swollen Legs at Home https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series