Best Practice Recommendations For Skin Health and Wound Management 2025

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

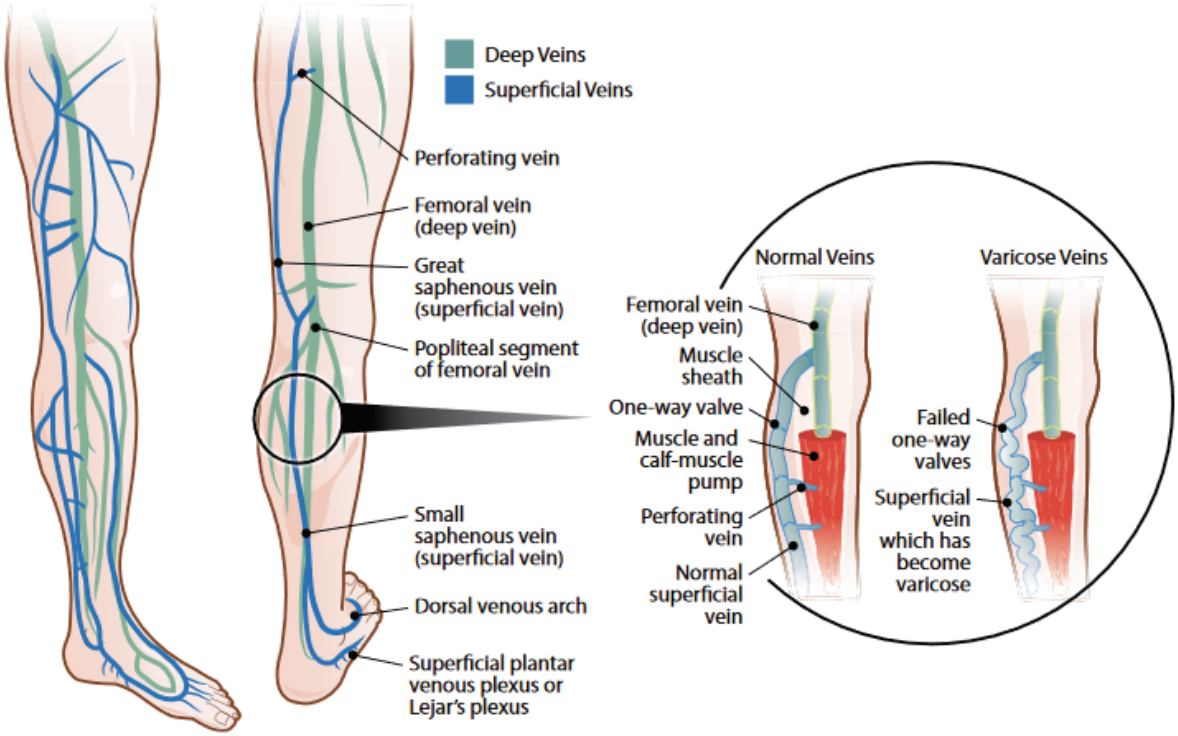


Figure 1b: Normal and Malfunctioning Valve

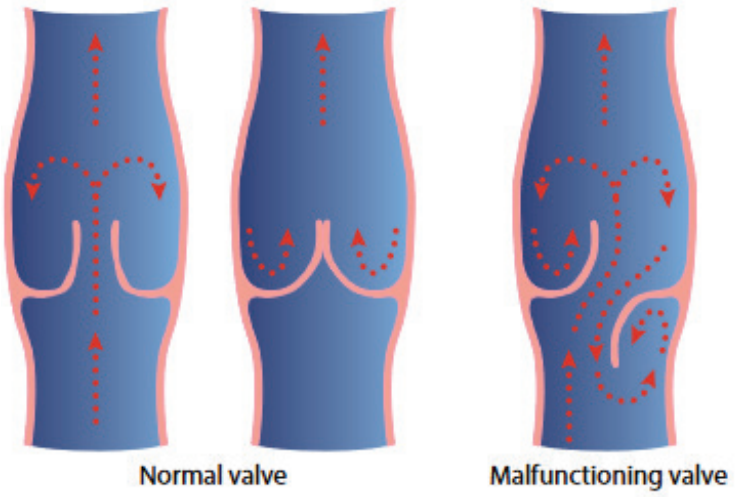


Figure 1c: Anatomy of the Lower Leg

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

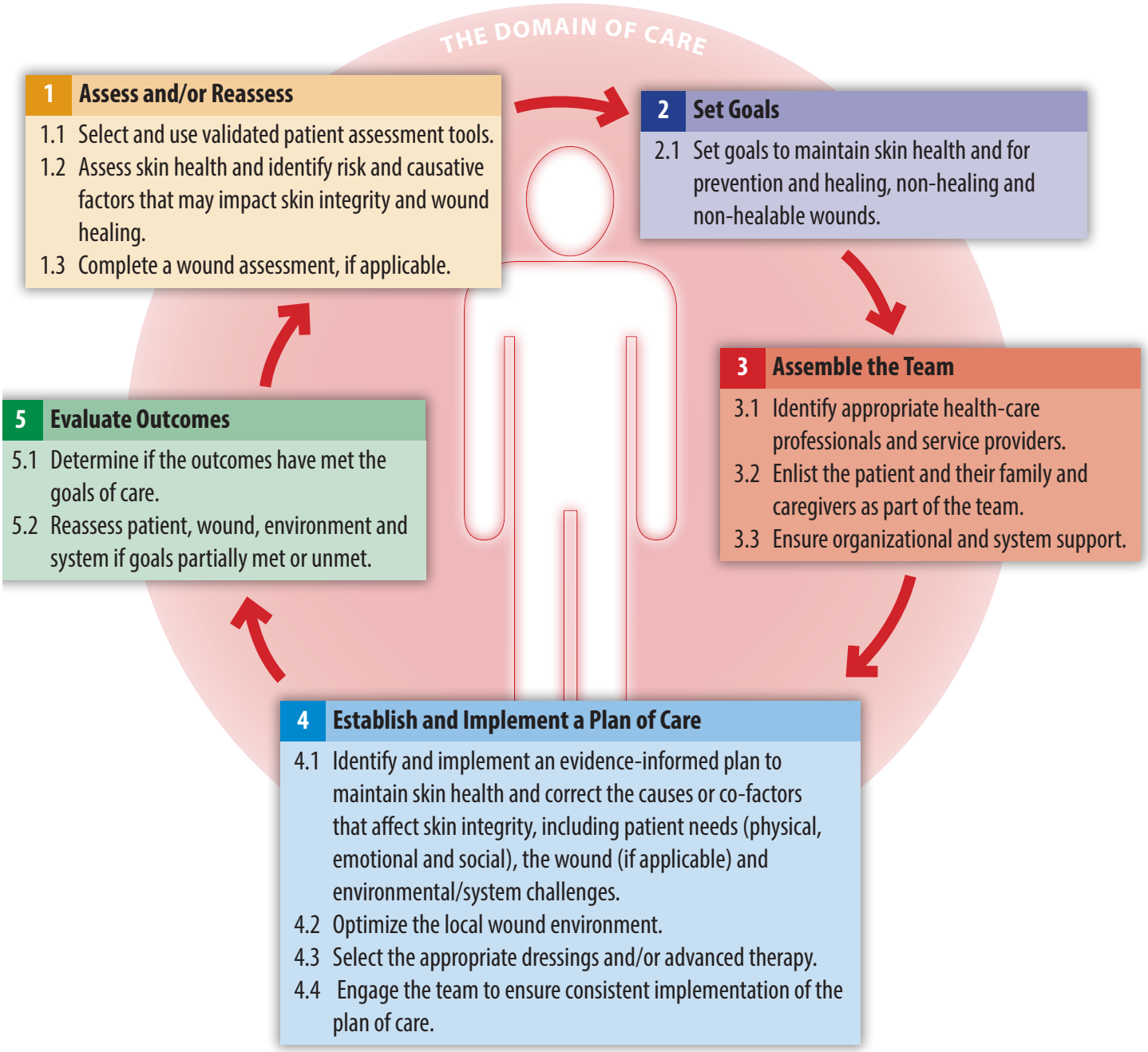
5 components	Applied to Venous Leg Ulcers
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practice guidelines to ensure most effective treatment Appropriate use of resources-examples compression, dressings, devices
Advancing 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 periwound 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.

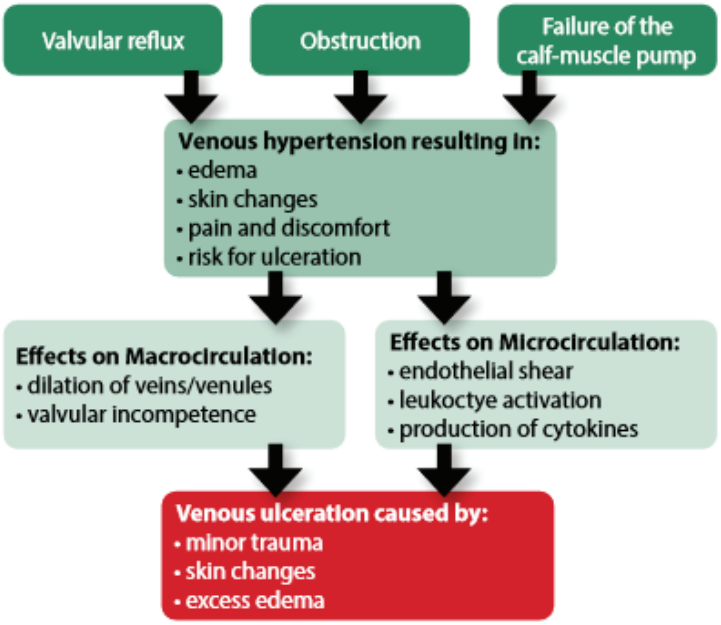
For the calf-muscle pump to function properly, the following are required:[47]

- 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



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 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]

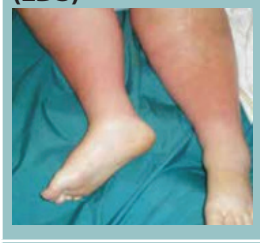
Physical assessment includes identifying physical changes in both limbs for edema, stasis changes, hyperpigmentation of the skin or hemosiderin staining, corona phlebectatica and varicosities. Acute lipodermatosclerosis (LDS) and chronic LDS (a woody texture to the skin) are evidence of progressive

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]
Retention Hyperkeratosis 	Common, benign skin condition related to reduction of edema and routing desquamation. Managed with skin hygiene protocols

cont'd. . . .

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
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]

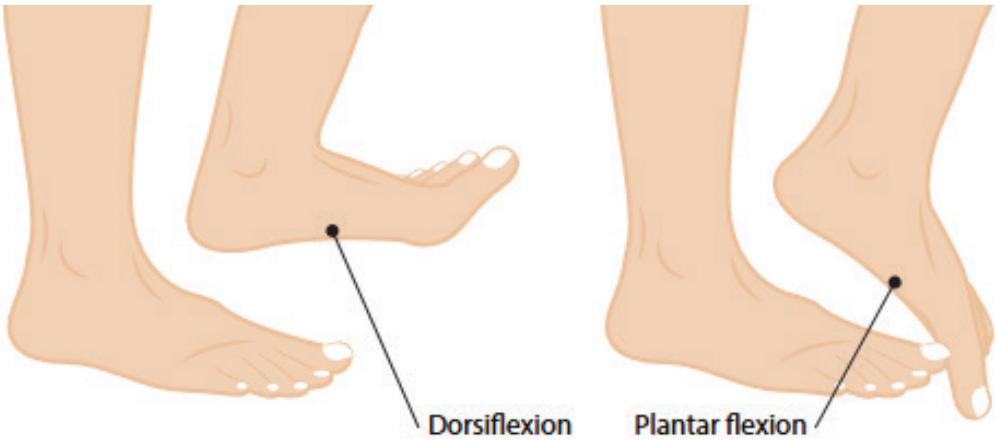
Clinical findings	C0	No visible or palpable signs of venous disease
	C1	Telangiectasias or reticular veins
	C2	Varicose veins; distinguished from reticular veins by a diameter of 3 mm or more
	C3	Presence of edema
	C4	Changes in skin and subcutaneous tissue secondary to CVD
	C4a Eczema or pigmentation	
	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

cont'd. . . .

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
Patho-Physiological cause	Pr	Reflux
	Po	Obstruction
	Pr,o	Reflux and obstruction
	Pn	No venous pathophysiology identified

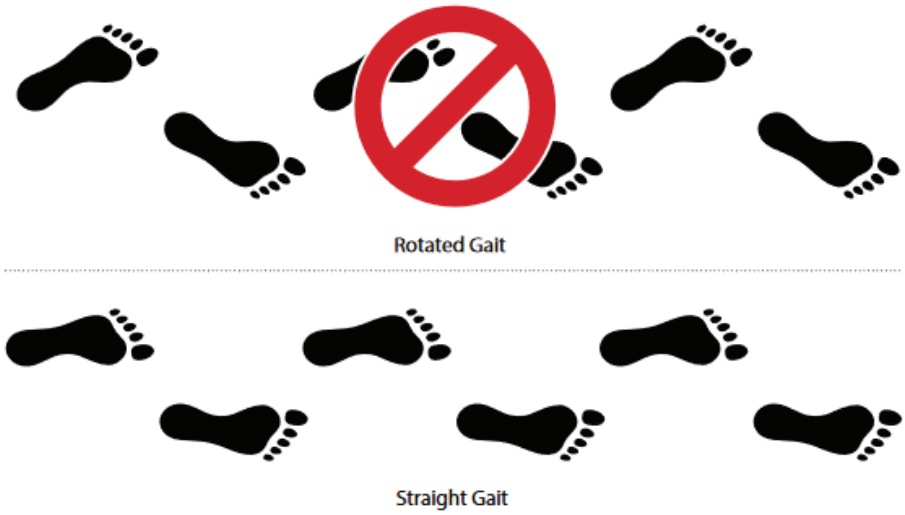
Investigation of the Calf-muscle Pump: Screening of the calf-muscle pump is an important part of an assessment of a person at risk of venous insufficiency and poor wound healing.[74] Calf-muscle pump failure is a key contributor to chronic venous insufficiency. The function of the calf-muscle pump is 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



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)



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

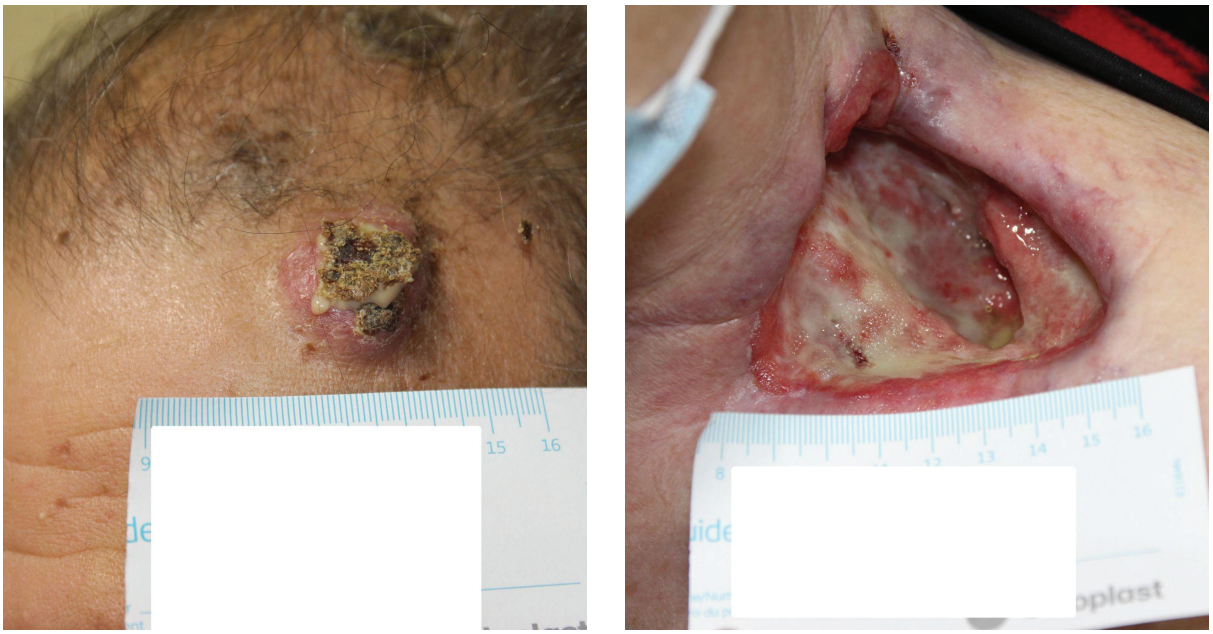
Wound infection develops as a result of micro-organisms invading the tissues, causing damage and invoking a local or systemic response in patients with VLU. Certain factors make VLUs unique in terms of infection, including large size or multiple ulcers, significant exudate and edema, stasis changes of 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 enter. 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

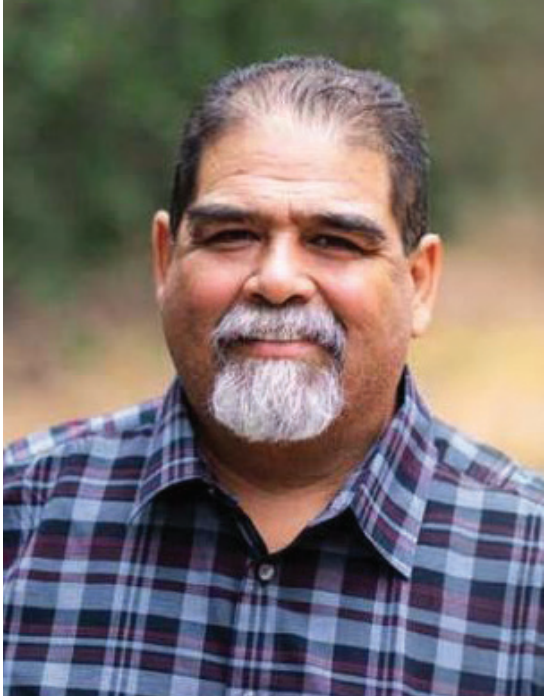
Goals should be developed to support the management of skin care, leg edema and the prevention, healing or recurrence of VLUs. Goals change over the course of care and should regularly be reviewed and reassessed with the patient and/or care partners.

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

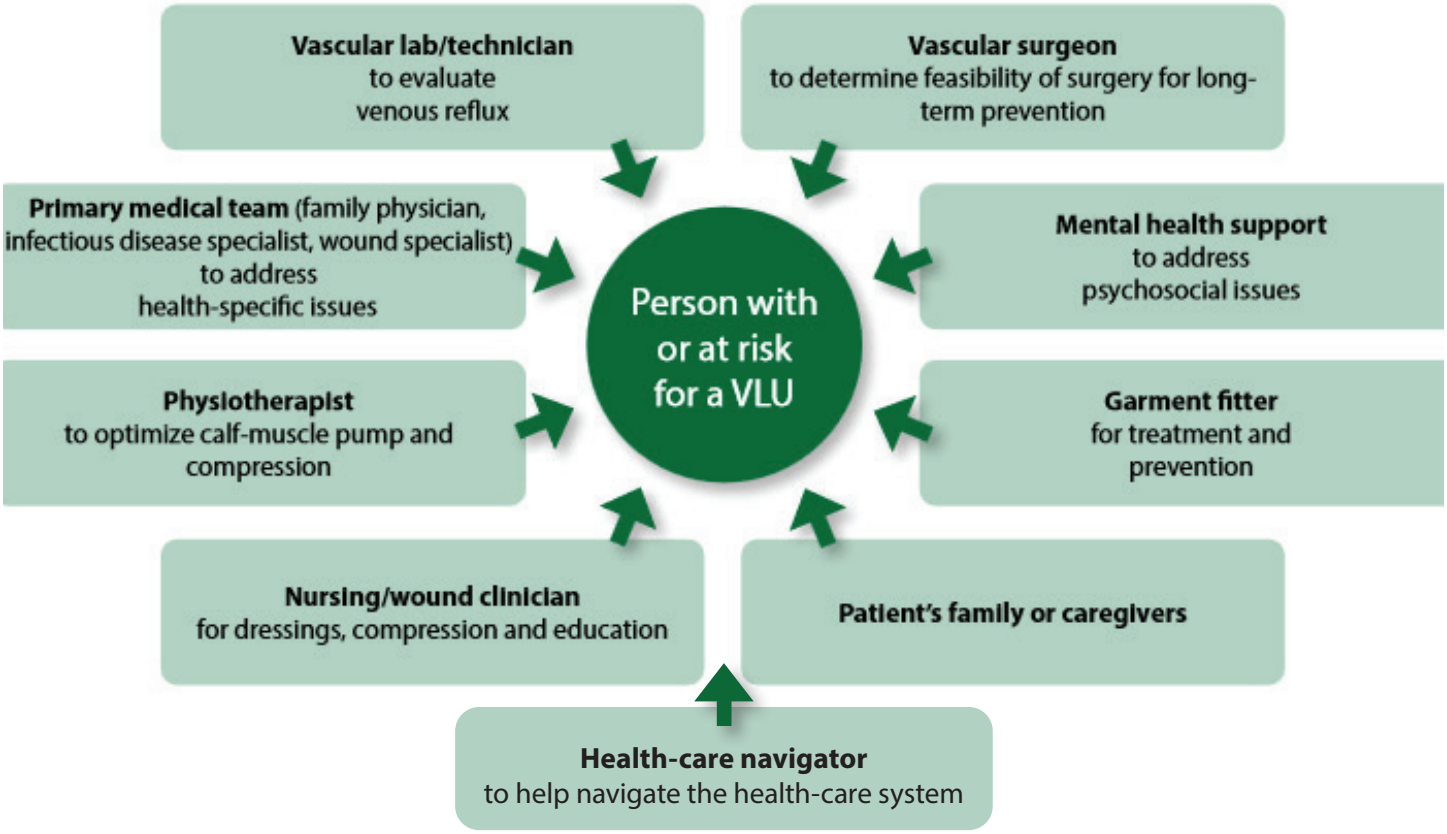
3.1 Identify appropriate health-care professionals and service providers

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

cont'd. . . .

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
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

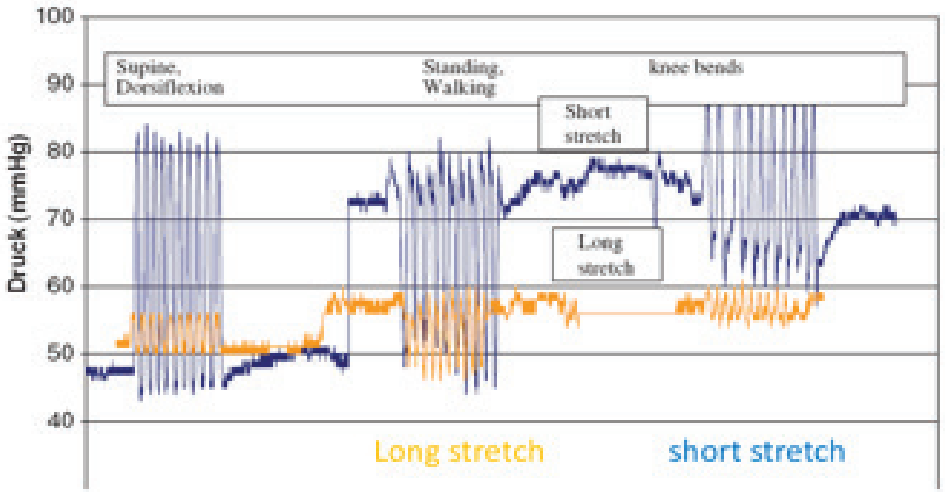
Type of bandaging	Alternate Name	Static Stiffness	Compression	
			Resting	With Activity
Long Stretch Bandaging (LSB)	Elastic	Low	High	Lower
Short Stretch Bandaging (SSB)	Inelastic	High	Low (support)	Higher

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]

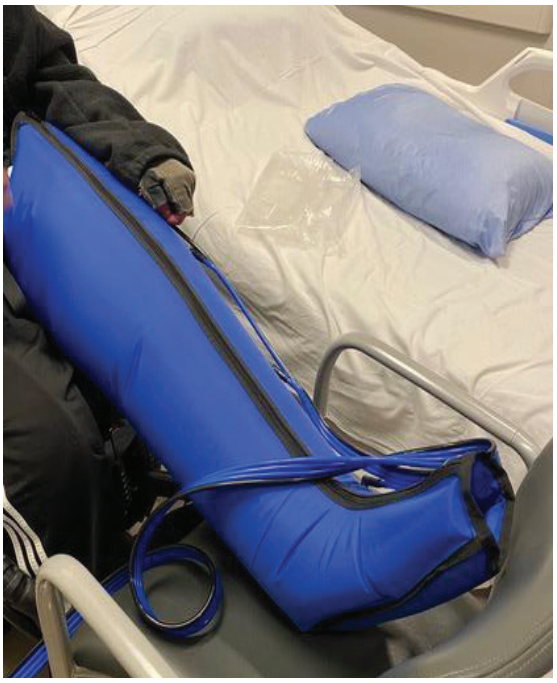
Donners and Doffers

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 excessive 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]

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	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]
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]

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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.

References

1. Sieggren MY, Kline RA. Venous disease and lymphedema management. In: Baranoski S, Ayello EA, editors. Wound care essentials: practice principles. Philadelphia (PA): Wolters Kluwer; 2016. pp. 340–375.
2. O'brien JA, Edwards HE, Finlayson KJ, Kerr G. Understanding the relationships between the calf muscle pump, ankle range of motion and healing for adults with venous leg ulcers: a review of the literature. Wound Practice & Research: Journal of the Australian Wound Management Association. 2012 Jun;20(2):80-5. Available from: https://search.informit.org/doi/abs/10.3316/INFORMIT.656336021803847
3. O'Donnell TF Jr, Passman MA, Marston WA, Ennis WJ, Dalsing M, Kistner RL, et al.; Society for Vascular Surgery; American Venous Forum. Management of venous leg ulcers: clinical practice guidelines of the Society for Vascular Surgery and the American Venous Forum. J Vasc Surg. 2014 Aug;60(2 Suppl):3S-59S. DOI: 10.1016/j.jvs.2014.04.049
4. Nelson EA, Adderley U. Venous leg ulcers. BMJ Clin Evid. 2016 Jan 15;2016:1902.
5. Grey JE, Patel GK. Venous and arterial leg ulcers. In: Price A, Grey JE, Patel GK, Harding KG, editors. ABC of wound healing. 2nd ed. John Wiley & Son's Limited; 2022.
6. Patel SK, Surowiec SM. Venous insufficiency.Treasure Island (FL): StatPearls Publishing; 2024 Jan. Available from: https://www.ncbi.nlm.nih.gov/books/NBK430975/
7. Probst S, Weller CD, Bobbink P, Saini C, Pugliese M, Skinner MB, et al. Prevalence and incidence of venous leg ulcers-a protocol for a systematic review. Syst Rev. 2021 May 12;10(1):148. DOI: 10.1186/s13643-021-01697-3
8. Vivas A, Lev-Tov H, Kirsner RS. Venous leg ulcers. Ann Intern Med. 2016 Aug 2;165(3):ITC17-ITC32 .DOI: 10.7326/AITC201608020
9. Raffetto JD, Ligi D, Maniscalco R, Khalil RA, Mannello F. Why venous leg ulcers have difficulty healing: overview on pathophysiology, clinical consequences, and treatment. J Clin Med. 2020 Dec 24;10(1):29. DOI: 10.3390/jcm10010029
10. Lal BK. Venous ulcers of the lower extremity: definition, epidemiology, and economic and social burdens. Semin Vasc Surg. 2015 Mar;28(1):3-5. DOI: 10.1053/j.semvascsurg.2015.05.002
11. Woo KY, LeBlanc K, Livingston M. Management of venous stasis ulcers in the older adult. Current Geriatrics Reports. 2015 Sep;4:229-36. DOI: 10.1007/s13670-015-0138-5
12. Rice JB, Desai U, Cummings AK, Birnbaum HG, Skornicki M, Parsons N. Burden of venous leg ulcers in the United States. J Med Econ. 2014 May;17(5):347-56. DOI: 10.3111/13696998.2014.903258
13. González-Consuegra RV, Verdú J. Quality of life in people with venous leg ulcers: an integrative review. J Adv Nurs. 2011 May;67(5):926-44. DOI: 10.1111/j.1365-2648.2010.05568.x
14. Folguera-Álvarez C, Garrido-Elustondo S, Rico-Blázquez M, Verdú-Soriano J. Factors associated with the quality of life of patients with venous leg ulcers in primary care: cross-sectional study. Int J Low Extrem Wounds. 2022 Dec;21(4):521-528. DOI: 10.1177/1534734620967562
15. Moffatt C. Compression therapy in practice. Aberdeen (UK): Wounds UK; 2007.
16. 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 DOI: 10.1111/j.1524-4725.2006.32039.x
17. Shaydakov ME, Ting W, Sadek M, Aziz F, Diaz JA, Raffetto JD, et al.; American Venous Forum Research Committee. Review of the current evidence for topical treatment for venous leg ulcers. J Vasc Surg Venous Lymphat Disord. 2022 Jan;10(1):241-247.e15. DOI: 10.1016/j.jvsv.2021.06.010
18. Finlayson K, Edwards H, Courtney M. Factors associated with recurrence of venous leg ulcers: a survey and retrospective chart review. Int J Nurs Stud. 2009 Aug;46(8):1071-8. DOI: 10.1016/j.ijnurstu.2008.12.012
19. Finlayson KJ, Parker CN, Miller C, Gibb M, Kapp S, Ogrin R, et al. Predicting the likelihood of venous leg ulcer recurrence: The diagnostic accuracy of a newly developed risk assessment tool. Int Wound J. 2018 Oct;15(5):686-694. DOI: 10.1111/iwj.1291
20. Gohel MS, Taylor M, Earnshaw JJ, Heather BP, Poskitt KR, Whyman MR. Risk factors for delayed healing and recurrence of chronic venous leg ulcers--an analysis of 1324 legs. Eur J Vasc Endovasc Surg. 2005 Jan;29(1):74-7. DOI: 10.1016/j.ejvs.2004.10.002
21. Edwards HE, Parker CN, Miller C, Gibb M, Kapp S, Ogrin R, et al Predicting delayed healing: the diagnostic accuracy of a venous leg ulcer risk assessment tool. Int Wound J. 2018 Apr;15(2):258-265. DOI: 10.1111/iwj.12859
22. Moffatt C, Kommala D, Dourdin N, Choe Y. Venous leg ulcers: patient concordance with compression therapy and its impact on healing and prevention of recurrence. Int Wound J. 2009 Oct;6(5):386-93. DOI: 10.1111/j.1742-481X.2009.00634.x
23. Abramson BL, Al-Omran M, Anand SS, Albalawi Z, Coutinho T, de Mestral C, et al. Canadian Cardiovascular Society 2022 Guidelines for Peripheral Arterial Disease. Can J Cardiol. 2022 May;38(5):560-587. DOI: 10.1016/j.cjca.2022.02.029
24. Hedayati N, Carson JG, Chi YW, Link D. Management of mixed arterial venous lower extremity ulceration: a review. Vasc Med. 2015 Oct;20(5):479-86. DOI: 10.1177/1358863X15594683
25. Dean SM, Valenti E, Hock K, Leffler J, Compston A, Abraham WT. The clinical characteristics of lower extremity lymphedema in 440 patients. J Vasc Surg Venous Lymphat Disord. 2020 Sep;8(5):851-859. DOI: 10.1016/j.jvsv.2019.11.014
26. Lymphoedema Framework. International consensus: best practice for the management of lymphoedema. London (UK): MEP Ltd; 2009. pp. 1-60. Available from: https://www.lympho.org/uploads/files/files/Best_practice.pdf
27. Keast DH, Burian EA, Moffatt C, Nørregaard S, Karlsmark T. The dilemma of wounds in chronic oedema/lymphoedema. Journal of wound care. 2021 Dec;30(12). Available from: https://research.regionh.dk/en/publications/the-dilemma-of-wounds-in-chronic-oedemalymphoedema
28. Canadian Lymphedema Framework. Lymphedema. 2023. Available from: https://www.canadalymph.ca/
29. Nundy S, Cooper LA, Mate KS. The quintuple aim for health care improvement: a new imperative to advance health equity. JAMA. 2022 Feb 8;327(6):521-522. DOI: 10.1001/jama.2021.25181
30. Orsted HL, Keast DH, Forest-Lalande L, Kuhnke JL, O'Sullivan-Drombolis D, Jin S, et al. Skin: anatomy, physiology and wound healing. In: Kuhnke JL, Burrows CA, Evans RM, Orsted HL, Rosenthal S, editors. Best practice recommendations for skin health and wound management 2025. Toronto (ON): Wounds Canada; 2025. DOI: 10.56885/PEWY3827
31. Orsted HL, Keast DH, Forest-Lalande L, Kuhnke JL, O'Sullivan-Drombolis D, Jin S, et al. Best practice recommendations for the prevention and management of wounds: an overview. In: Kuhnke JL, Burrows CA, Evans RM, Orsted HL, Rosenthal S, editors. Best practice recommendations for skin health and wound management 2025. Toronto (ON): Wounds Canada; 2025. DOI: 10.56885/CVEU6924

32. Meulendijks AM, de Vries FMC, van Dooren AA, Schuurmans MJ, Neumann HAM. A systematic review on risk factors in developing a first-time Venous Leg Ulcer. J Eur Acad Dermatol Venereol. 2019 Jul;33(7):1241-1248. DOI: 10.1111/jdv.15343
33. Parker C. Predicting the likelihood of non-healing: a venous leg ulcer risk assessment tool [PhD thesis]. Brisbane (AU): Queensland University of Technology; 2014. Available from: https://eprints.qut.edu.au/78680/1/Christina_Parker_Thesis.pdf
34. Parker CN, Finlayson KJ, Edwards HE. Predicting the likelihood of delayed venous leg ulcer healing and recurrence: development and reliability testing of risk assessment tools. Ostomy Wound Manage. 2017 Oct;63(10):16-33.
35. Parker C, Finlayson K, Atkin L, Ousey K, Assadian O, Koller S, et al. International validation of a venous leg ulcer risk assessment tool. J Wound Care. 2023 Apr 2;32(4):229-234. DOI: 10.12968/jowc.2023.32.4.229
36. Dietitians of Canada. 2023. About dietitians of Canada. Available from: https://www.dietitians.ca/About/About-Dietitians-of-Canada
37. Australian Wound Management Association, New Zealand Wound Care Society. Australian and New Zealand clinical practice guideline on prevention and management of venous leg ulcers. Osborne Park (AU): Cambridge Publishing; 2011 Oct. pp. 1-136. Available from: https://www.nzwcs.org.nz/images/luag/2011_awma_vlug.pdf
38. Vilela LH, Salomé GM, Pereira RC, Ferreira LM. Pain assessment in patients with venous leg ulcer treated by compression therapy with Unna's boot. J Tissue Sci Eng. 2016;7(171):2. DOI: 10.4172/2157-7552.1000171
39. RAND. 36-item short form health survey (SF-36). Available from: https://www.rand.org/health-care/surveys_tools/mos/36-item-short-form.html
40. Wound-QoL. About Wound-QOL. 2023. Available from: https://www.wound-qol.com/about/
41. Salomé GM, de Almeida SA, Ferreira LM. Association of socio-demographic factors with hope for cure, religiosity, and spirituality in patients with venous ulcers. Adv Skin Wound Care. 2015 Feb;28(2):76-82. DOI: 10.1097/01.ASW.0000459844.07689.02
42. Kuhnke J, Maxwell S. Patients' perspectives of pain, time, and hope when living with venous leg ulcers and using the geko™ device: a qualitative descriptive inquiry. Spotlight on Exploratory Research in Health. 2021. Available from: https://cbufaces.cairnrepo.org/islandora/object/cbu%3A2047
43. Kapp S, Santamaria N. The "self-treatment of wounds for venous leg ulcers checklist" (STOW-V Checklist V1.0): Part 1-Development, pilot and refinement of the checklist. Int Wound J. 2022 Mar;19(3):705-713. DOI: 10.1111/iwj.13666
44. Woodbury MG, Houghton PE, Campbell KE, Keast DH. Development, validity, reliability, and responsiveness of a new leg ulcer measurement tool. Adv Skin Wound Care. 2004 May;17(4 Pt 1):187-96. DOI: 10.1097/00129334-200405000-00018
45. Sieggreen MY, Kline RA, Sibbald RG, Weir GR. Arterial ulcers. In: Baranoski S, Ayello EA, editors. Wound care essentials: practice principles. Philadelphia (PA): Wolters Kluwer; 2012. pp. 376–397.
46. Sibbald RG, Elliott JA, Persaud-Jaimangal R, Goodman L, Armstrong DG, Harley C, et al. Wound bed preparation 2021. Adv Skin Wound Care. 2021 Apr 1;34(4):183-195. DOI: 10.1097/01.ASW.0000733724.87630.d6
47. Shiman MI, Pieper B, Templin TN, Birk TJ, Patel AR, Kirsner RS. Venous ulcers: a reappraisal analyzing the effects of neuropathy, muscle involvement, and range of motion upon gait and calf muscle function. Wound Repair Regen. 2009 Mar-Apr;17(2):147-52. DOI: 10.1111/j.1524-475X.2009.00468.x
48. Michel CC, Woodcock TE, Curry FE. Understanding and extending the Starling principle. Acta Anaesthesiol Scand. 2020 Sep;64(8):1032-1037. DOI: 10.1111/aas.13603
49. Schultz G, Tariq G, Harding K, Carville K, Romanelli M, Chadwick P, et al.WUWHS consensus document – wound exudate, effective assessment and management. Wounds International. 2019 Feb 1:1-34. Available from: https://woundsinternational.com/world-union-resources/wuwhs-consensus-document-wound-exudate-effective-assessment-and-management/
50. Mortimer PS, Rockson SG. New developments in clinical aspects of lymphatic disease. J Clin Invest. 2014 Mar;124(3):915-21. DOI: 10.1172/JCI71608
51. Comerota A, Lurie F. Pathogenesis of venous ulcer. Semin Vasc Surg. 2015 Mar;28(1):6-14. DOI: 10.1053/j.semvascsurg.2015.07.003
52. Carmel JE, Bryant RA. Venous ulcers. In: Bryant RA, Nix DP, editors. Acute and chronic wounds: current management concepts. St. Louis (MO): Elsevier; 2016. pp. 204–226.
53. Sibbald RG, Elliott JA, Verma L, Brandon A, Persaud R, Ayello EA. Update: topical antimicrobial agents for chronic wounds. Adv Skin Wound Care. 2017 Oct;30(10):438-450. DOI: 10.1097/01.ASW.0000524471.28441.b9
54. Uhl JF, Cornu-Thenard A, Satger B, Carpentier PH. Clinical analysis of the corona phlebectatica. J Vasc Surg. 2012 Jan;55(1):150-3. DOI: 10.1016/j.jvs.2011.04.070
55. Miteva M, Romanelli P, Kirsner RS. Lipodermatosclerosis. Dermatol Ther. 2010 Jul-Aug;23(4):375-88. DOI: 10.1111/j.1529-8019.2010.01338.x
56. Alavi A, Hafner J, Dutz JP, Mayer D, Sibbald RG, Criado PR, et al. Atrophie blanche: is it associated with venous disease or livedoid vasculopathy? Adv Skin Wound Care. 2014 Nov;27(11):518-24. DOI: 10.1097/01.ASW.0000455098.98684.95
57. Sibbald RG, Cameron, J. Dermatologic aspects of wound care. In: Krasner D, Sibbald RG, editors. Chronic wound care: a clinical source book for healthcare professionals. 4th ed. Malvern (PA): HMP Communications; 2007. pp. 221–232.
58. Sibbald RG, Alava A, Sussman G, Ayello EA, Goodman L. Dermatilogical aspects of wound care. In: Krasner DF, Rodeheaver GT, Sibbald RG, Woo KY, editors. Chronis wound care a clinical source book for healthcare professionals. 5th ed. 2012. pp. 207-222.
59. Registered Nurses' Association of Ontario (RNAO). Nursing best practice guideline: risk assessment and prevention of pressure ulcers. 2005 Mar. Available from: http://rnao.ca/sites/rnao-ca/files/Risk_Assessment_and_Prevention_of_Pressure_Ulcers.pdf
60. Gerhard-Herman MD, Gornik HL, Barrett C, Barshes NR, Corriere MA, Drachman DE, et al. 2016 AHA/ACC guideline on the management of patients with lower extremity peripheral artery disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation. 2017 Mar 21;135(12):e726-e779. Available from: DOI: 10.1161/CIR.0000000000000471
61. Farber A. Chronic limb-threatening ischemia. New England Journal of Medicine. 2018 Jul 12;379(2):171-80. DOI: 10.1056/NEJMcp1709326
62. Conte MS, Bradbury AW, Kolh P, White JV, Dick F, Fitridge R, et al.; GVG Writing Group for the Joint Guidelines of the Society for Vascular Surgery (SVS), European Society for Vascular Surgery (ESVS), and World Federation of Vascular Societies (WFVS). Global vascular guidelines on the management of chronic limb-threatening ischemia. Eur J Vasc Endovasc Surg. 2019 Jul;58(1S):S1-S109.e33. DOI: 10.1016/j.ejvs.2019.05.006

63. Eder S, Dissemond J, Vanscheidt W, Läuchli S, Partsch H, Stücker M. Buergers Test/Pole Test: einfache Methoden zur Überprüfung der arteriellen Perfusion vor geplanter Kompressionstherapie (Buergers Test/Pole Test: simple clinical tests to screen the arterial perfusion before compression therapy). Phlebologie im Druck. 2020 Apr. DOI: 10.1055/a-0865-7947
64. Scottish Intercollegiate Guidelines Network (SIGN). Management of chronic venous leg ulcers. 2010 Aug. Available from: https://www.sign.ac.uk/our-guidelines/management-of-chronic-venous-leg-ulcers/
65. Weir GR, Smart H, van Marle J, Cronje FJ. Arterial disease ulcers, part 1: clinical diagnosis and investigation. Adv Skin Wound Care. 2014 Sep;27(9):421-8. DOI: 10.1097/01.ASW.0000453095.19109.5c
66. Houghton P. The science behind ABPI. Wound Care Canada. 2019;17(1):10–21. Available from: 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
67. Wounds Canada Institute. How to assess blood flow using an ankle-brachial pressure index (ABPI) assessment. Wound Care Canada. 2019;17(1):22–24. Available from: 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
68. Schwarcz TH, Gatz VL, Little S, Geddings CF. Arterial duplex ultrasound is the most cost-effective, noninvasive diagnostic imaging modality before treatment of lower-extremity arterial occlusive disease. Journal for Vascular Ultrasound. 2009 Jun;33(2):75-9. DOI: 10.1177/154431670903300203
69. Franz RW, Jump MA, Spalding MC, Jenkins JJ 2nd. Accuracy of duplex ultrasonography in estimation of severity of peripheral vascular disease. Int J Angiol. 2013 Sep;22(3):155-8. DOI: 10.1055/s-0033-1336830
70. Khan SZ, Khan MA, Bradley B, Dayal R, McKinsey JF, Morrissey NJ. Utility of duplex ultrasound in detecting and grading de novo femoropopliteal lesions. J Vasc Surg. 2011 Oct;54(4):1067-73. DOI: 10.1016/j.jvs.2011.03.282
71. Meissner MH, Moneta G, Burnand K, Gloviczki P, Lohr JM, Lurie F, et al. The hemodynamics and diagnosis of venous disease. J Vasc Surg. 2007 Dec;46 Suppl S:4S-24S. DOI: 10.1016/j.jvs.2007.09.043
72. Zegarra TI, Tadi P. CEAP classification of venous disorders. Treasure Island (FL): StatPearls Publishing; 2023 Jan. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557410/
73. Lurie F, Passman M, Meisner M, Dalsing M, Masuda E, Welch H, et al. The 2020 update of the CEAP classification system and reporting standards. J Vasc Surg Venous Lymphat Disord. 2020 May;8(3):342-352. DOI: 10.1016/j.jvsv.2019.12.075
74. Qiu Y, Osadnik CR, Team V, Weller CD. Effects of physical activity as an adjunct treatment on healing outcomes and recurrence of venous leg ulcers: a scoping review. Wound Repair Regen. 2022 Mar;30(2):172-185. DOI: 10.1111/wrr.12995
75. Padberg FT Jr, Johnston MV, Sisto SA. Structured exercise improves calf muscle pump function in chronic venous insufficiency: a randomized trial. J Vasc Surg. 2004 Jan;39(1):79-87. DOI: 10.1016/j.jvs.2003.09.036
76. Turner BRH, Jasionowska S, Machin M, Javed A, Gwozdz AM, Shalhoub J, et al. Systematic review and meta-analysis of exercise therapy for venous leg ulcer healing and recurrence. J Vasc Surg Venous Lymphat Disord. 2023 Jan;11(1):219-226. DOI: 10.1016/j.jvsv.2022.09.003
77. Hofman D, Ryan TJ, Arnold F, Cherry GW, Lindholm C, Bjellerup M, et al. Pain in venous leg ulcers. Journal of wound care. 1997 May 2;6(5):222-4. DOI: 10.12968/jowc.1997.6.5.222
78. Dallam LE, Ayello E, Woo KY, Sibbald RG. Pain management and wounds. In: Baronski S, Ayello EA, editors. Wound care essentials: practice principles. Philadelphia (PA): Wolters Kluwer; 2016. pp. 281–306.
79. Kiecolt-Glaser JK, Marucha PT, Malarkey WB, Mercado AM, Glaser R. Slowing of wound healing by psychological stress. Lancet. 1995 Nov 4;346(8984):1194-6. DOI: 10.1016/s0140-6736(95)92899-5
80. Keast D, Angel D, Weir D, Haesler E, Ousey K, Carville K, et al. Wound infection in clinical practice: principles of best practice. Wounds International. 2022 Mar 2. Available from: https://woundsinternational.com/consensus-documents/wound-infection-in-clinical-practice-principles-of-best-practice/
81. Marston W, Tang J, Kirsner RS, Ennis W. Wound Healing Society 2015 update on guidelines for venous ulcers. Wound Repair Regen. 2016 Jan-Feb;24(1):136-44. DOI: 10.1111/wrr.12394
82. Upton D, Upton P. Psychology of wounds and wound care in clinical practice. Springer; 2015.
83. Jockenhöfer F, Gollnick H, Herberger K, Isbary G, Renner R, Stücker M, et al. Aetiology, comorbidities and cofactors of chronic leg ulcers: retrospective evaluation of 1 000 patients from 10 specialised dermatological wound care centers in Germany. Int Wound J. 2016 Oct;13(5):821-8. DOI: 10.1111/iwj.12387
84. Gethin G, Vellinga A, Tawfick W, O'Loughlin A, McIntosh C, Mac Gilchrist C, et al. The profile of patients with venous leg ulcers: a systematic review and global perspective. J Tissue Viability. 2021 Feb;30(1):78-88. DOI: 10.1016/j.jtv.2020.08.003
85. Keast DH, Bowering CK, Evans AW, Mackean GL, Burrows C, D'Souza L. MEASURE: A proposed assessment framework for developing best practice recommendations for wound assessment. Wound Repair Regen. 2004 May-Jun;12(3 Suppl):S1-17. DOI: 10.1111/j.1067-1927.2004.0123S1.x
86. Sieggreen MY, Kline RA, Sibbald RG, Weir GR. Arterial ulcers. In: Baranoski S, Ayello EA, editors. Wound care essentials: practice principles. Philadelphia (PA): Wolters Kluwer; 2012. pp.376–397.
87. Sieggreen MY, Kline RA. Venous disease and lymphedema management. In: Baranoski S, Ayello EA, editors. Wound care essentials: practice principles. Philadelphia (PA): Wolters Kluwer; 2012. pp. 340–375.
88. Pannier F, Rabe E. Differential diagnosis of leg ulcers. Phlebology. 2013 Mar;28 Suppl 1:55-60. DOI: 10.1177/0268355513477066
89. Bazaliński D, Przybek-Mita J, Barańska B, Więch P. Marjolin's ulcer in chronic wounds - review of available literature. Contemp Oncol (Pozn). 2017;21(3):197-202. DOI: 10.5114/wo.2017.70109
90. Ghasemi F, Anooshirvani N, Sibbald RG, Alavi A. The point prevalence of malignancy in a wound clinic. Int J Low Extrem Wounds. 2016 Mar;15(1):58-62. DOI: 10.1177/1534734615627721
91. Vowden P, Kerr A, Mosti G. Demystifying mild, moderate and high compression systems–when and how to introduce "lighter" compression. Wounds Int. 2020:1-25.
92. Vowden K, Vowden P. Effective compression therapy: how to guide. Wounds UK. 2017 May 25. Available from: https://wounds-uk.com/how-to-guides/effective-compression-therapy/
93. Dini V, Janowska A, Oranges T, De Pascalis A, Iannone M, Romanelli M. Surrounding skin management in venous leg ulcers: a systematic review. J Tissue Viability. 2020 Aug;29(3):169-175. DOI: 10.1016/j.jtv.2020.02.004
94. Maloy JP. Venous stasis ulcers. In: Brown P. Quick reference to wound care. 3rd ed. Boston (MA): Jones & Bartlett; 2009. pp.137–156.

95. Green T. Challenges of managing patients with chronic oedema and leg ulceration. Journal of Community Nursing. 2020 Jun 1;34(3). Available from: https://www.jcn.co.uk/journals/issue/06-2020/article/challenges-of-managing-patients-with-chronic-oedema-and-leg-ulceration
96. Rabe E, Partsch H, Morrison N, Meissner MH, Mosti G, Lattimer CR, et al. Risks and contraindications of medical compression treatment - a critical reappraisal. An international consensus statement. Phlebology. 2020 Aug;35(7):447-460. DOI: 10.1177/0268355520909066
97. Andriessen A, Apelqvist J, Mosti G, Partsch H, Gonska C, Abel M. Compression therapy for venous leg ulcers: risk factors for adverse events and complications, contraindications - a review of present guidelines. J Eur Acad Dermatol Venereol. 2017 Sep;31(9):1562-1568. DOI: 10.1111/jdv.14390
98. American Heart Association. Classes and stages of heart failure. 2024. Available from: https://www.heart.org/en/health-topics/heart-failure/what-is-heart-failure/classes-of-heart-failure
99. Schuren J, Mohr K. Pascal's law and the dynamics of compression therapy: a study on healthy volunteers. Int Angiol. 2010 Oct;29(5):431-5.
100. Partsch H, Mortimer P. Compression for leg wounds. Br J Dermatol. 2015 Aug;173(2):359-69. DOI: 10.1111/bjd.13851
101. Attaran RR, Ochoa Chaar CI. Compression therapy for venous disease. Phlebology. 2017 Mar;32(2):81-88. DOI: 10.1177/0268355516633382
102. Shi C, Dumville JC, Cullum N, Connaughton E, Norman G. Compression bandages or stockings versus no compression for treating venous leg ulcers. Cochrane Database Syst Rev. 2021 Jul 26;7(7):CD013397. DOI: 10.1002/14651858.CD013397.pub2
103. O'Meara S, Cullum N, Nelson EA, Dumville JC. Compression for venous leg ulcers. Cochrane database of systematic reviews. 2012(11). DOI: 10.1002/14651858.CD000265.pub3
104. Roaldsen KS, Elfving B, Stanghelle JK, Mattsson E. Effect of multilayer high-compression bandaging on ankle range of motion and oxygen cost of walking. Phlebology. 2012 Feb;27(1):5-12. DOI: 10.1258/phleb.2011.010084
105. Nelson EA, Bell-Syer SE. Compression for preventing recurrence of venous ulcers. Cochrane Database Syst Rev. 2014 Sep 9;2014(9):CD002303. DOI: 10.1002/14651858.CD002303.pub3
106. Nelson EA, Hillman A, Thomas K. Intermittent pneumatic compression for treating venous leg ulcers. Cochrane Database Syst Rev. 2014 May 12;2014(5):CD001899. DOI: 10.1002/14651858.CD001899.pub4
107. Weller CD, Buchbinder R, Johnston RV. Interventions for helping people adhere to compression treatments for venous leg ulceration. Cochrane Database Syst Rev. 2016 Mar 2;3(3):CD008378. DOI: 10.1002/14651858.CD008378.pub3
108. Young K, Ng Chok H, Wilkes L. Treatment in the home setting with intermittent pneumatic compression for a woman with chronic leg ulcers: a case report. BMC Nurs. 2017 Sep 21;16:56. DOI: 10.1186/s12912-017-0250-2
109. Williams KJ, Moore HM, Ellis M, Davies AH. Comparing the venous haemodynamic effect of a neuromuscular stimulation device to intermittent pneumatic compression in healthy subjects. 14th Meeting of European Venous Forum. 2013 Jun. pp. 27-30. DOI: 10.1177/0268355513500449
110. Meulendijks AM, Franssen WMA, Schoonhoven L, Neumann HAM. A scoping review on Chronic Venous Disease and the development of a Venous Leg Ulcer: the role of obesity and mobility. J Tissue Viability. 2020 Aug;29(3):190-196. DOI: 10.1016/j.jtv.2019.10.002
111. Kan YM, Delis KT. Hemodynamic effects of supervised calf muscle exercise in patients with venous leg ulceration: a prospective controlled study. Arch Surg. 2001 Dec;136(12):1364-9. DOI: 10.1001/archsurg.136.12.1364
112. O'Brien J, Finlayson K, Kerr G, Edwards H. Evaluating the effectiveness of a self-management exercise intervention on wound healing, functional ability and health-related quality of life outcomes in adults with venous leg ulcers: a randomised controlled trial. Int Wound J. 2017 Feb;14(1):130-137. DOI: 10.1111/iwj.12571
113. Kulprachakarn K, Nantakool S, Rojawat C, Ounjaijean S, Pongtam S, Prasannarong M, et al. Effectiveness of combined conventional treatment with a tailored exercise training program on wound healing in patients with venous leg ulcer: a randomized controlled trial. J Tissue Viability. 2022 Feb;31(1):190-196. DOI: 10.1016/j.jtv.2021.06.010
114. Klonizakis M, Tew GA, Gumber A, Crank H, King B, Middleton G, et al. Supervised exercise training as an adjunct therapy for venous leg ulcers: a randomized controlled feasibility trial. Br J Dermatol. 2018 May;178(5):1072-1082. DOI: 10.1111/bjd.16089
115. Orr L, Klement KA, McCrossin L, O'Sullivan Drombolis D, Houghton PE, Spaulding S, et al. A systematic review and meta-analysis of exercise intervention for the treatment of calf muscle pump impairment in individuals with chronic venous insufficiency. Ostomy Wound Manage. 2017 Aug;63(8):30-43. DOI: 10.25270/owm.2017.08.3043
116. Zhang Q, Lu L, Song JL, Wang L. Effects of exercise in treating patients with venous leg ulcers: a systematic review and meta-analysis. Int Wound J. 2023 May;20(5):1776-1783. DOI: 10.1111/iwj.14020
117. James CV, Murray Q, Park SY, Khajoueinejad N, Lee J, Ray K, et al. Venous leg ulcers: potential algorithms of care. Wounds. 2022 Dec;34(12):288-296. DOI: 10.25270/wnds/21160
118. Kitchens BP, Snyder RJ, Cuffy CA. A Literature Review of Pharmacological Agents to Improve Venous Leg Ulcer Healing. Wounds. 2020 Jul;32(7):195-207.
119. Raffetto JD, Eberhardt RT, Dean SM, Ligi D, Mannello F. Pharmacologic treatment to improve venous leg ulcer healing. J Vasc Surg Venous Lymphat Disord. 2016 Jul;4(3):371-4. DOI: 10.1016/j.jvsv.2015.10.002
120. Jull AB, Arroll B, Parag V, Waters J. Pentoxifylline for treating venous leg ulcers. Cochrane Database Syst Rev. 2012 Dec 12;12(12):CD001733. DOI: 10.1002/14651858.CD001733.pub3
121. Gloviczki P, Lawrence PF, Wasan SM, Meissner MH, Almeida J, Brown KR, et al. The 2023 Society for Vascular Surgery, American Venous Forum, and American Vein and Lymphatic Society clinical practice guidelines for the management of varicose veins of the lower extremities. Part II: Endorsed by the Society of Interventional Radiology and the Society for Vascular Medicine. J Vasc Surg Venous Lymphat Disord. 2024 Jan;12(1):101670. DOI: 10.1016/j.jvsv.2023.08.011
122. Carroll BJ, Piazza G, Goldhaber SZ. Sulodexide in venous disease. J Thromb Haemost. 2019 Jan;17(1):31-38. DOI: 10.1111/jth.14324
123. Wu B, Lu J, Yang M, Xu T. Sulodexide for treating venous leg ulcers. Cochrane Database Syst Rev. 2016 Jun 2;2016(6):CD010694. DOI: 10.1002/14651858.CD010694.pub2
124. Jull A, Wadham A, Bullen C, Parag V, Kerse N, Waters J. Low dose aspirin as adjuvant treatment for venous leg ulceration: pragmatic, randomised, double blind, placebo controlled trial (Aspirin4VLU). BMJ. 2017 Nov 24;359:j5157. DOI: 10.1136/bmj.j5157
125. de Oliveira Carvalho PE, Magolbo NG, De Aquino RF, Weller CD. Oral aspirin for treating venous leg ulcers. Cochrane Database Syst Rev. 2016 Feb 18;2(2):CD009432. DOI: 10.1002/14651858.CD009432.pub2

126. Rathbun SW, Kirkpatrick AC. Treatment of chronic venous insufficiency. Curr Treat Options Cardiovasc Med. 2007 Apr;9(2):115-26. DOI: 10.1007/s11936-007-0005-6
127. Leren L, Johansen E, Eide H, Falk RS, Juvet LK, Ljoså TM. Pain in persons with chronic venous leg ulcers: a systematic review and meta-analysis. Int Wound J. 2020 Apr;17(2):466-484. DOI: 10.1111/iwj.13296
128. Briggs M, Nelson EA, Martyn-St James M. Topical agents or dressings for pain in venous leg ulcers. Cochrane Database Syst Rev. 2012 Nov 14;11(11):CD001177. DOI: 10.1002/14651858.CD001177.pub3
129. Ryan S, Eager C, Sibbald RG. Venous leg ulcer pain. Ostomy Wound Manage. 2003 Apr;49(4 Suppl):16-23.
130. Gethin G, Cowman S, Kolbach DN. Debridement for venous leg ulcers. Cochrane Database Syst Rev. 2015 Sep 14;2015(9):CD008599. DOI: 10.1002/14651858.CD008599.pub2
131. Stott A. The effectiveness of debridement for venous leg ulcers. Am J Nurs. 2016 Sep;116(9):63. DOI: 10.1097/01.NAJ.0000494699.70993.87
132. Cardinal M, Eisenbud DE, Armstrong DG, Zelen C, Driver V, Attinger C, et al. Serial surgical debridement: a retrospective study on clinical outcomes in chronic lower extremity wounds. Wound Repair Regen. 2009 May-Jun;17(3):306-11. DOI: 10.1111/j.1524-475X.2009.00485.x
133. Greene E, Avsar P, Moore Z, Nugent L, O'Connor T, Patton D. What is the effect of larval therapy on the debridement of venous leg ulcers? A systematic review. J Tissue Viability. 2021 Aug;30(3):301-309. DOI: 10.1016/j.jtv.2021.05.005
134. Murphy CA, Houghton P, Brandys T, Rose G, Bryant D. The effect of 22.5 kHz low-frequency contact ultrasound debridement (LFCUD) on lower extremity wound healing for a vascular surgery population: a randomised controlled trial. Int Wound J. 2018 Jun;15(3):460-472. DOI: 10.1111/iwj.12887
135. Cutting KF, Harding KG. Criteria for identifying wound infection. J Wound Care. 1994 Jun 2;3(4):198-201. DOI: 10.12968/jowc.1994.3.4.198
136. Norman G, Westby MJ, Rithalia AD, Stubbs N, Soares MO, Dumville JC. Dressings and topical agents for treating venous leg ulcers (Review). Cochrane Database Syst.Rev.2018 Jun;6(6);1-258. DOI: 10.1002/14651858.CD012583.pub2
137. Robson MC, Cooper DM, Aslam R, Gould LJ, Harding KG, Margolis DJ, et al. Guidelines for the treatment of venous ulcers. Wound Repair Regen. 2006 Nov-Dec;14(6):649-62. DOI: 10.1111/j.1524-475X.2006.00174.x
138. O'Meara S, Al-Kurdi D, Ologun Y, Ovington LG, Martyn-St James M, Richardson R. Antibiotics and antiseptics for venous leg ulcers. Cochrane Database Syst Rev. 2014 Jan 10;2014(1):CD003557. DOI: 10.1002/14651858.CD003557.pub5
139. Bower P, Davies BJ. The microbiology of acute and chronic wounds. Wounds.1999 Jul;11(4):72–78. Available from: https://www.researchgate.net/publication/279672963_The_Microbiology_of_Acute_and_Chronic_Wounds
140. Dow G, Browne A, Sibbald RG. Infection in chronic wounds: controversies in diagnosis and treatment. Ostomy Wound Manage. 1999 Aug;45(8):23-7, 29-40.
141. Roche ED, Woodmansey EJ, Yang Q, Gibson DJ, Zhang H, Schultz GS. Cadexomer iodine effectively reduces bacterial biofilm in porcine wounds ex vivo and in vivo. Int Wound J. 2019 Jun;16(3):674-683. DOI: 10.1111/iwj.13080
142. Yang Q, Larose C, Della Porta AC, Schultz GS, Gibson DJ. A surfactant-based wound dressing can reduce bacterial biofilms in a porcine skin explant model. Int Wound J. 2017 Apr;14(2):408-413. DOI: 10.1111/iwj.12619
143. Phillips PL, Yang Q, Davis S, Sampson EM, Azeke JI, Hamad A, et al. Antimicrobial dressing efficacy against mature Pseudomonas aeruginosa biofilm on porcine skin explants. Int Wound J. 2015 Aug;12(4):469-83. DOI: 10.1111/iwj.12142
144. Moffatt C, Kommala D, Dourdin N, Choe Y. Venous leg ulcers: patient concordance with compression therapy and its impact on healing and prevention of recurrence. Int Wound J. 2009 Oct;6(5):386-93. DOI: 10.1111/j.1742-481X.2009.00634.x
145. Wounds Int. Simplifying venous leg ulcer management: consensus recommendations. 2015 May. Available from: https://woundsinternational.com/consensus-documents/simplifying-venous-leg-ulcer-management-consensus-recommendations/
146. Kapp S, Prematunga R, Santamaria N. The "self-treatment of wounds for venous leg ulcers checklist" (STOW-V Checklist V1.0): Part 2-The reliability of the Checklist. Int Wound J. 2022 Mar;19(3):714-723. DOI: 10.1111/iwj.13668
147. O'Meara S, Martyn-St James M. Foam dressings for venous leg ulcers. Cochrane Database Syst Rev. 2013 May 31;(5):CD009907. DOI: 10.1002/14651858.CD009907.pub2
148. O'Meara S, Martyn-St James M, Adderley UJ. Alginate dressings for venous leg ulcers. Cochrane Database Syst Rev. 2015 Aug 19;2015(8):CD010182. DOI: 10.1002/14651858.CD010182.pub3
149. Barwell JR, Davies CE, Deacon J, Harvey K, Minor J, Sassano A, et al. Comparison of surgery and compression with compression alone in chronic venous ulceration (ESCHAR study): randomised controlled trial. Lancet. 2004 Jun 5;363(9424):1854-9. DOI: 10.1016/S0140-6736(04)16353-8
150. Viarengo LM, Potério-Filho J, Potério GM, Menezes FH, Meirelles GV. Endovenous laser treatment for varicose veins in patients with active ulcers: measurement of intravenous and perivenous temperatures during the procedure. Dermatol Surg. 2007 Oct;33(10):1234-42. DOI: 10.1111/j.1524-4725.2007.33259.x
151. O'Hare JL, Earnshaw JJ. Randomised clinical trial of foam sclerotherapy for patients with a venous leg ulcer. Eur J Vasc Endovasc Surg. 2010 Apr;39(4):495-9. DOI: 10.1016/j.ejvs.2009.11.025
152. Samuel N, Carradice D, Wallace T, Smith GE, Chetter IC. Endovenous thermal ablation for healing venous ulcers and preventing recurrence. Cochrane Database Syst Rev. 2013 Oct 4;2013(10):CD009494. DOI: 10.1002/14651858.CD009494.pub2
153. Chapman S. Venous leg ulcers: an evidence review. Br J Community Nurs. 2017 Sep 1;22(Sup9):S6-S9. DOI: 10.12968/bjcn.2017.22.Sup9.S6
154. Veličković VM, Prieto PA, Krga M, Jorge AM. Superabsorbent wound dressings versus foams dressings for the management of moderate-to-highly exuding venous leg ulcers in French settings: An early stage model-based economic evaluation. J Tissue Viability. 2022 Aug;31(3):523-530. DOI: 10.1016/j.jtv.2022.04.005
155. Westby MJ, Norman G, Dumville JC, Stubbs N, Cullum N. Protease-modulating matrix treatments for healing venous leg ulcers. Cochrane Database Syst Rev. 2016 Dec 15;12(12):CD011918. DOI: 10.1002/14651858.CD011918.pub2
156. Norman G, Westby MJ, Stubbs N, Dumville JC, Cullum N. A 'test and treat' strategy for elevated wound protease activity for healing in venous leg ulcers. Cochrane Database Syst Rev. 2016 Jan 15;2016(1):CD011753. DOI: 10.1002/14651858.CD011753.pub2
157. Heyboer M 3rd, Grant WD, Byrne J, Pons P, Morgan M, Iqbal B, et al. Hyperbaric oxygen for the treatment of nonhealing arterial insufficiency ulcers. Wound Repair Regen. 2014 May-Jun;22(3):351-5. DOI: 10.1111/wrr.12176
158. Cullum N, Liu Z. Therapeutic ultrasound for venous leg ulcers. Cochrane Database Syst Rev. 2017 May 15;5(5):CD001180. DOI: 10.1002/14651858.CD001180.pub4

159. Aleksandrowicz H, Owczarczyk-Saczonek A, Placek W. Venous leg ulcers: advanced therapies and new technologies. Biomedicines. 2021 Oct 29;9(11):1569. DOI: 10.3390/biomedicines9111569
160. Bai Z, Wang H, Sun H, Cui L. Effect of hyperbaric oxygen therapy on the patients with venous leg ulcer: a systematic review and meta-analysis. Asian J Surg. 2023 Oct;46(10):4131-4137. DOI: 10.1016/j.asjsur.2023.01.068
161. Keohane C, Westby D, Nolan FC, Twyford M, Tawfick W, Walsh SR. Hyperbaric oxygen as an adjunct in the treatment of venous ulcers: a systematic review. Vasc Endovascular Surg. 2023 Aug;57(6):607-616. DOI: 10.1177/15385744231162924
162. Cooper B, Bachoo P. Extracorporeal shock wave therapy for the healing and management of venous leg ulcers. Cochrane Database Syst Rev. 2018 Jun 11;6(6):CD011842. DOI: 10.1002/14651858.CD011842.pub2
163. Nicholas MN, Yeung J. Current status and future of skin substitutes for chronic wound healing. J Cutan Med Surg. 2017 Jan/Feb;21(1):23-30. DOI: 10.1177/1203475416664037
164. Ontario Health. Skin substitutes for adults with diabetic foot ulcers and venous leg ulcers: a health technology assessment. 2021 Jun. Available from: https://www.hqontario.ca/Portals/0/Documents/evidence/reports/hta-skin-substitutes-for-adults-with-diabetic-foot-ulcers-and-venous-leg-ulcers.pdf
165. Jones JE, Nelson EA, Al-Hity A. Skin grafting for venous leg ulcers. Cochrane Database Syst Rev. 2013 Jan 31;2013(1):CD001737. DOI: 10.1002/14651858.CD001737.pub4
166. Liu Q, Zhou L, Cai X, Jin T, Wang K. Fluoroscopy versus ultrasound for image guidance during percutaneous nephrolithotomy: a systematic review and meta-analysis. Urolithiasis. 2017 Oct;45(5):481-487. DOI: 10.1007/s00240-016-0934-1
167. Elsharkawi M, Ghoneim B, Westby D, Jones D, Tawfick W, Walsh SR. Adipose-derived stem cells in patients with venous ulcers: Systematic review. Vascular. 2023 Oct;31(5):989-993. DOI: 10.1177/17085381221098279
168. Jones NJ, Harding KG, Ivins N, Edgon V, Taf RC. A case series evaluation the geko neuromuscular electrostimulation device on lower limb wounds of differing aetiology. Welsh Wound Innovation Centre. 2016. Available from: www.gekodevices.com/wp-content/uploads/2019/03/Abstract-_A-case-series-evaluating-the-geko-neuromuscular-electrostimulation-device-on-lower-limb-wounds-.pdf
169. Das SK, Dhoonmoon L, Chhabra S. Neuromuscular stimulation of the common peroneal nerve increases arterial and venous velocity in patients with venous leg ulcers. Int Wound J. 2021 Apr;18(2):187-193. DOI: 10.1111/iwj.13510
170. Bull RH, Clements D, Collarte AJ, Harding KG. The impact of a new intervention for venous leg ulcers: a within-patient controlled trial. Int Wound J. 2023 Aug;20(6):2260-2268. DOI: 10.1111/iwj.14107
171. Sultan S, Tawfick WA, Kavanagh EP, Hynes N. Topical wound oxygen versus conventional compression dressings in the management of refractory venous ulcers. In: Alexandrescu V, editor. Wound healing. New insights into ancient challenges. Intech; 2016. pp. 309–321.
172. Houghton PE. Electrical stimulation therapy to promote healing of chronic wounds: a review of reviews. Chronic Wound Care Management and Research. 2017 Jan 25;4:25–44. Available from: https://www.dovepress.com/electrical-stimulation-therapy-to-promote-healing-of-chronic-wounds-a--peer-reviewed-fulltext-article-CWCMR
173. Miller C, Kapp S, Newall N, Lewin G, Carville K, Santamaria N, Karimi L. Predicting concordance with multilayer compression bandaging. J Wound Care. 2011 Mar;20(3):101-2, 104, 106. DOI: 10.12968/jowc.2011.20.3.101
174. Kerr A, Kelly B, Ousey K, Hoyes LH, Atkin L, Last R, et al. Personalised self-care for people with venous leg ulcers: a toolkit for change. 2023 Sep. Available from: https://wounds-uk.com/best-practice-statements/personalised-self-care-for-people-with-venous-leg-ulcers-a-toolkit-for-change/
175. Edwards H, Courtney M, Finlayson K, Lindsay E, Lewis C, Shuter P, et al. Chronic venous leg ulcers: effect of a community nursing intervention on pain and healing. Nurs Stand. 2005 Sep 7-13;19(52):47-54. DOI: 10.7748/ns2005.09.19.52.47.c3950
176. Poku E, Aber A, Phillips P, Essat M, Buckley Woods H, Palfreyman S, et al. Systematic review assessing the measurement properties of patient-reported outcomes for venous leg ulcers. BJS Open. 2017 Nov 13;1(5):138-147 DOI: 10.1002/bjs5.25
177. Wounds International.Principles of compression in venous disease: a practitioner's guide to treatment and prevention of venous leg ulcers. 2013 May;1(24). Available from: https://woundsinternational.com/best-practice-statements/principles-compression-venous-disease-practitioners-guide-treatment-and-prevention-venous-leg-ulcers/
178. Nelson EA, Adderley U. Venous leg ulcers. BMJ Clin Evid. 2016 Jan 15;2016:1902.
179. Chen H, Xiao T, Zhang L, Liu N, Liang X, Li T, et al. Effect of ultrasound-supported wound debridement in subjects with diabetic foot ulcers: A meta-analysis. Int Wound J. 2023 Sep;20(7):2618-2625. DOI: 10.1111/iwj.14133
180. Dolibog P, Franek A, Taradaj J, Dolibog P, Blaszczak E, Polak A, et al. A comparative clinical study on five types of compression therapy in patients with venous leg ulcers. Int J Med Sci. 2013 Dec 14;11(1):34-43. DOI: 10.7150/ijms.7548
181. Kloth LC. Electrical Stimulation Technologies for Wound Healing. Adv Wound Care (New Rochelle). 2014 Feb 1;3(2):81-90. DOI: 10.1089/wound.2013.0459
182. Leloup P, Toussaint P, Lembelembe JP, Célérier P, Maillard H. The analgesic effect of electrostimulation (WoundEL®) in the treatment of leg ulcers. Int Wound J. 2015 Dec;12(6):706-9. DOI: 10.1111/iwj.12211
183. Houghton PE. Electrical stimulation therapy to promote healing of chronic wounds: a review of reviews. Chronic Wound Care Management and Research. 2017 Jan 25:25-44. DOI: 10.2147/CWCMR.S101323
184. Khouri C, Kotzki S, Roustit M, Blaise S, Gueyffier F, Cracowski JL. Hierarchical evaluation of electrical stimulation protocols for chronic wound healing: An effect size meta-analysis. Wound Repair Regen. 2017 Sep;25(5):883-891. DOI: 10.1111/wrr.12594
185. Ashrafi M, Alonso-Rasgado T, Baguneid M, Bayat A. The efficacy of electrical stimulation in lower extremity cutaneous wound healing: a systematic review. Exp Dermatol. 2017 Feb;26(2):171-178. DOI: 10.1111/exd.13179
186. Houghton PE. Clinical trials involving biphasic pulsed current, microcurrent, and/or low-intensity direct current. Adv Wound Care (New Rochelle). 2014 Feb 1;3(2):166-183. DOI: 10.1089/wound.2013.0446
187. Kloth LC. Electrical stimulation for wound healing: a review of evidence from in vitro studies, animal experiments, and clinical trials. Int J Low Extrem Wounds. 2005 Mar;4(1):23-44. DOI: 10.1177/1534734605275733
188. Dumville JC, Land L, Evans D, Peinemann F. Negative pressure wound therapy for treating leg ulcers. Cochrane Database Syst Rev. 2015 Jul 14;2015(7):CD011354. DOI: 10.1002/14651858.CD011354.pub2
189. Aziz Z, Cullum N. Electromagnetic therapy for treating venous leg ulcers. Cochrane Database Syst Rev. 2015 Jul 2;2015(7):CD002933. DOI: 10.1002/14651858.CD002933.pub6

190. Bavaresco T, Lucena AF. Low-laser light therapy in venous ulcer healing: a randomized clinical trial. Rev Bras Enferm. 2021 Nov 12;75(3):e20210396. DOI: 10.1590/0034-7167-2021-0396
191. Lee Y, Lee MH, Phillips SA, Stacey MC. Growth factors for treating chronic venous leg ulcers: a systematic review and meta-analysis. Wound Repair Regen. 2022 Jan;30(1):117-125. DOI: 10.1111/wrr.12982
192. Yammine K, Assi C. Surgery versus nonsurgical methods in treating neuropathic plantar forefoot ulcers: a meta-analysis of comparative studies. Int J Low Extrem Wounds. 2022 Mar;21(1):7-17. DOI: 10.1177/1534734620923425
193. Fang Q, Zhang Y, Tang L, Li X, Zhang X, Gang JJ, et al. Clinical study of platelet-rich plasma (PRP) for lower extremity venous ulcers: a meta-analysis and systematic Review. Int J Low Extrem Wounds. 2023;22(4):641-653. DOI: https://doi.org/10.1177/15347346211046203
194. Orsted H, O'Sullivan-Drombolis D, Haley J, LeBlanc K, Parsons L. The effects of low frequency nerve stimulation to support the healing of venous leg ulcers. A supplement of Wound Care Canada; 2017. Available from: https://www.woundscanada.ca/docman/public/health-care-professional/bpr-workshop/70-bpr-lfns-final-110316/file.
195. Tucker A, Maass A, Bain D, Chen LH, Azzam M, Dawson H, et al. Augmentation of venous, arterial and microvascular blood supply in the leg by isometric neuromuscular stimulation via the peroneal nerve. Int J Angiol. 2010 Spring;19(1):e31-7. DOI: 10.1055/s-0031-1278361
196. Bosanquet DC, Ivins N, Jones N, Harding KG. Microcirculatory flux and pulsatility in arterial leg ulcers is increased by intermittent neuromuscular electrostimulation of the common peroneal nerve. Ann Vasc Surg. 2021 Feb;71:308-314. DOI: 10.1016/j.avsg.2020.07.030
197. Griffin M, Bond D, Nicolaides A. Measurement of blood flow in the deep veins of the lower limb using the geko™ neuromuscular electro-stimulation device. Int Angiol. 2016 Aug;35(4):406-10.
198. Aquil S, Alharbi B, Navaratnam R, Sharma H, Luke PP, Sener A. Use of a muscle pump activator leads to improved lower limb edema, lower limb blood flow, and urine output compared with standard TED stockings and compression devices following kidney transplant: a randomized controlled trial. Transplant Proc. 2019 Jul-Aug;51(6):1838-1844. DOI: 10.1016/j.transproceed.2019.04.032
199. Summers JA, Clinch J, Radhakrishnan M, Healy A, McMillan V, Morris E, et al. The geko™ electro-stimulation device for venous thromboembolism prophylaxis: a NICE medical technology guidance. Appl Health Econ Health Policy. 2015 Apr;13(2):135-47. DOI: 10.1007/s40258-014-0139-0
200. GEKO Wound Therapy. The gekoTM device - wound therapy [video]. Available at: https://www.gekodevices.com/geko-videos/speckle-imaging-video-showing-microcirculatory-blood-flow-at-baseline-and-with-the-geko-device-switched-on/
201. Harris C, Duong R, Vanderheyden G, Byrnes B, Cattryse R, Orr A, et al. Evaluation of a muscle pump-activating device for non-healing venous leg ulcers. Int Wound J. 2017 Dec;14(6):1189-1198. DOI: 10.1111/iwj.12784
202. Harris C, Loney A, Brooke J, Charlebois A, Coppola L, Mehta S, et al. Refractory venous leg ulcers: observational evaluation of innovative new technology. Int Wound J. 2017 Dec;14(6):1100-1107. DOI: 10.1111/iwj.12766