Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 9

Prevention and Management of Surgical Wound Complications

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INTRODUCTION

Healthcare Excellence Canada (formerly Canadian Patient Safety Institute) considers surgical care safety a priority.[1] The International Surgical Wound Complications Advisory Panel (ISWCAP) defines a surgical wound complication as, "a disruption to normal incisional wound healing following surgery".[2] ISWCAP lists the most common surgical wound complications as: surgical site infections (SSI), wound dehiscence, scarring/hypergranulation, periwound maceration and breakdown, seromas/hematomas and medical adhesive-related skin injury (MARSI).

Surgical wound complications have negative impacts for patients, including pain, increased length of stay, delays in adjuvant therapies/treatments (e.g., chemotherapy, radiation, and plastic surgery reconstruction), negative psychological and quality of life (QoL) outcomes, readmission to hospital and increased mortality.[2]

Surgical site infection (SSIs) are a major concern and account for 20% of all hospital acquired infections (HAIs). SSIs are associated with a two- to 11-fold increase in the risk of mortality; and SSIs can extend hospital length of stay by 9.7 days and affect patient quality of life and outpatient and community care health-care costs.[3] Seventy-seven percent of surgical patient deaths are reported to be related to infection.[4,5] Infection has a direct correlation to open surgical wounds. Surgical site infection (SSI) is the most common health-care-associated infection among surgical patients. The costs of SSI hospitalizations can increase by more than $20,000 per admission, making prevention and education initiatives on reducing SSI crucial.[6,7]

Surgical procedures can be performed either as an inpatient or day surgery with admission of at least one night or, depending on the procedure, in outpatient ambulatory care settings. It is estimated that 75% of surgical procedures are performed on outpatients, making the issues of prevention, detection, treatment and reporting of SSIs in the community or long-term-care sectors challenging and essential.

SSIs are of growing concern to health-care systems due to a negative impact on health-related quality of life, increased length of stay in hospital, financial burden to health-care system and patient morbidity.[8] SSIs account for 16% of all health-care-associated infections; of these, 1% related to orthopedic procedures and 10% to large bowel surgery. SSIs can often be prevented through initiatives focused on pre-, intra- and post-operative care and education and through a collaborative approach to teamwork and communication.[9]

Surgical teams are responsible for establishing clinical and system reviews to identify any issues, review incidents, develop solutions and improve outcomes.[10,11]

The Government of Canada created the Canadian Nosocomial Infection Surveillance Program (CNISP), a network that conducts surveillance of health-care-associated infections in several areas including: "surgical site and device related infections associated with:

- central lines,
- hip and knee arthroplasty,
- cerebrospinal fluid shunts and
- adult and pediatric cardiac surgery".[6]

For more information visit the CNISP web page at: https://www.canada.ca/en/public-health/programs/canadian-nosocomial-infection-surveillance-program.html#a1

For more information see Health Care Excellence - Enhanced Recovery Canada. https://www.healthcareexcellence.ca/en/what-we-do/all-programs/enhanced-recovery-canada/

This document is written with the intent to encompass the quintuple aim for health care improvement. This is to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity. This equity piece is particularly important for patients living with surgical site infections (See Table 1). Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[13]

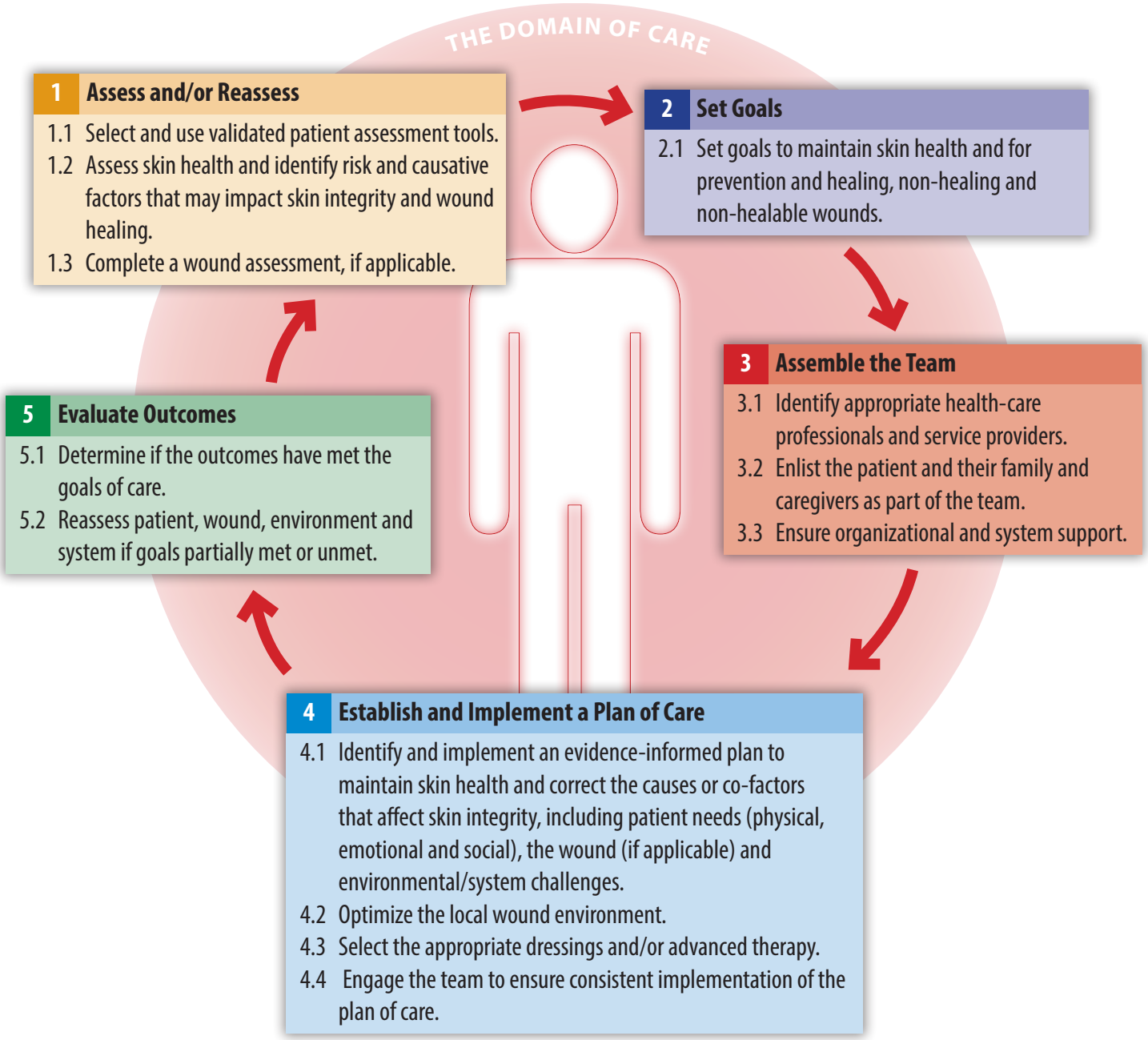
Table 1: Quintuple Aim and Management of Surgical Site Infections

5 components	Applied to Surgical Site Infections
Improving population health	Through prevention, education and self-management strategies
Reducing costs	Application of best practice to ensure most effective treatment Appropriate use of resources- screening for risk, intraoperative and postoperative dressings, nutrition, devices
Advancing health equity	Application of principles to all those at risk or affected by surgical site infections
Care team well-being	Providing clinically usable information for front line clinicians
Enhancing the patient experience	Providing a supportive process of care for all those with surgical site infections

THE WOUND PREVENTION AND MANAGEMENT CYCLE

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

Figure 1: The Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence using electronic databases to identify relevant articles. They are intended to support the clinician, patient, family and health-care team in planning and delivering the best clinical practice. Two foundational papers supplement this document with additional evidence-informed information and recommendations that are general to all wound types: Chapter 3: Skin: Anatomy, Physiology and Wound Healing[14] and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

Three guiding principles within the best practice recommendation papers (BPRs) support effective prevention and management of skin breakdown.

- Use of the Wound Prevention and Management Cycle regardless of the specifics to prevent and manage skin breakdown
- Constant, accurate and multidirectional flow of information within the team and across care settings, and
- The patient as the core of all decision-making.

Step 1: Assess and/or Reassess

Discussion: Clinicians should complete a holistic patient assessment to identify patient factors that may affect surgical wound healing in the pre-, intra- and postoperative phases.[9] The pre-operative phase is a critical time, offering the opportunity to create an environment that prevents surgical wound complications. It is important to note that reassessment needs to occur during the entire post-operative phase including transitions of care across the health-care system. Surgical wounds should be assessed and the findings documented using a standardized documentation and reporting approach including the integrated team.[3,16]

The pre-operative assessment assessment includes review of intact skin and any current skin issues and treatments being used. Immediately post-operatively, a comprehensive wound assessment tool should be used to establish a baseline to assist with identification of any wound changes. This information helps identify either wound healing or deterioration and should guide ongoing treatment decisions. Assessment of the person with a surgical wound begins immediately post-op; however, most surgical incisions are not usually assessed until 48 hours after surgery since, in most cases, the original post-operative dressing remains in place for the first 48 to 72 hours.[9,16]

Recommendations

1.1 Select and use validated patient assessment tools

Discussion: In addition to the wound assessment tools discussed in Chapter 4, the following are focused on assessment of surgical wounds:

- The ASEPSIS online calculator tool was developed to evaluate the effectiveness of antibiotic treatment on surgical site infections by examining wound characteristics.[17] It was validated for high inter-rater reliability but not evaluated for validity, intra-rater reliability or responsiveness.[18] Available from: https://www.medicalalgorithms.com/the-asepsis-scoring-method-for-postoperative-wound-infections
- The Granulometer's purpose was to assess the status of skin grafts and had inter- and intra-rater reliability when used by surgeons to determine wound-healing progression. It was not tested with other health-care professionals. It had a non-significant predictive ability for graft take, suggesting that it was not sensitive to small changes.[19]
- The Surgical Wound Assessment Tool (SWAT) was recently developed.[20] The developers reported intraclass correlation coefficient value of the overall scale was 0.79 (95% CI 0.67–0.89), $p < .001$, confirming excellent inter-rater reliability. Cohen's kappa value ranged from 0.5 to 1, demonstrating moderate to almost perfect level of agreement for individual items, except for one item on pain. Available from: https://www.swrwoundcareprogram.ca/uploads/contentdocuments/hcpr%20-%20surgical%20assessment%20guide.pdf

An additional assessment tool, which contains a section specifically for surgical wounds, is the Outcome and Assessment Information Set-C (OASIS-C), a modification of the Outcome and Assessment Information Set (OASIS) that home health agencies in the United States must collect in order to participate in the national Medicare program.[21] It provides guidance regarding what is and is not considered a surgical wound,[21] and how to classify surgical wounds.[22] OASIS-C

states that surgery on a pre-existing wound, or due to a traumatic injury involving the skin, is not classified as a surgical wound; however, surgery to repair or remove an injured internal organ due to trauma, where the skin was intact is considered a surgical wound.

Also according to OASIS-C, skin grafts over existing wounds are *not* surgical wounds, but donor sites are surgical wounds.[23] These definitions are open to discussion and interpretation and, generally, if a surgical procedure is involved, any resulting incision, wound or skin graft is considered either a surgical incision or a surgical wound. If it is not healed in 30 days, it is still considered to be a surgical wound. It is important that there is agreement within each health-care organization about what is and what is not categorized as an open surgical wound.

In OASIS-C item M1342, *Status of Most Problematic (Observable) Surgical Wound*, there are four possible choices, each with further description:[24]
0: Newly epithelialized,
1: Fully granulating,
2: Early/partial granulation and
3: Not healing (may or may not be associated with infection).[24]

For wounds healing by primary closure with well-approximated incisions, the close proximity of the incisional edges leaves no areas for granulation to occur. Therefore, only the, "newly epithelialized" and "not healing" choices apply. For wounds healing by secondary intention, all four choices would apply.[22] This guidance applies to surgical wounds closed by either primary intention (specifically, approximated incisions) or secondary intention (specifically, open surgical wounds).

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

Discussion: Performing a thorough and holistic pre-operative assessment will identify any patient-specific risk factors that can be addressed in preparation for surgery.[9] When the surgery is emergent and risk factors cannot be addressed before the intervention, it is important to identify any intrinsic and extrinsic factors that can be mitigated in the post-operative period and to intervene as soon as possible.[25]

1.2.1 Patient: Physical, emotional and lifestyle

Discussion: Many surgical procedures are complex and may carry significant risks for patients regardless of the health-care setting.[26] The patient facing surgery brings their own unique individual health, lifestyle and travel history.[27] Some bring excellent health with the expectation of rapid healing, while others have surgery when their complex health history or issues puts them at risk for impaired general recovery and wound healing.[16] Knowing which patients are at risk for a surgical wound complication such as an SSI, what to look for, and recognizing the signs and symptoms as early as possible are crucial in order to implement the appropriate plan of care. SSIs are one of the leading causes of nosocomial infections impacting patients.[3]

The American College of Surgeons Surgical Risk Calculator https://riskcalculator.facs.org/RiskCalculator/ is an invaluable tool designed to provide evidence-based insights into assessing the risk of SSI. With the ever-evolving landscape of health care, precise risk evaluation is crucial for timely and effective decision-making. This user-friendly online platform offers health-care professionals a systematic approach to estimate the risk of SSI events in individual patients. By inputting relevant patient data, including clinical history, biomarkers and risk factors, the Surgical Risk Calculator generates personalized risk assessments, aiding clinicians in identifying high-risk patients and tailoring interventions for optimal patient care.

Pre-operative Physical Assessment

An important strategy to prevent surgical wound complications is completion of a detailed pre-operative assessment to identify potential factors that may impact healing and increase the risk for an SSI. All factors identified pre-operatively that may affect wound healing must be reported to all health-care professionals involved in the

patient's post-operative care.[25] If the surgery required is urgent, pre-operative assessment should focus on the body system immediately involved.

The American Society of Anesthesiologists (ASA) 25 Class is a tool for communicating patient pre-anesthesia comorbidities. It was not specifically designed to predict perioperative risks like wound infection. The classification system alone does not predict risks like wound infection, but used with other factors, it can be helpful in predicting peri-operative risks. Patients assessed in Class III to V are at higher risk.[28] The physical status of the patient is classified by ASA as follows:

- Class I: A normally healthy patient with no functional limitations, non-smoking and minimal alcohol use
- Class 2: A patient with mild systemic disease without substantive functional limitations, current smoker, social alcohol use
- Class 3: A patient with severe systemic disease that limits activity, with substantive functional limitations
- Class 4: A patient with severe systemic disease that is a constant threat to life
- Class 5: A moribund patient who is not expected to survive without the operation
- Class 6: A patient who is declared brain-dead and whose organs are being harvested for donation.

See Statement on ASA Physical Status Classification System at: https://www.asahq.org/standards-and-practice-parameters/statement-on-asa-physical-status-classification-system for more information.

The following are key patient and surgery-related risk factors that contribute to surgical site infections.[29,30]

Patient-related factors
- Advanced age[1,9,31]
- Obesity[1,8,9,31]
- Hyperglycemia/diabetes[1,8,9,31]
- Dyspnea[31]
- Hypoxia[9]
- ASA class>II[14,31]
- Smoking[1,8,15,31]
- Substance use (alcohol)[31]
- Steroid use[1,31]
- Recent radiotherapy[31]
- Preoperative albumin ≤3.5mg/dL[31]
- Total bilirubin >1.0 mg/dL[31]
- Trauma/shock[9]
- Transfusion[9]
- Hypothermia[9]

Surgery-related factors
- Inadequate surgical scrub or skin preparation[9]
- Abdominal surgery[9,31]
- Surgery requiring a bowel anastomosis[9]
- Contaminated or dirty/infected procedures[9,31]
- Surgery for cancer[9]
- Emergency surgery[31]
- Complex surgery (work relative value unit ≥10)[31]
- Prolonged procedure[9]
- More than three diagnoses at time of discharged[9]

In relation to surgery, malnourishment is an independent risk factor for surgical site infection (SSI).[32] Malnutrition is either a lack or excess of nutrients, including protein, that affects overall health and function. It can be difficult to address when trauma has occurred or chronic conditions that cause inflammation are present and/or when appetite

is decreased.[33] Malnourishment slows and delays wound healing and increases SSI risk.[34,35] For patients of advanced age,[25] or who are obese and/or those living with diabetes mellitus,[36] the risk of infection increases.

A body mass index (BMI) that is above or below the recommended level will place the patient at increased risk of poor outcomes.[37] Of concern are males with a BMI > 25 kg/m2 and women with a BMI > 30 kg/m2, as these are associated with a five times greater risk of an SSI with subsequent complications than for non-obese individuals.[25,38] This is thought to be related to the increased cardiac output, stroke volume and poorly oxygenated adipose tissue in obese individuals.[39] When there is fatty tissue around the neck and diaphragm and laparoscopic gasses, breathing is hindered, causing hemodynamic compromise and further tissue hypoxia.

Surgical patients at risk of possible malnutrition should be screened by a registered dietitian. For hospitalized patients, the assessment should be conducted using a valid and reliable tool appropriate to the patient population. Screening should occur at admission or as soon as possible after admission and findings should be integrated in to the patient specific holistic plan of care.[40]

Patients living with diabetes mellitus (DM) are at double the risk of SSIs compared with persons without diabetes.[41] Elevated post-operative glycemic levels are a significant risk factor for SSIs and should be aggressively treated.[42] Ata et al. state that post-operative glycemic control is of more importance than pre-operative levels in relation to SSIs.[43] Hyperglycemia is associated with surgical mortality and morbidity.[44]

In a meta-analysis completed by Sorenson, it was identified that SSIs are two times as likely to occur in patients who smoke than those who do not smoke. Assuming that pre-operative screening can occur, smoking cessation should be encouraged for at least four weeks prior to surgery.[45] Discussion regarding risk of smoking when surgical interventions are planned should be part of informed patient consent.[44] In 2020, the World Health Organization released a statement on how smoking greatly increased risks of complications after surgery. Individuals who quit smoking approximately four weeks or more before surgery can lower their risks and have better surgical results up to six months afterward.[46]

Pre-operative preparation

Patients undergoing surgery require education as to specific activities they may be asked to undergo. They will be advised to have a pre-operative shower, remove nail polish and false nails and/or undergo nasal decolonization.[9,47] Depending on the type of surgery, patients may be given pre-operative prophylaxis antibiotics in accordance with antibiotic stewardship guidelines.

During this time, risk assessment and prevention of skin pressure injuries (care bundles) is completed and preventive measures such as positioning and repositioning, use of surfaces and pillows is recommended.[48] Consider use of prophylactic dressing to protect bony prominences and utilize offloading heel devices. For more information on pressure injuries see Chapter 7: Prevention and Management of Pressure Injuries.

Pre-operative Mental Health and Spiritual Assessment

Patient readiness for surgical intervention and mental health and wellbeing can impact healing and surgical outcomes such as pain and satisfaction.[49] Care of an individual includes recognizing their spiritual health in order to maximize their healing and recovery, so an early assessment is important.[50] For some, the surgery is a welcome solution to a physically limiting condition. For other patients, however, the surgery may be unexpected or consented to only as a life-saving procedure—for example, a motor-vehicle accident, where the patient may not be fully prepared for this body alteration. The emotional results of this will impact the engagement of the patient to participate in their health and recovery.

For some patients, surgery may mean the end of pain or hope for a cure. It is important to clearly communicate with the patient, family and care partners the intended clinical surgical outcomes and the potential unexpected results.

Some patients experience anxiety prior to surgery, and for people with pre-existing anxiety, it can be exacerbated. It is important clinicians offer patients and family members concise, clear and relevant information and support through all phases of surgical care, including during assessment.[9] Some methods to reduce anxiety include education and patient handouts, with opportunities to talk, and be listened to, about their concerns.[51] Also, listening to music, reading meditations, or using relaxation techniques may be of support.[52] Sedatives are often administered within two hours prior to surgery, which can help to relieve immediate stress. A comprehensive literature review by Rosenberger et al. found in five orthopedic studies that patients who were worried, anxious or depressed pre-operatively were likely to experience a slower recovery, but it did not link these factors to an increased risk of surgical site infection.[53] While we know that psychological stress impacts the immune system and can negatively impact wound healing, at this time the literature does not show a direct link to surgical site infections.[54]

Intra-operative Risk

The intra-operative risk of developing an SSI can be affected by the nature of the intended surgical procedure; whether or not an SSI develops can depend upon how these factors interact.[9] There are a number of potential risks.

- Patients with high ASA index[55]
- Hypothermia[55]
- Advanced age[55]
- Length of procedure (greater than 75th percentile of predicted operating time increases risk)[55]
- Status of surgery: i.e., clean; clean surgery involving placement of a prosthesis or implant; clean-contaminated; contaminated; or dirty and infected
- Type of surgery: Colon surgery carries the highest risk of an SSI, followed by vascular surgery, cholecystectomy and organ transplant
- Method of surgery: Laparoscopic versus open colorectal surgery has a statistically lower rate of SSI ($P < 0.0001$), although risk for both types is dependent on the classification (clean versus dirty) and length of surgery.[56] For patients who are obese, laparoscopic surgery reduces the SSI rate by 70 to 80% compared with open surgery across general abdominal surgical procedures[44]
- Level of oxygenation of the tissues: Surgical wounds are at high risk of hypoxia, so preventative measures should include keeping subcutaneous perfusion and oxygenation optimal (arterial pO2) and preventing conditions that restrict peripheral perfusion, such as hypovolemia, excessive pain, vasoconstricting drugs and hypothermia[9]
- Emergent (vs. elective) surgery[55]
- Implants (vs. no implants)
- Use of internal mammary artery grafts (for coronary artery bypass graft)
- Prolonged ventilation
- Use of blood products

During a surgery the risk of developing a pressure injury exists depending on the length of the procedure. A pressure injury risk assessment should be completed pre-operatively, and the findings integrated into post-operative care plan, including the use of pressure redistribution surfaces.

Although it can be assumed that the patient's stress levels are reduced with medication during surgery, Nilsson et al. examined the use of relaxing music played in the operating room and concluded that it may decrease post-operative pain.[57] There are pros and cons to playing music in the surgical theatre. In a review of 18 studies, researchers noted that certain music elements affect performance on a surgical task positively or negatively. Classical music when played softly can improve accuracy and speed of surgical tasks.[58]

Post-operative Risks

Wound dehiscence is a complete or partial disruption of wound closure with or without evisceration and protrusion of tissue or organs. This is a severe complication that may lead to immediate surgical intervention, the possibility of repeat dehiscence, a surgical site wound infection[61] and/or development of incisional hernia formation.[62]

While many of the SSI risks following surgery are the same as the pre-operative ones, there are some additional risk factors.

Post-operative dressing selection and integrity:
- Saturated and/or leaking dressings allow migration of bacteria to the wound in a rapid manner[59]

Wound care:
- Disruption of the sutured or staple incision by vigorous cleansing before it has re-epithelialized can introduce bacteria below the dermis[59]

Wound dehiscence:
- Exudate extending past the 48 hours post-operative period increases the potential for wound dehiscence, and often occurs around the seventh day post-op[22]
- Poor glycemic control, malnutrition, smoking, obesity and mechanical stress on the wound bed from heavy lifting, coughing, vomiting, sneezing and straining increase the risk of dehiscence[60]

Patient condition and interventions:
- Post-operative respiratory and urinary infections
- Infections secondary to wound sepsis or medical devices such as indwelling Foley catheters and intravenous (IV) lines, and diarrhea related to use of antibiotics (e.g., *Clostridium difficile* associated disease)[9]

In addition, hematomas or seromas may develop and require intervention.[16] The presence of hematomas and/or seromas increases pressure and compresses blood vessels, causing wound ischemia and, if untreated, may cause tissue necrosis. Hematomas can also cause flap necrosis due to a free-radical-induced cytotoxic mechanism.[63] There is an increased occurrence of hematoma or seroma in surgical wounds associated with the increased clinical use of anticoagulants and prophylactic treatments now recommended and implemented for deep vein thrombosis.[16]

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

Discussion: Poor patient self-efficacy, knowledge required for post-operative wound monitoring and communication may lead to negative clinical outcomes.[64] In the RNAO's Person and Family-Centered Care Nursing Best Practice Guideline, it is recommended that to achieve the goal of, "having the person's proactive and meaningful engagement as an active partner in their health care, we should listen and seek insight into the whole person to gain an understanding of the meaning of health to the person and to learn their preferences for care".[65] A therapeutic relationship between the person with the surgical wound, the care partners and family, and health-care professionals is needed to build a genuine, trusting and respectful partnership. Through surgical transitions of care (acute, rehab, home) or services, patients should have the opportunity to share any concerns related to wound care, devices, medications, appointments and transportation.[66,67]

It is essential to respect individuals as experts on their own lives, recognizing everyone's choices are shaped by their unique circumstances. Health-care professionals should engage with strong communication skills and a commitment to culturally sensitive, non-judgmental approach. Maintaining a respectful and supportive stance is essential to fostering trust and encouraging positive outcomes.[65] Families and care partners also have an important role in the care for and recovery of people who have had surgery, and if those supports are not part of an individual's normal life, the patient may be at increased risk for complications.[68]

The patient's values, preferences, literacy, beliefs, culture, ethnicity, spirituality, interests, life circumstances (including financial security or worry) and previous health experiences all affect their priorities, concerns and preferences.[65,66]

To support self-management skills, consider the following resources:
Self-Management BC https://www.selfmanagementbc.ca/home

Here is a list for the other provinces https://www.selfmanagementbc.ca/selfmanagementprogramsoutsidebc

1.2.3 Systems: Health-care support and communication

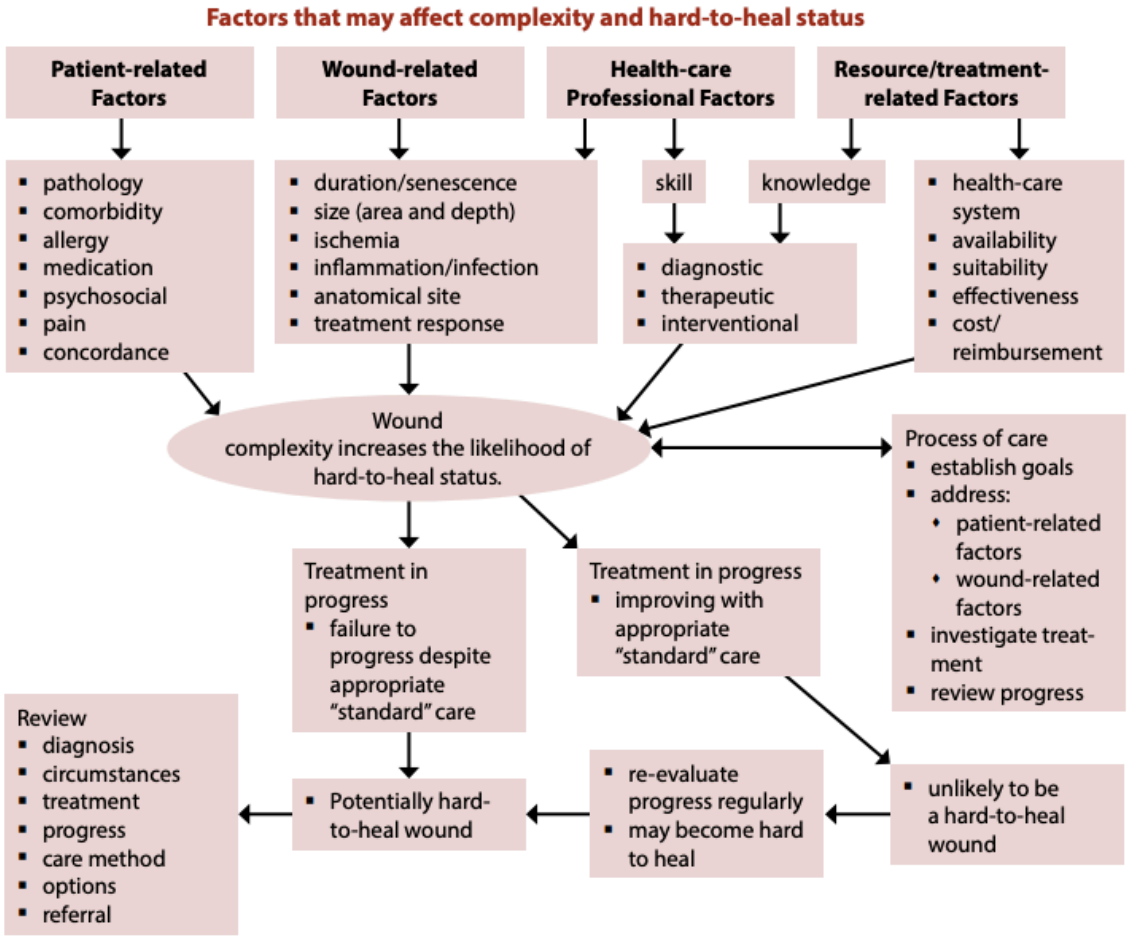
Discussion: It is the responsibility of health-care organizations to reduce harm, improve health care and protect Canadians by establishing SSI surveillance programs.[69] The National Healthcare Safety Network (NHSN) in the United States recommends that SSI surveillance periods be at least 30 days for superficial incisional, deep incisional and organ/space SSIs.[69] In addition, 90-day surveillance is required for specific surgeries (prosthesis/implants). The list of surgical procedures can be found at the National Healthcare Safety Network site[70]: https://www.cdc.gov/nhsn/pdfs/pscmanual/pcsmanual_current.pdf.

With an increasing number of surgical outpatient procedures taking place,[71] many SSIs will not be captured by hospital SSI surveillance programs. Post-discharge surveillance should occur, with participation of family physicians, nurse practitioners, community home-care agencies and long-term care facilities, and with a mechanism to report and track recognized signs and symptoms of SSI, so that outcomes and trends can be reported back to hospitals, surgeons and health authorities (e.g., surgical quality, surveillance and risk teams).[3]

Effective surveillance of SSI includes a focus on targeted high-risk and high-volume operative procedures. According to the Centers for Disease Control in the United States, successful SSI surveillance includes, "epidemiologically sound infection definitions and effective surveillance methods, stratification of SSI rates according to risk factors associated with SSI development, and data feedback".[71]

There are four main factors that may affect hard-to-heal wounds.[72] The algorithm in Figure 2 outlines the relationships among patient, wound, health-care professional and resource/treatment-related factors and is intended to support clinicians in recognizing the complexity of wounds.[48]

Figure 2: Predictors for Wound Healing



Source: *Moffat C, Vowden P. Hard-to heal wounds: a holistic approach. London: MEP Ltd; 2008. Reprinted with permission.*

1.3 Complete a wound assessment, if applicable

Discussion: Before completing the wound assessment it is important to complete a head-to-toe skin assessment to determine risk or presence of additional skin issues not directly related to the surgical interventions.[48]

A complete surgical wound assessment includes the peri-incisional skin and the incision line. When assessing the peri-incisional skin ensure to assess and address any medical-adhesive related skin injury (MARSI), which may present as dermatitis, skin stripping, maceration, folliculitis, skin-tears, or blistering.[73] In addition, assess for any skin and wound issues separate from the post-operative wound assessment (See Table 2).

Table 2: Surgical Wound Descriptions[23]

0 Newly epithelialized: • wound bed completely covered with new epithelium • no exudate • no avascular tissue (eschar and/or slough) • no signs or symptoms of infection
1 Fully granulating: • wound bed filled with granulation tissue to the level of the surrounding skin • no dead space • no avascular tissue (eschar and/or slough) • no signs or symptoms of infection • wound edges open
2 Early/partial granulation: • ≥ 25% of wound bed covered with granulation tissue • < 25% of wound bed covered with avascular tissue (eschar and/or slough) • no signs or symptoms of infection • wound edges open
3 Not healing: • wound with ≥ 25% avascular tissue (eschar and/or slough) OR • signs/symptoms of infection OR • clean but non-granulating wound bed OR • closed/hyperkeratotic wound edges OR • persistent failure to improve despite appropriate comprehensive wound management

Source: Wound, Ostomy and Continence Nurses Society (WOCN). WOCN's Nurses Society's guidance on OASIS-D integumentary items: best practice for clinicians. 2019. Available from: https://cdn.ymaws.com/member.wocn.org/resource/resmgr/docs/OASIS-D_Best_Practice_Docume.pdf

The following three steps provide a systematic approach to surgical wound assessment, goal planning and treatment. Depending on their organization, clinicians should follow the recommended assessment for post-operative surgical wound assessment.

1. What are you seeing? MEASURE is one example of a mnemonic that helps the team assess wound parameters.[74,75] The following parameters identified in the MEASURE mnemonic should be included in the wound assessment and may help the team connect in a common language when monitoring a wound.[74]

2. When are you seeing it? It is equally important to note when to look for changes in the surgical wound. Bates-Jensen and Woolfolk describe outcomes and expected time frames for positive and negative results of surgical wound healing.[76] (See Table 3).

3. What should you consider if you see it? Early recognition of alterations in healing, as outlined in point number 2, will support early intervention to return the patient to a healing trajectory.

Table 3	Positive	Negative
Incision	Colours of the incision progress Days 1–4: red with approximated edges Days 5–14: bright pink Day 15–1 year: pale pink The incision is well approximated and does not show signs of tension	Days 1–4: evidence of tension on the incision line Days 5–9: the incision may no longer be well-approximated, and the tension remains, and may progress to incisional dehiscence; the colour may remain red Days 10–14: the colour may remain red or progress to bright pink
Scar Tissue	Light-skinned persons will have white or silver scarring Persons with darkly pigmented skin will progress from pale pink to darker than usual skin colour	There may be prolonged epithelial resurfacing and/or keloid or hyper-trophic scarring that may present in the first year of healing
Peri-incision	Days 1–5: signs and symptoms of normal inflammation will be present, including: edema, erythema, warmth and mild pain	Absence or delay of normal inflammation Days 1–5: no evidence of edema, erythema, skin discolouration or warmth, and minimal pain at the incision site Days 5–9 extending to days 10–14: signs and symptoms of inflammation demonstrating a delay in healing progression Beyond this, healing can stall or plateau, with no healing and ongoing inflammation lasting 1–2 years or longer Hematoma or seroma formation which can progress to days 10–14
Exudate	Minimal/moderate sanguineous to serous exudate may be present between days 1–3 but should resolve by day 5	Minimal to moderate serosanguinous exudate between days 5–9 Serous or purulent; any type or amount of exudate beyond day 9 is abnormal
Closure	Epithelial closure should be seen by day 4 along the entire incision A healing ridge of newly formed collagen can be felt along the whole incision line during days 5–9 Wound closure materials are removed at some point between days 9–14, with skin closure strips or tape strips used after their removal	Removal of skin closures will be delayed when healing is not progressing as expected For wounds healing by secondary intention, the edges do not approximate, and the wound fails to contract There will be a lack of epithelial resurfacing of the entire incision by day 4, or it may be only partially present, with lack of the collagen healing ridge and dehiscence evident by day 14

SSIs can be acute (occurring within and lasting < 30 days) or chronic (occurring after 30 days) and range from superficial to deep incision or organ/space infection (See Figure 3).

After surgery, the wounds (not procedures) are classified as follows by the Centers for Disease Control and Prevention.[5]

Clean: An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital or uninfected urinary tracts are not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow non-penetrating (blunt) trauma should be included in this category, if they meet the criteria.

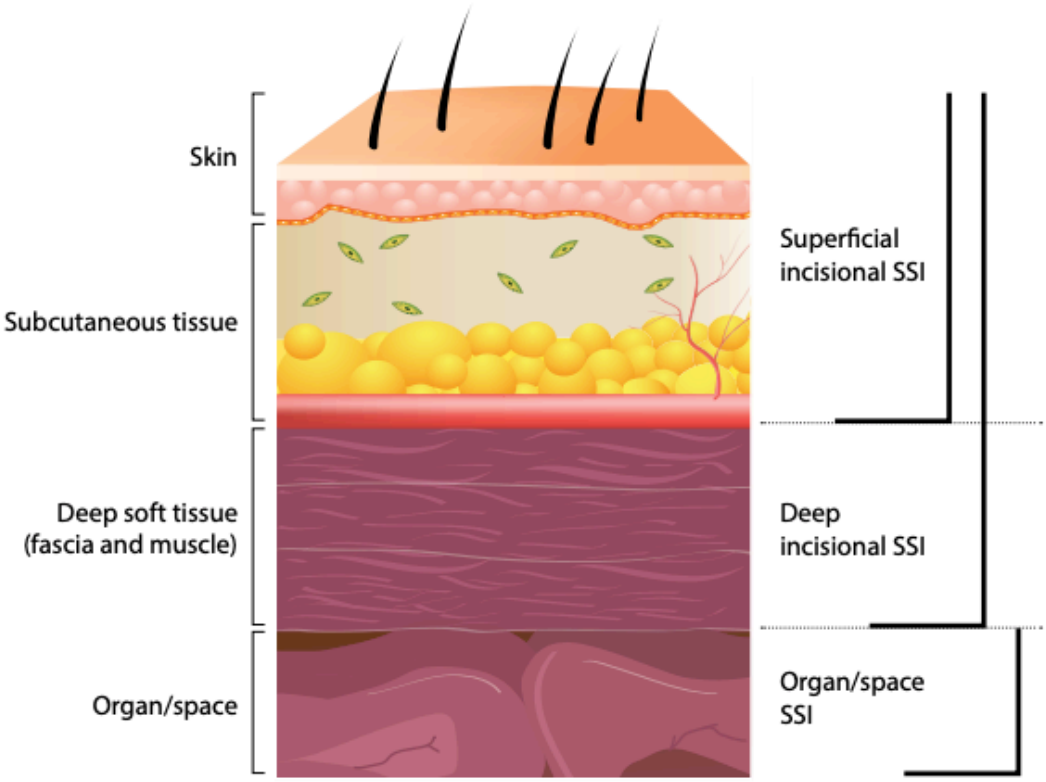
Clean-Contaminated: Operative wounds in which the respiratory, alimentary, genital or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, surgery involving the biliary tract, appendix, vagina and oropharynx is included in this category, provided no evidence of infection or major break in technique is encountered.

Contaminated: Open, fresh, accidental wounds. In addition, surgeries with major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, non-purulent inflammation is encountered, including necrotic tissue without evidence of purulent drainage (e.g., dry gangrene), are included in this category.

Dirty or Infected: Includes old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing post-operative infection were present in the operative field before surgery.

Figure 3: Cross-section of Abdominal Wall Depicting CDC Classifications of Surgical Site Infection[77]

The respective clinical presentations are different, with differing long-term outcomes. Studies have identified the importance of SSI surveillance for at least 30 days, if not for a year, following surgery.[78] SSIs related to artificial hardware, such as total hip or knee arthroplasty, can occur up to a year following the surgery and need to be identified as such.



SSIs can be divided into three categories, with various signs and symptoms. The three categories are:

- Superficial incisional SSI (primary or secondary): infection occurs in the skin (localized) where the incision was made,
- Deep incisional SSI (primary or secondary): infection occurs beneath the incision and in the tissues and surrounding muscles and
- Open or space SSI: involves any part of the body deeper than the fascial/muscle layers that is opened or manipulated during the operative procedure.[3]

For a detailed description of the criteria for each of the three categories of SSI—superficial incisional, deep incisional and organ/space—please visit the following page: https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf

Step 2: Set Goals

Discussion: Goals are set with patients about to undergo surgery and those living with surgical wounds, their family and/or care partner(s) and the interprofessional care team. Realistic goals should be based on identified risk factors and complete patient, wound and environmental assessments. Patient priorities and goals for health care in regard to the surgical wound must be identified along with the available options so that informed decisions can be made. Health-care providers must respect the person's right to choose the interventions they prefer for their health, even when those decisions are in conflict with medical opinion or recommendations.[65] There *are* times when the patient's wishes cannot be consulted: during surgery, if a decision must be made, based on clinical decisions alone, to leave the wound open to heal by secondary or tertiary means, or if a primarily closed wound continues to drain beyond the expected 48-hour timeframe and/or if the wound dehisces.

Recommendations

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

Discussion: Ideally, goals for the prevention of complications of the surgical wound should be set before the surgery takes place. Afterward, when the person is initially recovering from their surgery, they are also coping with the effects of anesthesia, analgesia, disrupted sleep patterns, bodily changes, changes to nutrition, and they may have weakness, nausea and pain. The initial short-term goals should address these issues and promote healing and prevention of complications, and the restoration of general health.

2.1.1 Identify goals based on prevention and healability of wounds

Discussion: In the absence of an SSI, the factors that delay healing in surgical wounds are similar to those in any healing wound. There are some significant differences, however, regarding the results of an SSI, when there are implanted devices, hardware, mesh or organ transplants.

From a clinical perspective there are three surgical wound closure goals:

1. Closed surgical wounds that heal by primary intention are those where the skin edges are joined together, without any areas of separation, eliminating dead space and minimizing the need for new tissue formation.[79] These wounds generally heal without complications and with minimal scar formation and do not contain granulation tissue. Exudate from acute surgical wounds is rich in white blood cells, essential nutrients and growth factors that support the stimulation of fibroblasts and production of endothelial cells.[80] Re-epithelialization of the uppermost approximated skin edges normally occurs within 24 to 48 hours and wound closure at two to three days.[81,82] Normal practice, however, is to keep sutures or staples intact for seven to 10 days and sometimes longer at the surgeon's discretion. Acute surgical wounds heal within an expected time frame and without complications.[16]

2. Delayed primary closure of a surgical wound may be used to prevent infection in contaminated surgical wounds. The wound is allowed to remain open for several days before final closure to ensure all sources of contamination have been removed and/or infection is resolved.[79] Another term for this method is *healing by tertiary intention*.

3. Surgical wounds that may be dirty or infected heal best by secondary intention, where the wound is left open and heals when granulation tissue fills the wound from the base up.[79] Failed primary closure incisions that dehisce or separate are often best left to heal by secondary intention.

It may also be that the wound is deemed 'non-healable', because there is no opportunity for healing due to co-morbid factors, or that major surgery is required to close the wound but the person's health precludes that from happening.

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

Discussion: Patients may not identify wound healing as a goal of care. Pain or tenderness alone can be a symptom of an SSI, and pain levels need to be

consistently addressed to determine if pain reduction goals are being met.[71] Patients are affected by surgical interventions in several ways, including their ability to return to driving, employment, school, social life, body image and overall functionality.[83,84]

Step 3: Assemble the Team

Discussion: Health-care professionals, patients, their care partners and family must take responsibility for doing all they can to support a holistic, integrated approach to care and work together to ensure the best possible outcomes. As surgery-related procedures, including preparation, intervention, discharge and follow-up, involve shorter hospital stays, a trusting, culturally sensitive, positive relationship must be developed among the patient, care partners, surgical team and follow-up clinicians. Patients need to know who the members of their team are, and the roles each plays, if they are to fully participate in the planning of their care long-term.

Recommendations
3.1 Identify appropriate health-care professionals and service providers

Discussion: Surgical-wound healing requires a collaborative team approach.[9] An integrated approach allows for the safe and efficient treatment of patients who are at high risk for surgical site complications.[85] From the physician consult to the laboratory and diagnostic department, community pharmacists, the pre-admission care team, community nurses, dietitians, spiritual care providers, physiotherapists, social workers, wound care clinicians, ostomy/continence nurses, discharge and transition of care planning teams[66] and the in-house surgical team—in pre-, intra- and post-operative phases—many clinicians are involved with the patient and family. It is important that the goals that are set support the patient and care partners through the physical and psychosocial challenges that arise from having a surgical wound—especially one with complications—and that the right team members are in place to do so. Managing an SSI may require that an infectious disease practitioner be added to the integrated team.

Collaboration and mutual respect, leadership sharing, decision-making, authority and responsibility are key elements of successful integrated teams, and this applies whether the team is within one organization, is using web-based or virtual communications, or practices remotely.[66] Surgeons hold primary responsibility for the patient's surgical care, including postoperative wound management and monitoring until healing is complete. Nurses play a role in wound care management and must adhere to the scope of practice and standards set by their College, and employer limits and conditions, ensuring they practice within their authorized scope and competencies.

For example, in Ontario, initiation of wound care below the dermis is within the controlled acts authorized for Registered Nurses (RNs) and Registered Practical Nurses (RPNs). The College of Nurses Ontario notes that, "Nurses may

independently decide that a specific procedure is required and initiate the procedure in the absence of a direct order or directive from a physician.[86] When a surgeon, or other provider, has provided an order for a specific wound treatment, a nurse does not have authority to change the order. Doing so, without contacting and communicating with the physician, jeopardizes the surgeon-patient-nurse relationship.

Instead, through surveillance and collaboration, teamwork helps to prevent surgical wound complications and manage them when they occur. Effective teamwork requires clear communication. Several researchers report that communication failures contribute to adverse events and patient injury, and many lead to malpractice claims.[87,88]

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

Discussion: Patient involvement starts in the doctor's office or emergency room, as soon as patients are made aware of the need for a surgical intervention.[9] When possible, patients and care partners can work with their family doctor, the surgeon and the pre-operative team for optimal surgical preparation to reduce post-surgical complications. Health-care professionals can help patients verbalize their wishes and set short- and long-term goals for transitions to sub-acute, rehabilitation and/or community care.

All communication should be individualized and consider the persons goals, culture, experiences, and values.[65] The plan of care needs to be meaningful to the person and their care partner within the context of their life.[65] In our richly diverse country, care should be culturally appropriate, sensitive to traditions and meet patient and family needs. Patients and care partners must be offered relevant, consistent communication (in most appropriate form) for all aspects of care, including risk of surgical site infection—or other complications—and how to prevent, and to whom to report, any concerns.[9]

3.3 Ensure organizational and system support

Discussion: The RNAO Intra-professional Collaborative Practice - Best Practice Guideline[89] has clear recommendations for leaders of key agencies to strengthen collaborative practice among interprofessional teams to ensure this type of care is a collective strategic priority.[89] Interprofessional care must align with organization initiatives for healthy work environments, including an evidence-informed approach to planning, implementation and evaluation of joint activities. This is especially important when patients are moving through the health-care system (called transitions in care and/or discharge planning).[66] As well, the Agency of Healthcare Research and Quality in the U.S. offers additional strategies and supports for transitions in care for health-care teams, especially related to effective and consistent communication with patients and their care partners.[67]

The reality is that the integrated health-care team for care of an open surgical wound may work for and report to a number of agencies, depending on the province or territory. For example, the surgical operating theatre personnel may write a report or discharge summaries that are not, or cannot be, shared with the regulated health-care providers responsible for patient care in the community (e.g., the primary care general practitioner, physician, nurse practitioner, home-care staff or long-term care staff). In the same way, community nurses are often challenged by a lack of patient post-operative surgical information and a secure electronic way of sending wound photographs to the surgeon. As well, there is a need for more research to develop and test options for integrated care/case conferencing and securely sharing patient information in a timely way within a virtual environment.

Step 4: Establish and Implement a Plan of Care

Discussion: The integrated team needs to create a treatment plan to eliminate or reduce factors that may negatively affect surgical-wound healing in the pre-operative, intra-operative and post-operative phases of care. Strategies that promote timely healing of surgical wounds are essential in all phases of care.

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

Discussion:
Pre-operative Strategies

Pre-operative treatment plans can reduce the risk of a surgical wound failing to heal, a wound dehiscence, an SSI or any surgical-wound complication. Focused assessments (i.e., respiratory, physical activity, obesity etc.) and malnutrition screening will assist in the development of the pre-operative plan. These plans may include smoking cessation (four weeks or longer ahead of surgical date), improved glycemic control, and nutritional adjustments to support intra-operative experience and post-operative healing.

Pressure injury prevention begins pre-operatively by completing a pressure injury risk screening and intervening (surfaces, prophylactic dressings over bony prominences, pillows).[48]

Medications for diabetes and autoimmune issues should be reviewed with specific instructions for use before surgery.[90]

The Canadian Malnutrition Task Force has guidelines and a screening tool, found at http://nutritioncareincanada.ca.

In addition, Healthcare Excellence Canada supports the understanding of the pre-operative mental health status (dementia, depression) of the person by establishing a baseline status.

Delirium is of great concern after surgery, medication changes, sleep changes, catheter use, and or change of living situation. Delirium increases the patient's length of hospital stay, increases mortality and reduces physical and mental functioning.[91]

Healthcare Excellence Canada has excellent resources to support delirium assessment, available at: https://www.healthcareexcellence.ca/en/what-we-do/all-programs/hospital-harm-is-everyones-concern/hospital-harm-improvement-resource/delirium-introduction/

Assess and address use of substances including opioids (strong opioids, or weak opioids)[92] pre-operatively (short-term, long-term- 90 days plus). Assess current usage, purpose and discuss with physicians and the pharmacist.[93,94] Golpen et al. reported long-term opioid users stayed one day longer in the hospital.[94] An expert consensus group released opioid prescribing guidelines for common surgical procedures to guide clinician decision making.[95]

Individuals having surgery and their care partners should receive information and advice on potential wound and dressing care including any ostomies, fistulas or drains, role of antibiotics and how to recognize problems with the wound and whom to contact if they are concerned.[9] Pre-operative education should involve a review of post-operative instructions with the patient, family and/or care partners. Patients may choose a family member or caregiver to participate in the education sessions.

Pre-op surgical education should be reinforced and continue post-operatively with the patient and family-designate.[9] Education materials for patients must reflect each individual's needs in terms of language, reading level, culture and traditions. Post-operative education topics should include hand hygiene, SSI risks, signs and symptoms of complications and team members' contact information. Education will need to be updated depending on the surgical phase of the patient's care, especially if they are readmitted to the hospital.

Recommendations for SSI reduction during the pre-operative phase include several strategies. Patients should be advised or helped to have a shower, bath or bed bath using soap on the day before or the day of surgery.[9] Recent studies report the role of pre-operative showering or bathing with antiseptics in preventing surgical site infections to be uncertain. More research is needed on this important topic.[9] Nasal decolonization (following protocol) in combination with a chlorhexidine body wash may be considered before procedures in which *Staphylococcus aureus* is likely to cause an SSI.[9] Similarly, evidence related to the role of pre-operative hair removal in reducing SSIs is insufficient. If hair removal is needed, it is best to clip hair the day of surgery using a single-use clipper.[9] Mechanical bowel preparation in colorectal procedures must follow protocols.[90]

International Guide for Infectious Diseases (2018). Guide to infection control in the healthcare setting: Preparing the patient for surgery. Available at https://isid.org/guide/infectionprevention/preparing-the-patient-for-surgery/

Individuals having surgery for which antibiotic prophylaxis is indicated receive this in accordance with the local antibiotic formulary.[9] Local epidemiology and resistance patterns do vary, especially as antibiotic choices can change with specific cases.

Enhanced Recovery Canada provides clinical pathways to support Enhanced Recovery After Surgery (ERAS) which include antibiotic protocols and SSI prevention strategies. These clinical pathways can be found at https://www.healthcareexcellence.ca/en/what-we-do/all-programs/enhanced-recovery-canada/

Safer Healthcare Now recommends the initiation of four key strategies in the peri-operative phase to reduce an SSI[69]:

1. Perioperative antimicrobial coverage
   a. appropriate use of prophylactic antibiotics
   b. antiseptic use – bathing, showering
   c. decolonization
   d. antiseptic-coated suture
2. Appropriate hair removal
3. Maintenance of peri-operative glucose control
4. Peri-operative normothermia.

Intra-operative Strategies

Surgical patients are cared for by an operating team that minimizes the transfer of micro-organisms during the procedure by following best practice in hand hygiene and theatre wear, and by not moving in and out of the operating area unnecessarily.[9] Staff protocols should include the removal of all hand jewelry, artificial nails and nail polish before operations.[9]

The skin should be prepared at the surgical site immediately before incision, using an antiseptic (aqueous or alcohol-based) preparation. Povidone-iodine or chlorhexidine are most suitable. Caution should be exercised regarding the use of skin antiseptics in babies (chlorhexidine, both alcohol-based and aqueous solutions).[9]

The recent NICE guidance does not recommend the use of diathermy for surgical incisions to reduce the risk of i nfection.[9] Diathermy increases the risk of an SSI, even though it is faster than a scalpel and causes less bleeding, both of which individually, when not associated with diathermy, *decrease* the risk of an SSI. If diathermy must be used, antiseptic skin preparations and alcohol-based preparations should be allowed to dry by evaporation.[9]

When using sutures, clinicians should consider using antimicrobial triclosan-coated suture, especially for pediatric surgery, to reduce SSI risk.[9]

As well, for cesarean surgery, clinicians should consider use of suture, not stapes to reduce risk of superficial wound dehiscence.[9] Studies comparing different closure techniques, such as continuous versus interrupted sutures, have not found a statistically significant difference in the SSI rate, but using continuous sutures is quicker.[96,97]

Suturing techniques such as progressive tension closure using a regular or a barbed suture technique in conjunction with drains for abdominoplasty are being explored as ways to decrease the risk of seromas.[98,99] Low-tension sutures are more conducive to healing than those applied with too much tension, which can cause skin injuries on their own.

Retention sutures, which are intended to prevent wound dehiscence in abdominal surgery, can cause increased pain, lacerations and device-related pressure injuries. A prospective study examining the benefit of prophylactic retention sutures post-laparotomy concluded there was no significant decrease in incidence of post-operative evisceration, wound infection and post-operative pain.[99]

Adults having surgery under general or regional anesthesia must have normothermia (normal body temperature) maintained before, during (unless active cooling is part of the procedure) and after surgery.[9] Strategies to maintain patient homeostasis and normal body functions during the intra-operative and post-operative periods include maintaining a body temperature of 37°C or 98.6°F, providing supplemental oxygen in the recovery room and maintaining a hemoglobin saturation rate (SpO2) of 95% during the operation and the immediate post-operative period.[9]

Proper hydration during the peri-operative period is warranted, although further research is required to demonstrate whether supplemental fluids reduce the risk of an SSI.[9]

Post-operative Strategies

Incisional healing: SSIs resulting from inpatient procedures may be recognized while the patient is still in hospital or, more commonly, after discharge. Furthermore, since up to three-quarters of all surgical procedures are performed in the hospital outpatient setting, most SSIs will be recognized in the community; therefore, discharge planning must address the recognition of the early signs and symptoms of surgical wound complications.[100]

Pain: Depending on the surgery type, post-operative pain can be either nociceptive or neuropathic, or a combination. Prescribed opiates remain key to post-operative pain management, but nonsteroidal anti-inflammatory agents (NSAIDS) can help to reduce the amount of opiates required in the acute phase, thus reducing opioid side effects, misuse, overdose or death.[95,101] Patients using opioids pre-operatively should be in consultation with the medical and pharmacy team to offer support in prescribing medication that is in line with the surgery type.[95]

Post-operative music therapy may reduce the patient's anxiety, pain and opiod/narcotic consumption.[102] Additional comfort measures such as non-adherent dressings, warmed solutions and sitz baths for perineal wounds can be tailored to the patient's needs and situation but need to be evaluated for effectiveness.[9] The patient must be given an opportunity to discuss their knowledge and beliefs about pain management strategies and provide information as needed. Their response to the pain management interventions must be consistently reassessed using the same re-evaluation tool. The frequency of reassessments will be determined by presence and type of pain, e.g., acute versus persistent, pain intensity, medical condition and practice setting.[9]

Nutrition: Consider prompt post-operative nutritional support to prevent wound dehiscence caused by malnutrition.[60]

System Support

SSIs affect 26,000 to 65,000 patients annually in Canada, and they cause considerable morbidity and increased medical costs.[36] Therefore, maintaining only in-hospital surveillance can conceal significant SSI rate increases or outbreaks and prevent timely feedback and implementation of interventions to improve patient outcomes. Because many post-operative infections occur after discharge from acute care, careful follow-up in the community is essential.[68] Community home health nurses are well-positioned to support post-discharge SSI surveillance programs among the various types of patients in which SSIs can occur.[103,104]

4.2 Optimize the local wound environment through:

4.2.1 Cleansing

Discussion: Wound cleansing at its best should remove foreign bodies such as organic or inorganic debris, inflammatory contaminants such as devitalized tissue, bacteria and wound exudate without causing trauma to healthy cells or introducing bacteria deeper into the wound.[105,106]

Care of a post-operative wound healing by primary intention should employ a non-touch aseptic technique using sterile saline up to 48 hours after surgery. Showering is permitted 48 hours after surgery in most cases; however, the decision is up to the attending surgeon and will be tempered by factors such as drains, hardware and skin grafts.[9] Attempts to cleanse a primary incision in early stages can disrupt the pathogenic organisms along the suture line.[107] Most surgical incisions do not require cleansing,[108] but cleansing may contribute to patient comfort and remove any materials that may delay the healing process.[77]

According to Rosen and Manna, "Wound dehiscence is a partial or total separation of previously approximated wound edges, due to failure of proper wound healing. This scenario typically occurs five to eight days following surgery when healing is still in the early stages. The causes of dehiscence are similar to the causes of poor wound healing and include ischemia, infection, increased abdominal pressure, diabetes, malnutrition, smoking, and obesity."[109]

Cleansing of surgical wounds that dehisce should be left to heal by secondary intention. These wounds may have an increased bacterial load which requires clinical assessment and consideration of the type of cleansing agent and technique to be used. Each of the options may have clinical benefits as well as precautions. The NICE guidelines recommend that tap water be utilized for wound care after 48 hours if the incision has separated or has been surgically opened to facilitate the drainage of pus.[9]

The Joanna Briggs Institute cautions that tap water for post-operative wounds should not be used if it has been declared non-potable.[110] If used, the tap should be run for 15–30 seconds prior to use, and safety of the tap water must be assured in rural areas. The choice of solution should reflect patient preference and a formal economic evaluation. Boiled and cooled water is an acceptable solution in the absence of potable tap water, although in the authors' experience, many health-care professionals still prefer to use sterile normal saline in their care of dehisced incisions, high-risk wounds and particularly when vascular grafts or hardware are involved.

A primary incision that has even small areas of dehiscence should never be irrigated without speaking with the surgeon first; irrigation can introduce pathogens into deeper compartments, causing increased risk of infection, particularly in highly vascularized areas such as the scalp and face.[111]

There are a number of wound irrigation considerations:

- Hand hygiene procedures and aseptic technique should be employed
- The clinician and patient should wear protective goggles and clothing as required
- Some clinicians advise that irrigation is not appropriate if you cannot see the base of the wound; decisions about irrigation of surgical wounds should rest with the surgeon, as noted above
- Forcing the irrigation fluid should never be done, as it can breach the fascial plane
- The volume of irrigation solution should be dependent on the size of the wound and the amount of infection and/or devitalized tissue. An adequate volume of solution should be used to assist in removal of debris (biofilm)[112]
- A non-sterile container should be used to catch and measure the amount of irrigation solution. Use of gauze, blue pads or abdominal pads to catch irrigation returns is needless and costly
- The tissue above the tunnel or undermining should be massaged gently to expel the irrigation fluid
- Where possible, the patient should turn from side to side to assist with irrigation returns
- It is important to ensure that the majority of the irrigation fluid is recovered. If it is not, irrigation is not appropriate
- Two adages may apply here: "The solution to pollution is dilution" and "Irrigate until the returns are clear."[111]

For more on cleansing, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

4.2.2 Debriding

Discussion: The removal of necrotic tissue will help to reduce bacterial burden in the management of an SSI. In collaboration with the surgeon, clinicians must determine what method of debridement or combination of methods is most appropriate. When considering who will be carrying out the debridement, consider scope of practice, competency (knowledge, skill, attitude, mentorship), environment and patient comfort.[113] Sharp debridement requires that appropriate analgesia be provided to the patient before, during and after the procedure, and that the setting allows for the achievement of hemostasis.

For more on debridement, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

4.2.3 Managing bacterial balance

Discussion: Management of bacterial balance is essential for decreasing SSI risk. A complete and holistic patient assessment prior to surgery will allow the health-care team to identify and address factors that increase a patient's risk of developing an SSI to more effectively reduce bacterial load and optimize patient status. If an infection is diagnosed clinically, a semi-quantitative wound swab for culture and sensitivity should be done to help determine the appropriate antimicrobial.

The use of peri-operative prophylactic antibiotics can effectively decrease bacterial load and SSI risk.[90] However, the indiscriminate use of antibiotics has contributed in part to the development of antibiotic-resistant strains of bacteria (e.g., methicillin-resistant Staphylococcus aureus [MRSA], vancomycin-intermediate or -resistant strains of Staphylococcus aureus [VISA/VRSA], vancomycin-resistant Enterococcus faecium and multi-drug-resistant Pseudomonas aeruginosa and Acinetobacter species). Peri-operative antibiotic prophylaxis should be used based on SSI risk assessment. Surgeries that require the use of antibiotic prophylaxis include clean surgeries involving the placement of a prosthesis or implant, clean-contaminated procedures and contaminated surgeries.[9]

When SSI occurs, treatment decisions are based on a number of patient and pathogen factors.

Acute SSI

Recommendations for the treatment of acute SSIs are shown in Table 4, organized by the parameters of time. SSIs uncommonly occur during the first 48 hours after surgery, and fever during this early period usually arises from noninfectious or unknown causes. Superficial SSIs are monitored for 30 days from the surgery for all procedure types. Surveillance timeframes for other SSIs are generally determined by the operative category and range from 30 to 90 days.[114]

Chronic SSI

Managing a chronic SSI requires treatment based on the duration (generally more than one month) and location of the wound and the type of infection involved. Clear guidelines for the management of chronic infection in a surgical wound are less well defined and usually rely on expert consultation (See Table 4).

Chronic SSI requires clinicians take a multimodal approach with medical and surgical interventions, as well as address any patient factors that have led to the infection. Further surgical intervention is frequently required, depending upon the problem, usually to remove devitalized tissue or infected foreign material, close a fistula or ulcer space or drain/remove a sinus tract.

Multi-resistant micro-organisms such as MRSA, Gram-negative bacteria or fungi may be involved. Long-term antimicrobial therapies are usually required, based on the antimicrobial susceptibility patterns of the isolated microbiota. Rehabilitation is frequently needed as part of the recuperation phase. In part, depending on the type of surgery involved, such as hip or knee arthroplasty, an SSI may mean a further loss of mobility.

In the Canadian Institute for Health Information (CIHI) report on compromised wounds in Canada 2011–2012, iatrogenic wounds, which include post-procedural complications/infection/disruption, post-device, implants and graft infection and obstetric surgical wound or puerperal infection, accounted for the following numbers:[115]

- Acute care 41,255 (1.7%),
- Home care 3,152 (2.9%),
- Continuing complex care 2,753 (13.8%) and
- Long-term care 1,818 (1.3%).

Table 4: Management Recommendations for Acute Surgical Site Infections[116-118]

Note: Empiric antimicrobial choices may differ based on local epidemiology; please refer to local guidelines for details.

Parameters of time	Action

Fever < 48 hours after procedure (and up to 96 hours)	• Less likely to represent SSI in this time period
	• If no other systemic signs/symptoms are present, observation is indicated
	• True soft-tissue emergencies include necrotizing clostridial, streptococcal or mixed anaerobic infections. Management for these cases includes the following:
	  • urgent surgical consultation for debridement of involved tissue
	  • administration of empiric antimicrobial therapy, based on the diagnosis, likely causative micro-organisms and local resistance patterns
	  • specialist (infectious disease) consultation may be required. Antimicrobial combinations (narrow based on infection / culture results) may include:
	  • piperacillin/tazobactam, ampicillin/sulbactam or carbapenems +/– vancomycin (empiric therapy choices)
	  • cefazolin + metronidazole
	  • penicillin G + clindamycin (definitive therapy)
	  • vancomycin + metronidazole

Fever > 96 hours after procedure	• Conduct a wound assessment for signs/symptoms of infection and assess for systemic signs/symptoms of infection • When applicable, remove sutures, perform incision and drainage of the surgical site and (sterile) culture for bacterial pathogens • Consider imaging studies to assess for abscess formation (e.g., ultrasound, CAT scan) • Empiric antibiotic therapy is indicated for cases with systemic signs of infection • For surgical procedures conducted above the waist (i.e., trunk, head, neck or extremities), consider the following antimicrobial therapy: first-generation cephalosporin with MSSA activity (e.g., cefazolin) vancomycin or linezolid (based on local MRSA rates) For surgical procedures involving the axilla, gastrointestinal tract, perineum or genitourinary tract, agents with activity against Gram negative and anaerobic bacteria are recommended: • cefazolin + metronidazole • ciprofloxacin + metronidazole • vancomycin + ciprofloxacin + metronidazole

Localized Infection

Wolcott et al. found that 95% of all bacteria that might be associated with, or causative factors for SSIs, are never isolated and so have never been identified and actually require molecular techniques to detect. More than 99% of bacteria identified in every environment are organized in biofilm communities (natural state of existence).[117] Biofilms are more successful on surfaces, especially interfacing wound surfaces, such as those found in many types of surgical wounds.[119]

Physical removal of biofilm by thorough and frequent debridement and/or wound cleansing (7 – 12 psi, 100 – 150 mL) forces the biofilm to reconstruct and makes it more susceptible to effective antimicrobials, antibiotics or antiseptics to prevent re-formation (using a debride-and-cover with antimicrobial dressing strategy).[117] Topical antimicrobials are not recommended without prior debridement of necrotic tissue and debris and thorough cleansing, as they need to be in contact with viable tissue and may be ineffective due to poor penetration.[120] Selection of antimicrobial depends on multiple factors; wound type, cost, availability and microbial burden.[121]

For more on managing bacterial balance, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

4.2.4 Managing moisture balance

Discussion: Provide optimal wound moisture balance to promote surgical wound healing by choosing an appropriate dressing for the different phases of surgical wound healing. Appropriate wound care and dressing selection promotes healing and reduces the risk of infection.[9] Surgical wounds often are associated with high levels of exudate due to complications such as inflammation, infection, seroma or hematoma, causing increased capillary leakage and edema, which can have an adverse effect on wound healing.[122] Drains used to support wound drainage should be removed when clinically indicated (there is no optimal time for removal).[123] Excessive moisture slows down wound healing by preventing cell proliferation, interfering with growth factor availability and elevating levels of inflammatory markers and cytokines. Excessive exudate will also cause the periwound tissue to become macerated (white, overly moist and non-viable), impairing the advancement of the wound edge and risking periwound skin injury.[124]

Moisture-associated skin damage (MASD) can occur in the tissue surrounding the surgical wound as a result of prolonged exposure to excessive wound exudate. The volume and composition of the wound exudate are key factors that contribute to development of MASD. Wound exudate containing heparin-binding proteins, proteolytic enzymes, high concentrations of inflammatory cytokines or high bacterial burden and their associated toxins all increase the likelihood of MASD.[125] Essential to the protection of periwound skin, while still keeping the wound bed moist, is choosing a dressing capable of containing wound exudate and wicking it from the periwound skin, and changing the dressing at a frequency that prevents skin irritation. For more on MASD, please see Chapter 5: Best Practice Recommendations For Prevention and Management of Moisture-associated Skin Damage.

For more on managing moisture balance, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[15]

4.3 Select the appropriate dressing and/or advanced therapy

Discussion: Appropriate wound care and dressing selection promote healing and reduce the risk of infection. Surgical wounds should be covered with an appropriate interactive dressing at the end of surgery. The patient should be referred to a wound care clinician with advanced education and training in wound management for advice on appropriate dressings for the management of surgical wounds that are healing by secondary intention.[9]

Most closed surgical wounds have minimal amounts of exudate and only require a simple dressing. However, large amounts of exudate may occur due to complications such as inflammation, infection, seroma or hematoma, causing increased capillary leakage and edema, which can have an adverse effect on wound healing.[117]

Post-operative Strategies

The post-operative team members that provide wound care and dressing changes for patients, and the patient's care partners, should receive education and support in order to provide care that reflects best practices.[9] Education for surgical staff should include the importance of continued assessment,[126] hand hygiene and the use of aseptic non-touch technique for changing or removing surgical wound dressings.[9] Dressing selection for surgical wounds is determined by the type of closure (primary, delayed primary or secondary intention), as well as the amount of infection, wound exudate and the presence of any tunnels, undermining, underlying vascular grafts or hardware. Consideration should also be given to patient concerns, care partner and family knowledge and time, setting and available resources.[124]

Primary intention

Incisions closed by primary intention generally require only the application of a dry, sterile semipermeable cover dressing for 24 to 48 hours, as the wound will re-epithelialize within two to three days.[127] More evidence is needed to support the use of any specific dressings immediately post-operatively for wounds healing by primary intention; the recommendation is that dressings should be selected on the basis of cost and the interactive properties of the dressing.[9] As reviewed by NICE, silver nylon dressings appear to be more effective than gauze in preventing surgical site infections.[9] Limitations were that the silver nylon was compared with gauze (not another advanced dressing), that infections were diagnosed by an unblinded member of the operating team, a potential bias, and that the length of the incision was not documented in each case. Further research is needed that compares silver dressings with other commonly used modern wound dressings.

Secondary intention

Acute surgical wounds that are left open to heal by secondary intention require a moist wound environment to support healing.[79] In addition to preserving moisture balance, the dressing should function to prevent bacteria from entering and critically colonizing wound tissue.[124,128] Interactive advanced wound products have an advantage over wet gauze dressings as they prevent bacterial penetration of the wound.[129]

Pouching is another option for the management of heavily exudating wounds[130] and associated fistulas (enterocutaneous & enteroatmospheric).[131] Although minimal research exists in this area, expert opinion supports the use of pouching when exudate, significant odour or the need for skin protection from exudate are of concern.

Generally, wounds with > 25 mL discharge or those requiring dressing changes more than three to four times per day may be considered for this option. Other important considerations for pouching include the location of the wound, patient comfort and mobility and staff time. Troughing a wound—using ostomy paste strip products and film dressings to channel the exudate into a pouch—may be an option for larger wounds. The involvement of an ostomy nurse and or a wound clinician with advanced training in ostomy, continence and wound management is encouraged when exploring pouching or troughing options.[132]

Negative Pressure Wound Therapy

There is an evolving body of evidence in support of prophylactic negative pressure wound therapy (NPWT) over closed incisions in adult patients on primarily closed surgical incisions in high-risk wounds (e.g., where there is poor tissue perfusion, bleeding or hematoma, dead space, intraoperative contamination), taking resources into account, for the purpose of preventing SSI.[123] When NPWT is used, communication with patients and care partners is essential to support engagement in care.[133]

The benefits of NPWT are thought to be the control of skin flora exposure, with the dressing being applied in the operating room under sterile conditions and remaining in place for five to seven days, the removal of exudate, the reduction of lateral incisional tension and the reduction of hematoma or seroma formation at the surgical site.[134] Evidence supporting the application of NPWT to the primary incision has been demonstrated in sternotomy, orthopedic[134] and vascular surgeries,[135,136] with multiple ongoing randomized controlled studies for a variety of surgical procedures currently underway.

The use of NPWT for open wounds has been an accepted wound treatment modality for many types of open wounds, as well as a method of bolstering flaps and skin grafts.[137,138] When the wound is highly exudative, the periwound skin benefits from protection with a barrier film/hydrocolloid and may also benefit from NPWT.[124] NPWT therapy should be considered as, "first-line treatment for dehisced sternal wounds following cardiac surgery".[139] There is also interest in using NPWT to prevent dehiscence, though there is little evidence to support it at this time. The NICE Evidence Update did report that NPWT appears to reduce SSI rates following invasive treatment of lower-limb trauma, but cautioned that it may be less effective in other patient groups with multiple co-morbidities and that further research is needed.[9]

NPWT is used when clinicians have been successful in advanced education required by their organization/agency. Policies and procedures and supported clinician education must be established prior to use of this therapy. NPWT use is accompanied with warnings, contraindications and precautions for each device and application use. Clinicians are responsible for being knowledgeable about the specific uses of NPWT, which offers advanced management of many wound types, including surgical. Patient selection, wound bed preparation, debridement, dressing selection, application and clear interprofessional team communication are crucial for successful use of NPWT.[140]

Dry Wounds

For some wounds, too little moisture causes the wound bed to dessicate, preventing growth of granulation tissue and re-epithelialization.[124] Dry surgical wounds with healing as a goal may benefit from the addition of a hydrogel, hydrocolloid, non-adherent mesh dressing or transparent film to hold moisture in and protect the wound bed.[124] For more information on dressing selection, please refer to the Wounds Canada Product Picker series, available at https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/library/183-resources-industry-partner/288-product-picker These can be adapted to be fillable PDFs so that once completed with the formulary for the given area, health-care providers can use them to guide decision-making, specific to their agency or institution.

Common Types of Surgical Wounds

The following discussion covers those types of surgical wounds commonly seen in wound clinics and community settings, but it is not inclusive of *all* types of surgical wounds that may be encountered.

Abdominal wound/ open abdomen +/– new ileostomy or colostomy, enterocutaneous fistula

An open abdomen surgical wound occurs when intra-peritoneal organs are exposed as a result of surgery for complex intra-abdominal situations where primary closure is not appropriate, such as in the case of severe sepsis, abdominal trauma and after grafting of ruptured aortic aneurysms.[9] When perforation of the bowel has occurred, and there is pus and fecal contents present in the abdominal cavity, surgeons usually choose to leave the abdominal wound open to heal by secondary intention to prevent further abscesses.[60] This may result in a large, heavily exudating wound with a new ostomy in close proximity. Due to the complexity of this type of wound the involvement of a nurse with expertise in ostomy, continence, fistula and complex wound and pouching management is recommended.[131]

Several wound and fistula management systems are available, although their success in managing large wounds close to a new ostomy or those containing a fistula will be dependent on the amount and type of fecal output and bodily contours that lead to leakage. Negative pressure wound therapy is often appropriate for these wounds. The end point is to achieve healing, either as delayed primary closure of the abdomen (particularly after an abdominal aneurysm repair), secondary healing, split-thickness skin grafts, mesh repair, muscle components separation, flaps or a combination of these.[9]

The presence of an enteric fistula within an open abdominal wound is called enteroatmospheric fistula and is a complication with a mortality rate as high as 70%.[131,141] The high mortality rate is directly related to the septic response arising from the bacterial load accompanying the bowel content soiling the open abdomen. Both surgical management and conventional wound care options are often ineffective.[142] There are a number of novel treatment options utilizing negative pressure wound therapy that might be considered, such as a fistula in an open abdomen.[143] One such option places the polyvinyl alcohol foam on the mouth of the fistula, so long as there is no mucosal eversion leading to primary closure.[142] Other primary closure treatments include the use of fibrin glue or fistula coverage with a muscular flap. If primary closure is not a possibility, then isolating and diverting effluent out of the abdominal wound and collecting it in an ostomy pouching system may prevent sepsis and promote wound healing.[142] The care of a patient with an enteroatmospheric fistula is complex and requires a team approach that includes the expertise of the ostomy and wound care clinician and a team that is aware of the risks.

Caesarian (C) section incision

C-section surgery has a five to 20 times higher risk of postpartum complications such as wound infections, endometritis, pelvic peritonitis or pelvic abscesses, compared with vaginal deliveries.[144,145] Premature rupture of the membranes, diabetes, obesity, hypertension, anemia, emergent rather than planned C-section and post-op wound hematoma have been identified as risk factors that need to be addressed.[146] Since hematoma was the strongest independent risk factor for SSI development post low-transverse C-section, the incision should be monitored for redness, swelling and pain.[147] In obese women, a vertical incision may be necessary. A vertical incision is associated with a higher rate of infection, as is the use of interrupted sutures or staples rather than a continuous intercutaneous suture.[148-150] The patient dealing with complications post C-section incision is also coping with a baby, physiological and hormonal changes, pain, inconvenience and concern regarding use of antibiotics which may be transferred to the baby if breastfeeding.

Hernia repair with infected mesh

The use of prosthetic polypropylene mesh is associated with fewer recurrences in ventral or inguinal hernia repair. In a 2022 review, three major modifiable patient issues were identified as significantly associated with SSI: obesity, tobacco smoking and diabetes.[151] Unfortunately, the risk of superficial SSI or deep infection of the mesh with complications resulting in exposed mesh or unincorporated mesh or the formation of chronic abscesses, sinuses and/ or drainage or development of spontaneous enterocutaneous fistula is as high as 3%.[149,152] Removal of the infected mesh is a difficult surgery that should be considered if local wound care cannot manage the wounds and drainage.[153] Prevention of post-operative evisceration and maintenance of a competent abdominal wall are key secondary goals of hernia mesh removal.[154] Many patients must live or choose to live with small, chronic draining areas that periodically require debridement of mesh, as it protrudes out of the wound. In these cases, the principles of long-term

wound self-care should be applied along with management of bacteria, odour, exudate and periwound irritation. Supports must be in place for patients with non-healable wounds, as management of wound drainage will impact an individual's quality of life, including patient frustration and disheartenment. Psychological and physiological stressors such as depression and anxiety have a relationship to delayed wound healing.[132,155]

Hip and knee arthroplasty

Chowdry and Chen described an ideal dressing to prevent SSIs in a post-operative orthopedic surgical incision as being absorbent, protective, permeable, transparent, able to provide a moist environment, able to remain *in situ* (i.e., to require minimal changes), able to act as a complete barrier, having low adherence and being cost-effective.[156] Orthopedic total joint arthroplasty incision complications include blistering and infection that may lead to dehiscence. A dressing requiring frequent changing, and skin trauma caused by dressing adhesive or blistering, can lead to exposure of external infectious sources. Although the incidence is low (1 – 2%), periprosthetic joint infection (PJI) after total hip or knee arthroplasty is considered to be a catastrophic complication. The infection may be just in the incision (localized SSI) or it may be deep at the area of the prosthetic (PJI). Santoso and colleagues identified multiple Mycobacterium species that could be responsible for hip/knee prosthetic joint infections (PJI); although *M. tuberculosis* is the most common causal pathogen, nontuberculous mycobacteria (NTM) should be considered as an emerging cause of hip/knee PJIs.[157]

The orthopedic surgeon needs to assess this as soon as possible and, until then, local interventions such as wound irrigation, probing or packing should be avoided due to the risk of inadvertently introducing bacteria. Diagnosis is often difficult and relies on the surgeon's judgment of the clinical presentation, the findings on physical examination and the interpretation of relevant investigations.[164] Deep infections that are caught early (within several days of their onset) and those that occur within weeks of the original surgery may sometimes be cured with a surgical washout of the joint and debridement of all contaminated soft tissues. The implant is thoroughly cleaned and plastic liners or spacers are replaced. After the procedure, intravenous antibiotics are prescribed for approximately six weeks. Sometimes, two or more surgeries are required, with removal of the prosthesis, an implant of antibiotic-laden cement and eventual replacement of the prosthesis. Amputation is also a possible consequence.[159,160]

Incision and drainage (I&D) of abscesses

Incision and drainage is historically the treatment of choice for cutaneous abscesses.[161] Treatment is dependent in part on the etiology, such as of sebaceous cyst, pilonidal sinus, hidradenitis suppurativa, foreign body; but generally abscesses requiring I&Ds are either sutured primarily or left open and packed loosely or not packed and dressed, with or without an oral antibiotic.[162] Community-associated MRSA is considered to be endemic in North America and is a frequent cause of abscesses, making it important to:

- Confirm the diagnosis of MRSA infection in immunosuppressed patients by Levine method semi-quantitative swab culture[163]
- Recognize that treatment with systemic antimicrobial therapy to which the bacterial isolate is susceptible is controversial[161]
- Recognize that for cases of mild illness (patient afebrile, abscess < 5 cm, no other medical co-morbidities) I&D with or without topical antibiotics may be sufficient.[164]

Packing of these wounds is controversial, yet a large number of patients in the home care setting are admitted with orders for daily packing for incision and drainage of abscesses (See Table 5).

Table 5: To Pack or Not to Pack

Study	Intervention	Packing versus No Packing
Mohamed Ahmed et al. 2021. 8 RCTs, n=485 patients[165]	cutaneous abscesses	I&D of cutaneous abscess with or without packing have comparable outcomes. However, considering the cost and post-operative pain associated with packing, performing the procedure without packing of the abscess cavity may be more favourable. More RCTs are needed
Nour et al., 2023. 3RCTs, n=490[166]	perianal abscesses	Not packing the wound post I&D of perianal abscess is associated with significantly reduced VAS pain scores, which may result in improved recovery and patient satisfaction and has no effect on recurrence rate or the occurrence of perianal fistula. More RCTs are needed
O'Malley et al. 2009. RCT (n = 48)[167]	I&D of simple cutaneous abscesses	There was no difference in complication or infection rate between groups, but it had limited real-world applicability due to the small size of the study
Tonkin et al. 2004. Randomized (n = 43)[168]	anorectal abscesses	There was a similar time to healing, but the median pain score in the non-packing group was significantly lower
Kessler et al. 2012. RCT (n = 57) pediatric patients[169]	abscesses	The failure rates were 19/27 (70%) with packing and 13/22 (59%) without. The difference was 11%, 95% confidence interval 15 – 36%
Schmitz 2011.[163]	cutaneous abscesses	The study suggests packing does not provide additional benefit
Liu et al. 2011.[170]	uncomplicated skin and soft tissue infections	I&D was recommended, but the authors' opinion was that antibiotics were not likely needed and did not mention packing
May et al. 2012. retrospective audit (n=135)[171]	inconsistencies in technique, irrigation methods, use of antibiotics and variation in packing techniques	The audit did not include outcomes for the types of packing. In the panel's opinion,packing is best used to wick the wound open to facilitate drainage

Tight packing allows the edges to scar and become fibrotic, which delays wound healing. Larger studies are needed to better validate the equivalency of these two strategies, which could potentially result in savings of many thousands of dollars spent on needless packing materials, prolonged need for analgesia and nursing visits. Retained packing or lost packing is a foreign body and becomes a source of infection. Each facility or organization should have a policy and procedure regarding types of packing agents to use (e.g., high tensile strength), strategies to avoid loss of packing agent (e.g., one piece of packing agent only, secure tail of packing on intact skin, etc.) and procedure to follow when unable to locate packing that should have been in the wound. Documentation of size and length of packing materials used in the wound is essential. Patients can tell you if they visualized packing that, "fell out," but if they did not see it, and you cannot find it, this must be reported to the responsible physician and an appointment made so that they can examine the patient and the wound.

Lower leg vascular bypass/saphenous vein harvesting

SSI incidence is between 3.5 and 32% with peripheral vascular surgery. SSIs can lead to major amputation as well as mortality.[172] An unfortunate fact is that the patients who require lower leg bypass surgery or coronary artery bypass graft (CABG) with saphenous vein harvesting often have diabetes, hypertension and obesity as well as other co-morbidities. Selected patients undergoing elective femoral popliteal bypass of a leg without critical limb ischemia

(CLI) required discharge to a rehabilitation or skilled nursing facility rather than to the home. Multiple risk factors such as diabetes, dialysis, congestive heart failure and cerebrovascular accident contribute to prevention of discharge back to the home. Patients who require discharge to a facility (either rehabilitation or skilled nursing) have higher rates of infectious complications, myocardial infarction, operative transfusion and unplanned reoperation while hospitalized for the initial surgery.[173]

Post-operative edema of the lower legs, lasting up to three months, often contributes to failure of primary closure of these incisions.[174] Edema is a multifactorial problem not only with vascular surgery, but also with orthopedic surgery and surgical interventions following trauma. Alterations in arterial and capillary perfusion, transcapillary fluid filtration and lymph transport all contribute to the formation of edema.[175] A lower level of physical activity in the initial post-operative period decreases the calf-muscle pump activity and increases the risk for accumulation of edema in the lower limb. Various methods of edema management are being utilized with varying effectiveness. Intermittent pneumatic compression (IPC) following femoropopliteal bypass surgery compared with compression stockings failed to show any statistical difference in reduction in edema in a small (n = 35) study, but the length of intervention was only one week.[175] In real-life practice, one week may be the usual time of hospitalization for these patients, and it would seem prudent to continue compression once discharged home.

Alireza et al. in a study with 100 patients having saphenous vein harvesting for coronary artery bypass graft surgery (CABG), compared the use of thigh-high medical grade compression stockings versus no compression stocking/stocking applied irregularly, for four weeks post-op.[176] There was a statistical difference in edema of the calf between the two groups at one, two and four weeks post-op ($P = 0.004$, $P < 0.001$, and $P < 0.001$ respectively), with the stocking group having less edema. Wound complications (ecchymosis and infection) occurred in 12 patients with edema but did not occur in patients without peripheral edema at four weeks ($P = 0.09$). They found that patients who were more physically active also had decreased edema, although low compression elastic stockings do not improve calf-muscle pump activity when the patient is walking.[177] Additional research is needed to look at the role of resistant compression bandages in preventing/reducing post-operative edema and wound healing.

With venous leg ulcers, pro-inflammatory cytokine and matrix metalloproteinase levels are reduced, and the anti-inflammatory cytokine IL-1 Ra are increased in response to multi-layer high-compression therapy.[178] In addition to having an anti-inflammatory effect, compression bandaging that provides resistance and is safe to use when the ankle brachial pressure index (ABPI) is between 0.5 and 0.8 actually increases laser Doppler flux under the bandage without decreasing the toe pressure or transcutaneous oxygen pressure ($TcPO_2$) distal to the bandage.[179] Resistant compression also potentiates the action of the venous pump by increasing the ejection fraction.[179] Compression therapy would ideally need to be used immediately post-operatively and for as long as the risk of edema is present, which may be weeks or months.[180] Further robust studies are needed to determine the best choices.

Pilonidal sinus surgery

The Harris Pilonidal Sinus Protocol outlines the complex reasons for failure of pilonidal sinus wounds to heal, whether they are healing by secondary intention or are a failed primary intention closure.[180-182] Recognition and treatment of signs and symptoms of localized and deep infections is key, particularly as there are three signs that happen with pilonidal sinus wounds that are not found in others: bridging and pocketing in the base of infected granulation tissue and premature epithelialization with corresponding tunneling running underneath. Treatment is aimed at multiple factors that contribute to the infection and lack of healing. Frequent meticulous removal of periwound hair, decontamination of periwound skin, optimal personal hygiene practices with increased self-care management strategies, reducing causes of chronic inflammation, optimizing nutrition and pain management, hygiene and dressing changes following bowel movements and modified physical activity all play a role. An update to the protocol is now available, which debates the use of silver nitrate in these wounds.[182]

Skin graft and donor sites

Skin grafts are a section of epidermis and dermis that has been completely separated from its blood supply in one part of the body (donor site) with the goal of transplanting it to another area of the body (recipient site).[183] Although the

OASIS tool (See Step 1.1) does not consider skin grafts to be surgical wounds if done to repair an existing wound, donor sites and skin grafts are the result of surgical interventions. Full-thickness skin grafts are used for small areas. Skin can be acquired from the pre-and post-auricular region, the neck, upper and lower extremities, groin and abdomen. Split-thickness grafts use the epidermis and a portion of the dermis. This skin is harvested from any body location, but the thigh is most common. Grafts may be non-meshed or meshed. If meshed, then it is created by pie-crusting with a scalpel or with a mesher that creates fenestrations at equal distances. The purpose of meshing is to create a larger surface area from a smaller graft. It also permits drainage of fluid from the wound to prevent hematoma or seroma formation.[184]

Donor site wound care requires the application of moist wound healing principles. There are many commercial dressings available to support moist wound healing.[184,185] Donor sites heal by re-epithelialization usually requiring transparent dressings or fine mesh gauze. The donor site can be more painful than the graft site and requires protection and patient education to heal.[184,186]

Recipient sites

Full-thickness and partial-thickness skin grafts are sutured, stapled or glued in place, treated like a primary incision and covered with a dressing. If a bolster dressing is utilized it should only be removed by the treating physician unless otherwise specified. NPWT is sometimes utilized as a bolster for skin grafting, as previously stated.[187] It is important that movement in the area of the graft site be minimized in the first five to seven days. The decision about which dressing is appropriate for the grafted recipient site usually remains with the surgeon responsible for the wound.

Post-operative risks are an SSI, seroma and/or hematoma formation and graft contracture. An SSI can lead to disintegration of the graft or excessive exudate that prevents the graft from adhering to the bed.[188] It can take three to six weeks for the skin graft to turn a normal colour and, until then, it may look gray, pale, purpuric or dull. Scars can take from 18 months to two years to mature and for inflammation to resolve. Unfortunately, grafts to the scalp following removal of skin cancers can be problematic, with chronic small areas of exposed skull or skull replacement materials at the margins of the graft. These wounds may never resolve and may require ongoing dressing use and protection.

Advanced Therapies

When warranted, the clinician should consider the use of advanced therapies and biologically active dressings as they pertain to surgical wounds.

Hyperbaric oxygen therapy (HBOT)

The Cochrane Review of HBOT for acute surgical and traumatic wounds reported two small trials suggesting that HBOT may improve the outcomes of skin grafting and trauma; these trials were at risk of bias. Further evaluation by means of high-quality RCTs was recommended.[189]

Zhou and colleagues (2023) completed a narrative review (14 studies) They stated, "HBOT, as primary or adjunctive therapy, showed many advantageous effects in the treatment of several medical conditions, especially for wound healing and infections. Despite the lack of valid randomized controlled trials, retrospective studies and case reports showed beneficial effects of HBOT in the treatment of SSIs or other similar infections. Considering increasing trends in the incidence of MDROs, HBOT can be effective in the prevention, management, or treatment of acute or chronic infections induced by such pathogens. We suggest conducting more research, especially randomized clinical trials and longitudinal investigations, to better standardize the treatment as well as to determine the full benefits and possible side effects of HBOT. We also suggest the development of specific indications to specify the potential contraindications to receiving this therapy".[190]

Electrical stimulation (ES)

In a review of 21 RCTs involving electrical stimulation for wound healing, Thakral et al. concluded that it is underutilized in plastic surgery and could improve flap and graft survival, accelerate post-operative recovery and decrease necrosis following foot reconstruction.[191] The authors described ES as addressing three key factors in surgical wound complications: decreasing bacterial proliferation and increasing local perfusion, thereby accelerating wound healing. They recommended more clinical trials to better determine the dosage, timing and type of ES for care of surgical wounds. A new muscle-pump activator worn at the knee electrically stimulates the common peroneal nerve, causing muscle activation replicating at least 50% of blood flow generated by walking.[192] It is recommended for prevention of vein thromboembolism (VTE).[9] Alharbi et al. demonstrated applicability of this device for kidney and pancreatic transplant surgery in preventing post-operative lower leg edema and improved blood flow.[193] Further research and evaluations are underway.

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

Discussion: Individuals within the circle of care must understand their roles and responsibilities in relation to the formal care team for each specific element of care.[65] Early recognition and treatment of surgical complications, including SSI, is important.

Providing the following information to patients, families and care partners improve prompt treatment and reduction of infection-related morbidity[9]:

- the risks of an SSI and what is being done to reduce it, including any antibiotics given in hospital,
- the signs and symptoms of an SSI, how they are managed and who to contact if they are concerned,
- the signs and symptoms of other surgical site complications such as a hernia or a wound dehiscence,
- who is responsible for what portion of their care and when follow-ups should be booked,
- who to call when they have concerns and
- how to care for the wound after discharge, including hand hygiene.

The team should use an integrated care pathway for preventing complications to help communicate this information to patients and all involved in their care after discharge from hospital. Documentation of the information shared is necessary. Several patient handouts are available online for public use. Examples can be found at the following websites:

Wounds Canada. Care At Home Series: Changing a Dressing https://www.woundscanada.ca/docman/public/patient-or-caregiver/1680-care-at-home-series-changing-a-dressing/file
Wounds Canada. Care At Home Series: Caring for Yourself After Surgery https://www.woundscanada.ca/docman/public/patient-or-caregiver/1772-home-surgical-wound-care-1943e/file
Wounds Canada. Care At Home Series: Preventing Skin Injuries for the Whole Family.
https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series
South West Regional Wound Care
https://swrwoundcareprogram.ca/53/Resources_By_Wound_TypeTopic

Step 5: Evaluate Outcomes

Discussion: Determine the effectiveness of interventions and reassess if healing is not occurring at the expected rate and if the goals the team has set have not been met or have been only partially met. Assess the wound and periwound regions to identify rate of healing and determine if the treatment approach is optimal.

Recommendations
5.1 Determine if the outcomes have met the goals of care

Discussion: The overall goal is to assist patients and their care partners in maximizing their rehabilitation potential. Progress toward achieving established goals is monitored with the patient, documented using standardized patient assessment tools and communicated to the appropriate team members. The responses observed in the patient's surgical wound are compared with the responses specified in the stated goals and expected outcomes. The patient and families and care partners should participate in decision-making and evaluation. The effectiveness of the interventions must be determined by a clinician who has the knowledge and skills to assess.

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

Discussion: A healable wound that is not responding to the treatment plan needs reassessment. Has the cause of the wound been addressed? What host factors are contributing to delayed healing?[15,124,132] Is the treatment optimal for the situation? When wound healing is not feasible, assess whether the treatment is preventing infection and deterioration, decreasing dressing frequency, managing pain and improving the patient's quality of life, where possible.[124,132]

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Discussion: Primary care physicians, nurse practitioners and visiting health-care professionals should recognize wound complications and immediately communicate and/or refer the patient back to the surgeon. However, it is patients and their care partners who are the first line of defence in preventing and identifying complications. As per Step 4.4, informational materials should be available for the patient and caregiver and discussed both before (if possible) and following surgery. This is essential so patients can prepare appropriately. They will need time to make adjustments to their environment, activities, nutrition, working lives, support system and more.

Outpatient clinics' and surgeons' time are important resources that should be optimized so that follow-ups for patients whose situation warrants it can be done in a timely manner, possibly avoiding unscheduled trips to hospital emergency departments.

Conclusion

While advances have been made in infection control practices, including improved operating room ventilation, sterilization methods, barriers, surgical technique and availability of antimicrobial prophylaxis, SSI remains a substantial cause of morbidity, prolonged hospitalization and death.[71,114] Therefore, the prevention and management of surgical wound complications remains an area of concern for patients, health-care professionals and administrators alike. Especially in these times of rationalization of health-care dollars, it is important to ensure that patients receive appropriate screening and care, beginning at the pre-operative assessment and continuing through to post-operative care and monitoring in the community.

The best practice recommendations presented in this chapter synthesize these resources and, when combined with evidence-informed interventions found in the discussions, should help clinicians develop the knowledge and skills needed to identify those at risk for complications and develop plans in collaboration with their patients to ensure a best practice approach to reduce the incidence of surgical wound complications.

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