Best Practice Recommendations for the Prevention and Management of Open Surgical Wounds

Heather L. Orsted, RN, BN, ET, MSc; David H. Keast, MD, MSc, FCFP; Janet Kuhnke, BSN, MS, ET; Pamela Armstrong, BN; Edie Attrell, RN, BN, ET; Maryse Beaumier, MSc; Stephan Landis, MD, FRCPC; James L. Mahoney, MD, FRCPC; Michelle Todoruk-Orchard, RN, MN, ET, CDE, CNS

Introduction

Open surgical wounds are a significant health issue, and surgical site infections (SSIs) are the third leading cause of hospital-acquired infections in Canada.[1] For inpatient surgeries, shorter hospital stays, patients with more challenging illnesses and more complex surgical procedures have all contributed to an increase in SSIs. However, since it is estimated that 75 per cent of surgical procedures are performed on outpatients, the detection of SSIs in the community is also of concern.[2,3] The most common reasons for a community nursing visit in the province of Ontario are post-operative wound infections and cellulitis, and surgical wound care accounts for as many as 50 per cent of these visits.[4] Recognition of the potential for surgical wound infection may be the most important issue to address when discharge planning for a post-surgical patient; despite this, there is often no formal relationship between in-hospital and community surveillance.[5]

The following 12 best practice recommendations provide the clinician with a synthesis of practice-based evidence, as identified in the National Institute for Health and Clinical Excellence (NICE) clinical guideline for Surgical Site Infection Prevention and Treatment of Surgical Site Infection[6] and several Registered Nurses' Association of Ontario (RNAO) best practice guidelines,[7] as well as many clinical papers that address key prevention and management issues regarding open surgical wounds. The NICE guideline was reviewed independently by a team of Canadian wound care clinicians using the Appraisal of Guidelines Research and Evaluation (AGREE) instrument[8] and rated an average score of 83/92. Areas of weakness noted in the NICE guideline were a lack of mention that a pilot had been implemented, and the fact that organizational barriers, implementation strategies and monitoring were not well discussed.

The 12 recommendations presented here are graded using the levels of evidence identified in either the RNAO best practice guidelines (Table 1) or the NICE guideline (Table 2).

These *Best Practice Recommendations for the*

To view Tables 1, 2 and 4 and the references for this article, please visit the CAWC website at www.cawc.net. Click on *Wound Care Canada*, under Professional Education.

Prevention and Management of Open Surgical Wounds have been developed for the Canadian Association of Wound Care (CAWC) and follow a format similar to previous best practice recommendations.[9] A summary of the 12 recommendations is listed in Table 3, followed by an algorithm designed to assist in clinical decision-making (Figure 1).

Recommendation 1: Complete a holistic assessment to identify factors that may affect surgical wound healing in the pre-operative, intra-operative and post-operative phases (NICE level 2+; RNAO level IV).

Pre-operative risk factors

The pre-operative phase is a critical time, offering the opportunity to create an environment that prevents complications such as open surgical wounds. The literature focuses on reducing the risk of SSIs by completing a detailed history and physical examination. Such a pre-operative assessment should focus on the patient's general health and comorbid conditions; glycemic control; recent weight loss or gain; overweight or obesity category[10]; physical activity level; present and past smoking history; and previous experience with anesthetic.

Smoking is a risk factor for SSIs and should be screened for in the pre-admission phase. Pre-operative smoking cessation is recommended to prevent wound dehiscence.[11]

Obesity has also been found to increase the risk of SSIs. In one study, 54 per cent of patients with SSIs had a body mass index (BMI) ≥25 kg/m2 and 23 per cent had a BMI ≥30 kg/m2, indicating a high rate of obesity in the study population.[12]

Generally, a surgical patient's pre-operative health status can be described as a continuum[13]:

- **Healthy ► mild systemic disease:** no functional limitations
- ► **Systemic disease:** limits activity but not incapacitating
- ► **Systemic disease:** constant threat to life
- ► **Moribund:** not likely to survive 24 hours
- ► **Emergency:** cannot fully assess physical status

If the surgery required is urgent, pre-operative assessment should focus on the body system immediately involved. For example, risk factors for sternal wound infections (osteomyelitis or wound dehiscence) following cardiac surgery include the following[14]:

- Diabetes mellitus
- Obesity
- Renal failure
- Use of internal mammary artery grafts
- Re-exploration of wound
- Prolonged ventilation
- Use of blood products
- Duration of operation

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.

Intra-operative risk factors

Several factors are significant during the intra-operative period, including the length of the procedure and the type of surgery (i.e., clean; clean surgery involving placement of a prosthesis or implant; clean-contaminated; contaminated; or dirty and infected).

Post-operative risk factors

Many factors in the post-operative period relate to the care and management of the surgical wound. One common factor in SSIs is the inappropriate use of cleansers (e.g., toxic antiseptics) and wound dressings that may hinder healing.

Recommendation 2: Create a treatment plan to eliminate or reduce factors that may affect surgical wound healing in the pre-operative, intra-operative and post-operative phases of care (NICE level 2+; RNAO level IV).

Strategies that promote timely healing of surgical wounds are essential in all phases of care. An interdisciplinary team approach can identify and minimize risk factors that cause open surgical wounds.

Some of the risk factors identified in the Centers for Disease Control and Prevention guideline include the following[2,3]:

- Coincident remote site infections
- Colonization
- Diabetes
- Cigarette smoking
- Systemic steroid use
- Obesity
- Extremes of age
- Poor nutritional status
- Peri-operative transfusion of certain blood products

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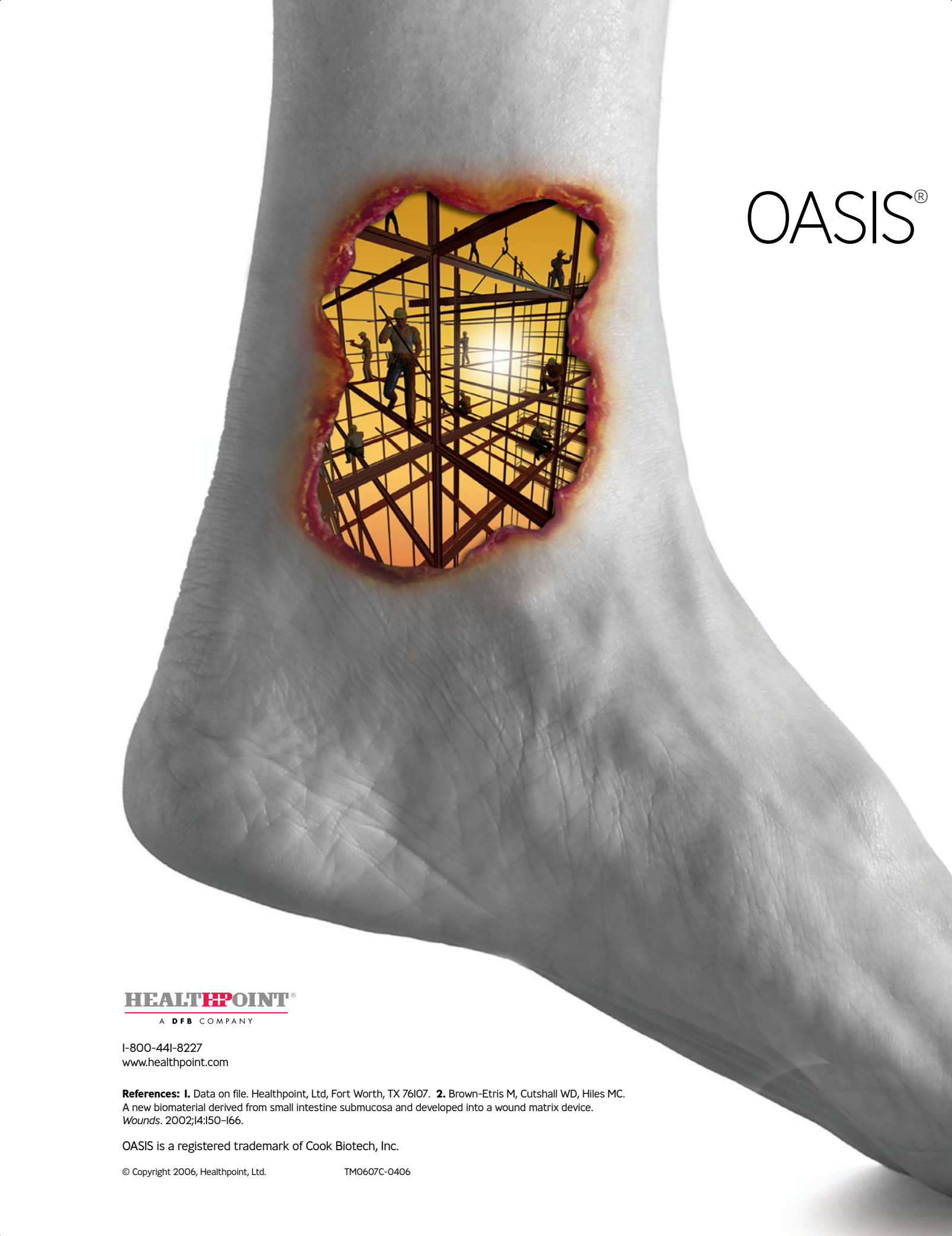

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References: 1. Data on file. Healthpoint, Ltd, Fort Worth, TX 76107. **2.** Brown-Etris M, Cutshall WD, Hiles MC. A new biomaterial derived from small intestine submucosa and developed into a wound matrix device. *Wounds*. 2002;14:150–166.

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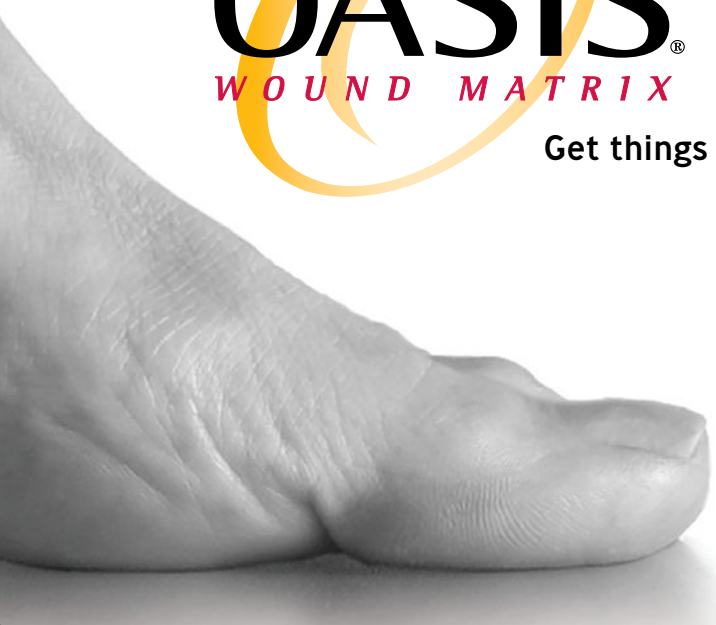

Pre-operative strategies

Pre-operative treatment plans can reduce the risk of a surgical wound failing to heal in a timely manner and potentially leading to a wound dehiscence, SSI or an open surgical wound. Plans in the pre-operative phase may include smoking cessation, review of physical activity levels, obesity assessment and education about glycemic control, as needed. Pre-admission nursing staff, family physicians, diabetes educators and pharmacists can all play a role in patient education and pre-operative discussions.

Recommendations for SSI reduction during the pre-operative phase include the following[6]:

- Asking patients to have a shower, bath or bed bath the day before or the day of surgery. Showering is generally preferable to bathing, as it is less likely to result in the transfer of organisms from highly colonized sites (such as the perineum) to less colonized sites[15]
- Pre-operative planning of hair removal using electric clippers with a single-use head on the day of surgery

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TABLE 3

Quick Reference Guide for the Prevention and Management of Open Surgical Wounds

	Recommendation	Strength of evidence NICE/RNAO
Cause		
1	Complete a holistic assessment to identify factors that may affect surgical wound healing in the pre-operative, intra-operative and post-operative phases	NICE level 2+ RNAO level IV
2	Create a treatment plan to eliminate or reduce factors that may affect surgical wound healing in the pre-operative, intra-operative and post-operative phases of care	NICE level 2+ RNAO level IV
Patient-centred concerns		
3	Include the patient, family and/or caregiver as members of the team when developing care plans	NICE level 4 RNAO level IV
4	Educate the patient, family and/or caregiver to optimize surgical wound healing	RNAO level IV Local wound care
5	Assess the surgical wound and document findings using a standardized approach	RNAO level IV
6	Debride the surgical wound of necrotic tissue	RNAO level Ib
7	Rule out or treat a surgical site infection	NICE level 4 RNAO level IIa
8	Provide optimal local wound moisture balance to promote healing by choosing an appropriate dressing for the acute and chronic phases of surgical wound healing	NICE level 1+ RNAO level IV
Re-evaluation		
9	Determine the effectiveness of interventions and reassess if healing is not occurring at the expected rate. Assess the wound edge and rate of healing to determine if the treatment approach is optimal	RNAO level IV
10	Consider the use of adjunctive therapies and biologically active dressings	NPWT: RNAO level IV ES: RNAO level Ib HBOT: RNAO level IV
Organizational concerns		
11	Recognize that surgical wound healing requires a team approach	NICE level 4 RNAO level IV
12	Implement a surgical site surveillance program that crosses clinical setting boundaries	NICE level 4 RNAO level IV

ES = electrical stimulation • HBOT = hyperbaric oxygen therapy • NICE = National Institute for Health and Clinical Excellence
NPWT = negative pressure wound therapy • RNAO = Registered Nurses' Association of Ontario

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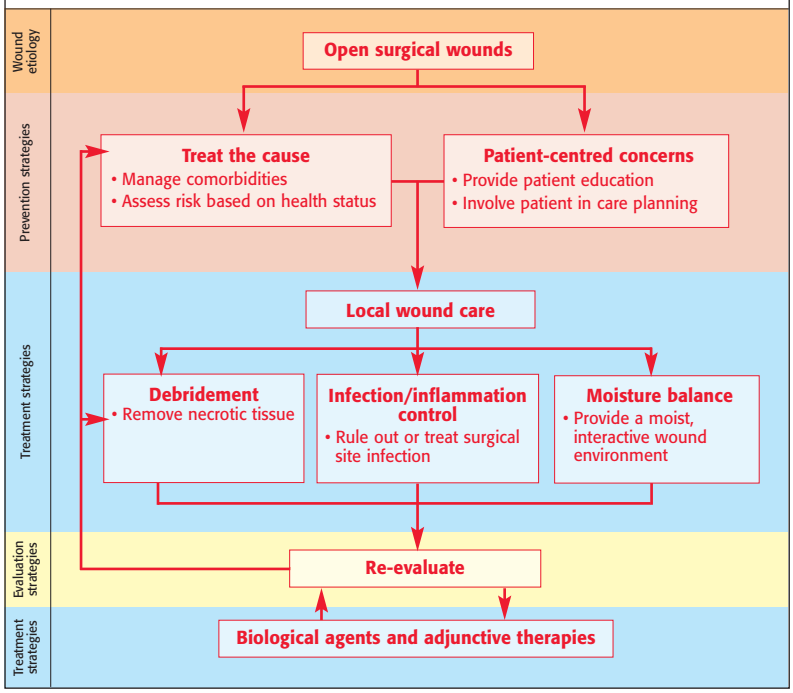
FIGURE 1

Pathway to the Prevention and Management of Open Surgical Wounds



- Having patients wear standard surgical clothing that maintains their dignity and comfort and allows surgical staff to provide intravenous access

Pre-operative nasal decontamination to reduce *Staphylococcus* is not done routinely; neither is mechanical bowel preparation.[6]

Prophylactic antibiotics may be indicated pre-operatively (Table 4). The delivery of antimicrobial prophylaxis includes:

> ...intravenous antimicrobial prophylaxis one hour before incision (two hours are allowed for the administration of vancomycin and fluoroquinolones); use of an antimicrobial prophylactic agent(s) consistent with published guidelines; [and] discontinuation of use of the prophylactic antimicrobial agent within 24 hours after surgery (discontinuation within 48 hours is allowable for cardiothoracic procedures for adult patients).[16]

Intra-operative strategies

During the intra-operative phase, surgical teams can also employ strategies to reduce SSIs. Staff should wear specific non-sterile theatre clothing in all areas where operations take place, keeping their movements in and out of the operating room to a minimum.[6] Staff protocols should include the removal of all hand jewellery, artificial nails and nail polish before operations.[6]

Two pairs of sterile gloves should be worn when the risk of contamination is high, or when the risk of glove perforation and the consequences of contamination are serious. Antiseptic skin preparations such as povidone-iodine or chlorhexidine are recommended for skin preparation at the surgical site.[6]

The use of iodophor-impregnated drapes during surgery may be considered; non-iodophor-impregnated drapes may increase the risk of SSIs.[6] However, more research is needed to determine the cost-effectiveness of disposable versus reusable drapes; technological developments in the materials used to make both reusable and disposable operative drapes and gowns may reduce the incidence of SSIs.[6]

Intra-operative patient homeostasis issues include keeping the patient warm, maintaining supplemental oxygen in the recovery room, and maintaining a hemoglobin saturation rate of 95 per cent during the operation and in the immediate post-operative period.[6] Proper hydration during the peri-operative period is warranted, although further research is required to demonstrate whether supplemental fluids reduce the risk of SSIs.[6]

Surgical wounds should be covered with an appropriate interactive dressing at the end of surgery[6] and the patient referred to the team wound care nurse/clinician.

Post-operative strategies

Post-operative surgical teams that provide wound care and dressing changes for patients should receive education and support in order to provide care that reflects best practices.[6] Education for surgical staff should include the use of aseptic non-touch technique for changing or removing surgical wound dressings.[6] Sterile saline is recommended for wound cleansing 48 hours after surgery, and showering is permitted 48 hours after surgery.[6]

For wounds that are healing in a normal, timely manner, topical antimicrobial agents are not required. For wound healing by secondary intention, interactive wound products should be used. Patients should be referred to the team wound care clinician or nurse for

specialized decision-making regarding the best wound care product choice.[6]

The goals of wound dressing products are to provide a moist wound bed, protect the open wound bed from trauma or potentially harmful agents, manage drainage/exudate and manage infection. Knowledge of wound care products and their appropriate use, as well as the phases of wound healing and use of products on wounds healing by secondary intention, is crucial. "The skills, knowledge and attitudes of health-care professionals can have a major impact on their ability to assess the complexity of a wound, control a patient's symptoms and manage associated problems."[17]

Pain assessment should be part of routine care: "A standard pain assessment should be considered before and after physical activities and other aspects of patient care, medication or treatment."[18] For patients with open surgical wounds, comfort is paramount to support the activities of home and work life while supporting the patient psychosocially. Psychosocial factors such as anxiety, depression, social isolation, low economic status and pain are all associated with delayed wound healing.[19] It is crucial that staff and wound care team members understand the phases of normal wound healing and wound healing in the presence of complications.

An intensive enhanced infection-control program involving a unified, multidisciplinary approach by senior surgical, (ward) nursing, infection control and management staff has been shown to lead to fewer methicillin-resistant *Staphylococcus aureus* (MRSA) infections in cardiothoracic patients.[20] These findings included significant decreases in both the number of patients acquiring MRSA on the ward and in the rate of bloodstream MRSA infections.[20]

To prevent post-operative wound dehiscence, consider prompt post-operative nutritional support.[11]

Figure 2 outlines four main factors that may affect hard-to-heal wounds. This algorithm outlines the relationships between patient-, wound-, health-care professional- and resource/treatment-related factors and supports clinicians in recognizing the complexity of wounds.[21]

Recommendation 3: Include the patient, family and/or caregiver as members of the team when developing care plans (NICE level 4; RNAO level IV).

Patient involvement in care

To promote prevention strategies and participation with respect to open surgical wounds, it is important to involve patients, families and caregivers in all phases of care. "Patient-centred care" is a term often used by health-care professionals, but how can we ensure that this occurs in practice? The Institute of Medicine defines patient-centredness as health care that establishes a partnership among practitioners, patients and their families. Patient-centred care ensures that decisions respect patients' wants, needs and preferences, and that patients have the education and support they require to make decisions and participate in their own care. Diagnoses, prognoses and treatment plans are no longer confidential and for "professional eyes only." The patient and family must be engaged in care.[22]

Patient-centred care includes a holistic assessment, including identifying beliefs and values such as "respect, human dignity, [that] clients are experts for their own lives, clients as leaders, clients' goals coordinate care of the health care team, continuity and consistency of care and caregiver, timeliness, [and] responsiveness and universal access."[23]

Patient-centred care also involves "advocacy, empowerment, and respecting the client's autonomy, voice, self-determination and participation in decision-making."[24] Each patient must be understood and approached as a unique human being.[25] Establishing therapeutic relationships requires an understanding of diversity, the person, his or her health or illness and the broad influences on health care and health-care policy in systems.[23] Frameworks for therapeutic relationships with patients and their foundational values and beliefs need to be expressed and embedded in care plans for patients with open surgical wounds. "Offering patients and [caregivers] clear, consistent information and advice throughout all stages of their care ... including the risks of SSIs, what is being done to reduce them and how they are managed" is a key priority.[6]

Core components of patient-centred care[26]

- *Dignity and respect:* listen to and honour patient and family perspectives and choices, and incorporate their knowledge, values, beliefs and cultural backgrounds into the planning and delivery of care.

- *Information sharing:* communicate and share complete and unbiased information in a timely and accurate way with patients and their families in ways that are affirming and useful.
- *Participation:* encourage and support patients and their families to participate in care and decision-making at the level they choose.
- *Collaboration:* patients, families, health-care practitioners and hospital leaders must collaborate in policy and program development, implementation and evaluation; health-care facility design; professional education; and the delivery of care.

Dignity and respect

As surgery-related procedures (including preparation, intervention, discharge and follow-up) involve shorter and shorter hospital stays, a trusting, positive relationship must be developed between the patient, the surgical team and any follow-up clinicians. Teaching hospitals provide many assets for patients, but also present many challenges, including the need to build relationships with a range of health-care professionals, including the surgeon, family doctor, nurses, anesthesiologist and technicians, as well as students from many disciplines. Patients need to know who the members of their surgical team are and the roles each play if they are to fully participate in the planning of their care.

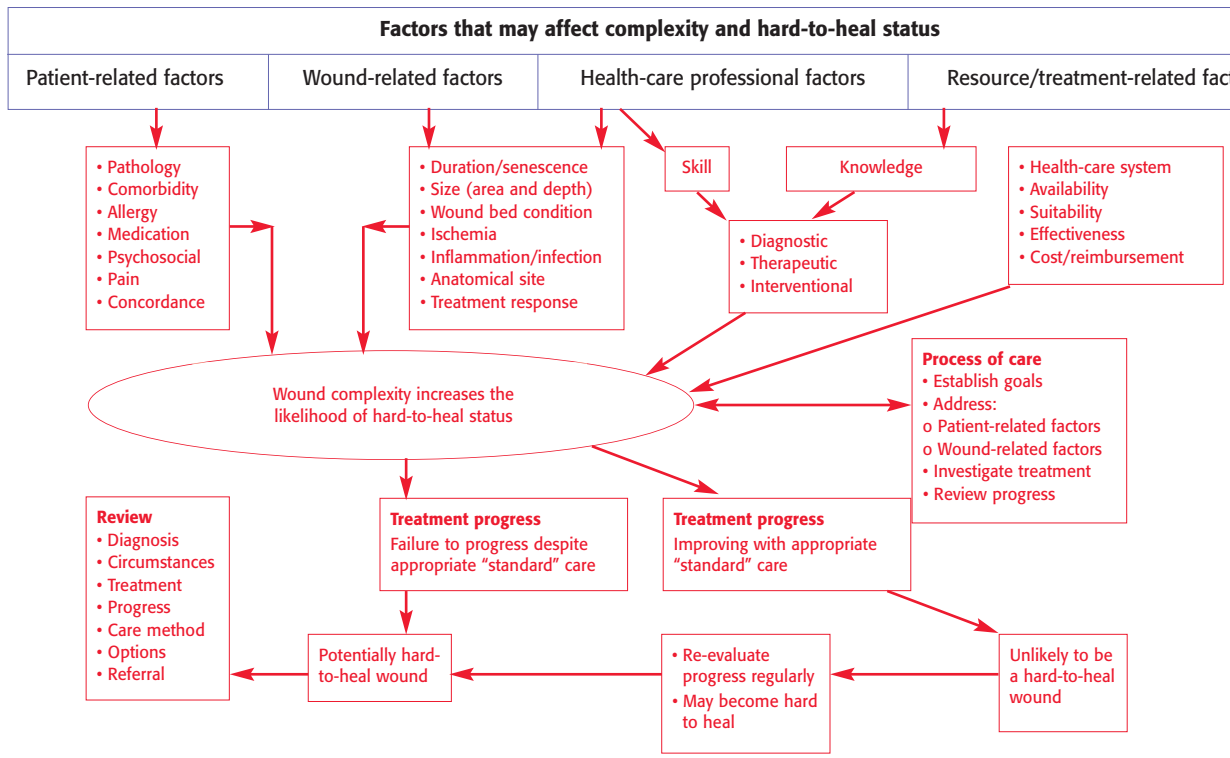
Patient involvement starts in the doctor's office, as soon as patients are made aware of the need for a surgical intervention. Patients can work with their family doctor, the surgeon and the pre-operative team for optimal pre-operative preparation to reduce post-surgical complications. Health-care professionals can help patients verbalize their wishes and set short- and long-term goals.

Information sharing

Communicating with patients requires that clinicians—regardless of discipline—be aware of factors that can

FIGURE 2

Predictors for Wound Healing[21]



Moffatt C, Vowden P. *Hard-to-Heal Wounds: A Holistic Approach*. London: MEP Ltd, 2008:1–17.

affect interactions, including disabilities (e.g., deaf, blind, mentally challenged); culture; gender factors; ethnicity; beliefs and spirituality; level of education; and literacy factors (jargon and medical lingo-speak). Patient stress and anxiety levels, conflict over roles, physical factors such as pain, intimacy issues, geography, travel and access to care issues and the personalities and perceptions of both the patient and the health-care professional all add to the communication challenges.

Poor, ineffective communication creates an environment of misunderstanding and miscommunication, as well as errors and patient safety issues, lack of disclosure, poor participation of patients and families, compliance failure, poor outcomes and increased liability.

A clinician's role in communicating effectively with patients can be broken down into a process that includes the following tasks[27]:

- *Engagement:* creates a connection between the clinician and patient and sets the stage for the establishment of a partnership. Barriers to engagement on the part of the clinician include the failure to introduce oneself, inquisition-type questioning and interruption of the patient's story.
- *Empathy:* occurs when a patient feels that he or she has been seen, heard and accepted.
- *Education:* allows for the cognitive, behavioural and effective needs of the patient to be addressed. Research shows that clinicians overestimate the time spent in the education of their patients by nine times. In reality, approximately one minute is actually spent on this crucially important task. Poor education of patients is a product of poor communication skills on the part of the clinician.
- *Enlistment:* occurs when the clinician invites the patient to collaborate in decision-making regarding the problem and the treatment plan.

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Participation

To enable and empower patients to be active participants of care, the National Patient Safety Foundation suggests three questions that patients should ask at their visits with health-care providers.[28] The questions that constitute the "Ask Me 3" model are:

- What is my main problem?
- What do I need to do about it?
- Why is it important for me to do this?

Recent studies show that the Ask Me 3 model adds structure to provider-patient communication and increases patient satisfaction with each visit.[28] It also decreases the number of missed visits and reduces the number of callbacks (patient calls for clarification or more information).[28] By taking an active role in the management of their illness, patients tend to feel empowered and motivated to work with their health-care professional. Despite the concerns of many health-care providers, this interaction did not add significant time to the length of patient visits.[28]

Collaboration

Once a relationship is established, a cooperative approach to planning care can occur. Care plans must be[22]:

- Safe: avoiding injuries from care.
- Timely: care is provided in a timely fashion, thereby reducing waits and delays.
- Efficient: care needs to avoid waste of resources (human, financial and time).
- Effective: care needs to be based on evidence.
- Equitable: care does not vary in quality due to personal characteristics.
- Patient-centred: care should be focused on the individual needs of the patient (physical, emotional, social and spiritual).

Achieving a good dialogue

- Allow time for questions in your patient interaction.
- Use open-ended questions. Instead of asking "Do you have pain?" say to the patient, "Describe your pain."
- Allow for pauses for reflection between questions.
- Encourage engagement and maintain good non-verbal communication, such as appropriate eye contact.
- Avoid cultural stereotyping.
- Confirm the information you have received from your patient and the information he or she is getting from you.

In joint care plan development, it is important that the health-care professional identifies and addresses any problems affecting the patient's health-related quality of life (e.g., wound pain, exudate leakage or odour). Dialogue should revolve around:

- Asking questions related to health-related quality of life.
- Identifying important influencing factors (e.g., wound pain).
- Addressing influencing factors (e.g., treat pain, support faster wound healing, manage exudate) by using the best possible treatments available.

Both health-care professionals and patients must take responsibility for doing all they can to support a holistic, integrated approach to care, working together to enable the best possible surgical outcomes.

Recommendation 4: Educate the patient, family and/or caregiver to optimize surgical wound healing (RNAO level IV).

To ensure optimal healing, patients, families and/or caregivers require information[6]:

- Offer patients, families and caregivers clear, consistent information and advice throughout all stages of care. This should include the risks of SSIs, what is being done to reduce them and how they are managed.
- Offer patients, families and caregivers information and advice about how to care for the wound after discharge.
- Offer patients, families and caregivers information and advice about how to recognize an SSI and who to contact if they are concerned. Use an integrated care pathway for health-care-associated infections to help communicate this information to patients and all involved in their care after discharge.
- Always inform patients after their operation if they have been given antibiotics.

Evidence from a single randomized controlled trial has suggested that education provided before discharge does not improve patient self-diagnosis.[6] The NICE

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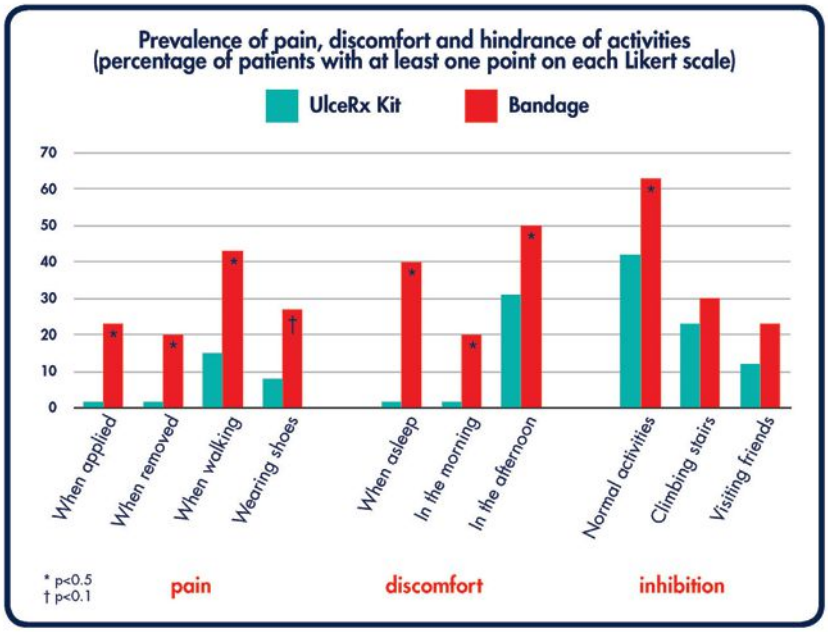

Source: The treatment of venous leg ulcers with a specially designed compression stocking kit. F. Mariani, et al. Phlebologie 2008; 37: 191-197. September 2008.

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panel noted that there is insufficient evidence to determine the specific information that should be given to patients and caregivers and how it should be provided to reduce the risk of SSIs. Nevertheless, the panel agreed that it was preferable to deal with an overestimation of cases than with an underestimation.[6] At a minimum, patients and caregivers should be provided with information and advice about the risks of SSIs associated with their particular type of procedure.[6]

A search of the Canadian Medical Association and Ontario MD websites for patient information on SSIs found only one information pamphlet for patients and caregivers regarding incision care, published by the American Academy of Family Physicians.[29] The handout advises patients that the edges of a healing incision may be slightly red. It goes on to explain that redness is normal, but that they should call their doctor if the redness increases or if it spreads more than half an inch from the wound. Patients are also advised to call their doctor if they see pus in the incision or if the incision is more than mildly tender or painful.

Information for patients and caregivers should be written in plain language and, in areas with large non-English-speaking populations, instructions should be made available in other languages. Furthermore, pamphlets or discharge instructions should not be simply handed to patients as they leave; instructions should be reviewed with them, and they should be given an opportunity to ask questions and provide feedback to ensure that the instructions have been understood. Patients on discharge should receive clear instructions about who to call should complications arise. If someone other than the surgical team is to be called, the discharge team must ensure that the discharge clinician responsible is aware of the discharge and has guidelines for when to refer to the surgical team.

Recommendation 5: Assess the surgical wound and document findings using a standardized approach (RNAO level IV).

A comprehensive wound assessment approach provides baseline data and identifies subtle changes that may indicate early signs of infection and, in turn, support timely, appropriate interventions. From the removal of the initial dressing through to closure/healing, peri-wound tissue, the wound bed and exudate should be assessed using a standardized wound assessment tool or wound scoring system.

Assessment of most surgical wounds should begin 48 hours after surgery. The operating room dressing should remain over the wound for the first 48 hours, and it should be reinforced if breakthrough drainage occurs.

As well, since many post-operative infections occur after discharge from acute care, careful and thorough assessment and follow-up in the community is essential.[5]

Early signs of infection in an acute wound can include serous exudate with erythema, swelling with an increase in exudate volume, edema, increase in local skin temperature and unexpected pain or tenderness.[30]

Surgical wound assessment: three steps

The three steps below provide a systematic approach to wound assessment and treatment.[7]

Step 1: What are you seeing?

The following parameters identified in the "MEASURE" mnemonic should be included in the wound assessment and may help clinicians connect in a common language when monitoring a wound (Table 5).

Step 2: When are you seeing it?

It is equally important to note when to look for changes in the surgical wound. Table 6 shows outcomes and expected time frames for unwanted results of surgical wound healing.

Step 3: What should you consider if you see it?

Early recognition of alterations in healing will support early intervention to return the patient to a healing trajectory (Table 7).

Recommendation 6: Debride the surgical wound of necrotic tissue (RNAO level Ib).

There is remarkably little discussion of surgical wound debridement in the literature. Several small studies exist, but they provide insufficient evidence to recommend a specific debridement technique for the removal of necrotic tissue from surgical wounds.[6] Many of the trials are old and the materials used do not reflect the under-

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[1]*Meaume S, Téot L, Lazareth I, Martini J, Bohbot S. (2004). The importance of pain reduction through dressing selection in routine wound management: the MAPP study. J Wound Care, 13(10), 409-413.*

TABLE 5

MEASURE for wound assessment[31]

Measurement of the wound	• Provides baseline data even if the incision line is well approximated • Measure the length of the incision and width of the approximated edge
Exudate quality and amount	• Colour, amount, consistency and odour (if present) • Drainage should diminish within three to four days • Signs of increasing bioburden may include increased serous exudates; purulent drainage; colour change from clear serous to opaque yellow; odour
Appearance of wound bed	• Tissue in the wound bed: quality, type and amount; epithelial tissue; granulation tissue; and presence of slough or necrotic tissue
Suffering	• Complete a pain assessment; note type, quality and degree of pain • Use a pain assessment tool to support consistent communication between patient and caregiver
Undermining	• Identify whether there is tunnelling or undermining, and measure the amount
Re-evaluation	• Too-frequent assessment may lead to inappropriate changes in the treatment plan, while infrequent assessment may miss significant deterioration • Most authors support formal assessment every two to four weeks • A 30 per cent reduction in wound surface area has been shown to be predictive of healing in 12 weeks, but this study was based primarily on venous and diabetic foot ulcers[32]
Edge of the wound	• Assess disruption of the approximated edge (gaps in the suture line). If dehiscence occurs, depth is added to the length × width measurement • Description of the peri-wound tissues should include colour, temperature and presence/location of edema or induration • Induration along both sides of the suture line may be expected, and may be a healing ridge[31]

Keast DH, Bowering K, Evans W, et al. MEASURE: A proposed assessment framework for developing best practice recommendations for wound assessment. *Wound Repair Regen.* 2004;12(3 suppl):S1–S17.

lying principles of modern wound management and debridement techniques.[6] Eusol and gauze, dextranomer or enzymatic treatments should not be used for debridement in the management of SSIs.[6]

The removal of necrotic tissue will help to reduce bacterial burden in the management of open surgical wounds. Clinical experience has also shown that the removal of infected foreign bodies (e.g., retained sutures and infected mesh in the base of the wound) may improve healing outcomes. Before clinicians embark on the debridement of chronic wounds, however, they must first ensure that they have the necessary skills to perform the task; that the skill is within their scope of practice; and that an agency or institutional policy is in place to support them. With surgical wounds, the clinician must be able to identify anatomical structures present in the wound before proceeding with any form of debridement.

A discussion of general debridement techniques for chronic wounds can be found in the CAWC *Best Practice Recommendations for Wound Bed Preparation*[35] and *Best Practice Recommendations for Preparing the Wound Bed: Update 2006*.[36] Both of these documents remain valid, and their principles may be applied to non-healing surgical wounds.

- Dressing selection should promote autolytic debridement where appropriate.
- Irrigation at safe pressures with appropriate irrigating fluids will help to mechanically debride, flush loose necrotic material and dilute toxins. When irrigating wounds, it is important to ensure that the majority of the irrigating fluid is recovered and that the staff member wears protective clothing as required.
- Conservative sharp debridement of surface necrotic material is a fast and effective method, provided it is within the clinician's skill level and scope of practice, and that the wound care team can provide care after the sharp debridement. More extensive debridement should be carried out only by the surgical team or by

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TABLE 6

Recognizing Unwanted Results of Surgical Wound Healing[33,34]

Outcome measure	Days 1–4 New wound	Days 5–9 Healing	Days 10–14 Proliferative healing	Day 15 to years 1–2 New skin forming
Incision	Red; edges approximated, but tension evident on incision line	Red; edges may not be well approximated; tension evident on incision line	May remain red, progressing to bright pink	Prolonged new skin formation, keloid or hypertrophic scar formation
Surrounding tissue inflammation	No signs of inflammation present: no swelling, no redness or skin discolouration, no warmth and minimal pain at incision site; hematoma (bruise) formation	Swelling, redness or skin discolouration; warmth and pain at incision site; hematoma (bruise) formation	Prolonged inflammatory response with swelling, redness or skin discolouration; warmth and pain; hematoma (bruise) formation	If healing, may be stalled at a plateau with no evidence of healing and continued signs of redness, pus, heat or coolness, pain or numbness
Drainage type	Bloody, progressing to yellow/clear	Red-tinged/yellow and pus	Any type of drainage (pus) present	Any type of drainage (pus) present
Drainage amount	Moderate to minimal	Moderate to minimal	Any amount present	Any amount present
Closure materials	Present, may be sutures or staples	No removal of any external sutures/staples	Sutures/staples still present	For secondary intention healing, failure of wound contraction or edges not approximated
New skin	Not present along entire incision	Not present along entire incision	Not present along entire incision, opening of incision line	Not present or abnormal skin appearance, such as keloid or hypertrophic scarring
Healing ridge	None present	Not present along entire incision	Not present along entire incision, opening of incision line	Abscess formation with wound left open to heal slowly

Brown P. *Quick Reference to Wound Care*, 3rd edn. Sudbury, ON: Jones & Bartlett, 2009. Bates-Jensen BM, Wethe J. Acute surgical wound management. In: Sussman C, Bates-Jensen BM (eds). *Wound Care: A Collaborative Practice Manual for Physical Therapist and Nurses*, 2nd edn. New York: Aspen Publishers, Inc., 1998:219–234.

persons with the appropriate skill level. Sharp debridement requires that appropriate analgesia be provided to the patient before, during and after the procedure, and that the setting allow for the achievement of hemostasis.

- In some centres, maggot therapy may be employed to debride dehisced surgical incisions, but this therapy is not commonly used in Canada.

Recommendation 7: Rule out or treat a surgical site infection (NICE level 4; RNAO level IIa).

Managing an SSI in an open surgical wound requires an interdisciplinary team approach that often includes infectious disease practitioners. SSIs in open surgical wounds are the second leading cause of nosocomial infections, accounting for almost 20 per cent of hospital-related infections. One Canadian retrospective review from an Ontario teaching hospital found that wound infections increase hospital-related nursing costs by up to 50 per cent and inpatient hospital costs directly related to the wound by almost $4,000 per infection.[37]

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.[2,3,38]

Risk factors

The risk of developing an SSI is determined by the nature of the surgical procedure; the size and virulence of the microbial inoculums; and the integrity of the individual's host defences. Whether an SSI develops is dependent upon how these factors interact.[39]

Patients at highest risk for an SSI include those with one or more of the following:

- Multiple comorbidities
- Smoking history
- Poor nutritional status
- Emergent (vs. elective) surgery
- Implants (vs. no implants)
- Clean (vs. dirty) surgery
- Complex hospitalizations

Knowing which patients are at risk for an open surgical wound, what to look for and recognizing the signs and symptoms as early as possible are crucial in order to implement appropriate treatment.

Classification

Surgical wounds can be classified as follows[40]:

- Clean: the surgical procedure does not enter into a normally colonized viscus or body lumen, and there are no breaks in surgical technique (one to two per cent infection rate).
- Clean-contaminated: the procedure enters into a colonized viscus or body cavity, but under elective or controlled conditions (six to nine per cent infection rate).
- Contaminated: there is gross contamination at the surgical operative site in the absence of clinical infection, or there are breaks in surgical technique (13–20 per cent infection rate).
- Dirty-infected: active infection is already present during the surgical procedure (40 per cent infection rate).

The use of routine peri-operative antibiotics reduces post-operative infection rates, primarily in the contaminated and infected categories.[41,42]

TABLE 7

Triggers for Action

General issues	Practice considerations
Recognize when the normal inflammatory process becomes abnormal	Concern if there is any redness/inflammation around the wound lasting several days, if the inflamed tissue is warmer than the surrounding area and if pain is noted. Mark the edge of inflammation with a marker and measure to support communication between staff members as to whether the "redness" has increased or decreased
The level of suspicion should be raised if more than one indicator of infection is present	Concern when pain begins or increases around the wound area in conjunction with other signs of inflammation/erythema several days after surgery
The presence of pus is an immediate indicator of infection	Any discharge from the wound 48 hours after surgery requires further investigation. Offensive-smelling discharge is a clearer indication of infection. Discharge due to infection is most common around five to 10 days post-surgery. If the patient is discharged prior to this, ensure teaching occurs
When the wound fails to heal or where there are disturbances to the normal healing process, further investigation is required	Assess potential causes for failure other than infection prior to a diagnosis of infection
To define infection, use validated tools (e.g., CDC definition)	Consistent use of a tool or system to assess infection is required

CDC = U.S. Centers for Disease Control

SSIs can be divided into three categories (Table 8).

In addition, SSIs can be acute (occurring within and lasting <30 days) or chronic (occurring after 30 days) (Table 9).[2,3] The respective clinical presentations are different, with differing long-term outcomes.

Treatment[43]

Acute SSI

Conceptually, SSIs rarely occur during the first 48 hours after surgery, and fever during this early period usually arises from noninfectious or unknown causes. Most SSIs occur within 30 days of surgery, or within one year if an implant has been inserted. The treatment of acute SSIs is shown in Table 10.

Chronic SSI

Managing a chronic SSI in an open surgical wound requires a team approach. The type of treatment is based upon the duration (generally more than one month) and location of the wound and the type of infection involved. Clear guidelines for the management of infection in a chronic open surgical wound are less well-defined, and usually rely upon expert opinion.

Generally, the clinician must identify and correct

TABLE 8

Categories of SSIs[2,3]

Category 1	Superficial incisional (involving skin and subcutaneous tissue); occurs within 30 days of operation • Involves only skin and subcutaneous tissue; • At least one of: – Purulent drainage; – Organism isolated from aseptically obtained culture; or – At least one of: pain or tenderness, localized swelling, redness or heat and the superficial incision is deliberately opened by the surgeon unless the incision is culture-negative. • Diagnosis of a superficial incisional SSI by surgeon or attending physician.
Category 2	Deep incisional (involving deep soft tissue, including fascia and muscle); occurs within 30 days of operation if no implant or within one year if implant in place. • Involves deep soft tissues (fascia and muscle layers) • At least one of: – Purulent drainage from deep incision; – Deep incision spontaneously dehisces or is deliberately opened by a surgeon when patient has at least one of the following: fever (>38° C) or localized pain unless incision is culture negative; – Evidence of infection (e.g., abscess) involving deep tissue found during direct examination, during re-operation or by histopathologic or radiologic examination; or – Diagnosis of a deep incisional SSI by surgeon or attending physician.
Category 3	Organ/space (involving any part of the body that does not include deep tissues, muscle or fascia, and that has been opened or manipulated during the surgical procedure); occurs within 30 days of operation if no implant, or within one year if implant in place. • Any part of body, excluding skin incision, fascia or muscle layers that is opened or manipulated during the operation. • At least one of: – Purulent drainage from a drain that is placed through a stab wound into the organ/space; – Organisms isolated from an aseptically obtained culture; or – Evidence of infection (e.g., abscess) involving organ/space found during direct examination, re-operation or by histopathologic or radiologic examination. • Diagnosis of an organ/space SSI by surgeon or attending physician.

SSI = surgical site infection

Mangram AJ, Horan TC, Pearson ML, et al. Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol.* 1999;20:250–78. Mangram AJ, Horan TC, Pearson ML, et al. Guideline for prevention of surgical site infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. *Am J Infect Control.* 1999;27:97–132.

the underlying surgical and non-surgical factors that have led to the infection. Further surgical intervention is frequently required, depending upon the surgical problem, usually to remove devitalized tissue or infected foreign material, close a fistula or ulcer space or drain/remove a sinus tract. Multiresistant microorganisms such as MRSA, other Gram-negative bacteria or even fungi may be involved. Long-term antibiotics are usually required, based on the antimicrobial susceptibility patterns of the isolated microflora. Rehabilitation is frequently needed as part of the recuperation phase.

Recommendation 8: Provide optimal local wound moisture balance to promote healing by choosing an appropriate dressing for the acute and chronic phases of surgical wound healing (NICE level 1+; RNAO level IV).

Moist wound healing is one of the cornerstones of evidence-based wound care in both the acute and chronic settings.[44–50] The advantages of moist wound healing include less intense and less prolonged inflammation; rapid keratinocytosis and increased fibroblast proliferation; an increased rate of collagen synthesis and epithelial cell migration, resulting in earlier angiogenesis; and faster contraction of full-thickness wounds.[45,46,49]

Acute surgical wounds

Acute wounds (including surgical wounds) are caused by external trauma to the human body and follow a systematic process of repair, progressing through vascular, inflammatory, proliferation and maturation stages of healing.[48,51]

Wounds with minimal tissue loss that are closed surgically heal by primary intention when the closure joins the wound edges, eliminating dead space and

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minimizing the need for new tissue formation.[51] These wounds generally heal with minimal scar formation. 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.[46]

Surgical wounds can be further classified into clean, clean-contaminated, contaminated or dirty-infected,[51] providing an indication of how the wound will heal. Delayed primary closure 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.[51] Surgical wounds described as dirty-infected, dehisced or ruptured heal best by secondary intention, where the wound is left open and heals when granulation tissue fills the wound from the base up.[51]

If an acute surgical wound fails to heal within 30 days, it becomes a chronic wound.[2,3]

Chronic surgical wounds

A chronic wound is defined as one that deviates from the expected sequence of tissue repair[48]; this may include infected or dehisced surgical wounds.

Chronic wounds do not always heal in a predictable fashion, due to a wide variety of host and local wound factors.[48] They are often described as being "stuck" in a prolonged inflammatory phase, in which the wound exudate is no longer beneficial and may in fact become harmful.[46,48] Chronic wound fluid shows higher levels of matrix metalloproteases, which may slow or block cell proliferation, degrade the wound matrix and contribute to the prolonged inflammatory stage.[46,48]

Dressing selection

Prior to the development of advanced wound products, gauze dressings were the primary wound dressings available and were changed frequently throughout the day. Although effective, gauze dressings can be very time-consuming for staff to apply and painful for the

TABLE 9

Acute versus Chronic SSIs

Acute SSI (<30 days)	**Symptoms:** localized heat, pain or tenderness, redness, swelling **Signs:** purulent drainage, fever (>38° C), spontaneous dehiscence (category 2 or 3), wound is deliberately opened by the surgeon or the surgeon confirms that an SSI is present • An abscess or other evidence of infection may be seen on direct examination or on histologic or radiographic assessment. Microorganisms are isolated from an aseptically obtained culture of fluid or tissue from the incision site • After 48 hours SSIs are more common sources of fever, and careful inspection of the surgical incision site is indicated. For patients with a temperature <38.5° C and without tachycardia, observation, dressing changes or opening the incision site suffices. For patients with a temperature >38.5° C or a heart rate ≥110 bpm, antibiotics are generally required, as well as opening of the suture line • Infections that develop after surgical procedures involving non-sterile tissue—such as colonic, vaginal, biliary or respiratory mucosa—may be caused by a combination of aerobic and anaerobic bacteria. These infections can progress rapidly and involve deeper structures than the skin (e.g., fascia, fat or muscle) • If the SSI is successfully managed, healing will resume and the long-term outcome is excellent
Chronic SSI (>30 days)	**Symptoms:** pain, decline in function; fever may be absent, with normal vital signs **Signs:** lack of healing of an acute SSI, unresolved dehiscence, new sinus or fistula formation, persistent wound drainage, presence of a foreign body or devitalized tissue, poor local vascularity, persistent odour, absence of healing or infected prosthetic implant • The features and extent of a chronic SSI depend upon the nature of the surgical procedure and which systems were involved (i.e., gastrointestinal, gynecological, orthopedic, neurological surgery or sternotomy). A chronic infection is more likely to be associated with a persistently open surgical wound

SSI = surgical site infection

TABLE 10

Treatment of Acute SSIs[43]

Time	Action
<48 hours after procedure	• Overall, an SSI is unlikely at this time. Look for symptoms and signs • True soft-tissue emergencies are necrotizing clostridial or mixed anaerobic cellulitis, or streptococcal necrotizing fasciitis. In this situation, the most important management steps include the following: – Urgent surgical consultation – Administration of a first dose of empiric antimicrobial therapy, based on likely causative microorganisms – Consultation with a pharmacist and consider using: • Penicillin G + clindamycin • Cefazolin + metronidazole • Vancomycin + metronidazole
>48 hours after procedure	• Look for symptoms and signs • Open the wound, and culture for microorganisms • Consider ultrasound to rule out underlying abscess • For surgical procedures conducted above the waist (i.e., trunk, head, neck or upper extremities), consider the following antimicrobial therapy: – Cefazolin – Clindamycin – Vancomycin • For surgical procedures involving the abdomen, perineum, genitourinary tract or lower extremities, consider the increased likelihood of surgical site contamination with microbial flora originating from the gut ("fecal veneer"). Consider the following antimicrobial regimens: – Cefazolin + metronidazole (or clindamycin) – Clindamycin + ciprofloxacin – Vancomycin + metronidazole + ciprofloxacin

Stevens DL, Bisno AL, Chambers HF, et al. Practice guidelines for the diagnosis and management of skin and soft-tissue infections. *Clin Infect Dis.* 2005;41:1375–407.

patient; they have also been shown to lead to higher infection rates and can cause dispersal of significant amounts of bacteria into the air when the dressing is removed.[52,53] Additionally, gauze dressings allow the wound bed temperature to decrease, which can result in delayed healing.[53] A large body of evidence supports the use of advanced wound products.[47,53] Indeed, studies have consistently shown improved patient outcomes, decreased pain with dressing procedures and decreased overall costs when dressing product and human resource costs are factored into the equation.

Choosing a dressing that provides a moist wound healing environment has been shown to promote the growth of granulation tissue, prevent prolonged inflammation and provide protection and thermal regulation in both acute and chronic wounds.[45,46,54] Dressing selection for surgical wounds is determined by the type of closure (primary, delayed primary intention or secondary intention), as well as the amount of wound exudate. Consideration should also be given to patient concerns; caregiver knowledge and time; setting; and available financial resources.[46,48,54]

Primary intention

Incisions closed by primary intention generally require only the application of a dry, sterile cover dressing for 24–48 hours; a dressing is required only for protection, as the wound will re-epithelialize within two to three days. Although there is no strong evidence to support the use of a dressing immediately post-operatively for wounds healing by primary intention, it is a generally accepted clinical practice.[6]

Secondary intention

Acute surgical wounds that are left open to heal by secondary intention require a moist wound healing

environment.[51] To achieve an optimal moisture balance in the wound, the goal is to keep the wound bed moist while simultaneously preventing it from becoming either too wet or desiccated, both of which can cause further deterioration or a delay in wound healing.[23,47,54,55] In addition to preserving moisture balance, the dressing should function to prevent bacteria from entering and critically colonizing the wound bed tissue.[46,48,54,55] Interactive advanced wound products have an advantage over wet gauze dressings, as they prevent bacterial penetration of the wound.[53]

Exudating wounds

In addition to delaying wound healing by prolonging inflammation and breaking down extracellular matrix proteins and growth factors, too much exudate will also cause the peri-wound tissue to become macerated (white, overly moist and non-viable).[48,54] In heavily exudating wounds, the clinician may select a calcium alginate, Hydrofiber or foam dressing that will not only maintain moisture in the wound bed, but will also protect or wick moisture away from the peri-wound skin, decrease pain on removal and provide thermal regulation.[46,48,54,55] Calcium alginates and Hydrofibers function by absorbing large amounts of exudate to become a soft gel that protects and hydrates the wound.[46,48,54,55] Calcium alginates also have the property of hemostasis and therefore are the best choice for bleeding wounds.

Foam dressings are also optimal for heavily exudating wounds. Foams are available in a wide variety of sizes and absorbencies, with both lateral and vertical wicking abilities and varying degrees of moisture vapour permeability (allowing the exudate to evaporate through the dressing into the air).[54]

Pouching is another option for the management of heavily exudating wounds. 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 enterostomal therapy nurse is encouraged when exploring pouching or troughing.[50]

When the wound is highly exudative, the peri-wound skin benefits from protection with a barrier film/hydrocolloid and may also benefit from negative pressure wound therapy (NPWT) (see page 29).[54,55]

Dry wounds

Conversely, too little moisture causes the wound bed to dry, preventing growth of granulation tissue and re-epithelialization.[54,55] Dry surgical wounds 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.[54]

For more information on dressing selection, please refer to the CAWC Product Picker, available at www.cawc.net.

Summary

Regardless of the type of dressing selected, all surgical wounds require reassessment at regular intervals to evaluate the rate of healing and effectiveness of the treatment plan, and to identify and address any factors that may contribute to delayed healing.[32,48,54,55]

Recommendation 9: Determine the effectiveness of interventions and reassess if healing is not occurring at the expected rate. Assess the wound edge and rate of healing to determine if the treatment approach is optimal (RNAO level IV).

Regular assessment and documentation of wound healing is essential to determine whether the wound is progressing through an orderly sequence of healing.[23,46,48,54–56] In wounds that are healing by secondary intention, for example, a 20–40 per cent reduction in size in the first two to four weeks is a good predictor of healing.[46]

Tools are available that allow for systematic wound assessment (see Recommendation 5). Standardization of assessment is crucial, particularly when multiple caregivers are involved. Assessment generally involves the following:

- Wound measurement
- Description of the appearance of the wound bed

- Documentation of tunnelling or undermining
- Documentation of the amount, colour and consistency of wound exudates
- Assessment of the wound edge and condition of the peri-wound skin

Assessment of the advancement of the wound edge is an excellent way of determining if the wound is responding to the treatment plan. Wound edges should be assessed for distinctness, degree of attachment to the wound base and degree of advancement of the wound edge.[32,48,54–56] A wound edge that does not advance, or a rolled wound edge, indicates that the wound is not responding to the treatment plan, the cause of the wound has not been addressed or host factors are contributing to delayed healing.[46,54–56] Re-evaluation of the wound is then required to ensure the cause has been treated and that treatment is optimal. If the wound edge is still not migrating after all local wound, host factors, health-care professional and resource/treatment-related factors have been addressed, then advanced wound therapies should be considered, including vascular surgery, skin grafts or bioengineered tissue.[46,48]

In situations where wound healing may not be a feasible goal, evaluation should be targeted at ensuring the treatment is maintaining the wound and preventing infection, decreasing dressing frequency, decreasing pain and improving patient quality of life.[46,48]

Recommendation 10: Consider the use of adjunctive therapies and biologically active dressings (NPWT: RNAO level IV; ES: RNAO level Ib; HBOT: RNAO level IV).

Consultation and collaboration with the physician/surgeon and specialists in wound care related to the use of adjunctive therapy interventions is recommended. Before considering adjunctive therapies to support wound healing, an overall assessment of the patient's general health and wound-specific factors must be addressed to determine healability.[48]

Literature supporting the use of adjunctive therapies in the treatment of infected surgical wounds is limited; however, NPWT, electrical stimulation (ES) and hyperbaric oxygen therapy (HBOT) are recommended to support the healing of stage I–IV pressure ulcers.[57]

Negative pressure wound therapy

In topical NPWT, applying controlled subatmospheric pressure mechanically stresses tissues. This stimulates mitosis and the formation of new vessels, and the wound draws closed.[58] Fluids are drawn from the open wound into tubing and collected in a sealed container.

The general aims of NPWT are "to remove exudate and reduce peri-wound edema, increase local microvascular blood flow/test vascularity, promote formation of granulation tissue, reduce complexity/size of the wound, optimise the wound bed prior to and following surgery [and] reduce complexity of surgical wound closure procedures."[59] NPWT supports a moist wound bed environment and enhances circulation when interstitial fluid is removed, increasing oxygenation to compromised tissue. Removal of edema in the surrounding tissues and removal of stagnant infected fluid in the wound result in increased granulation tissue development.[58,60]

TABLE 11

Factors Increasing the Success of NPWT[61]

Wound has/is ...	Patient is/has ...
• Good blood supply	• Medically stabilized (e.g., nutrition, blood pressure, blood glucose, fluid balance, infection)
• Healthy, granular wound bed	• Few or well-controlled comorbidities
• Freshly debrided	• Comfortable (e.g., not in pain)
• High levels of exudates	• Adherent with therapy
• >2.0 cm wide	

NPWT = negative pressure wound therapy

World Union of Wound Healing Societies' Initiative. Vacuum assisted closure: recommendation for use: A consensus document. http://www.wuwhs.org/datas/2_1/11/VAC_English_WEB.pdf.

Indications/benefits

A post-operative surgical wound that has resulted in wound dehiscence and become non-healing is a good example of an open surgical wound that may benefit from NPWT. According to the World Union of Wound Healing Societies, NPWT therapy should be considered as "first-line treatment for dehisced sternal wounds following cardiac surgery."[61] Indeed, NPWT has "revolutionized the treatment of open abdominal wounds … [by] improving survival, decreasing the number of dressing changes, enabling a higher rate of total abdominal wall closure, decreasing the need for secondary surgical reconstruction, [and] reducing complications (e.g., incisional hernia, infection)."[61]

Table 11 lists factors that may increase the success of NPWT.

Contraindications/cautions

- Contraindications to NPWT include the presence of intracutaneous fistulae, necrotic tissue, untreated osteomyelitis and malignancy.[48]
- Debridement, including bone if osteomyelitis is present,[58] is necessary prior to the application of NPWT. The wound must be free of active, untreated infection (e.g., cellulitis); it must also be ensured that the wound bed does not involve fistulas to internal organs or body cavities.[48]
- Wounds with exposed blood organs or blood vessels require the application of a nontoxic, nonadherent barrier before conducting NPWT[58]; risk must be assessed when considering NPWT in these situations.
- NPWT is not appropriate in wounds with malignant cells, as it results in increased cell proliferation.[58]
- Patients receiving anticoagulants may use NPWT with caution; consideration of homeostasis, amount of NWPT suction pressure and monitoring of bruising and laboratory values should be part of the care plan.
- In patients over 65 years of age, issues with hypergranulation and wound odour are considerations to assess throughout NPWT treatment; modification to the care plan may be necessary.
- Guidelines for NPWT state that "NPWT should be discontinued if a patient complains of pain at the wound site during the treatment and comfort measures such as analgesics, a change to continuous from intermittent subatmospheric pressure, or reduction of subatmospheric pressure, are ineffective."[58]

Precautions when using NPWT include treating the infection with an appropriate systemic antimicrobial agent for deep compartment infections.[48] NPWT can be used as an adjunct therapy in infected wounds, but not as a sole treatment. NPWT has been shown to be effective in supporting the body's defence system against invading organisms; however, there is no evidence that it can be an adequate treatment for infection as a stand-alone intervention.[58,61]

Summary

Guidelines for the use of NPWT suggested by the manufacturer can support clinicians in the application of NPWT. Clinicians have a professional responsibility to ensure that use of the device is appropriate to the situation, the cause of the wound has been investigated and patient safety issues have been addressed, including the patients' ability to problem-solve and adhere to treatment.

Electrical stimulation

ES is the "use of electrical current to transfer energy to a wound by capacitative coupling of an applied surface electrode through a wet electrolytic current."[62] ES treatments involve delivery of electrical energy to the wound bed. With a "monopolar setup with specialized electrodes composed of sterile conductive material, the active electrode is placed directly into the wound, and a larger dispersive electrode is placed on intact skin away from the wound."[63] Several ES devices are available, and some have become easier to use in the clinical setting.

Chronic wounds, including open surgical wounds, may benefit from the advancements in the field of ES. ES has been used for pressure ulcers, diabetic ulcers, arterial ulcers and venous ulcers.[64] Animal studies suggest "ES facilitates survival of failing skin grafts and musculocutaneous flaps"[65] and several randomized clinical trials have found ES to be effective in facilitating wound healing in pressure ulcers, venous stasis ulcers and diabetic foot wounds.[66] One study found that ES with high-voltage pulsed current (HVPC) for chronic leg ulcers of venous, arterial and diabetes etiology led to a "reduced wound surface area over the 4-week treatment period to approximately one half the initial wound size … which was more than two times greater than that observed in wounds treated with the sham

unit."[67] HVPC may also be effective in treating stage II chronic dermal ulcers.[68]

Clinicians with expertise in ES can help in patient selection, wound care and measurement, duration of treatment, type of ES device used and dosage frequency and treatment parameters.[69] Clinicians must have specialized training in this equipment and competence in using it.[63] ES specialists are necessary in helping to determine the appropriate negative or positive polarity to facilitate a specific wound response.[64]

Indications/benefits

The therapeutic effects of ES include increased blood flow, tissue oxygenation, angiogenesis and wound tensile strength, and decreased wound pain and diabetic peripheral neuropathic pain.[66] Studies have shown that ES influences the migration of macrophages, fibroblast, mast cells, neutrophils and epidermal cells.[70] It has also been shown to increase the proliferation of fibroblasts and protein syntheses as well as the growth of neuritis,[70] factors that are all essential to the healing of open surgical wounds.

ES provides benefits in three of the four phases of wound healing.[62] In the inflammatory phase, ES:

> …increases circulation, which effects phagocytosis and tissue oxygenation, reduces microvascular leakage, stimulates fibroblasts and epithelial cells, stimulates DNA syntheses [and] may have bactericidal effects. During the proliferative phase, ES will stimulate fibroblasts and epithelial cells, stimulate DNA and protein synthesis, increase ATP generation and membrane transport, improve the organization of the collagen matrix [and] stimulate wound contraction. During the epithelialization phase, ES will stimulate epidermal cell reproduction/migration.[62]

Contraindications/cautions

Patients receiving ES must be "under the direct supervision of a physical therapist or a licensed health-care practitioner who is trained in ES."[64] Precautions and contraindication for ES include "presence of osteomyelitis, patients with demand-type pacemakers, wounds with heavy metal residue, pregnancy, electrode placement over the carotid sinus, history of dysrhythmia, placement of electrodes tangential to the heart, placement of electrodes over the laryngeal musculature [and] malignancy."[62]

Summary

The benefits of ES may support the healing of open surgical wounds. Further study is warranted to support ES along with standard wound care treatment.

Hyperbaric oxygen therapy

Oxygen is needed at all phases of wound healing. As the majority of chronic wounds are hypoxic, they therefore require increased oxygen to allow adequate healing.[66,71] Therapeutic amounts of oxygen have been used to assist wound healing for >40 years; the benefits include angiogenesis, collagen synthesis, osteoclastic activity and the release of vascular endothelial growth factor.[72,73]

Central tissue hypoxia stimulates wound healing and cellular responses that require oxygen, such as the production of hydroxyproline, collagen synthesis and cross-linking.[71] Hard-to-heal wounds are typically hypoxic. Transcutaneous pO_2 values adjacent to non-healing wounds have been found to be <20 mm Hg, while those in healing wounds are approximately 50–80 mm Hg. In diabetic foot ulcers, peri-wound transcutaneous pO_2 values of <20 mm Hg have been shown to be associated with a 39-fold increased risk of primary wound healing failure.[71]

HBOT allows for a reversal of hypoxia by increasing the oxygen diffusion in blood plasma and local tissues.[74,75] Patients breathe oxygen at two to three times atmospheric pressure, resulting in increased dissolved oxygen in the blood plasma, making more oxygen available to the wound. A sample HBOT treatment plan may be one to two hours per day of HBOT, five days per week. Despite this reasonably short regimen, the systemic and local effects and benefits are thought to be prolonged.[66,75]

HBOT is defined as an adjunctive therapy in which the patient "breathes 100% oxygen intermittently while the pressure chamber is increased to greater than one atmosphere absolute (atm abs). Current information indicates that pressurization should be at least 1.4 atm abs. This may occur in a monoplace (single-person) or multiplace (two or more people) chamber."[76]

Indications/benefits

The benefits of HBOT for hypoxic wounds are improved cellular energy metabolism, local tissue oxygenation, leukocyte-killing ability, effectiveness of antibiotics, uptake of platelet-derived growth factor-BB, collagen deposition, neoangiogenesis and epithelial migration, and decreased local tissue edema.[77]

Indications for use of HBOT include "air or gas embolism, carbon monoxide/cyanide poisoning, clostridial myositis and myonecrosis, crush injury, compartment syndrome and other acute traumatic ischemias, decompression sickness, enhancement of healing in selected problem wounds, exceptional blood loss, intracranial abscess, necrotizing soft tissue injuries, refractory osteomyelitis, soft tissue/bone radiation necrosis, compromised skin grafts and flaps, [and] thermal burns."[76,77] HBOT should be closely managed by certified hyperbaric physicians/clinicians, including patient selection, monitoring of wounds, contraindications and risks of HBOT use and indications for discontinuation.

HBOT differs from topical HBOT, which delivers a regulated, pressurized oxygen flow directly to a specific wound area. This is accomplished by using a portable device (e.g., a soft plastic sleeve or hard plastic chamber) that can be secured to a body surface or around an extremity to create an airtight seal.[78] Controversy exists as to the therapeutic value of topical oxygen delivery to local tissues/wounds.

HBOT and chronic wounds

In work with patients with compromised skin grafts and flaps, HBOT has been found to "enhance the viability of flaps by decreasing the hypoxic insult to the tissues, improving fibroblast and collagen synthesis, neoangiogenesis and the positive effects on the microcirculation."[73]

Increasing oxygen levels in hypoxic wounds is felt to enhance phagocytosis and bacterial killing by neutrophils or polymorphonuclear cells; when oxygen tensions fall to <30 mm Hg, the body's ability to combat bacteria and prevent infections is decreased.[72] There are six actions through which HBOT combats clinical infection. It supports tissue rendered hypoxic by infection; activates and increases the efficiency of neutrophils; increases macrophage activity; inhibits bacterial growth; inhibits the release of bacterial endotoxins; and enhances the effect of antibiotics.[72]

Summary

HBOT in open surgical wounds may be beneficial, but considerations such as access to HBOT treatment, costs to patients/families (including travel costs) and reimbursement fees must be taken into account. Other considerations, including patient preferences and impact on social, home and economic life require further investigation.

Biologically active dressings

Various biologic dressings—such as living human fibroblasts, extracellular matrix, collagen-containing preparations, hyaluronic acid and platelet-derived growth factor—have been developed in an effort to find adjunctive exogenous factors to induce and stimulate healing or to produce a skin substitute for use in acute and chronic wounds. Used alone, these dressings will not effectively produce results if proper wound bed preparation does not first occur. Wound bed preparation, together with an appropriately chosen wound dressing or tissue substitute, can lead to a more effective treatment of acute and chronic difficult-to-treat wounds.[78]

Caution

Advanced skill is required for patient selection. Biologically active dressings should not be used on wounds with infection, sinus tracts or excessive exudate, or on patients known to have hypersensitivity to any of the product components. Cultural issues related to the source of the biologically active dressing may be of concern to some patients.[54]

Summary

The NICE guideline does not address the use of biologically active dressings for use with surgical wounds; however, some authors believe that these dressings show promise in open surgical wounds. There is extensive literature regarding the use of biologic dressings in chronic wounds such as venous leg ulcers and burns, but studies evaluating these dressings in acute surgical wounds and dermatologic surgery have been limited.[79]

Recommendation 11: Recognize that surgical wound healing requires a team approach (NICE level 4; RNAO level IV).

Teamwork is required at all phases of wound healing, from initial consults through to the time the wound closes. An interdisciplinary approach allows for the safe and efficient treatment of patients who are at high risk for surgical site complications.[14] From the physician consult to the laboratory and diagnostic department, community pharmacists, the preadmission care team, community nurses and the in-house surgical team—from pre-operative and intra-operative to post-operative phases—many practitioners are involved with the patient and family to support them through the physical and psychosocial challenges that arise from having an open surgical wound. The attitude and approach of the team can affect surgical wound healing.

Surveillance

Teamwork supports surveillance of surgical wound infection rates. With teamwork, information-gathered can be enhanced to become more complex, accurate and complete.[80] Indeed, focusing on preventing open surgical wounds through wound surveillance and feedback to surgeons has been found to help reduce the number of SSIs.[80]

Through surveillance, teamwork helps to prevent open surgical wounds and supports monitoring of the surgical and peri-operative teams. This should include providing information on SSI rates and process measures to individual surgeons and hospital management on a routine basis.[16]

Quality improvement

Teamwork is also identified as essential to the prevention of adverse events. Indeed, it has been found that "communication failure is at the core of nearly every medical error and adverse event."[81]

In Australia, a quality improvement initiative established a team consisting of the clinical services director, an orthopedic surgeon, an infection control nurse, the operating suite and surgical unit nurse managers, a general surgeon and a university professor.[82] With team effort and the education of staff and patients, they were able to reduce post-operative infection rates for elective hip and knee replacement patients.[82] One strategy was to screen patients for risk factors: if the patient had more than two risk factors, surgery was delayed until the factors were rectified.[82]

Patient-centred care

The RNAO recommendations in the *Client-Centred Care Nursing Best Practice Guideline* support nurses in embracing values and beliefs that improve the quality of care and support they offer patients with open surgical wounds.[24] Nurses should embrace the values and beliefs that "clients are experts for their own lives … [that] client's goals coordinate care of the health-care team … [that care has] timeliness, responsiveness and [clients have] universal access to care."[24] Applying these success factors for patient-centered care and acknowledging that there are challenges and barriers may help surgical teams to work most effectively with patients and families who are dealing with an open surgical wound.[24]

Good communication between the health-care professional and the patient is essential.[6] This includes respect for the patient's age, his or her capacity to make decisions (including children <16 years of age), the cultural appropriateness of information, respect for patients with additional needs (e.g., sensory or learning disabilities), language ability and preferences regarding health-related information (i.e., written vs. oral/verbal traditions).

In 2005, the Health Council of Canada published a paper entitled *The Health Status of Canada's First Nations, Métis and Inuit Peoples*,[83] which pointed to the need for "culturally-appropriate programs and services" for patients and families. Such knowledge can affect how health-care professionals work with culturally diverse populations across the country.

Collaboration

Surgical teams can also benefit from the work done by the RNAO on collaborative practice among nursing teams.[84] The RNAO recommendations go from the bedside to the wider workplace and the team or teams that health-care professionals are part of every day. These may help surgical teams to become more collaborative in practice, examining "the Healthy Work Environments framework and reflect[ing] physi-

cal/structural, cognitive, psychological, social, cultural and professional and occupational components of teamwork that must be addressed at the individual and team level to ensure best practice" is delivered.[84]

Recommendation 12: Implement a surgical site surveillance program that crosses clinical setting boundaries (NICE level 4; RNAO level IV).

SSI surveillance is an essential component of the recognized guidelines and quality improvement initiatives that inform best practice for the prevention of infection and the improvement of patient outcomes. It has been shown to reduce SSI rates by 32 per cent.

Successful SSI surveillance programs focus on targeted high-risk and high-volume operative procedures. They include epidemiologically sound definitions, stratification of SSI rates according to risk factors, effective surveillance methods and data feedback.[16] The Centers for Disease Control and Prevention National Nosocomial Infections Surveillance System has set definitions that are the standard for SSI surveillance programs; infections occurring within 30 days after "non-implant" surgery and within 12 months of prosthetic implant surgery constitute the surveillance period.[85]

However, ascertaining accurate SSI rates is challenging. Most SSI surveillance is performed in hospital settings, but between 12 and 84 per cent of SSIs are found post-discharge.[16] Studies have identified the importance of SSI surveillance for at least 30 days, if not for a year, following surgery.[86,87] Two studies have shown that most infections become evident within 21 days after surgery. Another report on 10 published studies has shown that the overall SSI rate for an institution increases with the inclusion of post-discharge surveillance data.[88]

Significant infections (deep incisional and organ/space) require readmission to hospital, outpatient clinics or emergency room visits and can be captured by in-hospital surveillance programs.[86,89] On the other hand, superficial SSIs are managed in the community and may not be captured by the operating hospital's surveillance program. Early identification of SSIs in the community is primarily important for the prompt initiation of treatment strategies; it also offers the opportunity to provide SSI data to hospital or surgical facility surveillance programs.

SSIs are the third most common hospital-acquired infections in Canadian acute-care facilities, and they cause considerable morbidity and increased medical costs. Maintaining only in-hospital surveillance can could conceal significant SSI rate increases or outbreaks and prevent timely feedback and implementation of interventions to improve patient outcomes. Community-care nurses are well-positioned to support post-discharge SSI surveillance programs among the various types of patients in which SSIs can occur.[90,91]

Surveillance procedure

1. Assess patient's risk factors for an SSI90:
   a) Provide health education
   b) Determine care plan and monitoring frequency
2. Observe patient for signs and symptoms of an SSI85:
   a) For 30 days after the procedure if no implant and for one year following implant surgery
   b) Criteria for SSI include classification and a combination of purulent drainage, organisms isolated, deliberate reopening of the incision, radiological evidence or a physician's diagnosis
3. Determine if the patient's procedure is included in the operating facility's targeted SSI surveillance
4. Report identified SSIs:
   a) To own agency's post-discharge surveillance program
   b) To the operating hospital or surgical facility
   c) To the surgeon

Conclusion

The prevention and management of open surgical wounds should be of great concern to patients, health-care professionals and administrators alike. 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. By using the information presented in these best practice recommendations, clinicians can develop the skills and tools needed to identify those at high risk for infection and develop plans—in collaboration with their patients—to ensure a best practice approach.

Note to readers

A patient information sheet on incision care is available at **www.cawc.net**.

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