WOUND CARE AND HEALING IN PERIOPERATIVE PRACTICE

1972
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PURPOSE/GOAL
The purpose of this study guide and accompanying video is to educate perioperative registered nurses (RNs) and other interested health care personnel about the physiology of wound healing and to review key concepts and practices for providing wound care in the perioperative setting.

OBJECTIVES
After viewing the video and completing the study guide, the learner will be able to:

1. Define wound healing.
2. List types of wound closure.
3. Describe the physiology of wound healing.
4. Describe how wounds are classified.
5. Discuss factors that affect wound healing.
6. Categorize surgical site infections (SSI).
7. Describe practices to prevent SSIs.
8. Describe perioperative wound management practices and treatments.
INTRODUCTION
Wounds are caused by surgical incision or excision; by trauma secondary to mechanical, thermal, or chemical destruction of tissue; and by underlying acute or chronic disease processes. Wound healing can be defined as the body’s process of re-establishing continuity in the tissues by replacing dead and missing cellular structure and tissue layers with viable tissue. Wound management is an essential competency area for perioperative RNs who care for patients with a wide range of wounds every day in both inpatient and ambulatory settings. To optimize wound healing, these patients need treatment that is tailored to their unique medical and surgical histories and specific wound characteristics. Patient education also is crucial for successful wound healing because by necessity, much wound care occurs outside the hospital or ambulatory surgery facility.

To provide quality wound management, perioperative RNs and other clinical personnel need to fully understand the physiology of wound healing, risk factors for impaired and delayed healing, and best practices and current products that support healing. In addition, perioperative RNs should be competent in classifying and documenting surgical wounds in accordance with the Centers for Disease Control and Prevention’s (CDC) Surgical Wound Classification system.
The field of wound management has become increasingly complex as emerging research reveals new information about wound healing and as new wound care products enter the market. This study guide and the accompanying video will review wound care and wound healing based on current research and expert clinical recommendations.

TYPES OF WOUND CLOSURE
There are three main types of wound closure.

Closure by primary intention. This type of closure occurs when the clinician creates an operative wound in an aseptic environment with minimal destruction of tissue and tissue reaction. The wound also heals under optimal conditions – the skin edges are approximated with skin staples or tape soon after wounding; there is no tissue loss or dead space; drainage is minimal; and the wound is handled with strict adherence to aseptic technique.

Closure by secondary intention. Typically, this type of closure involves chronic wounds, contaminated wounds, and wounds characterized by marked tissue loss. The skin edges typically cannot be approximated, and the wound is left open and allowed to heal from the inside to the outside surface. This practice enables cleaning and dressing of the healing wound. The tissue gap gradually fills in with granulation tissue made up of fibroblasts and capillaries and subsequently contracts to reduce the size of the wound. The healing process takes longer and involves substantially more scar tissue than closure by primary intention.

Delayed primary closure (tertiary closure). In this type of closure, the wound is closed three or more days after injury or surgery. Clinicians may elect delayed primary closure for markedly contaminated wounds, such as wounds incurred in war zones, ileostomy closure, and peritonitis, or if a patient is hemodynamically or otherwise unstable. Delayed primary closure typically requires a primary and secondary suture line, such as the use of retention sutures, and clinicians use delayed primary closure surgery to reduce the risk of surgical site
infections (SSI). In a meta-analysis of eight randomized studies of delayed primary versus primary closure, however, researchers found flaws in design and outcomes assessment.\(^4\) The researchers concluded that the trials included in the meta-analysis had failed to provide definitive evidence that delayed primary closure prevents SSI. Additionally, in a Cochrane systematic review, the researchers concluded that there was a lack of robust evidence to guide clinical decision-making regarding when to close traumatic wounds.\(^5\) In a retrospective study of fractures, researchers identified a significantly higher rate of deep infections in delayed primary closures (17.8%) compared with primary closure cases (4.1%; \(P = 0.0001\)).\(^6\) The researchers concluded that immediate closure of carefully selected grade I, II, and IIIa open fractures was safe and was associated with a lower infection rate than delayed primary closure.

**PHASES OF WOUND HEALING**

The physiology of wound healing is highly complex and dynamic, and research continues to reveal new information about the cellular, humoral, and molecular processes involved. The literature does not concur on the number or nomenclature of stages involved in wound healing. For the purposes of this study guide, however, we will define three main phases of wound healing as: *inflammation*, *proliferation*, and *remodeling*.\(^1\)

The cellular- and tissue-level events of wound healing often overlap or occur simultaneously. The first and immediate physiologic response to wounding, however, involves the mechanism of *hemostasis*. Immediately after injury, blood vessels at the wound site undergo *vasoconstriction* to minimize blood loss. Platelets activate the intrinsic clotting (or coagulation) pathway, and injured tissue activates the extrinsic clotting pathway.\(^2\) Platelets adhere to the damaged endothelium and release adenosine diphosphate (ADP), which triggers platelet clumping to help fill the wound and slow bleeding. Vasoconstriction is followed by histamine-induced vasodilation, which enables platelets and other blood cells to enter the wound. Fibrinogen is cleaved into fibrin, which in turn enters the wound to form an initial coagulum, or clot. Thrombocytes (platelets) release growth factors, and chemokine-chemotactic receptors recruit neutrophils and macrophages, which release cytokines (extracellular signal proteins or peptides) such as interleukins that help direct and orchestrate the healing process. These events induce the first phase of wound healing, the *inflammatory phase*.\(^1\)

The inflammatory phase usually lasts one to four days.\(^1\) During this phase, plasma, neutrophils, and macrophages leak into the wound, causing the classic signs of inflammation: redness, swelling, heat, and pain. An exudate from the wound may also be observed. Neutrophils predominate during the early inflammatory phase, while macrophages predominate later.\(^2\) Macrophages secrete numerous factors that trigger the multiplication of smooth muscle and endothelial cells. Leukocytes phagocytize bacteria and dead or damaged tissue, helping to clean and debride the wound and prevent infection.

The *proliferative (or granulation) phase* is characterized by
the production of granulation tissue, neovascularization, and re-epithelialization. During proliferation, granulation tissue composed of connective tissue and new capillaries fills the wound gap. Myofibroblasts (connective tissue cells) attach to collagen and contract, pulling the edges of the wound together to reduce scar tissue. Epidermal growth factors induce epithelial cells to migrate from the edges of the wound across the bed of granulation tissue, covering and closing the defect with a thin tissue layer. This protective barrier helps prevent fluid and electrolyte loss and reduces the risk of infection.

The third phase of wound healing is remodeling, which begins approximately two to four weeks after the initial wound and may continue for up to one year or longer. During this phase, granulation gradually stops and apoptosis (programmed cell death) causes the recession of existing granulation tissue. Wound contraction continues, and scar tissue gradually re-organizes into an avascular, acellular matrix primarily composed of parallel bundles of collagen. This process improves the tensile strength of the wound, although scar tissue has only about 80% of the strength of unwounded tissue.

FACTORS AFFECTING WOUND HEALING
Numerous patient-specific and perioperative risk factors affect the rate and outcome of wound healing. Patient-specific risk factors for delayed wound healing include the following:

- **Aging** slows the healing process, especially in males, even when they do not have comorbid conditions.
- **Decreased oxygen levels** decrease oxygen tension to the wound and compromises its tensile strength.
- **Obesity** places excess tension on wound edges and is associated with local hypoperfusion, contaminated skin folds, and pressure injuries which increase the potential for complications of the wound healing process.
- **Psychological stress** increases blood glucose levels which may negatively affect the healing process.
- **Smoking** increases the risk for infections, wound rupture, Anastomotic leakage, and wound and flap necrosis and decreases wound tensile strength.
- **Alcohol consumption** increases susceptibility to infection and impairs angiogenesis (eg, growth of new blood vessels).
- **Malnutrition** impairs wound healing as a result of inadequate intake of dietary protein.
- **Systemic steroid medications** cause wounds to heal with incomplete granulation tissue and reduced wound contraction.
- **Chemotherapeutic medication** delays cell migration into the wound, decreases early wound matrix formation, lowers collagen production, impairs proliferation of fibroblasts, and inhibits wound contraction.
- **Chronic diseases and immunocompromised conditions** (eg, diabetes) delay wound healing.

**Diabetes mellitus** is one of the most prevalent patient-specific risk factors for delayed wound healing or non-healing. This disease affects an estimated 8.3% of the US population and about 27% of US adults aged 65 years and older. Diabetes mellitus is caused by insufficient levels or response to the hormone insulin and is characterized by high blood glucose levels. Diabetes is associated with serious complications such as blindness, kidney failure, heart and blood vessel disease, stroke, and premature death. It is the seventh leading cause of death in the United States.

Diabetic foot ulcers affect an estimated 15% of patients with diabetes mellitus and are the leading cause of non-traumatic lower limb amputation. Factors contributing to non-healing
foot ulcers include defective T-cell immunity; impaired leukocyte chemotaxis, phagocytosis, and bactericidal activity; diminished peripheral circulation; decreased local angiogenesis; and neuropathy.

The key diagnostic test for diabetes is a fasting glucose level. A fasting glucose level of 70 to 100 mg/dL is considered normal. Patients with levels between 100-125 mg/dL have impaired fasting glucose, a type of prediabetes. Impaired fasting blood glucose is considered a risk factor for type 2 diabetes mellitus and its complications. Diabetes is diagnosed in persons with fasting blood glucose levels that are 126 mg/dL or higher. An impaired glucose tolerance (IGT), a 2-hour post-meal glucose level between 140 and 199 mg/dL, is also considered a risk category for diabetes mellitus.

Patients with type 1 diabetes mellitus have an absolute deficiency of insulin because of insufficient production of this hormone by pancreatic beta cells. In contrast, patients with type 2 diabetes mellitus have a condition known as insulin resistance, which occurs when insulin no longer acts normally on target tissues and compensatory insulin secretory response is inadequate. Additional causes of diabetes include pregnancy (ie, gestational diabetes), genetic defects, surgery, and drug-induced hyperglycemia.

Perioperative patients with diabetes mellitus are at risk for numerous potential complications. Degeneration of small blood vessels can occur in many organs, leading to a range of medical problems. Other complications of diabetes mellitus include delayed wound healing, hyper- or hypoglycemia, hypertension, surgery-related pressure ulcers, and increased risk of SSI or other infections.

Glucose is a major source of energy for most cells of the body, including the brain. Because stress increases blood glucose levels, both diabetic and non-diabetic patients may have very high blood sugars in the perioperative period, and clinicians should perform frequent blood glucose monitoring.

Perioperative factors also affect wound healing. For example, many surgical patients are at risk for unplanned hypothermia in the relatively cool environment of the OR suite. Hypothermia causes peripheral vasoconstriction, which can compromise wound healing. Perioperative RNs should implement measures that assist the patient in maintaining normothermia during operative procedures. Other examples of perioperative factors that affect wound healing include adherence to sterile technique and limiting the duration of surgery and the amount of traffic and number of persons in the OR.

SURGICAL SITE INFECTIONS

The most common cause of impaired wound healing in surgical patients is a surgical site infection (SSI). Left untreated, SSIs can progress and cause serious complications including delayed healing, nonhealing, systemic infection, and even death. Surgical site infections are also associated with an increased risk for revision surgery, antibiotic therapy, and prolonged hospital stays, which can adversely affect patients’ quality of life and add substantially to health care costs. The increasing prevalence in healthcare settings of antibiotic-resistant bacterial pathogens, such as methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant enterococci (VRE) have increased the need to prevent SSIs. These resistant pathogens are associated with poor outcomes and major increases in health care costs.

Diverse factors affect the risk of SSIs, including the:
- patient’s underlying susceptibility to infection;
- severity of the primary disease or condition and number and severity of comorbid conditions;
- the correct type, dose, timing, and route of antimicrobial prophylaxis administered when indicated;
- exposure of the incision to environmental contaminants or the patient’s own microflora;
- adherence to sterile technique; and
- implemented surgical techniques that minimize tissue damage, eliminate dead space, and reduce the amount of time the operative wound is exposed to air.

Prevention of SSIs

Before an operative or other invasive procedure, patients may be instructed to follow a series of essential practices to reduce the risk of SSIs. Clinicians often instruct patients to shower with soap or with an antiseptic solution before the procedure to cleanse the skin at the incision site. This practice helps
reduce the microbial load at the site, thus decreasing the risk of infection.25

Patients also may undergo a complete preoperative history and physical assessment, which may include laboratory and other diagnostic testing. This assessment and testing can identify abnormal laboratory values and other indicators of underlying conditions that could increase the risk of postoperative infection.

On the day of surgery, the procedure room should be prepared by perioperative personnel following AORN recommendations for environmental cleaning and using sterile technique when opening instrument packs, drapes, and other supplies.22,26 Additionally, the perioperative team should follow recommended hand hygiene protocols.27 If a surgical site requires hair removal, clipping is recommended, rather than shaving, to reduce the risk of opening the epidermis at the surgical site and increasing susceptibility to infection.21

The perioperative team’s coordinated efforts to prevent SSIs should continue in the operative suite. Perioperative RNs should perform preoperative skin antisepsis of the surgical site to remove soil and transient microorganisms from the skin, reduce the microbial count to sub-pathogenic levels, and inhibit growth of microorganisms.21 All team members should practice strict adherence to sterile technique, monitor for breaks in sterile technique, and be prepared to immediately communicate about and correct breaks if they occur.22 The team should also wear correct surgical attire to reduce the likelihood of lint and other particles contaminating the incision.28 The RN circulator should monitor traffic and the number of persons in the OR should be kept to a minimum to reduce air currents that could contaminate the surgical site.22,29 The team should monitor the patient’s physiological status carefully and take steps to promote normothermia and sufficient oxygenation.19 Additionally, the surgeon should practice good surgical technique by working carefully and efficiently to reduce the amount of trauma to the tissues and the time that the open incision is exposed to air. At the end of the surgical procedure, perioperative RNs should determine and document the surgical wound classification according to the CDC Surgical Wound Classification system.3,30 When the operative procedure is completed, the surgical incision should be protected with sterile dressings that remain over the site for 24-48 hours postoperatively.32

Wound classification

The CDC Surgical Wound Classification system is used to classify wounds based on the likelihood and degree of wound contamination at the time of surgery. It is important to note that if there is no wound, there is no wound classification (for example, in a closed reduction of a fracture, or examination and manipulation of a joint under anesthesia). The four wound classifications are:3,30,32

- Class 1 (Clean)
- Class 2 (Clean-contaminated)
- Class 3 (Contaminated)
- Class 4 (Dirty or Infected)

**Class 1- Clean wounds** are uninfected operative wounds in which no inflammation is encountered, and the respiratory, alimentary, genital, or uninected urinary tracts are not entered. In addition, class 1 wounds are primarily closed, and, if necessary, are drained with closed drainage. Operative incisional wounds that follow non-penetrating (blunt) trauma should be included in this category if they meet these criteria. An example of a Class 1/clean procedure is a total hip replacement.

**Class 2- Clean-contaminated wounds** are operative incisions in which the respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions without evidence of infection or contamination. Examples of Class 2/clean-contaminated procedures include operative procedures where the biliary tract, appendix, vagina, bladder, and oropharynx are entered, provided that there is no evidence of infection or major break in surgical technique, such as spillage from the gastrointestinal tract.

**Class 3- Contaminated wounds** include open, fresh, accidental wounds, wounds associated with operative procedures in which there was a major break in sterile technique, procedures where there was gross spillage from the gastrointestinal tract, or incisions in which acute, nonpurulent inflammation is encountered. An example of a Class 3/contaminated procedure is an
operative procedure performed with unsterile instruments.

**Class 4- Dirty or infected wounds** are old traumatic wounds with retained devitalized tissue, existing clinical infection (e.g. purulence), or perforated viscera. The definition suggests that the organisms causing postoperative infection were present in the operative field before the operation. An example of a Class 4-Dirty, infected procedure is a surgical incision and drainage of an abscess.

These surgical wound classifications reflect the likelihood that wound infection will occur. Wound classification allows for comparison of wound infection rates associated with different surgical techniques, surgeons, and facilities. This comparison is not only useful for research, but may also serve to alert infection prevention personnel regarding wounds at increased risk for infection, which could enable health care providers to implement surveillance and preventative measures.

Surgical Wound Classification Decision Tree is designed to enable perioperative nurses to accurately classify surgical wounds based on the CDC surgical wound classification system. The decision tree asks a series of yes or no questions that enable perioperative nurses to accurately classify wounds based on the descriptions in the CDC classification system. When using the decision tree, it is important for the perioperative RN to keep in mind that incisions from similar operative procedures might be classified differently based on factors such as whether the genitourinary tract was entered; whether infection was encountered during the operative procedure; or other considerations related to surgical wound classification.

Patients, support persons, and home care providers usually are responsible for the majority of wound care after operative procedures. Therefore, postoperatively, patient and caregiver education is very important. Perioperative RNs need to educate patients and their support person about warning signs of infection such as redness, marked swelling, fever, and purulent discharge or foul odor at the incision site. Patients and support persons should also be instructed verbally regarding hand washing techniques, dressing changes, and patient restrictions on bathing and showering. Sending written directions home with the patient or support person helps to reinforce these important messages.

Perioperative RNs are positioned to serve as leaders in SSI prevention within many health care organizations. However, studies point to the need for improved patient education efforts in this area. In a survey of surgical patients, 26% of respondents thought that education regarding SSIs could be improved, 16% could not remember discussing SSI risks and prevention with any health care worker, and only 60% recalled receiving written information about SSIs from the health care facility.

**CATEGORIES OF SSIs**

SSIs are categorized by the affected tissues.
**Superficial incisional SSIs** occur within 30 days after the operative procedure, involve only the skin and subcutaneous tissue of the incision, and have at least one of the following:

- Diagnosis of superficial incisional SSI by the physician or attending surgeon
- Purulent drainage from the incision site
- Organisms cultured aseptically from tissue or fluid obtained from the superficial incision
- Pain or tenderness, localized swelling, redness, or heat at the surgical site

If a superficial incisional infection is present, the surgeon deliberately opens the superficial incision to allow drainage, unless the incision is culture-negative.

**Deep incisional SSIs**, infection occurs within 30 or 90 days of the operative procedure, the infection involves deep soft tissues such as fascial and muscle layers of the incision, and must meet one of the following criteria:

- The attending surgeon or physician has diagnosed the infection as a deep incisional SSI.
- There is purulent drainage from deep tissues but not the organ/space component of the surgical site.
- A detectable abscess is present and/or the patient experiences spontaneous dehiscence, or the surgeon deliberately opens the surgical site when the patient has fever, localized pain, and/or tenderness (unless the site is culture-negative).

**Organ/space SSIs** are defined as infection within 30 or 90 days of the operation. Additionally, the infection must involve a part of the anatomy, other than the incision, that was opened or manipulated during the operation and must meet at least one of the following criteria:

- There is purulent drainage from a drain placed into the organ or organ space;
- Clinicians have cultured organisms from an aseptically obtained sample of fluid or tissue in the organ or organ space;
- Detectable abscess or other sign of infection involving the organ or organ space is present, or
- The surgeon or attending physician has diagnosed an organ or organ space SSI.

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**PERIOPERATIVE WOUND TREATMENTS**

**Topical Hemostatic Products.** Wound healing begins with hemostasis. Many methods are used to stop bleeding during surgery and may include applying pressure, suturing or using electrocautery on bleeding vessels or tissue, and administering blood and blood products. When traditional methods are ineffective or not feasible to attain hemostasis, surgeons may choose to apply a topical hemostatic product to help control bleeding. These products can also potentially reduce total procedure time and promote faster patient recovery.

**Passive or mechanical hemostatic agents** are applied at the bleeding site and rely on the normal clotting cascade to work. They provide a barrier to stop blood flow and a surface that enables blood to clot more rapidly. Examples of passive hemostatic agents include collagens (AviteneTM sheet and flour, UltrafoamTM, Helistar®, Helitene®, and Instat®), cellulose (Surgicel®, Surgicel Fibrillar®, and Nu-Knit®), gelatins (porcine gelatins include Gelfoam® sponge and powder, and Surgifoam® sponge and powder), and polysaccharide spheres (Arista®, Hemostase®, and Vitasure®).

**Active hemostatic agents** contain thrombin and products mixed with thrombin. They act at the end of the coagulation cascade to enhance clotting at the bleeding site. Active hemostatic agents made from human and bovine sources, and recombinant thrombins are licensed for clinical use in the United States. Specific products available in the United States include Thrombin, Topical, Bovine Origin (Thrombin-JMI®); Thrombin, Topical, Human (EvithromTM OmrixTM Bio-
pharmaceuticals, Ltd); and Thrombin, Topical, Recombinant (Recothrom™ ZymoGenetics, Inc).

**Flowables** are combinations of passive and active hemostatic agents that mechanically obstruct the flow of blood and actively convert fibrinogen in blood into fibrin at the site of bleeding. Because flowables do not contain fibrinogen, they require direct contact with blood to provide the fibrinogen for conversion into fibrin. Flowables may be made of bovine gelatin and pooled human thrombin (Floseal®), or porcine gelatin with or without thrombin (Surgiflo®).

**Fibrin sealants** promote blood clotting by supplementing the patient’s own clotting factors, speeding up local coagulation, and catalyzing the activation and aggregation of platelets and formation of fibrin. The fibrin in these products is derived from pooled or individual human plasma, equine or bovine collagen, and bovine thrombin. Synthetic sealants are also licensed for clinical use. They are made from polyethylene glycol polymers and cyanoacrylates. Specific products include Tisseel®, Tachosil®, Vitagel®, Coseal®, Duraseal®, Bioglue®, and Omnex™.

It is important to keep in mind that patients can have adverse reactions to topical hemostatic agents as a result of allergies or previous sensitization. The most immediate risk is anaphylaxis resulting from allergies or previous sensitization to immunogenic substances. Bloodborne pathogen infection is also a risk when patients are exposed to products derived from blood, although this risk has decreased with improved donor screening programs. It is important to follow the manufacturer’s written directions for preparing the topical hemostatic product for patient use or delivering it to the sterile field.

**Growth factors.** Growth factors are naturally occurring peptides and cytokines, that are sometimes used in wound care. These soluble proteins help initiate and direct the mitosis (cellular division) of fibroblasts, smooth muscle cells, epidermal cells, and vascular endothelial cells, all of which are central to wound healing. Both human and recombinant growth factors are used in wound care and management. Platelet-derived growth factors are extracted from 50 to 200 mL of venous blood. The platelets are separated out and activated with thrombin to create a gel. The gel is applied to the clean wound bed.

**Irrigation.** This is an important practice for cleaning and hydrating wounds, preparing the wound bed for further treatment, and allowing care providers to better visualize the wound. Irrigating a wound through a continuous or pulsed release of fluid to the wound surface serves to flush contaminants and nonviable tissue from the wound. Sufficient pressure and volume of irrigation fluid are needed to achieve good results, but care also must be taken to minimize damage to healthy tissue. One study found that excessive irrigation pressure during acute orthopedic surgery was associated with visibly damaged bone, bacterial contamination of the medullary cavity, and delayed fracture healing. The volume of irrigating solution should be adjusted based on the size of the wound and the extent of contamination, and the edges of the wound may need to be separated to fully irrigate the tissue. After irrigation, the wound should be examined, and additional irrigation should be performed if necessary to flush remaining contaminants and dead tissue from the site. Some options for irrigation solutions include normal saline, sterile water, and commercial wound cleansers.
Incision and drainage. This is performed to release pus from an abscess. To perform incision and drainage, the clinician antiseptically prepares the skin and uses a sterile instrument to make a small incision. He or she deepens the incision until pus is observed, and then explores and enlarges the incision with a surgical instrument. Specimens are often taken for culture and the surgeon can use a gloved finger to break up any loculations (i.e., sealed pockets of pus). The surgeon enlarges the wound to ensure sufficient drainage, and may loosely pack it with gauze or place a drain. After treatment, the wound is often left open to heal by granulation. In some cases, incision and drainage are very painful, and may be performed under general anesthesia.

Debridement. This is performed to remove dead and devitalized tissue from a wound and facilitates wound healing and closure. If nonviable tissue is not debrided and remains in the wound, it can impede healing and serve as an infection nidus (i.e., a place for infection to begin). Methods of debridement include mechanical methods such as pressure irrigation; surgical debridement with a scalpel or scissors; application of debriding agents with enzymatic action that contain collagenase; and biologic methods such as sterile maggot debridement therapy. Each approach has benefits and risks; for example, surgical debridement can result in bacteremia as bacteria at the wound site enter the bloodstream. Wounds that lack intrinsic, extrinsic, or mechanical damage may be closed immediately after debridement. If the debridged wound is not immediately closed and is left to heal by secondary intention, follow-up assessment is required. Debrided wounds also may require secondary debridement to optimize healing.

Negative pressure wound therapy. This therapy, which emerged in the late 1990s, is another technique that can be used to facilitate wound healing. In negative pressure wound therapy, the wound is filled with one or more sterile sponges and sealed with occlusive dressing material. The negative pressure wound therapy device, which is a closed, sealed system, promotes evacuation of excess fluid via suction tubes into a liquid waste collector. This therapeutic modality has been used for many types of lesions including open abdominal wounds, skin graft donor sites, open fractures, acute burns, pressure ulcers, trauma-induced wounds, diabetic foot ulcers, split-thickness skin grafts, sternal wounds, and in type 1 (i.e., clean) wounds in obese patients. Furthermore, indications for the use of negative pressure wound therapy are increasing as more negative pressure wound therapy systems enter the market. Negative pressure wound therapy can potentially reduce the risk of SSI and expedite healing. Potential adverse effects of this modality include pain and skin damage. Patients have also reported concerns about decreased mobility, sleep disturbances, and the noise created by these systems. To prevent and minimize adverse outcomes, negative pressure wound therapy devices should be used by personnel with verified competency in their use. In addition, it is important not to cut sponges directly over the wound, to carefully monitor the number and sizes of sponges placed in the wound, follow the health care organization’s protocols for patient assessments, and follow the manufacturer’s instructions for correct pressure ranges.

Skin substitutes. These materials are created by placing human cells onto matrixes of collagen or synthetic materials.
The human cells then grow and divide, secreting growth factors that trigger cellular migration into the wound field and in turn promote epithelialization and revascularization. Because of these characteristics, skin substitutes can be useful as a temporary bridge to permanent closure of burns and other complex wounds, such as chronic ulcers. Skin substitutes also may be used to cover skin graft donor sites. Both biological and synthetic skin substitutes are available. Examples of specific skin substitute products include Biobrane®, Dermagraft®, TransCyte®, Apligraf®, AlloDerm®, Oasis®, and Integra®. Different products are approved for different uses, such as diabetic foot ulcers or superficial burns. Skin substitutes can provide relatively long-term wound coverage and also have the advantage of being compatible with autologous tissue, readily commercially available, and associated with fewer risks of adverse effects involving the donor area.

**Drains.** Drains provide an exit for serum, blood, lymph, intestinal secretions, bile, and pus from the operative site. They may also be used to prevent deep wound infections. Drains are most commonly made from latex, polyvinyl chloride (PVC), or silicone. It is important to ensure that patients are not latex-sensitive before placing latex drains. The surgeon usually inserts a drain at the time of surgery through a separate small incision called a stab wound near the primary incision. In some cases, he or she may suture the drain to the skin.

**Simple drains** permit free flow through the drain onto a dressing. An example is a Penrose drain in which fluid flows along the outside of the drain onto a dressing by means of gravity and capillary action. A T-tube drain is also a simple drain.

**Closed drainage systems** are airtight circuits that help prevent environmental contamination of the drainage site. They are portable, self-contained, closed wound suction systems, and use suction to pull drainage from the wound into a collection unit. Jackson-Pratt and Hemovac® systems are closed drainage systems.

**Chest drainage systems** are designed to drain air, blood, pus, or lymph from the pleural cavity; prevent fluid and air from re-entering the pleural cavity; and enable the patient’s lungs to re-expand and restore normal negative intrapleural pressure. A water-seal container is connected to the chest tube to allow one-way movement of liquid and air out of the pleural cavity. Changing or emptying the container should be accomplished according to the manufacturer’s instructions and the health care organization’s policy and procedure.

**Dressings.** These help protect the site of a wound from infection or further injury. Dressings have several functions, including absorption of drainage, providing an environment that promotes healing, and provision of a mechanism to apply medications. Dressings also are used to support, splint, and immobilize injuries, and are used in some cases for aesthetic reasons. Dressings come in many options including:

- cotton mesh gauze, nonadherent dressings (e.g., Telfa®, Adaptic®, scarlet red gauze, Xeroform®);
- transparent films (e.g., Bioclusive®, Opsite®, Tegaderm™);
- hydrocolloid dressings (e.g., Comfeel®, Sorbex®, DuoDERM®, Tegsorb™);
- hydrogel (e.g., Carrasyn®, SoloSite Gel®, NU-GEL®, Curagel™, Vigilon®);
- alginates (e.g., AlgiDerm®, Algosteril®, Curasorb™, SeaSorb®, Kaltostat®, Sorbsan™);
- foam (e.g., Lyofoam®, KendallTM Foam, Allevyn™, Flexzan™, BioPatch™, VigiFOAM®);
- silicone (e.g., Cica-Care® Silicone Gel Sheeting, Mepiform®, Oleeva®);
- collagen (e.g., FibracolTM Plus, Promogran™, Cellerate RX™, Biostep®, Catrix®, ColActive®, Collieva®, Biopad®); and
Despite this variety of available dressing materials, current research does not definitively support the use of one type of dressing over another. In a meta-analysis of 16 controlled trials involving 2,594 patients, researchers found no evidence that any one type of dressing significantly reduced the risk of SSIs or reduced the risk of pain or scarring compared with other types. However, the researchers also concluded that results were unclear or at high risk of bias.

Postoperative care for some operative procedures includes sterile dressing changes. Dressing changes that cause the patient substantial pain may require anesthesia. Examples include dressing changes in patients who have extensive burn injuries or who have traumatic abdominal wounds that were closed by tertiary intention with placement of a negative pressure wound therapy device. Such patients could require several surgeries to change the dressings as the wound heals.

**Collodion** is a topical, flexible occlusive dressing for use on surgical incisions. Before using collodion, the care provider should confirm that patients are not allergic to ether, alcohol, or cellulose-based products. Because collodion is a mixture of ethyl alcohol (22%) and ether (67%), it is EXTREMELY FLAMMABLE. Lasers and electrosurgery devices should not be activated in the presence of flammable agents such as collodion until the agents are dry and the vapors have dissipated. Care providers should follow the manufacturer’s instructions for use, be familiar with the Safety Data Sheets about the product, and follow the facility’s policies regarding storage and use of collodion. Perioperative personnel should follow local and state fire regulations regarding the storage of flammable liquids such as alcohol-based skin antiseptic solutions, hand sanitizers, alcohol, acetone, and collodion and the location of dispensers.

**Casts, splints, and braces** are used to help protect and immobilize extremities during wound healing. For example, a femoral cast brace might be placed after orthopedic surgery to repair a femoral shaft fracture, or a short arm cast might be placed to immobilize and protect a radial fracture while it heals. Splints or casts are made from plaster or fiberglass. Padding is placed between the skin and the splint or cast to prevent skin burns or damage from plaster casting materials that produce heat as they harden.

Before and after an operative procedure in which a cast, splint, or brace is placed, to the perioperative RN should assess and document the patient’s circulation, motion, and sensation (CMS check) in the affected extremity. After surgery, the immobilized limb is usually elevated with pillows or foam padding devices which promotes venous return and helps prevent edema.

Patient education is an important aspect of nursing care for patients with casts, splints, or braces. Perioperative RNs should instruct patients not to remove casts or splints unless they are told to do so by a physician. Patients also need to understand whether and in what manner bathing or showering is permitted; and to communicate with their health care provider if they experience signs of impaired circulation and nerve compression of the affected extremity (e.g., pain, lack of easily detectable pulse, pallor, pressure, poikilothermia [inability to maintain a constant core temperature], tingling or burning, inability to move muscles around the cast); and signs and symptoms of infection (e.g., drainage or a foul odor near the cast’s edges).

Patients should also be instructed to practice good skin care around the cast and not to insert objects (e.g., coat hangers), creams, lotions, or powder under the cast.

**COMPLEX WOUND CARE**

The term complex wound is used to refer to wounds that are challenging and costly to treat and require individualized, coordinated approaches to wound management. This category of wounds includes ostomies, chronic venous ulcers, ulcers associated with vasculitis or diabetic neuropathy, deep pressure sores, traumatic or necrotizing wounds, burns, post-radiation wounds, and complicated surgical wounds. Complex wounds may require an individualized treatment approach using advanced wound care therapies developed by a multidisciplinary team. Surgery is sometimes indicated for complex wounds. Debridement may be performed to remove nonviable tissue, while grafts or tissue flaps may be used to reconstruct lost skin and subcutaneous tissue. Other therapies for complex wounds include the use of biological skin equivalents and negative pressure wound therapy. Some patients with complex wounds also benefit from nutritional and behavioral counseling to help them understand and cope with the need for ongoing care at home.

**PEDIATRIC WOUND CARE**

Many of the principles of adult wound care also apply to infants and children. However, some aspects of wound care must be tailored because of physiological and developmental differences between children and adults. For example, infants and young children may not be able to verbally express pain, which can increase the risk of pressure sores or friction blisters. Additionally, the skin of infants is more susceptible to epidermal tears and blisters, because their epidermis is only loosely attached to the underlying dermis. Children’s skin
also is more sensitive to certain chemicals found in topical products. Antiseptic solutions such as alcohol, povidone iodine, and hydrogen peroxide can be cytotoxic and can delay wound healing, particularly in children.

Children also may try to pull off wound dressings; thus, topical or paint-on products may provide superior wound protection. Some children experience pain during application of tissue adhesives, and may benefit from a topical analgesic applied before application of the tissue adhesive. One prospective study found that amniotic membrane was superior to silver sulfadiazine in children with burn wounds. Use of amniotic membrane was associated with reduced hospital stay and number of dressing changes. It is important to note that dosages of topical wound care products intended for adults should be carefully evaluated and reduced when necessary for children. Furthermore, perioperative personnel need to follow product manufacturers’ written instructions for use.

Surgical site infections are an important consideration in children and adolescents as well as adults. Studies indicate surgeons and RN circulators classify pediatric wounds differently. In a single-center retrospective cohort study of 312 pediatric appendectomy cases, the surgeon diagnosis-based and RN circulator-based surgical wound classifications differed in 92% of cases, and differed by more than one classification in 56% of cases. The researchers concluded that such inconsistencies could significantly affect outcome measures, which could cause misdirection of quality-improvement efforts and incorrect inter-hospital ratings. Another small cross-sectional study reported poor consensus among pediatric surgeons on the classification of incisions on neonates.

Guidelines for prevention of specific types of SSIs may be lacking in children even when available for adults, and the incidence rates of pediatric SSIs may be poorly understood or underreported. Researchers conducting an online survey of 89 congenital heart programs recently reported that the incidence of pediatric sternal wound infections was 1.53%. The researchers also found that pediatric programs did not consistently follow adult guidelines for SSI prevention. Based on their findings, the researchers recommended protocol-based management of pediatric blood glucose levels and sending mediastinal wound cultures at the time of surgical closure.

Personnel at some health care facilities have implemented pediatric-specific measures to prevent postoperative wound complications. For example, nurses in the cardiac and main ORs at a major children’s hospital designed and implemented a tool to assess patient risk and plan nursing interventions to prevent pressure ulcers in pediatric surgery patients. A prospective study indicated that use of the tool in conjunction with increased awareness and education regarding pressure ulcer prevention, and a hospital-wide focus on skin care helped to reduce pressure ulcers in pediatric surgery patients.

**COLLABORATION**

Collaboration between health care team members can help to achieve optimal outcomes in wound care. Perioperative RNs provide wound care in collaboration with a diverse range of clinical providers, such as physicians and licensed independent practitioners, infection preventionists, wound and ostomy RNs, advanced practice nurses, and other health care personnel. Collaboration is always important, and is especially important in cases of chronic and complex wounds, such as venous ulcers, which require the efforts of a multidisciplinary team to manage challenges and complications as they arise. Collaboration is also essential for patients who have comorbid conditions such as diabetes or other risk factors for delayed healing or non-healing.

**SUMMARY**

Perioperative RNs and their colleagues should understand the complex physiology of wound healing; identify patient risk factors that negatively affect wound healing; and implement evidence-based nursing practices for improved wound healing. These practices include providing

- preoperative patient education and preparation;
- intraoperative care, including maintaining sterile technique and correctly classifying surgical wounds;
- postoperative assistance in the treatment and management of perioperative wounds;
- collaboration and communication with clinical providers involved in wound management; and
- wound management education for patients.

Perioperative nurses play a key role in managing wound care and preventing SSIs in surgical patients.
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REFERENCES


69. Prevention Strategies: Core Intraoperative Measures slide 17.
1. A shoulder examination under anesthesia is an example of what class of wound?
   a. Class 1
   b. Class 2
   c. Class 3
   d. No wound classification

2. The most common cause of impaired wound healing in surgical patients is
   a. diabetes mellitus.
   b. inadequate dietary protein intake.
   c. intraoperative hypothermia.
   d. surgical site infections.

3. Which physiologic response to wounding is primarily characterized by granulation tissue, neovascularization, and re-epithelialization?
   a. Hemostasis
   b. Inflammatory phase
   c. Proliferative phase
   d. Remodeling phase

4. An advantage of closure by secondary intention is
   a. ability to clean the wound surface.
   b. faster healing.
   c. less scarring.

5. A patient presents 10 days after hernia repair with a fever of 101°F (38.3°C). The suture line has partially dehisced and you observe purulent discharge from the tissue underlying the incision. What kind of surgical site infection is this most likely to be?
   a. Deep incisional
   b. Organ or space
   c. Superficial incisional

6. Choose the TRUE statement about topical hemostatic products.
   a. Active hemostatic products include cellulose and gelatins.
   b. Fibrin sealants increase levels of fibrinogen and thrombin at a bleeding site.
   c. Flowables contain fibrinogen.
   d. Passive or mechanical hemostatic products contain thrombin.

7. A Penrose drain is an example of a
   a. chest drainage system.
   b. closed drainage system.
   c. simple drain.

8. Choose the TRUE statement about dressings.
   a. Certain dressings are definitively associated with improved outcomes.
   b. Primary dressings are bulkier than secondary dressings.
   c. Primary dressings are usually made of adherent material.
   d. Secondary dressings absorb discharge, protect wounds, and promote hemostasis.

9. Ostomies, burns, chronic venous ulcers, and necrotizing wounds are examples of
   a. class 1 wounds with low risk of infection.
   b. complex wounds that require individualized treatment.
   c. superficial surgical site infections that require antibiotic therapy.
   d. wounds that require delayed primary closure.

10. Use of the Center for Disease Control and Prevention’s Surgical Wound Classification System
    a. adds significant time to operative procedures.
    b. enables comparison of infection rates and assessment of infection risk.
    c. is recommended primarily for complex or high-risk wounds.
    d. must be performed by a surgeon.
POST-TEST ANSWERS
WOUND CARE AND HEALING IN PERIOPERATIVE PRACTICE

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