Reducing the Risk of Surgical Site Infections

by Ashley Coffey, RN, BSN, BA

CE2216 | 0.50 contact hrs

Course Objectives

The goal of this course is to provide perioperative nurses and surgical technologists with information to assess risk for and prevent surgical site infections in the perioperative setting.

After taking this course, you should be able to:

- Identify surgical site infections by primary vs. secondary and superficial vs. deep
- List three risk factors for surgical site infections.
- Describe three ways perioperative professionals can help prevent surgical site infections.

An Introduction to Surgical Site Infection (SSI)

Physiologic Wound Healing

Wound healing sounds like a simple process: Following a cut or incision, healed skin eventually grows back over the area. However, it is not quite that simple. Wound healing actually involves several processes, some of which occur simultaneously and others which occur after the completion of other parts of other processes. It is most easily understood as three overlapping phases, but there are researchers who have dedicated their entire careers to studying a single type of cell's work within one phase of the healing process. The three phases of wound healing are (Avishai, Yeghiazaryan, & Golubnitschaja, 2017):

- Hemostasis: When the hemostasis phase is triggered, the vasculature contracts, platelets aggregate, and fibrin clots form, which triggers the inflammation phase.
- Inflammation/proliferation: In the inflammation phase, platelets are activated, and the injured tissue releases cytokines and chemo-attractants which signal neutrophils, macrophages, and lymphocytes to accumulate at the site of injury. The area surrounding the wound becomes supplemented with platelets, macrophages, and s[illegible] cells, all of which promote fibroblast activation, leading into the proliferative phase. As fibroblasts make their

to the wound, local endothelial cells trigger revascularization, which promotes the proliferation of fibroblasts and blood supply, priming the area for remodeling.

- *Remodeling: Fibroblasts encourage the growth of the components of extracellular matrix (ECM), like collagen, glycosaminoglycans, and proteoglycans. This process of growth (proliferation) and reshaping the wound (remodeling) may take days to years, depending on the severity of the injury.*

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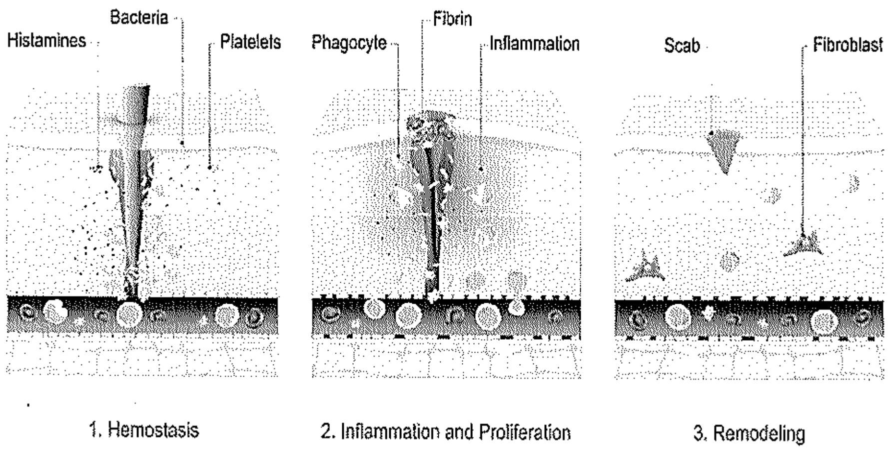
Wound healing



Defining SSI

An SSI is an infection occurring at/near a surgical incision (incisional or organ/space) within 30 days after surgery, or within 90 days if an implant is in place (Magill et al., 2014). SSIs delay the recovery of 2 to 5% of patients with surgeries outside the abdomen (such as thoracic and orthopedic surgeries) and up to 20% of patients with abdominal procedures (colon or gynecological surgeries). SSIs account for nearly 40% of all HAIs in surgical patients and are the second-most reported HAI (NHSN, 2021).

Superficial incisional SSIs
There are two types of superficial incisional SSIs (NHSN, 2017):

- Primary: Superficial incisional SSI identified in the primary incision in a patient who has had a surgery with one or more incisions (e.g., chest incision for coronary artery bypass graft)
- Secondary: Superficial incisional SSI identified in the secondary incision in a patient with multiple incisions (e.g., donor site incision for coronary artery bypass graft with both chest and donor site incisions)

Superficial incisional SSIs involve skin or subcutaneous tissue that goes no deeper than the adipose layer. Muscle and fascia are not involved. Other signs and symptoms include purulent drainage, and a single sign of inflammation (e.g., pain/tenderness, swelling, erythema, or heat). Superficial SSIs are usually caused by aerobic organisms when isolated from fluid/tissue.

Deep incisional SSIs
There are also two types of deep incisional SSIs (NHSN, 2017):

- Primary: Deep incisional SSI identified in the primary incision in a patient who has had a surgery with one or more incisions (e.g., chest incision for coronary artery bypass graft)

- Secondary: Deep incisional SSI identified in the secondary incision in a patient with multiple incisions (e.g., donor site incision for coronary artery bypass graft with both chest and donor site incisions)

Deep incisional SSIs involve deep soft tissues, including fascia and/or muscle. They are characterized by purulent drainage from the deep incision that is not from the organ/space, deep incision dehiscence, and/or the presence of an abscess above the level of the fascia. Sometimes these wounds will be left open deliberately by the surgeon due to signs of severe inflammation. Organisms may be aerobic or anaerobic.

Organ/Space SSI

Organ/Space SSIs involve the underlying anatomical structures operated on during the surgery, not including the skin, incision, fascia, or muscle layers (NHSN, 2017). Organ/Space SSIs may have purulent drainage from a drain placed into the organ/space and a visible abscess on an anatomical or histological exam that is also often detectable in imaging. These are usually cause by anaerobic organisms isolated from a fluid/tissue culture of the organ/space beneath the fascia.

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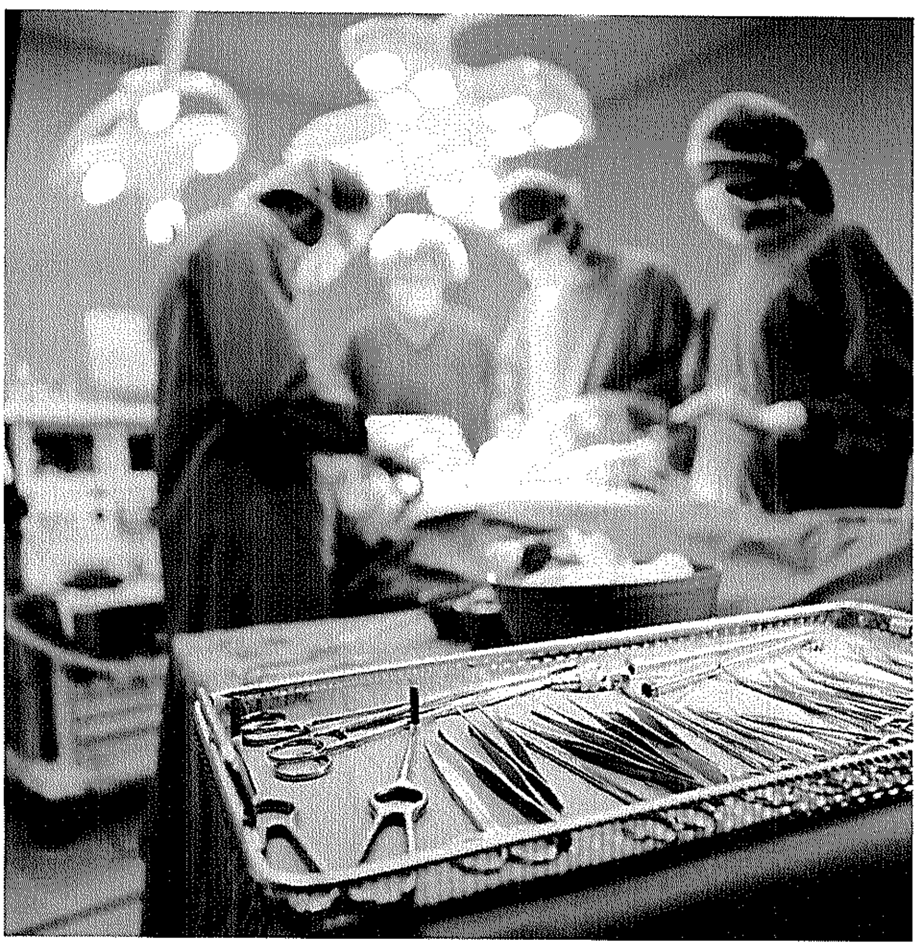
Risk Factors for SSI



Even with the best surgical techniques, skin disinfection, and other prevention strategies, SSIs still occur. Once surgery begins, every surgical incision becomes contaminated from bacteria on the skin or the internal surgical organ if pathogens are present. Contamination is usually due to endogenous flora on the skin at the surgical site, on mucous membranes, or in the hollow digestive viscera (Anderson & Sexton, 2021b). Contamination can also result from exogenous sources, including the OR staff/environment, the air ventilation system, and surgical instruments. Usually, the patient's immune system eliminates the contaminating organisms, and no infection develops.

Patient-Related Risk Factors

Because wound healing is a complicated, overlapping cascade, there are many factors which may contribute to poor wound healing during any phase of the healing process. For example, neuropathy and local tissue ischemia following surgery can block neutrophils, macrophages, and lymphocytes from receiving the signal to accumulate during the hemostasis/inflammatory phase (Armstrong & Meyr, 2021). By extension, any existing condition resulting in neuropathy may impact wound healing. For example, infection and tissue death may alter the inflammatory balance and compete for resources, like oxygen, at the site of injury. This means that any underlying condition that may promote/worsen infection or tissue death may also impact wound healing.

Some patient-related risk factors are not modifiable. There is also a great deal of ongoing research exploring the impact of many genetic markers within the inflammatory cascade and how they each affect wound healing. Just a few non-modifiable risk factors include (Avishai, Yeghiazaryan, & Golubnitschaja, 2017):

- Age older than 65 years
- Down syndrome
- Immune system disorders
- Disorders which inhibit hemoglobin synthesis (i.e., sickle cell anemia)
- Genetic predisposition to vascular disease
- Male gender
- Connective tissue disorders (i.e., Ehlers-Danlos and Werner syndromes)

Modifiable risk factors include (Avishai, Yeghiazaryan, & Golubnitschaja, 2017):

- Psychological stress
- Smoking and nicotine replacement therapy
- Excessive alcohol consumption
- Poor nutrition (poor appetite and obesity)
- Immobilization

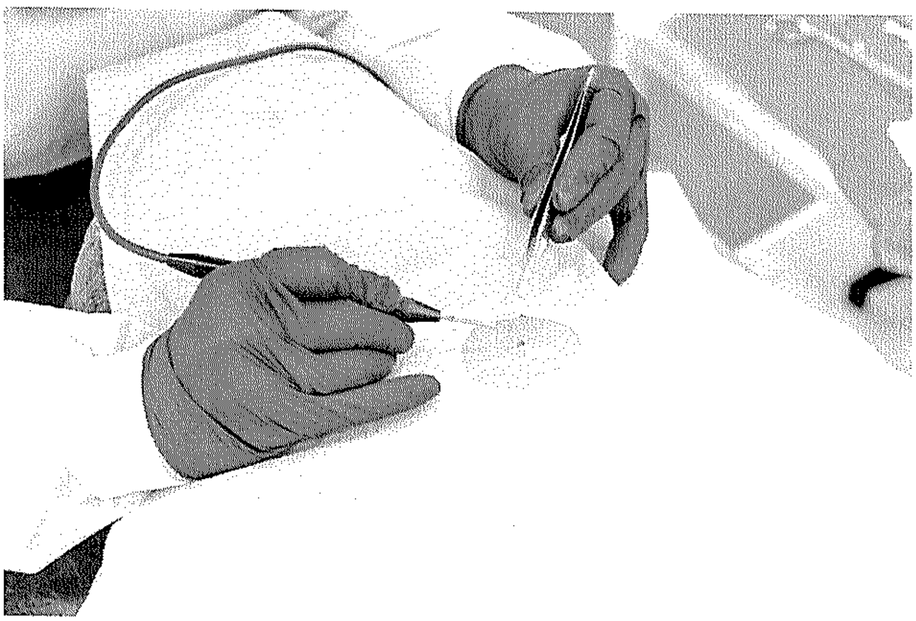
Comorbidities that may contribute to SSI include (Avishai, Yeghiazaryan, & Golubnitschaja, 2017):

- Diabetes
- Vascular disease
- Cancer
- Immunosuppressive therapy
- Infection

- Blood transfusion

Procedural Techniques

Procedural techniques, such as electrocautery on the skin, can influence the risk for infection. Residual "dead space" in the wound following closure may foster favorable living conditions for bacteria to multiply and lead to infection (Anderson & Sexton, 2021a). Some surgeons use a protective wound edge drape or incise sheet on top of the skin prior to incision. The incise sheets may be clear plastic or iodophor-impregnated. Some surgeons also irrigate the surgical site with sterile saline or antibiotic solution before closing to decrease pathogen count.

- 

Environment

Environmental considerations include thoroughly cleaning surfaces with U.S. Environmental Protection Agency-approved disinfectants and minimizing the spread of air particulates. Surfaces like push plates, cabinet handles, knobs, buttons, and keyboards can breed harmful bacteria and other organisms (Anderson & Sexton, 2021a). ORs have specialized air systems that exert positive pressure to prevent pathogens from circulating. Some specialty rooms may have laminar airflow units that function to filter the cleanest air toward the sterile field or use ultraviolet light to destroy bacteria on surfaces for additional protection. Note that air can never be completely sterilized, despite efforts to achieve the cleanest air possible.

> Though the air quality is maintained at the cleanest levels possible, the air itself is never sterile.

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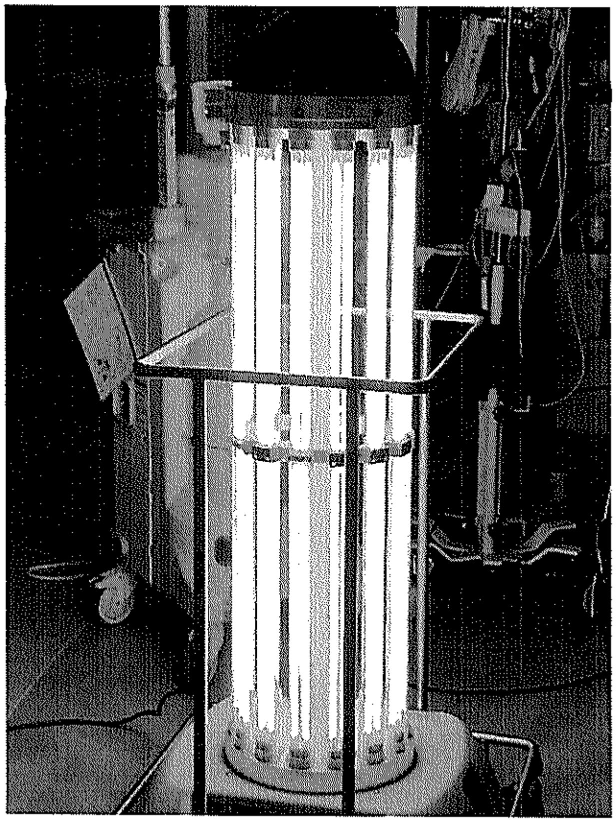

OR staff attire, such as sterile gowns and gloves, hair covers that completely enclose the hair and ears, and masks, may also impact bacterial spread. Skull caps should be avoided because hair may stick out at the nape of the neck, shedding bacteria and other particulates into the surgical site (Anderson & Sexton, 2021a).

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Note that all clinicians in this picture have their caps and masks on appropriately, with hair secured within the cap.

Risk Assessment

The number of bacteria present in the incision at the end of surgery is the primary source of SSIs.

Four classes of surgical procedures are used to determine the likelihood of SSI depending on the duration and type of exposure to pathogens (Anderson & Sexton, 2021b):

- **Class 1:** Clean procedures: Uninfected primary surgical incision with no inflammation; respiratory, GI, biliary, or genitourinary tracts not entered; 1 to 2% infection rate without prophylactic antibiotics. Closed by primary intention, may be drained with closed-system drainage. Possibly a non-penetrating blunt trauma injury opened for exploration in the OR. No break in sterile technique.
- **Class 2:** Clean-contaminated procedures: Surgical incisions in which respiratory, GI, biliary, and genitourinary tract are entered under controlled conditions with minimal spillage and no infected urine or bile; 6 to 9% infection rate without prophylactic antibiotics. No break in sterile technique.
- **Class 3**: Contaminated procedures: Open, fresh, accidental wounds (of less than four hours' duration) and surgeries with major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the GI tract; also includes incisions in which acute, non-purulent inflammation is present; 13 to 20% infection rate without prophylactic antibiotics.
- **Class 4:** Dirty/infected procedures: Purulent inflammation present. Includes old traumatic wounds (of more than four hours' duration) with retained necrotic tissue and those involving existing clinical infection or perforated viscera; about 40% infection rate without prophylactic antibiotics.

Surgical risk is further described by three additional risk factors: An operation lasting more than 2 hours, abdominal surgery, or a patient who has three or more underlying diagnoses (Anderson & Sexton, 2021b). The addition of these three factors to the wound classification system makes risk prediction of a wound infection more useful than the traditional wound classification alone.

Importantly, wound class documentation must be completed at the *end* of the surgical procedure rather than before or during surgery, as it is impossible to accurately predict surgical outcomes.

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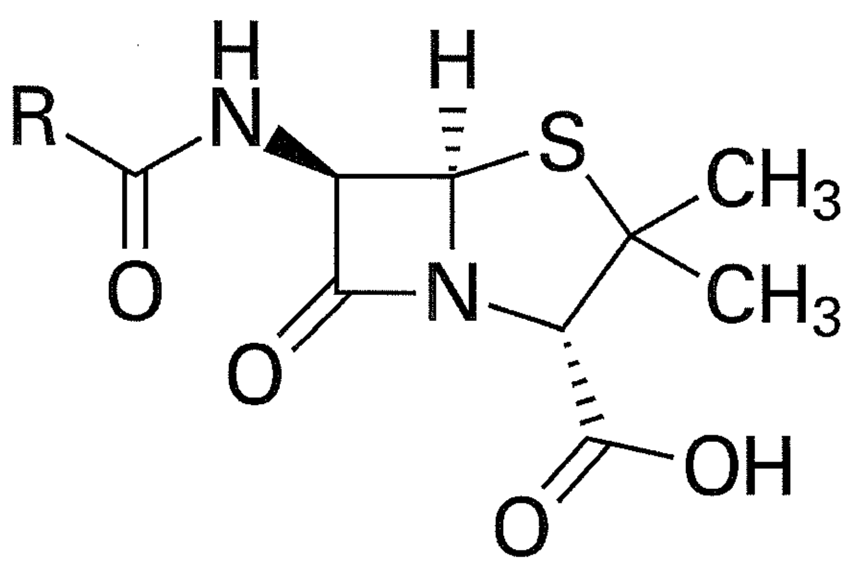
Surgical Care Improvement Project (SCIP) Core Measure Set



• *Penicillin was discovered by Alexander Fleming in 1928.*

Penicillin core by Yikrazuul, Public domain, via Wikimedia Commons

The advent of antibiotics contributed to the belief that wound infections following surgery might be a thing of the past. In the 1960s, the first of many hundreds of studies helped establish the efficacy of certain antibiotics to prevent SSIs (Anderson et al., 2014). These studies informed the first guidelines for prophylactic antibiotic administration. However, as bacteria continue to develop drug resistance, it has become clear that not all antibiotics are prescribed or timed appropriatel ... t SSIs.

Antibiotic resistance tests: The culture on the left shows susceptibility to the antibiotics within the white paper discs. The bacteria on the right are resistant to most of the antibiotics.

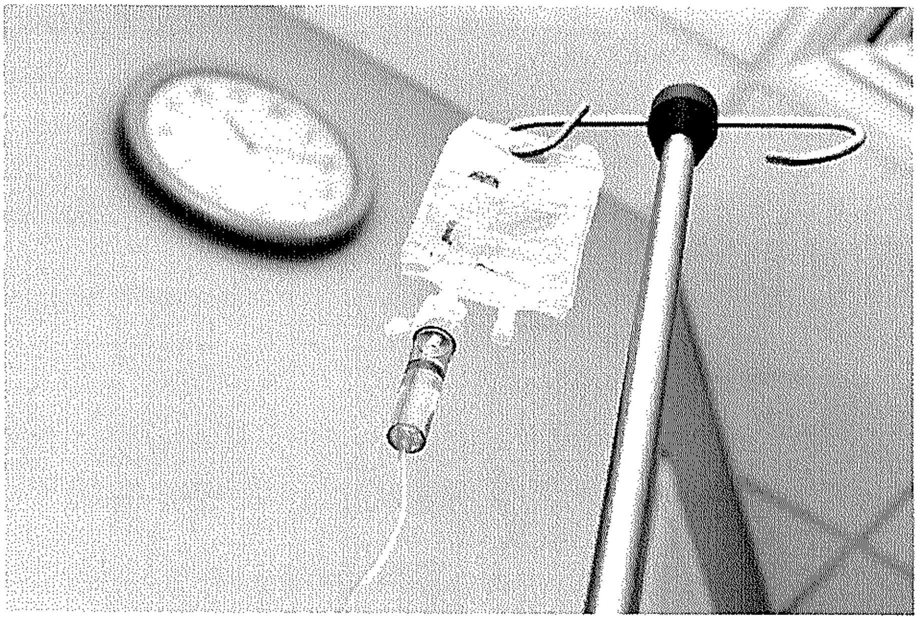
The Surgical Care Improvement Project (SCIP) is a set of performance measures developed in 2005 by the Centers for Medicare & Medicaid Services (CMS), The Joint Commission (TJC), the Center for Disease Control and Prevention (CDC), the American College of Surgeons (ACS), and the American Hospital Association (AHA) to improve patient safety and monitor progress on many performance markers with early and particular focus on improving SSIs. These performance measures are now tied to reimbursement and accreditation through CMS and TJC, so the incentive to improve the rates of preventable SSIs is high. These are the performance measures currently used to help to reduce SSIs (Anderson & Sexton, 2021b):

- The prevention of infection through proper selection, timing, and administration of antimicrobial prophylaxis
- Postoperative blood glucose control in cardiac surgery patients
- Proper hair removal outside the OR
- Maintain body temperature between 36° C (96.8° F) and 38° C (100.4°F) within 1 hour of leaving the OR
- Appropriate hygiene and gowning for all members of the surgical team prior to OR entry
- Appropriate post-surgical wound care and maintenance

With the goal of improving patient care in mind, nurses, surgeons, surgical technologists, anesthesiologists, infection control specialists, pharmacists, and administrators must work together to improve patient safety by providing evidence-based care that is consistent with clinical practice guidelines. The SCIP performance measures provide an evidence-based framework for clinicians to reduce the risk of SSIs.

SCIP Infection 1: Prophylactic Antibiotic Within 1 Hour Before Surgical Incision

Prophylactic antibiotic should be administered no earlier than 1 hour before surgical incision or within 2 hours before incision if vancomycin (Vancocin™) or a fluoroquinolone (e.g., ciprofloxacin) for prophylaxis (Anderson & Sexton, 2021b). Timing is important if a tourniquet is used. Antibiotics should be allowed adequate dwell time before the tourniquet is inflated.



The timing of antibiotic administration is critical to prevent SSIs. Antibiotics should be given as close to incision time as clinically possible, but not more than 60 minutes before surgery/tourniquet inflation (unless using a fluoroquinolone or vancomycin).

Facilities may enact policies to ensure that prophylactic antibiotics are delivered no more than 1 hour before the incision is made. Patients should receive antibiotics in the preoperative area/OR rather than "on-call."

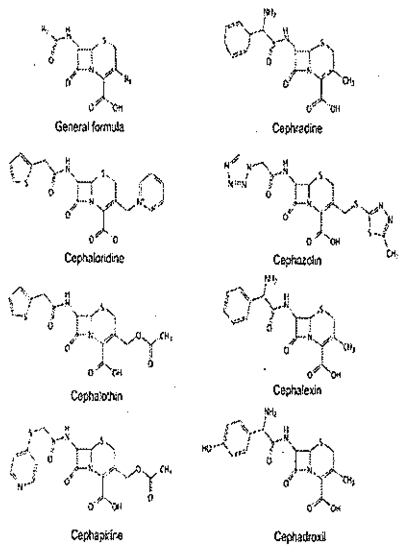
> On-call dosing may result in case delays and patients receiving preoperative doses outside of the recommended time frame (Anderson & Sexton, 2021b). If an "on-call" dose is given and then the case is delayed, the patient will need to be re-dosed.

SCIP Infection 2: Prophylactic Antibiotic Selection

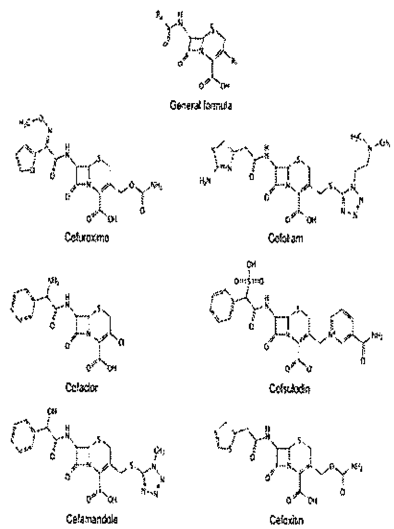
Surgical patients should receive prophylactic antibiotics recommended by current published guidelines for each type of procedure (Anderson & Sexton, 2021b). For most surgeries, cephalosporins are appropriate. First- or second-generation cephalosporins, such as cefazolin (Ancef™, Kefzol™) or cefoxitin (Mefoxin™) for colon surgeries, are ideal for prophylaxis. Colon procedures on patients requiring bowel prep may also benefit from oral antibiotics at the same time.

Open each of the images below in a new tab to view a larger version.

Antibiotics: Cephalosporins 1st generation



Antibiotics: Cephalosporins 2nd generation



To ensure that appropriate prophylactic antibiotics are used, hospitals should follow guidelines from the American Society of Health-System Pharmacists, the Infectious Diseases Society of America, the Sanford Guide to Antimicrobial Therapy, and/or the Surgical Infection Society.

> Routinely consulting pharmacists for all antibiotic dosing helps ensure adequate timing and dosing, especially within special patient populations (Anderson & Sexton, 2021b).

SCIP Infection 3: Prophylactic Antibiotics Discontinued Within 24 Hours After End of Surgery

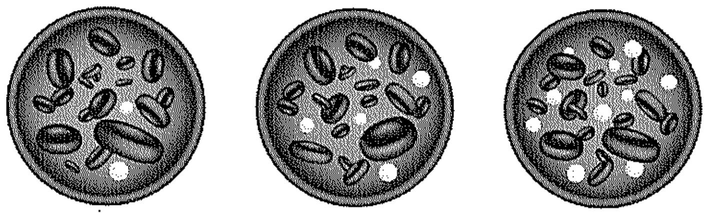
Prophylactic antibiotics should be discontinued within 24 hours after surgery, except for cardiothoracic surgery, when 48 hours is appropriate (Anderson & Sexton, 2021b). Studies suggest that antibiotic prophylaxis beyond 24 hours after closing the incision does not offer additional benefits, and more likely contributes to the development of *Clostridium difficile* and other antibiotic-resistant organisms.

SCIP Infection 4: Controlled Postoperative Serum Glucose

> Surgical patients with a perioperative blood glucose level of 200 mg/dL or more have a greater risk of SSI (Berrios-Torres et al., 2017).

Hyperglycemia leads to diminished host defenses by weakening leukocyte functions, including adherence, chemotaxis, phagocytosis, and bactericidal activity. Hyperglycemia was associated with a 102% increase in the risk for wound infection in one study of cardiothoracic patients, which is why this measure is only applied specifically to cardiac surgery patients (Reddy, Duggar, & Butterworth, 2014). Additionally, patients with diabetes undergoing cardiac surgery have a two to three times greater risk of infection than patients without diabetes.

THE GLUCOSE LEVELS



Hyperglycemia is also risky for non-cardiac surgery patients. The risk of infection increases four times over if the patient becomes hyperglycemic at any time during the first postop day (Galindo, Fayfman, & Umpierrez, 2018).

> While this performance measure is limited to cardiac surgery, maintaining blood glucose levels less than 200 mg/dL is important for other postoperative patients as well. The current recommendation is a blood glucose level from 140 to 180 mg/dL (Galindo, Fayfman, & Umpierrez, 2018).

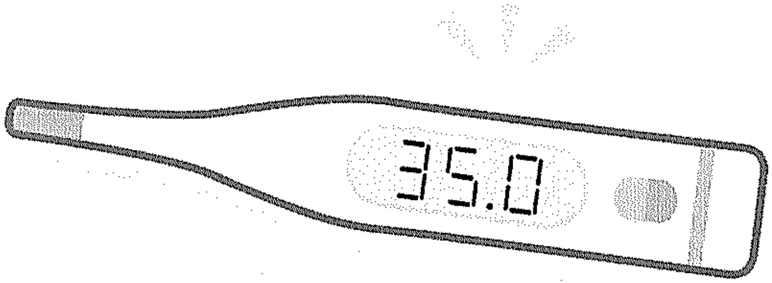
SCIP Infection 6: Appropriate Hair Removal

Cuts from preoperative shaving increase the risk of SSIs. Even with careful skin preparation, up to 20% of bacteria remain on the skin beneath the surface, in hair follicles and sebaceous glands (Anderson & Sexton, 2021a). Shaving permits these bacteria to sift into microscopic cuts in the skin. To reduce SSIs, current best practice is to not remove hair. If it is unavoidable, shaving should be performed in the immediate preoperative area, using electric clippers and a disposable, single-patient-use cutting head (Anderson & Sexton, 2021a).

> - Clipping should not be performed in the OR.

SCIP Infection 10: Perioperative Temperature Management

Hypothermia (i.e., core body temperature less than 36° C [96.8° F]) almost always occurs during surgery, from exposure to the cool ambient air in the OR and the effects of anesthesia (Anderson & Sexton, 2021a). General anesthesia inhibits normal thermoregulation, which shifts heat from the body's core to the periphery, leveling off at around 34° C (93.2° F). As body temperature decreases, vasoconstriction shunts blood away from subcutaneous tissue, reducing oxygen supply to wounds and impairing immune function. Even mild hypothermia may increase hospital length of stay for patients.



While this SCIP measure is targeted only for colorectal surgery, all patients should maintain temperatures as close to 37° C (98.6° F) (i.e., normothermia) as possible during surgery (Anderson & Sexton, 2021a). This is accomplished by keeping the OR relatively warm and using pre-operative/intra-operative measures to warm the patient, like warmed IV fluids and blankets.

Early studies measuring the success of SCIP show that when facilities strive to meet all measures, there is a greater improvement in care than if they focus on a single measure.

> All surgical team members share the professional obligation to adhere to these recommendations to ensure the safest surgical care possible for patients.

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Conclusion

Course Summary

Now that you have finished viewing the course content, you should have learned the following:

- Three or more risk factors associated with SSIs
- At least three ways perioperative clinicians can reduce the risk of SSI