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Prevention of Surgical Site Infections

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S*urgical site infections* (SSIs) are defined as infections that occur within 30 days of the operation if no implant is left in place or within 1 year of operation if an implant is left in place and the infection appears to be related to the operation. These infections are further defined by their anatomic location (**Figure 1**):[1,2] *superficial infections* (47%) involve only skin or subcutaneous tissue of the incision; *deep infections* (23%) involve the fascia and muscle layers; and *organ space infections* (30%) involve any part of the anatomy (other than the incision) that was opened or manipulated during the operation. SSIs complicate 2% of major operations and are the most common nosocomial infection among surgical patients.[3,4] Patients who develop SSIs are 60% more likely to spend time in an intensive care unit, are 5 times more likely to be readmitted to the hospital, and are twice as likely to die than patients without these infections.[5] Studies have shown that hospitals could save an average of $3152 and reduce length of stay by 7 days by preventing a single SSI.[6]

In 2002, the Centers for Medicare and Medicaid Services (CMS) and the US Centers for Disease Control (CDC) initiated the National Surgical Infection Prevention Project (SIP) to decrease SSI morbidity and mortality.[7] National experts and representatives of major surgical professional organizations developed 3 performance measures addressing prophylactic antibiotic administration. The SIP measures focus on commonly performed procedures in which there is little controversy over the need for prophylaxis. Refined and nationally standardized versions of these measures have been adopted by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and are required to be reported to the CMS by all hospitals receiving Medicare reimbursement.[8] In 2005, the Surgical Care Improvement Project (SCIP) was launched. SCIP is a national quality partnership of organizations committed to improving the safety of surgical care through the reduction of postoperative complications such as SSIs. The SCIP measures incorporate the SIP measures for antibiotic prophylaxis and target specific at-risk patient populations for additional infection prevention measures.[9] This article, which is the third in a series addressing recent evidence-based recommendations for improving the quality and safety of surgical

TAKE HOME POINTS

- Prophylactic antibiotics should be administered in all clean cases that involve implantation of a foreign body, coronary artery bypass grafting, or clean-contaminated cases (ie, those undergoing elective open surgery of the respiratory, gastrointestinal, or genitourinary tract with minimal spillage and without encountering infected urine or bile; or a minor break in technique).
- Prophylactic antibiotics should be administered within 60 minutes before surgery and should also be discontinued within 24 hours after surgery. Novel broad-spectrum agents that are typically used as frontline therapeutic agents should be avoided.
- Normothermia should be maintained during most surgical procedures unless hypothermia is specifically indicated.
- For patients who have undergone cardiac surgery, 6 AM blood glucose levels should be at or below 200 mg/dL on the first 2 postoperative days.
- Hair removal, if necessary, should be performed using electric clippers immediately before the operation.

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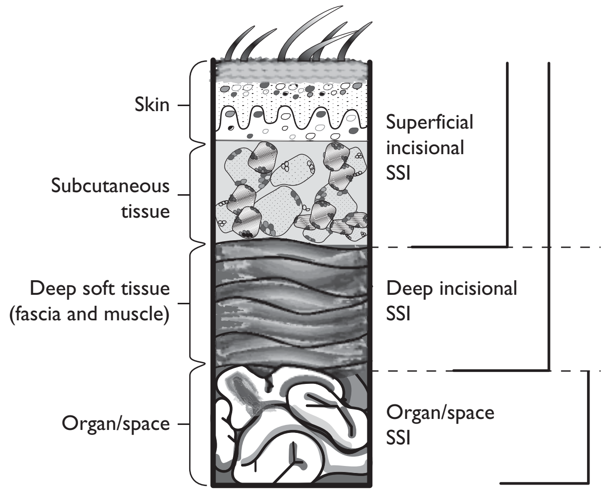

Figure 1. Cross-section of abdominal wall depicting US Centers for Disease Control classifications of surgical site infections (SSIs). (Adapted from Horan TC, Gaynes RP, Martone WJ, et al. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. Infect Control Hosp Epidemiol 1992;13:606–8.)

Table 1. Risk Factors Associated with Surgical Site Infection

Modifiable risk factors
Long preoperative stay
Inappropriately timed antibiotic prophylaxis
Surgical site shaving 1 day before surgery
Duration of operation
Drains in wounds
Tissue damage
Blood loss/blood transfusion
Nonmodifiable/difficult to modify risk factors
Old age
Malnutrition
Obesity
Immunosuppression
Diabetes mellitus
Corticosteroid use

Adapted with permission from Gyssens IC. Preventing postoperative infections: current treatment recommendations. Drugs 1999;57:177.

care, reviews the principles of SSI prevention and provides illustrative cases to demonstrate the approach to preventing these infections.

RISK FACTORS

Multiple factors influence the development of SSIs.[1] These include preoperative factors (preoperative hospitalization, prophylactic antibiotic administration, and preoperative skin cleansing), intraoperative factors (length of operation, wound contamination, wound hemostasis, and tissue damage), postoperative factors (blood glucose control, incision care, and wound surveillance), and patient factors (preexisting infection, diabetes, chronic steroid use, smoking, and malnutrition). Some risk factors for SSIs are readily modifiable (eg, treatment of preexisting infections), whereas others are not (eg, patient comorbidities; **Table 1**).

- **How is the risk of SSI quantified preoperatively?**

Surgical procedures can be classified by the degree of wound contamination (**Table 2**), with SSI incidence increasing with the degree of contamination.[10] Several other models are used to predict risk for developing SSI. In 1985, the Study on the Efficacy of Nosocomial Infection Control (SENIC) developed a risk index for surgical wound infection that is based on 4 variables: (1) abdominal operation; (2) length of operation greater than 2 hours; (3) contaminated or dirty infected operation; and (4) presence of more than 2 diagnoses.[11] The National Nosocomial Infection Surveillance (NNIS) classification system was introduced in 1991. This classification system stratifies surgical patients into 4 risk index groups by assigning each of the following a value of 1, if present: (1) the degree of preoperative contamination (dirty or contaminated); (2) American Society of Anesthesiologists score of 3 or more; and (3) a surgical operation lasting longer than a threshold time (≥ the 75th percentile for the procedure) depending on the operation performed.[12] Recently, an SSI risk index was developed using the Patient Safety in Surgery study and Veterans Affairs National Surgical Quality Improvement Project (NSQIP) data.[13] The NSQIP risk index is based upon patient factors, preoperative laboratory values, and operative characteristics. An advantage of this risk index is that it can be used preoperatively to determine an individual patient's risk.

PREVENTIVE MEASURES

Preoperative, intraoperative, and postoperative management can modify the risk for developing a SSI. Although the SCIP measures target specific patient populations, they are based on general principles that should be applied to all patients.

Antibiotic Prophylaxis

Prophylactic antibiotics are administered when there is risk for infection. Prophylactic antibiotics are recommended when the risk for perioperative bacterial contamination is high and/or when infection will lead to

Table 2. Classification of Operative Wounds and Risk of Infection

Classification	Criteria	Risk (%)
Clean	Elective, not emergency, nontraumatic, primarily closed; no acute inflammation; no break in technique; respiratory, gastrointestinal, biliary, and genitourinary tracts not entered	< 2
Clean-contaminated	Urgent or emergency case that is otherwise clean; elective opening of respiratory, gastrointestinal, biliary, or genitourinary tract with minimal spillage (eg, appendectomy) and not encountering infected urine or bile; minor break in technique	< 10
Contaminated	Nonpurulent inflammation; gross spillage from gastrointestinal tract; entry into biliary or genitourinary tract in the presence of infected bile or urine; major break in technique; penetrating trauma < 4 hr old; chronic open wounds to be grafted or covered	~20
Dirty	Purulent inflammation (eg, abscess); preoperative perforation of respiratory, gastrointestinal, biliary, or genitourinary tract; penetrating trauma > 4 hr old	~40

Adapted from Cruse PJ, Foord R. The epidemiology of wound infection. A 10-year prospective study of 62,939 wounds. Surg Clin North Am 1980;60:28. Copyright 1980, with permission from Elsevier.

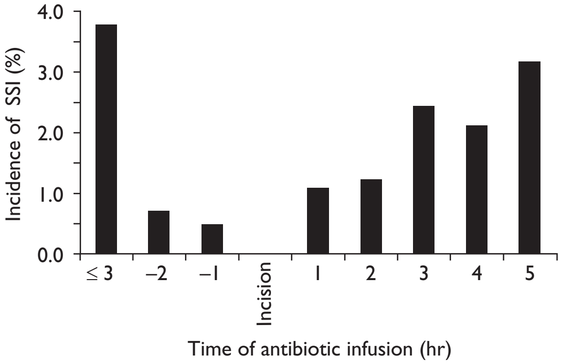

Figure 2. Antibiotic timing and incidence of surgical site infection (SSI). (Adapted from Classen DC, Evans RS, Pestotnik SL, et al. The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. N Engl J Med 1992;326:281–6.)

serious morbidity and mortality. The indication for antibiotic prophylaxis varies with the wound classification (Table 2). Prophylactic antibiotics should be administered in all clean-contaminated cases. Contaminated and dirty wounds are already infected and therefore require *therapeutic* antibiotics, not prophylaxis. Prophylactic antibiotics for SSI are often not indicated for clean cases, with the exception of cases involving prosthetic graft implants or when developing an infection would be catastrophic. For example, antibiotic prophylaxis for breast surgery and herniorrhaphy is controversial, but many studies have found them to be beneficial.[14–17] In breast surgery, SSI can delay subsequent radiation therapy and result in worse outcomes in patients with cancer.[18] Data from 2 recent meta-analyses support prophylactic antibiotics for breast surgery to decrease the risk of SSI.[14,19] In herniorrhaphy with mesh prosthesis, infection may require mesh removal, which is associated with significant morbidity.[20] However, a recent meta-analysis of antibiotic prophylaxis for inguinal herniorrhaphy with mesh concluded that further research is needed before routine prophylaxis can be endorsed.[21]

Three performance measures address proper antibiotic prophylaxis: (1) prophylactic antibiotics are given in the appropriate time frame before surgical incision, (2) the appropriate antibiotic is selected, and (3) prophylactic antibiotics are discontinued in the appropriate time frame following surgery.[8]

Antibiotic administration. An estimated 40% to 60% of SSIs are preventable with properly administered prophylactic antibiotics.[1] Timing of administration is critical in order to ensure effective drug levels, as both early and late administration are associated with increased infection rates (**Figure 2**).[21] Consensus guidelines state that prophylactic antibiotics should be given within 60 minutes prior to incision to achieve effective levels.[1,7,22] One of the most frequent problems encountered is administration of antibiotic infusion more than 60 minutes prior to incision.[23,24] However, a study within the Veterans Affairs Healthcare System found that prophylactic antibiotic administration in the operating room was more likely to be timely for all procedures and antibiotic types.[25]

Antibiotic selection. Antibiotics used for prophylaxis should be safe, cost-effective, and active against commonly encountered pathogens based on procedure type (**Table 3**). The choice of antibiotic should also be guided by local resistance patterns. First- and second-generation cephalosporins are appropriate prophylaxis for most procedures, although coverage of anaerobes is necessary for colon and some gynecologic surgery (**Table 4**). Vancomycin can be used as prophylaxis for patients who are allergic to β-lactam antibiotics. Additionally, clindamycin and fluoroquinolones are acceptable alternatives to cephalosporins under

Table 3. Operations and Likely Surgical Site Infection Pathogens

Operations	Likely Pathogens
Placement of all grafts, prostheses, or implants	*Staphylococcus aureus;* coagulase-negative staphylococci
Cardiac	*S. aureus;* coagulase-negative staphylococci
Neurosurgery	*S. aureus;* coagulase-negative staphylococci
Breast	*S. aureus;* coagulase-negative staphylococci
Ophthalmic*	*S. aureus;* coagulase-negative staphylococci; streptococci; gram-negative bacilli
Orthopedic	*S. aureus;* coagulase-negative staphylococci; gram-negative bacilli
Total joint replacement	
Closed fractures/use of nails, bone plates, other internal fixation devices	
Functional repair without implant/device	
Trauma	
Noncardiac thoracic	*S. aureus;* coagulase-negative staphylococci; *Streptococcus pneumoniae;* gram-negative bacilli
Thoracic (lobectomy, pneumonectomy, wedge resection, other noncardiac mediastinal procedures)	
Closed tube thoracostomy	
Vascular	*S. aureus;* coagulase-negative staphylococci
Appendectomy	Gram-negative bacilli; anaerobes
Biliary tract	Gram-negative bacilli; anaerobes
Colorectal	Gram-negative bacilli; anaerobes
Gastroduodenal	Gram-negative bacilli; streptococci; oropharyngeal anaerobes (eg, peptostreptococci)
Head and neck (major procedures with incision through oropharyngeal mucosa)	*S. aureus;* streptococci; oropharyngeal anaerobes (eg, peptostreptococci)
Obstetric and gynecologic	Gram-negative bacilli; enterococci; group B streptococci; anaerobes
Urologic†	Gram-negative bacilli

Adapted from 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;20:255.

*Limited data; however, prophylaxis is commonly used in procedures such as anterior segment resection, vitrectomy, and scleral buckles.

†Antibiotic prophylaxis may not be beneficial if urine is sterile.

certain conditions. Prophylaxis with vancomycin may also be advocated based on hospital methicillin-resistant *Staphylococcus aureus* patterns, although the threshold rate of this pathogen has not been established.[1] In order to prevent and retard the development of resistance, novel broad-spectrum agents that are typically used as frontline therapeutic agents should be avoided.[26]

A single dose of prophylactic antibiotic given prior to incision is sufficient for most surgical procedures.[27,28] However, there are situations where this approach may need to be modified. Consideration should be given for redosing the antibiotic intraoperatively when massive intraoperative hemorrhage occurs or when the operation lasts longer than 3 hours.[27] The decision to redose antibiotics intraoperatively should be based on antibiotic half-life (**Table 5**).[7] Most standard antibiotic dosing recommendations are based on ideal body weight. With the increase in obese patients undergoing surgical procedures, more consideration should be given to adjusting the dose of the prophylactic antibiotic.

Antibiotic discontinuation. There is no documented benefit to prolonged courses of prophylactic antibiotics.[29] Antibiotics administered as prophylaxis should be discontinued within 24 hours of the operation; however, antibiotic prophylaxis for cardiac surgery may be continued for 48 hours, due to concerns related to invasive lines and drains. Prolonged courses of prophylactic antibiotics are associated with the development of resistant bacteria and infection with *Clostridium difficile*.[30–35] Prolonged use of prophylactic antibiotics also may mask signs of established infections, make diagnosis more difficult, and prevent patients from receiving timely and adequate treatment. Additionally, the complexity of surgical intervention or the patient's condition is not an indication for continuing prophylaxis more than 24 hours following surgery.

SCIP Performance Measures

The SCIP measures provide an approach to reducing SSI incidence and improving overall surgical outcomes. These measures specifically target patient populations in which there is significant evidence to support intervention. In addition to the 3 prophylactic antibiotic measures developed by the SIP, SCIP proposes 4 infection prevention measures: (1) postoperative serum glucose control for cardiac surgery patients, (2) proper hair removal, (3) maintenance of normothermia in patients undergoing colorectal surgery, and (4) postoperative wound surveillance for SSIs in all patients. These measures will be discussed in more detail in the following cases.

Other Prevention Measures

In addition to the antibiotic prophylaxis and SCIP measures, there are several evidence-based interventions associated with decreased rates of SSI (**Table 6**).[1] The development of SSIs is a multifactorial process, just as the prevention of SSIs is multifaceted. In order to provide the highest level of care to patients and prevent SSI, it is important to apply all the evidence-based interventions available.

APPLYING PREVENTIVE MEASURES

Case 1: Elective Right Hemicolectomy

A 52-year-old man who is in good health is referred for evaluation of a fungating mass in the colon proximal to the hepatic flexure. His prior medical and surgical history is otherwise negative. He is scheduled for elective extended right hemicolectomy.

- **What measures are appropriate to prevent SSI in this patient?**

Based on the information provided, the patient is considered to be a clean-contaminated case. Prophylactic antibiotics are indicated, which could consist of any of the regimens listed in Table 4. As this patient is undergoing colorectal surgery, he will require measures to maintain normothermia during surgery.

Normothermia. Perioperative hypothermia is associated with impaired wound healing, adverse cardiac events, altered drug metabolism, and coagulopathies. Inadvertent hypothermia often occurs due to the combination of operating room environment and impaired thermoregulation. Both general and neuraxial anesthesia inhibit thermoregulation by inhibiting sweating, vasoconstriction, and shivering.[36–38] As a consequence, nearly all surgical patients become hypothermic unless warming measures are used. Impaired vasoconstriction allows for redistribution of blood flow from the core to the periphery and is associated with heat loss. Redistribution of heat to the peripheral circulation decreases core temperature 1°C to 1.5°C during the first hour of general anesthesia.[39]

Hypothermia reduces resistance to infection by directly impairing immune function and decreasing cutaneous blood flow. The oxidative capacity of neutrophils is impaired by hypothermia.[40] Protein wasting and impaired collagen synthesis, associated with hypothermia, decrease wound healing capacity.[41] Among patients undergoing elective colorectal surgery, hypothermia (core temperature, 34.7°C) was associated with longer hospital stay and tripled the incidence of SSI.[41] Additionally, hypothermia is associated with increased incidence of blood product administration, myocardial infarction, and mechanical ventilation.[42]

One SCIP performance measure targets patients undergoing colorectal surgery with immediate normothermia (temperature ≥ 36°C) within the first hour after leaving the operating room.[8] Multiple strategies exist for maintaining normothermia perioperatively. Intravenous (IV) fluids should be warmed prior to infusion. Each liter of IV fluid infused at ambient temperature or each unit of blood infused at 4°C

Table 4. Prophylactic Antibiotic Regimen Selection for Surgery

Surgical Procedure	Approved Antibiotics
Coronary artery bypass graft, other cardiac or vascular procedures	Cefazolin, cefuroxime, or vancomycin* If allergic to β-lactam antibiotics: vancomycin† or clindamycin†
Hip/knee arthroplasty	Cefazolin or cefuroxime OR vancomycin* If allergic to β-lactam antibiotics: vancomycin† or clindamycin†
Colon	Cefotetan, cefoxitin, ampicillin/sulbactam, or ertapenem‡ OR Cefazolin or cefuroxime + metronidazole If allergic to β-lactam antibiotics: clindamycin + aminoglycoside, or clindamycin + quinolone, or clindamycin + aztreonam OR metronidazole with aminoglycoside or metronidazole + quinolone
Hysterectomy	Cefotetan, cefazolin, cefoxitin, cefuroxime, or ampicillin/sulbactam If allergic to β-lactam antibiotics: clindamycin + gentamicin, or clindamycin + quinolone, or clindamycin + aztreonam OR metronidazole + aminoglycoside or metronidazole + quinolone OR clindamycin monotherapy

Adapted from the Centers for Medicare & Medicaid Services and the Joint Commission on Accreditation of Healthcare Organizations. Specifications manual for National Hospital Quality Measures [version 2.3a, Oct 2007]. Available at www.qualitynet.org. Accessed 10 Sep 2007.

*Vancomycin is acceptable with a physician/advanced practice nurse/physician assistant–documented justification for its use.

†For cardiac, orthopedic, and vascular surgery, vancomycin or clindamycin are acceptable substitutes if the patient is allergic to β-lactam antibiotics.

‡A single dose of ertapenem is recommended for colon procedures.

Table 5. Suggested Initial Dose and Time to Redosing for Antimicrobials Commonly Used for Surgical Prophylaxis

Antimicrobial	Half-life Normal Renal Function (hr)	Half-life End-stage Renal Disease (hr)	Recommended Infusion Time (min)	Standard IV Dose	Weight-Based Dose Recommendation*	Recommended Redosing Interval† (hr)
Aztreonam	1.5–2	6	3–5‡	1–2 g	Maximum 2 g (adults)	3–5
Cefamandole	0.5–2.1	12.3–18§	3–5‡ 15–60‖	1 g	—	3–4
Cefazolin	1.2–2.5	40–70	3–5‡ 15–60‖	1–2 g	20–30 mg/kg < 80 kg body weight: 1 g ≥ 80 kg body weight: 2 g	2–5
Cefotetan	2.8–4.6	13–25	3–5‡ 20–60‖	1–2 g	20–40 mg/kg body weight	3–6
Cefoxitin	0.5–1.1	6.5–23	3–5‡ 15–60‖	1–2 g	20–40 mg/kg body weight	2–3
Cefuroxime	1–2	15–22	3–5‡ 15–60‖	1.5 g	50 mg/kg body weight	3–4
Ciprofloxacin	3.5–5	5–9	60	400 mg	400 mg	4–10
Clindamycin	2–5.1	3.5–5.0¶	10–60 (Do not exceed 30 mg/min)	600–900 mg	< 10 kg: at least 37.5 mg ≥10 kg: 3–6 mg/kg body weight	3–6
Erythromycin base	0.8–3	5–6	NA	1 g orally 9 hr before surgery	9–13 mg/kg body weight	NA
Gentamicin	2–3	50–70	30–60	1.5 mg/kg	*See* formula#	3–6
Metronidazole	6–14	7–21	30–60	0.5–1.0 g	15 mg/kg body weight (adult), 7.5 mg/kg body weight on subsequent doses	6–8
Neomycin	2–3 (3% absorbed under normal gastro-intestinal conditions)	12 ≥ 24	NA	1 g orally 9 hr before surgery	20 mg/kg body weight	NA
Vancomycin	4–6	44.1–406.4 (Clcr <10 mL/min)	1 g ≥ 60 min (use longer infusion time if dose < 1 g)	1.0 g	10–15 mg/kg body weight (adult)	6–12

Adapted from Bratzler DW, Houck PM. Antimicrobial prophylaxis for surgery: an advisory statement from the National Surgical Infection Prevention Project. Surgical Prevention Guideline Writers Workgroup. Am J Surg 2005;189:399. Copyright 2005, with permission from Elsevier.

Clcr = creatinine clearance; DW = dosing weight; IBW = ideal body weight; IV = intravenous; NA = not applicable.

*Weight-based doses are primarily from published pediatric recommendations.

†For procedures of long duration, antimicrobials should be redosed at intervals of 1 to 2 times the half-life of the drug. The intervals in the table were calculated for patients with normal renal function.

‡Dose injected directly into vein or running IV fluids.

§Intermittent IV infusion.

‖In patients with a serum creatinine of 5–9 mg/dL.

¶The half-life of clindamycin is the same or slightly increased in patients with end-stage renal disease as compared with patients with normal renal function.

#If the patient's weight is 30% above their IBW, DW can be determined as follows: DW = IBW + 0.4 (total body weight – IBW).

decreases core body temperature by 0.25°C. Infusion of unwarmed fluids can significantly decrease core body temperature, especially if large volumes are required. Most heat loss occurs via the skin during surgery. Cutaneous heat loss can be minimized by limited exposure of bare skin. A single layer of blankets can decrease heat loss by 30%.[43,44] Active warming is often necessary to prevent intraoperative hypothermia; forced air is generally the most effective method available.[44] Although the SCIP measure specifically targets colorectal

Table 6. Class I Evidence-Based Guidelines to Prevent Surgical Site Infections

Preoperative management
Identify and treat all infections remote to the surgical site before elective operation and postpone elective operations on patients with remote site infections until the infection has resolved.
Require patients to shower or bathe with an antiseptic agent on at least the night before the operative day.
Encourage tobacco cessation. At a minimum, instruct patients to abstain from smoking cigarettes, cigars, pipes, or other form of tobacco consumption for at least 30 days before elective operation.
Before elective colorectal operations, mechanically prepare the colon by use of enemas and cathartic agents. Administer nonabsorbable oral antimicrobial agents in divided doses on the day before the operation.
Operative management
Do not remove hair preoperatively unless the hair at or around the incision site will interfere with the operation; if hair is to be removed, remove immediately before the operation, preferably with electric clippers.
Adequately control serum blood glucose levels in all diabetic patients and particularly avoid hyperglycemia perioperatively.
Use an appropriate antiseptic agent for skin preparation.
Keep nails short and do not wear artificial nails.
Perform a preoperative surgical scrub for at least 2 to 5 minutes using an appropriate antiseptic. Scrub the hands and forearms up to the elbows.
Administer a prophylactic antimicrobial agent only when indicated, and select it based on its efficacy against the most common pathogens causing surgical site infection for a specific operation and published recommendations.
Administer the initial dose of prophylactic antimicrobial agent by the intravenous route, timed such that a bactericidal concentration of the drug is established in serum and tissues when the incision is made.
Do not routinely use vancomycin for antimicrobial prophylaxis.
Keep operating room doors closed except as needed for passage of equipment, personnel, and the patient.
Wear a surgical mask that fully covers the mouth and nose when entering the operating room if an operation is about to begin or already under way, or if sterile instruments are exposed. Wear the mask throughout the operation.
Change scrub suits that are visibly soiled, contaminated, and/or penetrated by blood or other potentially infectious materials.
Handle tissue gently, maintain effective hemostasis, minimize devitalized tissue and foreign bodies (ie, sutures, charred tissues, necrotic debris), and eradicate dead space at the surgical site.
Use delayed primary skin closure or leave an incision open to heal by second intention if the surgeon considers the surgical site to be heavily contaminated (eg, class III and class IV).
If drainage is necessary, use a closed suction drain. Place a drain through a separate incision distant from the operative incision. Remove the drain as soon as possible.
Postoperative management
Use a sterile dressing for 24 to 48 hours postoperatively to protect an incision that has been closed primarily.
Wash hands before and after dressing changes and any contact with the surgical site.

Data from 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;20:250–80.

surgery, normothermia should be maintained during most surgical procedures unless hypothermia is specifically indicated.[45]

Case 2: Elective Aortic Aneurysm Repair in a Diabetic Patient

A 65-year-old retired man was found to have a pulsatile, nontender upper midline abdominal mass on routine physical examination. Subsequent work-up documented a 6.5-cm abdominal aortic aneurysm. His past medical history is significant for hypertension, type 2 diabetes mellitus, and a 40 pack-year history of tobacco use. The patient is scheduled for elective open repair.

- **What measures are appropriate to prevent SSI in this patient?**

Based on this information, the patient is considered to be a clean case, and prophylactic antibiotics are indicated (Table 4). Additionally, this patient has type 2 diabetes, and he requires glucose monitoring and control both intraoperatively and postoperatively. Finally, hair should be removed with clippers prior to incision.

Preoperative hair removal. Preoperative shaving of the surgical site is associated with significantly increased risk of infection because shaving causes microscopic abrasions that serve as a focus for bacterial multiplication.[46–51] Shaving the surgical site the night before an operation is associated with significantly increased risk of SSI.[49] Multiple randomized trials have demonstrated lower infection rates when using electric clippers for hair removal prior to surgery as compared with using a razor.[49–51] Using electric clippers to remove hair immediately prior to surgery was associated with decreased incidence of infection and health care expenditure.[49] Although use of depilatory cream has been associated with a lower risk of infection than shaving or clipping,[46–48] there is an increased risk of hypersensitivity reaction.[46] Routine hair removal prior to surgery has also been questioned, and 2 randomized trials were unable to document increased incidence of infection among patients without hair removal as compared with shaved patients.[52,53] One SCIP measure recommends use of electric clippers or depilatory creams if hair removal is necessary.[8] According to CDC guidelines, hair removal is indicated when hair at or around the incision would interfere with the operation.[1]

Glucose control. Among patients with diabetes who undergo cardiothoracic surgery, hyperglycemia is an independent predictor of short-term infectious complications.[54,55] Hyperglycemia impairs white blood cell phagocytic activity and IgG complement fixation.[56–58] Hyperglycemia has been associated with increased in-hospital morbidity and mortality for multiple medical and surgical conditions, although the association is not as clear among nondiabetic patients; all patients, however, can benefit from glycemic control.

The incidence of deep wound infection and associated costs were decreased in diabetic patients undergoing cardiac surgery after implementing a blood glucose control protocol to keep mean glucose levels below 200 mg/dL in the postoperative period.[59] Among open heart surgical patients with diabetes, use of perioperative continuous IV insulin protocol compared with sliding-scale subcutaneous insulin significantly reduced the incidence of SSI and decreased costs.[60] Among critically ill patients with diabetes, intensive insulin therapy (to maintain glucose level < 110 mg/dL) is associated with decreased incidence of bloodstream infections, acute renal failure, blood transfusion, ventilator support, reduced use of intensive care units, and lower hospital mortality.[61] The current SCIP measure specifies that all patients should have 6 AM blood glucose levels below or at 200 mg/dL on the first 2 postoperative days following cardiac surgery.[8]

Case 3: Urgent Exploratory Laparotomy in an Obese Patient

A 63-year-old moderately obese woman presents to the emergency department complaining of left lower quadrant pain associated with fever, anorexia, and nausea for the past 48 hours. She had been hospitalized 3 years ago for an episode of uncomplicated diverticulitis that resolved with medical treatment. On examination, her face is pale, heart rate is 120 bpm, and blood pressure is 105/50 mm Hg. She has a diffusely tender abdomen with involuntary guarding in all 4 quadrants. Further work-up reveals a white blood cell count of 18,000/µL and free intra-abdominal air and fluid on abdominal computed tomography scan. Following fluid resuscitation and stoma marking, an urgent exploratory laparotomy is planned.

- **How should this patient be managed?**

Based on this information, the patient is considered to be a dirty case and therefore therapeutic antibiotic treatment is required. The duration of therapeutic antibiotics in this case is dictated by the patient's clinical progression. Although this is a dirty case, it is still important to apply the other SCIP measures to this patient: maintenance of normothermia, hair removal with clippers, and glucose control if hyperglycemia occurs.

- **When should this patient receive antibiotic therapy?**

Therapeutic antibiotics. This case illustrates a patient with a surgical infection who should receive therapeutic weight-adjusted antibiotics. Prophylactic antibiotics are not indicated for operations classified as "dirty;" these patients should receive therapeutic antibiotics perioperatively for the established infection.[62] Prophylactic antibiotics should be given within 1 hour prior to surgical incision to prevent infection and should be discontinued within 24 hours of the operation. Conversely, therapeutic antibiotics should be administered as soon as the surgical infection is diagnosed and are often given for more than 24 hours. Patients who have small bowel or colon perforations more than 12 hours old or who have gastroduodenal perforations more than 24 hours old are considered to have established intra-abdominal infections and should receive therapeutic antibiotics.[63]

Postoperative wound surveillance. Surveillance of surgical sites for signs of infection is important to reduce infection rates. An estimated 47% to 84% of SSIs occur after discharge, and most of these infections are managed in the outpatient setting.[64–66] Methods for detecting SSIs after discharge include patient self-assessment with telephone or postal questionnaires.[67]

Infections that are diagnosed after hospital discharge are associated with impaired physical and mental health.[68] Patients with SSIs diagnosed after discharge incurred substantial excess health care resource utilization.[3,68] Multiple studies have demonstrated a decrease in SSI incidence when surveillance programs have been implemented that include feedback of infection rates to practitioners.[10,47,48,69,70] Identifying preventable infections improves care for future patients by discovering systemic problems and implementing preventive measures. Direct observation of surgical sites is the most accurate method for detecting SSIs.[68] Indirect detection of infection by infection control personnel through review of laboratory reports and patient records can also be used.[62]

CONCLUSION

Prevention of SSIs is multifactorial, just as the development of SSIs is multifactorial. SCIP provides evidence-based measures that may lower the rate of SSIs and improve surgical outcomes. Although the measures are directed at specific patients and procedures, there are principles that can be applied to all patients. **HP**

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