CHAPTER **41**

CURRENT RECOMMENDATIONS IN PREVENTING SURGICAL SITE INFECTIONS

Leslie B. Dowling, DPM, MBA

INTRODUCTION

Although there have been major advances in surgical management, surgical site infections (SSI) remain the most common complications for surgeons. The Centers for Disease Control and Prevention (CDC) defines SSIs as infections related to the operative procedure that occur at or near the surgical incision within 30 days of an operative procedure or within one year if an implant is left in place. Of more than 27 million patients undergoing surgery every year, it is estimated that SSIs develop in 2 to 5 percent (1). These complications increase morbidity, mortality, and cost, and result in worse outcomes than in the uninfected cases. Surgeons must consider all factors in the preoperative, intraoperative, and postoperative phases to effectively prevent SSIs (2, 3).

PREOPERATIVE MANAGEMENT

Preoperative strategies for reducing infection rates include indentifying high-risk patients, as well as identifying and correcting modifiable risk factors. High-risk patients include those with multiple comorbidities such as diabetes mellitus, peripheral arterial disease, chronic renal failure, obesity, and rheumatoid arthritis. Other preoperative factors to consider are nutritional status, tobacco use, preoperative bathing, and hair removal (4, 5).

Diabetes Mellitus

Diabetic patients have a 50% chance of having surgery in their lifetime (6). Studies have shown a direct association between diabetes and an increased risk of SSIs (4). Hyperglycemia impairs neutrophil and monocyte phagocytosis, therefore reducing the body's immune response to invading bacteria. The initial inflammatory response of wound healing is also diminished, which delays the overall progression through the subsequent phases (7). All efforts should be made to reduce the hyperglycemic state in this population. Diabetic patients should have hemoglobin A1C levels checked preoperatively with results <6.9% before proceeding with elective surgery (3). Performing day of surgery accu-checks <200 mg/dl are recommended before proceeding with surgery. Ideally, surgery for this patient population should be scheduled as early in the morning as possible to minimize the disruption of their management routine while being nil per os. Epidural anesthesia is preferred to general anesthesia because of its minimal effects on glucose metabolism and insulin resistance (6).

Peripheral Arterial Disease

Peripheral arterial disease (PAD) affects as many as 20% of Americans over age 65 years, and of those, only 25% receive treatment. PAD impedes healing due to the impairment of perfusion and oxygenation to the surgical site (8). A thorough history and physical examination will identify those patients in need of noninvasive vascular studies prior to surgery, such as those with nonpalpable pulses and complaints of rest pain. The vascular surgeon should be consulted if the patient has an ankle/brachial index less than 0.7, toe pressures less than 40 mm Hg, or transcutaneous oxygen tension less than 30 mm Hg to assess for the necessity of revascularization to increase the healing potential (7). A close working relationship with a vascular surgeon is critical as the number of patients with PAD rises.

Chronic Renal Failure

In patients with chronic renal failure, albumin deficiency, and protein malnutrition significantly impair wound healing. For those patients with end-stage renal disease (ESRD) on hemodialysis, infections are more likely to occur due to the dysfunction of the white blood cells after contact with dialysis membranes (7). These patients may also be exposed to contaminated fluids or waterborne bacteria during treatment, which would also increase infection rates. Since these patients are at an increased risk for infection and have usually undergone various antibiotic therapies, resistant organisms are not uncommon (7). In general, patients with ESRD should have dialysis the day before surgery. An option to consider is giving the preoperative antibiotics during dialysis instead of dosing on the day of surgery. Consults for nephrology and assistance with pharmacokinetic dosing, especially for antibiotics, are helpful in managing these

patients (9). The surgeon must remember the overall increased risk of infection and complications and evaluate their absolute need for elective surgeries (7).

Obesity

Obesity has plagued the United States over the past 30 years. Currently, nearly 34% of the adult and 17% of the pediatric population is obese. Providing postoperative wound care for this population can be challenging. The cardiovascular system is strained to provide oxygenated blood to all tissues. Adipose tissue is poorly vascularized and is less tolerant to hypoxia than the epidermis. The risks of infection and delayed wound healing are significant within the obese population. Some patients have been encouraged by their physician to consider surgical options, like gastric bypass, before proceeding with major reconstructive surgery (10). Appropriate durable medical equipment should be chosen to allow the patient to ambulate while protecting the incision until healing occurs. Prolonged bed rest may lead to pressure ulcerations and increased risk for thromboembolic events. From the previous experience of surgeons, dressing changes may be performed more frequently to ensure the incision is free of infection.

Rheumatoid Arthritis

Patients with rheumatoid arthritis undergoing total joint arthroplasty are at a 2 to 3-fold greater risk of acquiring a postoperative SSIs than are patients with osteoarthritis (3). Those patients who are treated with corticosteroids, methotrexate, or Enbrel are at an increased risk for developing infections and delays in wound healing. Several studies have compared the continuation versus discontinuation of methotrexate and have found no statistically significant difference in the rates of infection or wound healing complications. Increased risks were revealed in this population when other comorbidities were present, such as diabetes. The current recommendation is to continue the use of disease-modifying antirheumatic drugs (DMARDs) and corticosteroids in the perioperative period for patients with rheumatoid arthritis undergoing elective surgery. Discontinuing these medications may be necessary for those patients with multiple comorbidities. Preoperative planning should include the patient's rheumatologist to devise an appropriate preoperative and postoperative plan to reduce the risk of postoperative flares (7).

Nutritional Status

Malnutrition in surgical patients can lead to a host of complications including increased susceptibility to infection, poor wound healing, and increased frequency of decubitus ulcerations. Protein-energy malnutrition is commonly seen in the elderly, disabled, and chronically ill populations where chronic wound healing tends to develop. Serum albumin, the major protein synthesized by the liver, maintains plasma oncotic pressure and delivers metabolites, enzymes, drugs, and hormones in the bloodstream. During trauma and surgery, albumin synthesis decreases and the utilization of albumin is increased at the wound site. At our hospital, serum albumin levels less than 3.2 mg/dl is a predictor of protein depletion. A well-balanced diet and additional supplements such as Vitamin C, zinc, and Vitamin A can increase collagen synthesis, aid in wound healing and are beneficial for the preoperative and postoperative phases (4, 7).

Tobacco Use

Tobacco use results in microvascular vasoconstriction, which can impair oxygen delivery to healing tissues. In addition, chemicals from cigarette smoke break down Vitamin C, which can reduce collagen synthesis and delay wound healing. Cessation of smoking for 1 month before elective surgery is recommended, but this duration has not been proven in the literature. Options are available to assist the patient in abstaining from tobacco use like transdermal nicotine patches, prescription medications like varenacline (Chantix) or bupropion (Zyban), as well as counseling. Approximately 1 mg of nicotine is contained in 1 cigarette. Nicotine patches can be dosed accordingly to the number of cigarettes smoked per day by the patient. Physicians are employing the use of smoking cessation contracts and tobacco testing in both the preoperative and postoperative periods (4, 11). Levels of nicotine and continine can be assessed with a simple, yet expensive, blood test, which may be warranted in high-risk patients.

Hair Removal

The method and timing of preoperative hair removal is another concern. The CDC recommends minimal hair removal with electric clippers or a depilatory agent, rather than razors, just prior to the surgical incision (3). Studies have shown that using a safety razor more than 24 hours before surgery carries a 20% infection rate secondary to microscopic cuts in the epidermis (4). Opting to remove no hair or using a depilatory agent is associated with the lowest rate of infection of 0.6% (4).

INTRAOPERATIVE MANAGEMENT

Antibiotics

The use of prophylactic antibiotics has proven to be efficacious in preventing SSIs. Cefazolin (1-2 g intravenous [IV]) is the antibiotic of choice since the most commonly encountered bacteria on skin are gram-positive cocci. For those with a beta-lactam allergy, clindamycin (600 mg or 900 mg IV) or vancomycin (1g IV) is the antibiotic

of choice. Prophylaxis with vancomycin (1g IV) should be considered if the patient is a known carrier or has had a previous infection of methicillin-resistant Staphylococcus aureus (3).

For safety and effectiveness, proper timing of antibiotic administration is critical. Antibiotic therapy should begin within 1 hour prior to the surgical incision, except for vancomycin, which is started 2 hours prior to surgery to decrease the incidence of red man syndrome. In 1977, Cunha et al, found the cefazolin concentrations in bone were 60 times the minimum inhibitory concentration for penicillin-resistant Staphylococcus aureus following immediate pre-operative intravenous drug administration (4). For surgical procedures lasting longer than 4 hours or when >1,500 ml of blood is lost, repeat antibiotic dosing is recommended every 1-2 half-lives of the drug (cefazolin every 2-5 hours, clindamycin every 3-6 hours, and vancomycin every 6-8 hours) (2, 3).

Research indicates no additional protection from SSIs with antibiotic prophylaxis longer than 24 hours postoperatively. Continuing antibiotics may only lead to superinfection with drug-resistant organisms. At our hospital, we typically give cefazolin (2g IV) preoperatively followed by 2 doses of cefazolin (1g IV) over the next 24 hours.

Surgical Skin Antisepsis

Skin antiseptics for both the patient and members of the surgical team include chlorhexidine gluconate (CHG), alcohol-based solutions, and iodophors such as povidone-iodine. CHG disrupts the cellular membranes of bacteria and is favored for its long-lasting activity against gram-positive and gram-negative organisms typically found on the skin. The iodophors act on the same organisms, but have a shorter activity period and can be inactivated by blood or serum proteins if not given long enough to dry completely. Alcohol has germicidal activity against bacteria, viruses, and fungi, but is limited by its lack of residual activity and its flammable properties (4).

Skin antisepsis can begin preoperatively with practices such as preoperative bathing and decolonization of S. aureus carriers. Preoperative bathing reduces the skin's bacterial load prior to surgery and CHG is most commonly utilized. Studies show the use of CHG does reduce the skin's bacterial load, but consecutive treatments may predispose the development of resistant organisms. There is currently no sound evidence that preoperative bathing with CHG is any more effective than other products, such as bar soap, for reducing the incidence of SSIs (3). S. aureus is commonly found in orthopedic SSIs and there is a strong correlation between nasal carriage of S. aureus and the development of S. aureus wound infections. Literature suggests a topical decolonization protocol with mupirocin ointment applied to the nares twice daily for five days prior to surgery. Questions are still unanswered on which surgical patients should be screened and treated; however, current recommendations are for high-risk patients, such as the immunocompromised and those undergoing implantation of a foreign device (2, 4).

Over the past few years, research has provided foot and ankle surgeons with specific recommendations for pre-operative surgical site preparations.In 2005, Ostrander et al compared the bacterial load on feet prepped with CHG, iodine/isopropyl alcohol, or chloroxylenol scrub and found CHG was superior to reducing bacterial load but no difference was detected in infection rates among these (12). Keblish et al found the use of a brush versus a standard applicator to apply isopropyl alcohol scrub was superior in reducing the number of positive cultures of specimens from the web spaces and nail folds of the feet (13). Research suggests that povidone-iodine may impair wound healing because of its toxicity to fibroblasts and keratinocytes and does not recommend its use for the preparation of open wounds or on postoperative dressings. For surgical site skin preparation, CHG-based solutions have proven to be superior to povidone-iodine solutions. To take advantage of the excellent antimicrobial properties of alcohol yet combat its lack of residual activity, a combination of both alcohol and CHG can be used (5).

The surgical team must take all precautionary measures to remove and kill bacteria from their hands. Traditionally, surgeons have used either CHG or povidone-iodine solutions with a full 10 minute scrub. In a recent Cochrane review, the authors found alcohol-based rubs containing ethanol, isopropanol, or n-propanol to be as effective as aqueous solutions for preventing SSIs (3). Physician compliance is increased with the alcohol-based solutions, and there are fewer complaints about skin dryness and irritation. Recommendations from the latest research suggests the surgical team should wash with soap and water for the first scrub of the day, or when their hands are grossly contaminated, use a nail pick to clean under the nails, and dry with paper towels. They should then use an alcohol-based rub for three minutes, which should be used for all subsequent cases. The use of scrub brushes is not recommended since they may increase the risk of infection as a result of skin damage (3).

Sterilization of Instruments

Flash sterilization is a procedure used by operating room staff to sterilize instruments or implants with steam when needed. This process is not equivalent to the 3 to 4 hour sterilization in central processing in which the instruments are properly cleansed, sterilized, dried, and packed in

containers that ensure maintenance of sterility by trained personnel. Flash sterilization should be used only for dropped instruments or emergency situations. To prevent the incidence of flash sterilization, the literature recommends increasing physician awareness about the inadequacy of the technique; ensuring timely delivery of equipment from outside vendors; purchase of more frequently flash-sterilized items; and improve surgical scheduling to reduce equipment shortages (3).

Surgical Drains and Wound Closure

Surgical drains attempt to decrease hematoma formation and manage dead space while allowing the passage of material from the wound. Closed suction drains do have less retrograde bacterial migration than simple drains. According to a large retrospective study, drains left intact for longer than 24 hours are associated with a higher incidence of the wound becoming infected with methicillin-resistant S. aureus than methicillin-sensitive S. aureus (14). Parker et al evaluated the use of drains in joint replacement surgical wounds and found no difference in rates of infection, wound hematomas, reoperations for wound complications, limb swelling, thromboembolic events, or length of hospital stays (15). A recent Cochran review concluded closed surgical drains did reduce bruising and the need for reinforcement dressings; however, they were associated with an increased need for blood transfusions and no difference was noted in the rates of SSIs (16). Recent recommendations support operations without the use of surgical drains.

There is limited literature on wound closure in orthopedic procedures. Studies show blood flow is higher on postoperative day 1 than day 5 and found perfusion in wounds closed with subcutaneous sutures is greater than wounds closed with mattress sutures or surgical staples. Sutures with an antiseptic coating, usually triclosan, have been shown to decrease SSIs; however, there is a 7-10% increase in costs (3). The literature recommends subcuticular wound closure with monofilament suture to minimize tissue ischemia and decrease the incidence of bacterial contamination (5).

POSTOPERATIVE MANAGEMENT

Wound dressings act as a protective barrier to reduce bacteria from migrating into the wound. Many studies have demonstrated occlusive dressings are superior and aid in increased re-epithelialization and collagen synthesis when compared to wounds exposed to air. The proper timing of dressing removal is still debated by many. The CDC recommends removal of the dressing 24 to 48 hours postoperatively. There is little evidence that leaving the dressing on past this time period will decrease the infection rate. If the dressing is blood-soaked, it should be removed immediately rather than reinforced to avoid any potential for becoming a source for microbes to grow. Broad-spectrum antibiotic ointments, such as bacitracin and triple antibiotic ointment, show a decrease in infection rates, provide occlusion and increase epithelialization while the wound heals (5).

Postoperative wound healing is also dependent on edema control and immobilization. Continuous elevation of the limb at a level above the heart, with a maximum of 30 minutes in dependency at a time, is recommended to control edema. Icing either to the posterior knee and/or the anterior ankle for 15 minutes every hour will limit edema formation also. Immobilization of the extremity and maintaining a nonweight-bearing status may be the best option in those patients with a significant risk for wound dehiscence (7). External fixation and percutaneous pins are strongly associated with an increase in infection. Current recommendations on pin site care include the daily application of isopropyl alcohol, bacitracin ointment, and an open-cell foam once a day for 5-7 days post-operatively (17).

CONCLUSION

Many steps can be taken by the surgeon and health care professionals to reduce the number of SSIs by addressing these factors in all phases of the surgical process. Currently the CMS is changing the government reimbursements for infections that arise as a result of hospital care. In October 2008, the Centers for Medicare and Medicaid Services (CMS) made initial decisions to not reimburse for infectious complications such as catheter-associated urinary tract infections, central venous catheter-associated infections, and SSIs following spine, neck, shoulder, or elbow procedures. Surgeons and health care professionals must be aware of the current evidence-based recommendations to prevent future SSIs and avoid penalties as a result of not complying with standards of care (3). Incorporating these simple recommendations into daily practice will aid in the prevention of surgical site infections.

REFERENCES

1. Department of Health and Human Services. Surgical site infections. Centers for Disease Control and Prevention. URL:http://www.cdc.gov/ncidod/dhpq/FAQ_SSI.html#B.
2. Anderson D, Sexton D. Control measures to prevent surgical site infection. In: UpToDate, Basow, DS (Ed), UpToDate, Waltham, MA, 2010.
3. Bosco JA, Slover JD, Haas JP. Perioperative strategies for decreasing infection. J Bone J Surg Am 2010;92:232-38.
4. Evans RP, et al. Surgical site infection prevention and control: an emerging paradigm. J Bone J Surg Am 2009;91:Suppl 6:2-9.
5. Fletcher N, Sofianos D, Berkes MB, Obremskey WT. Prevention of perioperative infection. J Bone J Surg Am 2007;89:1605-18.
6. Khan NA, Ghali WA, Cagliero E. Perioperative management of diabetes mellitus. In: UpToDate, Basow, DS (Ed), UpToDate, Waltham, MA, 2010.
7. Schweinberger MH, Roukis TS. Wound complications. Clin Podiatr Med Surg 2009;26:1-10.
8. Sieggreen MY, Kline RA. Arterial insufficiency and ulceration: diagnosis and treatment options. Adv Skin Wound Care 2004;17:242-51.
0. Soundararajan R, Golper TA. Medical management of the dialysis patient undergoing surgery. In: UpToDate, Basow, DS (Ed), UpToDate, Waltham, MA, 2010
10. Wilson JA, Clark JJ. Obesity: impediment to postsurgical wound healing. Adv Skin Wound Care 2004;17:426-35.
11. Reichman DE, Greenberg JA. Reducing surgical site infections: a review. Rev Obstet Gynecol 2009;2:212-21.
12. Ostrander RV, Botte MJ, Brage ME. Efficacy of surgical preparation solutions in foot and ankle surgery. J Bone Joint Surg Am 2005;87:980-5.
13. Keblish DJ, Zurakowski D, Wilson MG, Chiodo CP. Preoperative skin preparation of the foot and ankle: bristles and alcohol are better. J Bone Joint Surg Am 2005;87:986-92.
14. Manian FA, Meyer PL, Setzer J, Senkel D. Surgical site infections associated with methicillin-resistant Staphylococcus aureus: do postoperative factors play a role? Clin Infect Dis 2003;36:863-8.
15. Parker MJ, Roberts CP, Hay D. Closed suction drainage for hip and knee arthroplasty. A meta-analysis. J Bone Joint Surg Am 2004;86:1146-52.
16. Parker MJ, Livingston V, Clifton R, McKee A. Closed suction surgical wound drainage after orthopaedic surgery. Cochran Database Syst Rev 2007;3:CD001825.
17. Bibbo C, Brueggeman J. Prevention and management of complications arising from external fixation pin sites. J Foot Ankle Surg 2010;49:87-92.