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Surgical Site Infection Prevention Following Spine Surgery

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Abstract

Study Design: Literature review.

Objectives: Surgical site infection (SSI) following spine surgery leads to significant patient morbidity, mortality, and increased health care costs. The purpose of this article is to identify risk factors and strategies to prevent SSIs following spine surgery, with particular focus on avoiding infections in posterior cervical surgery.

Methods: We performed a literature review and synthesis to identify methods that can be used to prevent the development of SSI following spine surgery. Specific pearls for preventing infection in posterior cervical spine surgery are also presented.

Results: SSI prevention can be divided into patient and surgeon factors. Preoperative patient factors include smoking cessation, tight glycemic control, weight loss, and nutrition optimization. Surgeon factors include screening and treatment for pathologic microorganisms, skin preparation using chlorhexidine and alcohol, antimicrobial prophylaxis, hand hygiene, meticulous surgical technique, frequent irrigation, intrawound vancomycin powder, meticulous multilayered closure, and use of closed suction drains.

Conclusion: Prevention of SSI following spine surgery is multifactorial and begins with careful patient selection, preoperative optimization, and meticulous attention to numerous surgical factors. With careful attention to various patient and surgeon factors, it is possible to significantly reduce SSI rates following spine surgery.

Keywords
infection, surgical site infection, spine surgery

Introduction

Surgical site infections (SSIs) result in increased patient morbidity, mortality, and health care costs. The cost of preventable SSIs has been approximated to be $345 million annually in the United States.[1,2] Although the reported incidence of deep SSIs after spine surgery ranges from 1% to 4%, postoperative infection is one of the most common complications resulting in hospital readmission following surgery and results in extension of hospital length of stay by approximately 9.7 days.[3,4] Furthermore, development of SSI affects patient outcomes with significantly more back pain and less likelihood of reaching the minimum clinically important difference (MCID) compared with matched patients without an infection.[5] Importantly, over 156 000 spine infections could potentially be averted with appropriate screening and optimization of preoperative risk factors.[6] Strategies to reduce SSIs following spine surgery, therefore, are of paramount importance for all stakeholders. This review focuses on preoperative patient optimization and surgical (intraoperative) factors that can be utilized to prevent surgical site infections, with particular focus on posterior cervical surgery.

Patient Factors

The need to optimize patients preoperatively with the goal of improving surgical outcomes is widely recognized. From an infection standpoint, preoperative optimization includes

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smoking cessation, glycemic control, malnutrition/ obesity management, and screening and decolonization of organisms.[7,8]

Smoking Cessation

Smoking is a critical modifiable risk factor that significantly increases the risk of SSI after spine surgery by several mechanisms, including vasoconstriction, local tissue hypoxia, and impairing the reparative processes of wound healing and neutrophil defense against microorganisms.[6,9-11] Thomsen et al[12] found that compared with patients who smoked, surgical complications were nearly halved in patients who stopped smoking prior to surgery. Furthermore, Sorensen et al[13] performed a randomized controlled trial (RCT) and found that the infection rate of a wound near the sacrum was 12% and 2% in smokers and nonsmokers, respectively. Smoking cessation should take place at least 4 weeks prior to surgery to be significantly important in decreasing infection risk.[14] Smoking cessation referral is appropriate to minimize potential SSI risk prior to surgery.

Blood Glucose Monitoring

Complications of diabetes leading to poor wound healing due to local ischemia secondary to microangiopathic changes have been well described.[15] Meng et al[7] showed significantly higher rates of infection among diabetic patients compared to nondiabetic patients after spine surgery (odds ratio [OR] 2.04, 95% confidence interval [CI] 1.69-2.46).[16] Cancienne et al[17] found that patients undergoing single-level lumbar decompression with a hemoglobin (Hb) A1C level of 7.5% or higher had a significantly higher risk for development of SSI compared with those with HbA1C level less than 7.5% (OR 2.9, 95% CI 1.8-4.9, $P < .01$). Furthermore, Hikata et al[18] evaluated 345 patients undergoing posterior thoracic or lumbar fusion surgery with instrumentation and found patients with preoperative diabetes had a 5-fold increase in infection rates. Subgroup analysis of these patients revealed HbA1C values <7% had a 0% infection rate whereas patients with values >7% had an infection rate of 35.3%.[18] Olson et al reported that patients with diabetes have an 8-fold increase (OR 8.4) in developing surgical site infection compared with nondiabetics.[39] As such, screening of HbA1C levels preoperatively and appropriate referral to a dietician or endocrinologist for tight glycemic control in patients with Hb A1C levels greater than 7% is essential prior to elective spine surgery.

Malnutrition/Obesity

Hypoalbuminemia, defined as an albumin level less than 3.5 g/dL, has been shown to be a significant risk factor for delayed wound healing.[3,19,20] Bohl et al[19] performed an analysis of over 4300 lumbar spinal fusion patients in the NSQUIP (National Surgical Quality Improvement Program) database and found that hypoalbuminemia was associated with increased rates of infection and wound complications. Even in obese patients, malnutrition and hypoalbuminemia can be present[10] due to inadequate protein intake despite excessive calorie consumption.[6]

Obesity is a well-known risk factor for development of SSI following spinal surgery.[7,21,22] Furthermore, the skin-to-lamina distance at L4 and thickness of subcutaneous tissue was significantly associated with increased SSI rates.[23,24] Meng et al[7] reported an increased risk of infection in patients with a body mass index (BMI) >30 kg/m^2 with an OR of 2.13 (95% CI 1.55-2.93). Increased tissue necrosis from retraction injury may be a contributing factor.[25] As such, preoperative optimization of body weight is a critical risk factor that requires optimization prior to surgery. Jackson and Devine[22] found that treatment effect of operative pathology is at least as equivalent if not better in obese individuals, and so this comorbidity should not prohibit surgery but rather optimization is required. Referral to a dietician, exercise counselor, or bariatric surgeon may be required prior to elective spine surgery in this population.

Surgeon Factors

Preoperative Bacterial Screening

Gram-positive bacteria such as *Staphylococci*, *Streptococci*, and *Enterococcus* continue to be the most common organisms in spinal SSI.[26] Gram-negative organisms, however, are also not uncommon. Abdul-Jabbar et al[27] found gram negative microbes were identified in 30.5% of cases of spinal SSI, particularly in cases involving the sacrum. *Proprionibacterium acnes* species is also being increasingly recognized and was seen in 7.9% of patients in this series.[27,28] Because of the continued preponderance of methicillin-sensitive *Staphylococcus aureus* (MSSA) and methicillin-resistant *Staph aureus* (MRSA) SSIs, however, current prevention screening protocols still focus on these organisms. Current prevention protocols recommend nasal swab with culture 30 days prior to surgery in all patients. Patients with a positive culture should undergo a 5-day course of 2% mupirocin ointment twice daily, combined with 2% chlorhexidine gluconate scrub daily for 5 days preceding surgery.[6,29-31] This standardized screening and treatment regimen can significantly reduce SSI rates in patients undergoing spinal surgery.

Preoperative Antibiotics

The use of antimicrobial prophylaxis preoperatively is well established, with efficacy related to appropriate timing of administration.[32-35] The timing and the administration of prophylactic antibiotics within 30 minutes of surgery has been shown to significantly decrease the risk of SSI when compared with the time frame of 30 to 60 minutes prior to incision.[36] Most antibiotic guidelines focus on the treatment of gram-positive bacteria (staphylococcus), and the standard antibiotic of choice is cefazolin, a first-generation cephalosporin.[37] It should be noted that antibiotic dosage (cefazolin <20 mg/kg) needs to be adjusted appropriately in obese patients to be effective in reducing infection risk.[38,39] It should also be noted that antibiotics should be redosed every 4 hours or after 1500 mL of blood loss in spinal deformity cases.[40] Furthermore, special consideration must be made to recognize patients that are at risk for harboring gram-negative species, such as incontinent patients or those that have a history of urinary tract colonization. Nunez-Pereira et al[41] studied an individualized antibiotic regimen based on preoperative risk factors for harboring gram-negative bacteria and found a statistically decreased number of patients developing SSI due to gram-negative bacteria.

Skin Antisepsis

Preoperative skin preparation aims to sterilize the skin just prior to skin incision. Iodine, chlorhexidine, and alcohol compounds are the most commonly used preparations. In a randomized trial, Savage et al[42] found no difference between ChloraPrep (2% chlorhexidine and 70% isopropyl alcohol; Enturia, El Paso, TX) and DuraPrep (0.7% available iodine and 74% isopropyl alcohol; 3M Healthcare, St Paul, MN) in the rate of positive culture results after skin preparation. In 2 other RCTs, however, Ostrander et al[43] and Saltzman et al[44] found that ChloraPrep was superior to the other agents, with lower rates of positive cultures. Positive cultures, however, do not directly translate to rates of SSIs, which is a limitation of these RCTs. Swenson et al[45] sought to look at SSI rates directly and found that DuraPrep had the lowest SSI rates, compared with betadine and ChloraPrep. Darouiche et al[46] found the lowest infection rates were in the ChloraPrep group compared with the betadine group. In a recent meta-analysis, Sidhwa et al[47] found that alcohol-based agents are generally superior to aqueous solutions. Use of either DuraPrep or ChloraPrep therefore would provide adequate intraoperative skin preparation.

Intraoperative Temperature Regulation

Inadvertent hypothermia is common in patients undergoing surgical procedures, particularly in longer cases with significant blood loss such as spine surgery. This phenomenon may be due to the suppression of central mechanisms of temperature regulation due to anesthesia, and prolonged exposure of large surfaces of skin to cold temperatures in operating rooms.[48] Hypothermia within the perioperative environment may have various physiological effects associated with significant morbidity such as surgical site infection and wound-healing delay.[48,49] Active warming with forced air warming units is one method that is effective in preventing and managing hypothermia in the perioperative environment.[49] Madrid et al[48] conducted a Cochrane review concluding that forced-air warming has a beneficial effect in terms of lowering SSI rate compared with those not applying any active warming system, at least in patients undergoing abdominal surgery. Furthermore, forced air warming may reduce cardiovascular complications in patients with substantial cardiovascular disease, reduce transfusion rates, and improve patient comfort.[48]

Intrawound Vancomycin Powder

The use of intrawound vancomycin, a broad-spectrum glycopeptide antibiotic that provides coverage for gram-positive organisms, including MRSA, MSSA, and skin flora, is rapidly being adopted for the prevention of SSIs in spine surgery.[50,51] Topical vancomycin provides a high local concentration of vancomycin with minimal systemic absorption. Intrawound vancomycin powder is applied subfascially or suprafascially and provides a high local concentration of vancomycin. Numerous studies, though retrospective in nature, support the use intrawound vancomycin in spine surgery.[52-56] Ghobrial et al[50] evaluated a total of 9721 patients and found the SSI rate among the control and vancomycin-treated group to be 7.47% and 1.36%, respectively, with an overall adverse event rate of 0.3%.

Betadine Irrigation

Betadine is an antiseptic that has bactericidal activity against a broad spectrum of organisms, including MRSA. The use of betadine irrigation in spinal wounds removes debris and decreases bacterial contamination. Maximum effectiveness against pathogens occurs as a dilution of 0.5% to 4%, with cytotoxicity occurring at concentrations greater than 5%.[57] A prospective RCT of 414 patients undergoing cervical and thoracolumbar surgeries evaluated the efficacy of a 3.5% povidone-iodine solution used for 3 minutes followed by copious normal saline irrigation compared with normal saline irrigation alone.[58] The authors found a significantly lower rate of SSI in the group that underwent dilute betadine irrigation (0% vs 3.5%). Furthermore, no adverse events occurred as a result of betadine irrigation, thus providing an additional simple, inexpensive form of SSI prophylaxis.

Closed Suction Drains

The use of closed suction drains following spine surgery remains controversial. A deep surgical drain serves to decrease the risk of blood accumulation in the closed surgical wound, which theoretically helps prevent epidural hematomas and wound-healing complications.[51] As the drain provides a direct route to the outside environment, however, there is concern that it may lead to an increase in SSI. Parker et al[59] evaluated closed suction drainage in 5464 patients undergoing a variety of orthopedic procedures, including spine surgery in a Cochrane review and found no statistically significant difference in the incidence of wound infection, dehiscence, hematoma formation, or reoperations. Blood transfusion was required more frequently in the group receiving drains. Diab et al[60] evaluated closed suction drainage in patients undergoing posterior fusion for idiopathic scoliosis and similarly found no difference in SSI rate or other complications in patients receiving drains versus no drains, with a higher transfusion rate in the drained group. In a randomized trial, Liang et al[61] evaluated the efficacy of subcutaneous closed-suction drains versus conventional drains following scoliosis surgery and found that subcutaneous closed-suction drainage offer a reasonable alternative to conventional deep drains. Although the use of drains is controversial, these studies did not find an increase in SSI rate with the use of surgical drains.

Infection Prevention in Posterior Cervical Spine Surgery

Posterior cervical spine surgery carries a much higher infection risk compared with anterior cervical procedures, with a reported infection rate up to 18%.[62] This is in stark contrast to the reported infection risk of less than 1% in anterior cervical procedures.[63] Several potential factors contributing to the dramatic increase in infection for posterior cervical approaches include stripping of paraspinal cervical muscles and creation of devascularized tissue from electrocautery during exposure, and formation of large potential dead space due to inadequate soft tissue approximation during wound closure. The senior author (KDR) has used specific surgical techniques during exposure and closure to dramatically lower if not eliminate infections related to posterior cervical spine procedures.[64] The specific steps are outlined below.

After appropriate preoperative optimization as outlined above, the method for skin preparation begins with the patient shaving one to two days before the surgery. This allows the skin to heal, saves preparation time and eliminates loose hair in the operating room. Prior to standard preparation, the surgical site is squared off with plastic drapes. Preliminary preparation with alcohol foam is used over the surgical site and the surrounding plastic drapes. During exposure, every effort is made to preserve tissue vascularity and minimize tissue trauma. The microscope is routinely used from skin incision to wound closure. The dissection is carefully carried out using monopolar electrocautery on "cut"; maintaining the dissection in the avascular, amuscular midline to minimize bleeding and the need for electrocoagulation. This minimizes soft tissue devascularization and necrosis during exposure. Finding the "midline" may sound straightforward, but in reality, this avascular and amuscular plane is rarely exactly in the middle (due to asymmetric retraction, uneven traction from taping of the shoulders, anatomical variances, etc), and there is no "line" during surgery to guide the dissection. The best way to maintain dissection in the "midline" is to start with the neck maximally flexed, if not otherwise contraindicated, and at the caudal end of the incision, where the spinous process is most easily palpated. The spinous processes starting at C7 and below are only covered by the nuchal ligament/supraspinous ligamentous complex. Therefore, it is relatively easily palpated, hence it is fittingly called vertebra prominence. One can easily dissect down to the bony prominence, find the midline ridge of the spinous process and then dissect cranially, staying in the avascular plane. Once the midline dissection is carried down to the bifid spinous processes, the lateral tissue attachments of the bifid processes are preserved, and the tip of the bony bifid processes are cut with a bone cutter. Then the paraspinal muscle, attached to the tip of the cut spinous process is tagged with sutures and dissected subperiosteally. These tips of the bifid processes attached to paraspinal muscles can serve as muscle anchor points and facilitate muscle reapproximation during the wound closure stage. Use of sharp-tipped cerebellar retractors to retract the muscles should be avoided, as they tend to tear the muscles and increase tissue trauma and bleeding. Use of smooth, self-retaining retractors, such as McCulloch (V. Mueller) retractors are recommended. If hemostasis is required, it is preferable to use hemostatic agents and cottonoid patties, as opposed to electrocautery whenever possible to minimize creation of devascularized tissue. Throughout the procedure, frequent irrigation is used to keep the tissues moist and to wash away any bacteria. Outer gloves are changed every few hours.

During closure, irrigation is used and intrawound vancomycin powder (1 g) is routinely applied with placement of a surgical drain to decrease postoperative seroma/hematoma formation. Multiple drains may be used in obese patients or patients with greater than a 2 cm layer of subcutaneous fat. However, if a tight, multilayer closure is performed, the only drain that is necessary is the deep one. A multilayered closure is key to eliminate as much potential dead space as possible, as seroma or hematoma in the potential dead space is a nidus for infection. It is much harder for infection to develop in a tightly-closed wound with well vascularized tissue and minimal dead space. Specifically, the paraspinal muscles are first reapproximated by suturing around the "tagged" bifid processes during initial exposure on either side using 0-Vicryl suture and tying them together to pull the muscles back to the midline. Next, 0-Vicryl sutures are placed along the muscle sheaths (not muscle itself) between the bifid process "anchor points" to strengthen the muscle reapproximation. The wound is then tightly closed with interrupted sutures in multiple layers. After the fascia layer is approximated, 2-0 Vicryl sutures are used to close the subcutaneous layers. Each layer is tacked down to the previous layer, obliterating the dead space. This is done by burying the needle completely under the last layer such that the needle enters on one side of the wound and emerges out the opposite side without being visible in the middle.

This is preferable to grabbing the two sides separately and tying the knot, in which case, that layer is not tacked down to the previous one. The skin is closed with a running 3-0 Monocryl suture and reinforced with Steri-strips and dressing. In the senior author's clinical practice, it is not unusual to use more than 140 sutures to close a 6-inch posterior cervical wound. Perioperative antibiotics are routinely administered for 24 hours postoperatively and the surgical drain is removed when the output is less than 30 cm^3 in an 8-hour shift. Following this specific perioperative protocol and surgical technique, infection associated with posterior cervical surgery has become exceedingly rare in the senior author's practice regardless of the case.[64]

Conclusions

Surgical site infection following spine surgery may lead to significant morbidity, mortality, and health care costs.

Preoperative optimization includes smoking cessation, strict glucose control, weight loss, nutritional optimization, and MRSA decolonization. Intraoperative optimization includes preoperative antibiotics, skin antisepsis, meticulous dissection and closure, betadine irrigation, vancomycin powder, and use of closed suction drains. With careful attention to patient and surgeon factors, it is possible to significantly reduce SSI rates following spine surgery.

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