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Surgical Site Infections in Spine Surgery: Preoperative Prevention Strategies to Minimize Risk

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Abstract

Study Design: Literature review.

Objectives: A review of the literature identifying preoperative risk factors for developing surgical site infections after spine surgery and discussion of the preventive strategies to minimize risks.

Methods: A review of the literature and synthesis of the data to provide an updated review on the preoperative management of surgical site infection.

Results: Preoperative prevention strategies of reducing surgical site infections in spine surgery remains a challenging problem. Careful mitigation of modifiable patient comorbidities, blood glucose control, smoking, obesity, and screening for pathologic microorganisms is paramount to reduce this risk. Individualized antibiotic regimens, skin preparation, and hand hygiene also play a critical role in surgical site infection prevention.

Conclusions: This review of the literature discusses the preoperative preventive strategies and risk management techniques of surgical site infections in spine surgery. Significant decreases in surgical site infections after spine surgery have been noted over the past decade due to increased awareness and implementation of the prevention strategies described in this article. However, it is important to recognize that prevention of surgical site infection requires a system-wide approach that includes the hospital system, the surgeon, and the patient. Continued efforts should focus on system-wide implementation programs including careful patient selection, individualized antibiotic treatment algorithms, identification of pathologic organisms, and preoperative decolonization programs to further prevent surgical site infections and optimize patient outcomes.

Keywords
spine surgery, surgical site infection, preoperative antibiotics, prevention

Introduction

Surgical site infections (SSIs) represent a large proportion of hospital-acquired infections, 31% in a recent study in the acute care setting.[1] Hospital-acquired infections have gained increased attention among the public, health care providers, and health care systems due to the benchmarking that occurs between facilities as well as changes in reimbursement models. SSIs are the most common infections treated by spinal surgeons and are associated with increased morbidity, mortality, cost, and inferior outcomes. Rates of SSI vary greatly based on the invasiveness of the procedure, underlying spinal pathology, and patient population.[2] The rates of SSI are reported to be as low as 0.07% in patients undergoing anterior cervical discectomy and fusion, to 2.94% in posterior cervical surgery, 2.4% for spinal tumors, 8.8% in primary lumbar fusions, and 12.2% in revision lumbar fusions in a Medicare population.[3-6]

SSI after spine surgery poses a significant burden on patients and the health care system. It is estimated that in

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2005 SSI extended hospital lengths of stay on average by 9.7 days and incurred an additional cost of $20 842 per admission.[7] Blumberg et al found that the average cost of spine SSI treatment at a single tertiary referral center to be $16 242 per case.[8] These figures do not include the indirect cost of SSI and therefore underestimate the overall financial burden. The impact of SSI is felt not only in cost but also in patient morbidity, mortality, and outcomes. Petilon et al performed a propensity case-control cohort study that found patients with deep infection after instrumented fusion had more back pain and were less likely to reach MCID (minimum clinically important difference) at 2 years compared with patients without infection.[9] Additionally, Casper et al reported patients with spine SSI following elective surgery had increased mortality rates compared with controls at 1, 2, and 5 years with an overall mortality rate of 12%.[10]

As a result, there has been great focus across medicine and within the field of spine surgery to identify risk factors; optimize patients pre-, intra-, and postoperatively; as well as change surgical practice. In this article, we will highlight modifiable preoperative strategies to minimize the risk of SSI in spine surgery.

Patient Selection Optimization

Several underlying patient risk factors can be modified preoperatively to lessen the risk of SSI in spine surgery patients including optimizing hyperglycemic states, smoking cessation, obesity management, and screening for and eradicating methicillin-sensitive *Staphylococcus aureus* (MSSA)/methicillin-resistant *Staphylococcus aureus* (MRSA) in carriers.[11,12] These modifiable risk factors need to be considered and optimized prior to elective spine surgery and their implications should be discussed carefully with the patient to achieve compliance.

Preoperative Blood Glucose Monitoring

The long-term sequelae and complications of diabetes leading to poor wound healing due to local ischemia secondary to microangiopathic changes have been well described.[13] Due to the disruption of the vascular system in patients with diabetes, SSIs across all specialties are increased in this patient population. In a meta-analysis performed by Meng et al, the authors reported an odds ratio (OR) of 2.04 (95% confidence interval [CI] = 1.69-2.46) of increased infection rates among diabetic patients,[11] who also have been shown to have worse patient-reported outcomes up to 2 years after spine surgery.[14] In a study by Hikata et al, the authors evaluated 345 patients undergoing posterior thoracic and/or lumbar fusion surgery with instrumentation. The patients with preoperative diabetes had a 5-fold increase in infection rates. Subgroup analysis of these patients revealed that patients with hemoglobin A1C values <7 had a 0% infection rate, whereas patients with values >7 had an infection rate of 35.3%.[15] Due to the reported increased rate of infection and worse outcomes in patients with diabetes, it is imperative that patients be screened for hemoglobin A1C values and tight control of blood glucose levels be achieved and documented prior to embarking on elective spine surgery.

Smoking Cessation

Aside from the known detriments of nicotine on bone healing, smoking is also implicated in increased SSIs. In the meta-analysis mentioned previously by Meng et al, smoking had an increased OR of infection of 1.17 (95% CI = 1.03-1.32) after spine surgery. In a systematic review performed by Thomsen et al, it was noted that surgical complications were nearly halved in patients who successfully stopped smoking prior to surgery, OR 0.56.[16] Therefore, smoking cessation is a critical modifiable risk factor for SSI and imperative prior to elective spine surgery. The optimal preoperative intervention of smoking cessation techniques and duration of cessation remains unknown, but a recent Cochrane review suggests that a combination of cognitive therapy, behavioral therapy, and nicotine replacement therapy yields the best results and to be effective needs to be initiated 4 to 8 weeks prior to surgery as cessation less than 4 weeks does not appear to influence the risk of SSI.[17]

Obesity

With obesity rates reported in the United States at 34.9% of adults, SSI in this population remains a challenge as SSI rates are strongly correlated with obesity.[18] In the meta-analysis performed by Meng et al, they reported an increased risk of infection in patients with a body mass index >30 kg/m^2 with an OR of 2.13 (95% CI = 1.55-2.93), the strongest predictor of all 3 of the modifiable risk factors discussed thus far. In studies by Mehta et al, the distribution of adipose tissue, the skin-to-lamina distance, and the thickness of the subcutaneous tissue were significantly associated with increased SSI rates likely due to increased tissue disruption, creation of a larger dead space, and increased operative times.[19,20] Additionally, obesity is associated with other comorbidities that may further increase risk for SSI including diabetes.[21] Therefore, preoperative optimization of body weight is critical in order to minimize SSI. Interventions such as dietary counseling, referral to a bariatric surgeon for consideration of banding or gastric bypass procedures, as well as exercise counseling may be required prior to performing elective spine surgery. A caveat to substantial weight loss prior to surgery after bariatric surgery is malnutrition, especially as it pertains to bone health, with several studies noting a greater risk of osteoporosis, reduced bone mineral density, vitamin D deficiency, and an increased risk of spinal fracture.[22-24]

Bacterial Screening and Eradication

Gram positive bacteria continue to be the most common organism for spinal SSI. However, Abdul-Jabbar et al reviewed a single institution's experience in a 5-year period of 239 spinal SSIs. Gram positive organisms accounted for the majority of infections but Gram negative microbes were identified in 30.5% of cases and were more common in those cases involving the sacrum. The most common pathogens isolated were *Staphylococcus aureus* (45.2%) and *Staphylococcus epidermis* (30.4%). Interestingly, *Proprionibacterium acnes* species was seen in 7.9% of patients in this series.[25] Due to the preponderance of MSSA and MRSA SSIs and their colonization in healthy patients, screening programs have been designed in an attempt to preoperatively eradicate these organisms. Kim et al evaluated 7019 patients and identified 22.6% and 4.4% as MSSA and MRSA as carriers, respectively. In this study, they institutionalized a decolonization program entailing showering with 2% chlorhexidine once daily for 5 days and intranasal 2% mupirocin ointment twice daily for 5 days preoperatively and reported a significantly decreased rate of SSI from 0.45% to 0.19% for all elective orthopedic procedures.[26] Several other studies, including a randomized, double-blinded, placebo-controlled trial, have supported these findings, albeit in the joint arthroplasty literature.[27-29]

Recently, concerns have been raised concerning the presence of *P acnes* colonization in instrumented spine surgery procedures. A study by Shifflett et al reported a series of 112 revision spine surgeries with no preoperative suspicion for infection in which intraoperative cultures were obtained. They identified 45 patients with positive cultures, staphylococcus species were present in 57.8%, and *P acnes* was present in 48.9%.[30] Our identification of *P acnes* as a pathogen in spinal SSI is likely underreported given that it requires holding cultures for 14 days, and until recently was not identified as a pathogen. Further research is ongoing to help identify preventative strategies for limiting exposure to *P acnes* preoperatively.

Day of Surgery Optimization

Perioperative Antibiotics

Prevention of SSIs in spine surgery remains of paramount importance, and the use of prophylactic antibiotic therapy has been shown to reduce the risk of postoperative infection.[31-34] The majority of the guidelines that have been established focus on the treatment of gram positive bacteria (staphylococcus), and the standard antibiotic of choice is cefazolin, a first-generation cephalosporin, which has a long half-life in bone and serum and efficacious in treating gram positive bacteria and some gram negative bacteria. This antimicrobial prevention strategy is effective in most elective spine surgeries, but as mentioned previously gram negative bacteria are becoming more prevalent and it is important to recognize patients that are at increased risk of harboring these gram negative species.[35] In patients at risk of harboring gram negative species, not a normal component of the skin flora, such as incontinent patients or patients that have a history of urinary tract colonization and/or infection, should be carefully prescreened with urine cultures and have individualized additional antibiotic regimens administered. In the study by Núñez-Pereira et al, the authors studied an individualized antibiotic regimen based on preoperative risk factors for harboring gram negative bacteria and found a statistically decreased number of patients developing an SSI due to gram negative bacteria.[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 timeframe of 30 to 60 minutes prior to incision, and for longer duration surgeries the antibiotic should be redosed every 4 hours.[36] Other considerations are that for patients who have an allergy to beta-lactam antibiotics (penicillin), clindamycin should be substituted. The use of intravenous vancomycin should be used sparingly due to the risk of developing bacterial resistance but is the antibiotic of choice in patients who test positive for MRSA colonization preoperatively or who have a history of MRSA infections. Additionally, prophylactic antibiotics should only be administered for 24 hours postoperatively.

Recently, the use of intrawound vancomycin powder is rapidly being adopted for the prevention of SSIs in spine surgery.[37,38] Topical vancomycin provides a high local concentration of antibiotic with minimal systemic absorption. Intrawound vancomycin powder is applied subfascially, suprafascially, or equally throughout. Approximately 24% of pediatric spine surgeons currently use intrawound vancomycin, and both adult- and pediatric consensus-based guidelines recommend that intrawound vancomycin be considered routinely in instrumented cases or cases with risk factors such as prolonged duration or significant patient comorbidities.[39,40] Adverse events, though rare, include anaphylactic reaction, renal toxicity, and hearing loss.[37,41] Although numerous reviews support the use of intrawound vancomycin powder in spine surgery, the majority of these studies are retrospective in nature.[42-46] At least one randomized trial has reported conflicting evidence.[47] These studies may be limited due to bias in study design, lack of precision, controls, and small sample sizes. Evaniew et al found that the pooled estimate from 8 observational studies indicated a statistically significant reduction in odds of infection with the use of intrawound vancomycin (OR = 0.19, 95% CI = −0.08 to 0.47, $P = .0003$).[43] However, a randomized trial performed by Tubaki et al failed to demonstrate any benefit in 907 patients (OR = 0.96, 95% CI = −0.34 to 2.66, $P = .93$).[47] A recent review performed by Ghobrial et al evaluating a total of 9721 patients 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%.[37] Despite the lack of support from Level 1 studies, intrawound vancomycin has been widely adopted and does appear to be safe and effective for reducing postoperative SSIs in spine surgery with a low rate of morbidity. Further high-quality studies defining the dosage and delineating the exact population of efficacy are warranted.

Skin Antisepsis

The goal of intraoperative skin preparation of the surgical field is to sterilize the skin just prior to skin incision. The most commonly used commercial preparations are iodine and chlorhexidine combined with isopropyl alcohol compounds. Mechanisms of action are variable depending on the antiseptic compound being utilized, and there is no definitive clinical evidence that one skin preparation solution effectively lowers SSI rates compared with others. Three prospective randomized controlled trials in orthopedic surgery have compared the effectiveness of antiseptic preparations in eradicating skin flora.[48-50] Savage et al[50] found no difference between ChloraPrep (2% chlorhexidine and 70% isopropyl alcohol; Enturia, El Paso, Texas) and DuraPrep (0.7% available iodine and 74% isopropyl alcohol; 3M Healthcare, St Paul, Minnesota) in the rate of positive culture results after skin preparation. On the contrary, Ostrander et al[48] and Saltzman et al[49] found that ChloraPrep was superior to the other agents, with lower rates of positive cultures. When translated to rates of SSI, however, the ideal skin preparation solution remains unclear. Swenson et al[51] found that the lowest infection rates were seen with the use of DuraPrep, compared with Betadine and ChloraPrep, and Darouiche et al[52] found the lowest infection rates were in the ChloraPrep group compared with the Betadine group. A recent meta-analysis evaluating 10 randomized controlled trials concluded that alcohol-based agents are likely superior to aqueous solutions[53]; thus, use of either DuraPrep or ChloraPrep would provide adequate intraoperative skin preparation.

Hand Hygiene and Surgical Gloves

Hand hygiene plays a crucial role in preventing SSIs. Current commercially available solutions are generally either chlorhexidine-based or povidone iodine–based solutions. A recent Cochrane review found no evidence that one type of hand antisepsis is better than another in reducing SSIs.[54] Although chlorhexidine-based scrubs were shown to reduce skin colony counts more effectively, this did not translate into incidence of postoperative infection rates.[54,55] In a randomized trial with 4387 consecutive patients, Parienti et al found that hand rubbing with an aqueous alcohol solution was as effective as traditional hand scrubbing with antiseptic soap in SSI prevention.[56] Importantly, the hand-rubbing protocol was better tolerated and faster, with improved compliance rates.

With regard to surgical gloves, double gloving significantly reduces glove perforations and also allows earlier detection of perforation when the inside gloves are of a different color, which theoretically reduces rates of SSI.[57] Furthermore, Rehman et al showed that removal of outer gloves, as opposed to wearing the same pair of double gloves, prior to handling instrumentation in posterior spinal fusions resulted in a significant reduction of infection rates from 3.35% to 0.48%.[58] Additionally, Bible et al found that bacterial contamination of the operative microscope was found to be significant after spine surgery, particularly around the optic eyepieces. The authors recommend changing gloves after making adjustments to the optic eyepieces and avoid handling any portion of the drape above the eyepieces.[59]

Conclusion

This review of the literature discusses the preoperative preventive strategies and risk management techniques of SSIs in spine surgery. Even though we have seen significant decreases in SSIs after spine surgery over the past decade due to increased awareness and implementation of the prevention strategies described in this article, it is important to recognize that prevention of SSI requires a system-wide approach that includes the hospital system, the surgeon, and the patient. Continued efforts should focus on system-wide implementation of careful patient selection, individualized antibiotic treatment algorithms, identification of pathologic organisms, and preoperative decolonization programs to further prevent SSIs and optimize patient outcomes.

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