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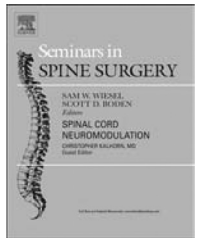

Postoperative spine infections

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A B S T R A C T

Postoperative spine infections can be a devastating complication with significant consequences for a patient. Focus should be placed on prevention, early diagnosis, and successful treatment strategies. Surgeons should maintain a high index of suspicion and initiate proper diagnostic workup and evaluation when concerned for a possible infection. This article will provide a global review of postoperative spine infection including incidence by surgical approach, specific risk factors, common presentations, diagnostic workup, prevention strategies, and both nonsurgical and surgical management.

1. Introduction

Postoperative infection of the spine is a feared complication that can be devastating to patients. In addition to the increased morbidity and poor patient outcomes, infections account for several billion dollars in U.S. health care expenditures.[1] Deep infections after spinal fusion have been shown to result in a greater than 4 times increase in total costs, in excess of $100,000 in some cases.[2] Prevention, early diagnosis, and successful treatment strategies are critical to reducing morbidity and health care costs. Surgeons should maintain a high index of suspicion for infection and initiate proper diagnostic workup and evaluation when concerned.

1.1. *Epidemiology and incidence*

The incidence of surgical site infection (SSI) following spine surgery has historically been reported in the literature between 1% to 6%, with some reports up to 20%.[3–9] This wide variation is in part due to variation in the definition of SSI, the length of follow up, and small heterogenous patient populations. A recent report from the Scoliosis Research Society Morbidity and Mortality Committee reported a 2.1% infection rate (0.8% superficial and 1.3% deep) from their database of 108,419 spine surgery cases.[10] However, incidence varies depending on spine region (cervical, thoracic, or lumbar), surgical technique (MIS or open), approach (anterior, posterior or lateral), and presence of instrumentation.

Non-instrumented procedures typically have lower rates of infection. Lumbar discectomy have reported rates of less than 1%,[11,12] and one series of 262 endoscopic discectomies reported no infections.[13] Higher rates have been reported between 1.25% to 2% with laminectomy without fusion [14–15] and even slightly higher between 2.1% to 3.5% when noninstrumented fusion is performed.[15,16] In general, longer, more invasive procedures with greater blood loss and soft tissue dissection have been shown to increase the risk for infection.[17]

A higher incidence of infection is seen with the use of instrumentation in posterior spine procedures at approximately 5%.[18–22] The SRS M&M database reported a 28% higher rate of infection in cases with implants than those without (2.3% vs 1.8%).[10] The implants do not introduce the source of infection but rather serve as a site for secondary inoculation.[23] Colonization of implants may also lead to delayed and resistant infections.[24]

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https://doi.org/10.1016/j.semss.2019.100754
1040-7383/

Anterior spinal procedures have a very low incidence of infection which is likely in part due to improved vascularity of the anterior spinal column and less soft tissue trauma. Reported rates are as low as 0 to 1%.[6,25–27] Combined anterior-posterior have the highest risk of infection,[10,27] but are typically more complex. Minimally invasive techniques are designed to minimize soft tissue disruption, blood loss, and thereby theoretically decrease infection risk. However, several studies have reported inconsistent results. Some studies favor a lower infection risk with MIS,[28–29] whereas others show no difference,[30,31] but there does appear to be a benefit of MIS in multilevel fusions.[32]

Spine trauma patients are a particularly high-risk population due to significant soft tissue injury and subsequent tissue necrosis and hematoma formation. Surgically treated traumatic spine injuries have postoperative infection rates reported between 9% to 15%.[33] Blam et al. reported a 9.4% postoperative wound infection rate in 256 spinal trauma patients compared to a 3.7% infection rate in 112 patients undergoing elective spine surgery.[34] Another study demonstrated similar rates in both trauma and elective patients.[35]

1.2. *Risk factors*

Causes of postoperative infections are multifactorial and risk factors are both patient-specific and surgery-specific. Patient specific risk factors are important to recognize in the preoperative work-up because many can be modifiable and if addressed early, improve surgical outcomes. These modifiable risk factors include tobacco and alcohol use, obesity, diabetes, and malnutrition.[8,28,36–38]

Obesity is frequently encountered and can lead to poor outcomes.[28,39–40] Obese patients typically require longer operative times, more extensive tissue dissection, and greater retraction force resulting in tissue necrosis in already poorly vascularized adipose tissue. The distribution of adipose tissue may serve as a better predictor for SSI than actual BMI.[41,42] Mehta et al. showed a significant association between SSI and the thickness of subcutaneous fat and lamina-to-skin distance.[41] Meng et al. reported an odds ratio of 2.13 for patients with a BMI > 30 kg/m2.[43] Obesity is also typically associated with diabetes, malnutrition, and other medical comorbidities which further increase the risk of infection.

Poorly controlled diabetes significantly impairs wound healing and increases risk for infection. Postoperative wound infections have been reported up to 24%.[28,44] Schuster et al. performed a large meta-analysis where the majority of studies found diabetes and elevated glucose levels to have a statistically significant association.[45] Chen et al. performed a retrospective level II study which showed that diabetic patients undergoing spinal fusion are greater than 4 times more likely to develop SSI.[46] Olsen et al. found DM patients to be 3.5 times as likely to develop an infection in their cohort of 2316 patients.[40] Meng et al. reported a 2 times higher risk of infection in diabetic patients.[43] In regards to hemoglobin A1C, Hikata et al. showed that patients with values greater than 7 had a 35% infection rate compared to no infections seen in patients with a values less than 7.[47] Diabetes can also lead to cardiovascular and renal disease which further increases infection risk. Strict perioperative control of blood glucose levels should be maintained.

Malnutrition is commonly undetected but has been shown to impair the immune response and delay wound healing. Common indices used are serum albumin less than 3.5 mg/dL or a total lymphocyte count less than 1500 cell/mm.[48] Klein et al. reviewed 114 patients undergoing elective spine surgery and 1 out of every 4 were considered malnourished.[37] Of these 13 malnourished patients, 11 (85%) developed a postoperative wound infection. Malnutrition can also develop during postoperative hospitalizations or between staged procedures.[49] Malnutrition can also be a sign of malignancy which has infection rates reported up to 20%.[6,50]

Tobacco use significantly increases the risk of postoperative wound infections.[51] Meng et al. found a relative risk of 1.17 [43] and Thomsen et al. showed that patients who stopped smoking had half as many complications.[52] Proposed mechanisms include poor tissue oxygenation and impaired neutrophil function.[53] Routine preoperative counseling on smoking cessation should be performed.

Non modifiable risk factors include immunocompromised states, rheumatoid arthritis medications, steroid use, and age.

Radiation therapy for the management of tumors poses a higher risk of infection.[54] Spine surgery following neoadjuvant irradiation to the surgical site increases the risk of infection and wound healing issues.[8,50,55] Therefore, elective spine surgery should typically be delayed for 6 to 12 weeks after preoperative radiation therapy. For postoperative radiation therapy, a delay of 3 weeks after surgery is typically recommended.

Surgery specific risk factors include increased number of levels, surgery greater than 5 h, blood loss greater than 1 liter, blood transfusion, and high complexity of procedure are associated with increased risk of infection.[56–57] Revision surgery, use of allograft, and procedures involving the sacrum or pelvis are also surgical risk factors.[18,58]

2. Patient evaluation

2.1. *Presentation*

The presentation of a patient with postoperative spine infection is different for superficial and deep infections, but the most common presenting symptom for both is pain. A superficial infection occurs above the fascia and typically presents within the first 2 postoperative weeks with local tenderness, erythema, warmth and drainage. If presenting early and without the presence of systemic symptoms or increasing surgical site pain, superficial infections can often be adequately treated with local wound care and 2 weeks of oral antibiotics. However, there should be a high index of suspicion for a deep infection if the wound continues to drain, surgical site pain worsens, or systemic symptoms such as fever, chills, night sweats, lethargy, or malaise develop.

The presentation of deep infections is variable and can occur anytime postoperatively from weeks to months to years.[59,60] Pain, fever and night sweats may be seen, but many have no systemic symptoms. New onset of pain is particularly worrisome. There may be purulent drainage from a sinus tract to the skin or a lack of any impressive external

evidence. Delayed presentations typically have back pain, drainage and erythema but without fever. Neurologic deficits can occur, usually due to a spinal epidural abscess.

2.2. Evaluation

Diagnostic work up should include a thorough history and physical exam, labs, imaging and further studies as indicated. Laboratory tests include WBC, ESR, and CRP. Results can be difficult to interpret in the immediate postoperative period. WBC can be elevated from surgical stress. ESR elevates immediately postoperatively to a peak at day 4 before normalizing two to four weeks later.[61] Higher peak ESR values have been shown to correlate with the more extensive or invasive the procedures is.[61] Persistently elevated ESR, particularly over 2 standard deviations, are concerning for infection.[62] CRP is also elevated in the immediate postoperative period with a peak at day 3, but with a more rapid decline than ESR, with complete normalization occurring at 10–14 days. The rapid decline makes CRP a more sensitive and useful diagnostic tool and CRP is nearly always elevated in SSI.[63] Variations in pathogen virulence as well as host immunocompetence can mitigate results, but when taken together and viewed as a trend, WBC, ESR and CRP can be helpful in recognizing a postoperative infection as well as monitor treatment efficacy and prognosis.

Identification of the offending organism requires reliable cultures. Blood cultures should be taken prior to the initiation of antibiotics and if positive for a specific organisms, it can be presumed to be the causative organism. Wound cultures can be obtained easily but are often contaminated with skin flora and unreliable. CT guided aspiration can obtain more precise deep cultures. The most precise cultures come directly from the source during surgical debridement when intervention is feasible and necessary.

2.3. Imaging

Imaging can also aid in the diagnosis. Evidence on plain radiographs often takes up to 4 weeks to show.[64] Early findings can include lucency around instrumentation, soft tissue gas, bony destruction, and disc space narrowing which eventually transition to vertebral body collapse, endplate sclerosis, and osteolysis months later.[65–66] Distinguishing early changes from coexisting degenerative disc disease can be difficult. CT can provide better detail than plan radiographs on bony changes in early infection or as a substitute when MRI is contraindicated or difficult to interpret due to artifact. CT can also be used to assist in biopsy and delineate an abscess with contrast enhancement.

MRI is the most sensitive (93%) and specific (96%) for diagnosing spinal infections.[67–68] MRI findings of discitis or osteomyelitis are marrow and disc space hypointensity on T1-weighted sequence and hyperintensity on T2-weighted or STIR sequences (Fig. 1).[68] Additional findings of endplate destruction and disc space narrowing further contribute to the diagnosis of infection. A spinal epidural abscess appears isointense on T1-weighted sequence and hyperintense on T2-weighted sequence, and typically is compressing neural elements (Fig. 2). Addition of gadolinium contrast delineates an abscess with rim enhancement. MRI can also identifies adjacent soft tissue masses.

3. Prevention techniques

3.1. Preoperative options

Prevention is the first step to reducing postoperative infections and begins with preoperative optimization of modifiable

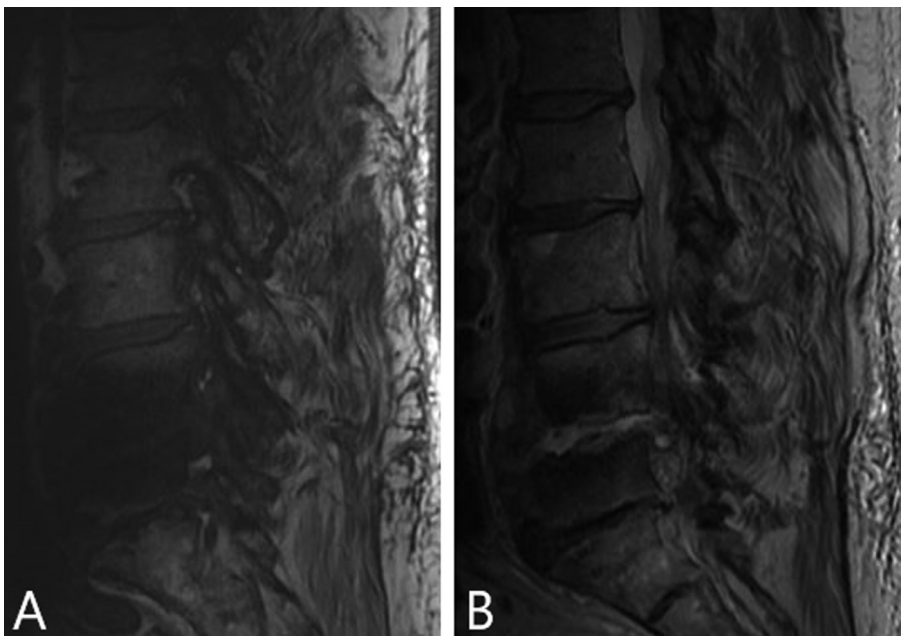

Fig. 1 – 65 year old male with severe lumbar osteomyelitis and spondylodiskitis. (A) Sagittal T1 weighted MRI demonstrating L4-L5 disc space and adjacent marrow hypointensity. (B) Sagittal T2 weighted MRI demonstrating relative hyperintensity in the same region.

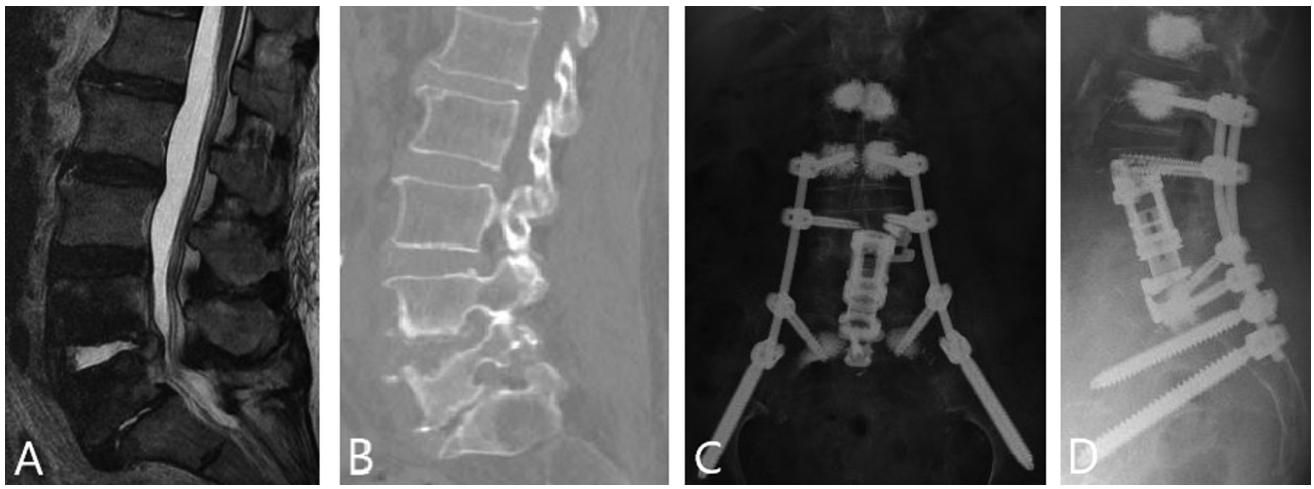

Fig. 2 – 75 year old diabetic female with end stage renal disease who presented with severe progressive back pain and lower extremity weakness with epidural and retroperitoneal abscess. (A) Sagittal T2 MRI image showing an anterior epidural abscess extending from L4-S1. (B) Sagittal CT reconstruction demonstrating severe end plate erosions of L5 and S1. (C and D) Postoperative AP and lateral radiographs following anterior debridement, L4 and L5 corpectomy, L4-S1 interbody cage reconstruction and L3 to pelvis posterior instrumentation with PMMA cement augmentation.

risk factors including smoking cessation, nutritional status, and glycemic control. Smoking cessation for a minimum of 4 weeks prior to surgery has been shown to reduce SSI.[69] Nutrition should be optimized prior to surgery with a focus on serum albumin and total lymphocyte count.[34] Obesity patients may require dietary or exercise counseling, or referral for bariatric surgery. Tight glycemic control should be maintained in the perioperative period. Any infection including urinary tract, gastrointestinal or respiratory should be fully resolved prior to elective surgery. Hair over the surgical site should be removed with clippers rather than a razor to avoid inadvertent microabrasions. MSSA and MRSA screening and eradication with intranasal 2% mupirocin ointment and 2% chlorhexidine gluconate (CHG) showers for 5 days lowered the rate of SSI after spine surgery by half.[70–71]

3.2. *Intraoperative options*

Prophylactic antibiotics against common skin flora has shown a trend toward decreasing infection rates [62,72–73] and is recommended by the North American Spine Society.[74] Recently cephalosporin administration 30 min prior to skin incision was shown to significantly decrease SSI risk compared to the previous recommendation of 31 to 60 min prior to incision.[75] Cephalosporins should be readministered every 4 h or after 1500 mL of blood loss and vancomycin and gentamycin should be redosed every 8 h.[76–78] Cefazolin is a first generation cephalosporin that is most commonly used because it is effective against gram-positive bacteria such as Staphylococcus Aureus. Clindamycin can be used as a substitute for patients with beta lactam allergies, and vancomycin for patients with a history of MRSA. Postoperative antibiotics are typically discontinued after 24 h and the use of drains should not alter the duration.

Proper sterile technique and skin antisepsis preparation with iodine or chlorhexidine solutions should be performed in all cases. Surgeon double gloving to prevent perforation,[79] and intermittently changing outer gloves, particularly prior to handling instrumentation has also been shown to reduce SSI during spine surgery.[80] Intraoperatively, surgeons should periodically release retractors, maintain hemostasis and remove of any necrotic tissue that could become infected.[81–82] Surgical site irrigation with saline or various solutions have been used without much significant clinical data to support one solution over another. However, Cheng et al. performed a prospective, blinded and randomized study using 3.5% betadine irrigation for 3 min after saline versus saline alone in 414 spine surgeries and reported a significant reduction in deep SSI without any adverse events.[83]

The use of topical vancomycin powder applied directly to the wound provides a locally high concentration of antibiotic without systemic implications. Several meta-analyses and systematic reviews support its use in significantly reducing postoperative SSI.[84–87] Khan et al. reported a relative risk of 0.34 with the use of vancomycin powder.[88] Sweet et al. reviewed 1732 consecutive posterior instrumented thoracic and lumbar fusions and reported an SSI rate of 2.6% in 821 patients receiving IV cephalexin prophylaxis alone compared to 0.2% in 911 patients when adjunctive vancomycin powder was added.[89] Vancomycin powder is cost effective,[90] safe in adults [89,91] and children,[92–93] easy to deliver and provides broad coverage

The use of postsurgical drains is controversial. The goal is to prevent hematoma formation and therefore the risk of subsequent seeding. Some studies report decreased risk of SSI while others report no difference or an increased risk of SSI.[94–95] Use of drains have been associated with higher rates of blood transfusions.[96] Prolonged use of antibiotics with the use of a drain have not been supported.[97]

4. Management of infection

4.1. Nonsurgical

The goal of nonsurgical and surgical debridement is resolution of the infection while maintaining spinal stability. Determining the timing, location and extent of the infection will help guide the choice of management. Infections presenting early in the first few weeks postoperatively are typically due to direct inoculation of more virulent bacteria such as MRSA.[28,98–99] In contrast, delayed infections present several months after the index surgery and are commonly associated with less virulent bacteria that may have colonized instrumentation with a biofilm, such as Propionibacterium acnes.[100–101] Preoperative imaging may identify the region of infection. Minor superficial infections without wound breakdown, purulence, or fluctuance may only require local wound care and antibiotics. If no organism is identified, antibiotics targeting skin flora, such as Staphylococcus, may be adequate. For anything beyond a simple stitch abscess, a typical course is 6 weeks IV antibiotics followed by 6 weeks of oral antibiotics.[102] An orthotic brace can help mitigate symptoms.

Surgeons should remain cautious and maintain close follow up with serial inflammatory markers because these nonsurgical interventions may not completely resolve the infection. Failure to respond to antibiotics or presence of neurologic deterioration, spinal instability or severe persistent pain may necessitate surgical debridement in addition to IV antibiotics.

4.2. Surgical

Surgical intervention includes meticulous and systematic debridement of nonviable tissue, obtaining multiple deep and superficial tissue cultures and exploration of the wound for sinus tracts and integrity of instrumentation. Preoperative antibiotics should be withheld until culture specimens are obtained. The wound bed should be copiously irrigated and the need for repeat debridement should be determined based on the severity of the infection and surgeon discretion. A scoring system was developed to assist surgeons with this decision. The Postoperative Infection Treatment Score for the Spine (PITSS) predicts which patients may need multiple irrigation and debridements based on 6 categories – location, comorbidity, microbiology, distant site infection, instrumentation and bone graft.[103] Low risk, indeterminate and high risk correspond to scores of 7–14, 15–20, and 21–33, respectively. Repeat debridements typically take place 48 to 72 h after initial debridement.

No consensus exists on whether to remove well-fixed instrumentation. No level I or II evidence is available on retention versus removal. Some authors support routine removal of all instrumentation regardless of fusion status in order to adequately eradicate the infection.[59,60,104–107] Others authors advocate retaining well-fixed instrumentation after a thorough debridement to prevent loss of correction or catastrophic instability leading to neurologic compromise or deformity.[4,18,57,108–116] These authors have also demonstrated adequate removal of infection with retained instrumentation. Retaining instrumentation in favored in early infection whereas removal of instrumentation is favored in delayed infection.[117] Another technique is to rely on suppressive IV antibiotics until a solid fusion is achieved and then remove instrumentation. If loose instrumentation is encountered and must be reimplanted into an infected site, titanium implants are favored over stainless steel implants because they are more resistant to glycocalyx biofilm formation.[118] Pseudoarthrosis is encountered more frequently after infection and close follow-up should be maintained, particularly if instrumentation is removed and there is a risk for instability.[57,119]

Primary layered wound closure after adequate debridement and irrigation is typically preferred, if feasible. Significant infection and myonecrosis often results in large soft tissue defects that require multiple returns to the operating room and delayed closure via secondary intention or potentially reconstructive soft tissue coverage such as a trapezius rotation flap [120] or paraspinal muscle flap.[121] The use of a drain to eliminate dead space is typically recommended. The use of vacuum-assisted closure (VAC) devices safely and effectively has been described [56,98,122–124] and some authors recommend using it on all postoperative spine infections.[125] The wound VAC is thought to eliminate dead space, improve vascularity and decrease bacteria levels.[6] Lee et al. reported 42 patients with deep postoperative spinal infections treated with wound VACs that all fully healed. 30 patients also had exposed dura which were covered with a layer of Jelonet or Mepitel, a white sponge, and negative pressure limited to 50 mmHg and no complications occurred from the wound VAC. Wound VACs have also shown efficacy in MRSA or multiple bacteria infections.[126]

Patients should be followed for symptomatic improvement of back pain and downtrending ESR, CRP, and WBC. Serial Imaging can used to evaluate for maintenance of instrumentation, alignment, fusion. Evidence of resolution of infection on imaging may lag behind treatment for several weeks to months.

5. Conclusions

Postoperative spinal infections can have devastating outcomes for patients. Prevention is the critical first step to protecting patients. Patients should be medically optimized and modifiable risk factors should be addressed preoperatively. Intraoperative measures include routine administration of preoperative antibiotics, maintenance of proper sterile technique, and application of vancomycin powder prior to closure. Despite these precautions, postoperative infections inevitably occur and therefore require a high index of suspicion. Patients with increasing surgical site pain or pain out of proportion to what is expected, particularly with concomitant systemic symptoms, should undergo a diagnostic infectious work up. MRI with and without contrast should be obtained along with ESR, CRP, WBC, blood cultures, and possibly CT guided or open biopsy to tailor antibiotics. Most patients may be adequately treated with antibiotics alone, but surgical debridement is often necessary. Single or multiple thorough debridements may be required with primary or delayed

closure. There is no consensus on whether to remove or retain instrumentation. Patients should be followed closely for improvement and be wary of the development of pseudoarthrosis or instability.

Disclosures

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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