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REVIEW

Management of postoperative spinal infections

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Abstract

Postoperative surgical site infection (SSI) is a common complication after posterior lumbar spine surgery. This review details an approach to the prevention, diagnosis and treatment of SSIs. Factors contributing to the development of a SSI can be split into three categories: (1) microbiological factors; (2) factors related to the patient and their spinal pathology; and (3) factors relating to the surgical procedure. SSI is most commonly caused by *Staphylococcus aureus*. The virulence of the organism causing the SSI can affect its presentation. SSI can be prevented by careful adherence to aseptic technique, prophylactic antibiotics, avoiding myonecrosis by frequently releasing retractors and preoperatively optimizing modifiable patient factors. Increasing pain is commonly the only symptom of a SSI and can lead to a delay in diagnosis. C-reactive protein and magnetic resonance imaging can help establish the diagnosis. Treatment requires acquiring intra-operative cultures to guide future antibiotic therapy and surgical debridement of all necrotic tissue. A SSI can usually be adequately treated without removing spinal instrumentation. A multidisciplinary approach to SSIs is important. It is useful to involve an infectious disease specialist and use minimum serial bactericidal titers to enhance the effectiveness of antibiotic therapy. A plastic surgeon should also be involved in those cases of severe infection that require repeat debridement and delayed closure.

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Key words: Surgical site infection; Spine surgery; Discitis; Postoperative infection

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INTRODUCTION

Postoperative surgical site infection (SSI) in the lumbar spine is a relatively frequent complication of invasive spine procedures. The management of a SSI can be costly due to its potentially devastating consequences, including lost productivity during prolonged treatment and recovery, increased morbidity, the need for subsequent reoperation and even death. With the rise in prevalence of antibiotic-resistant organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA), the prevention and treatment of SSIs has become even more difficult, particularly in those patients with spinal instrumentation.

This review describes the factors that contribute to the development of a SSI and strategies for their prevention, the range of presentations of SSIs, and the challenges that arise during diagnosis and treatment.

PATHOGENESIS AND PREVENTION

Although multifactorial, the various risk factors that contribute to the development of a SSI can be broadly divided into three categories: (1) microbiological; (2) patient/host; and (3) procedure-related. Understanding the contribution of these risk factors to SSIs enhances measures aimed at the prevention of this common yet dreadful complication.

Microbiological factors

The most common organism causing a SSI is *Staphylococcus aureus* (*S. aureus*), although other reported causative organisms include *Staphylococcus epidermidis* (*S. epidermidis*), *Enterococcus faecalis, Pseudomonas* spp., *Enterobacter cloacae,* and *Proteus mirabilis*[1,2]. Trauma patients are more likely to present with infections due to gram-negative bacteria, which may result from hematogenous spread in the setting of urosepsis, frequently in patients with neurological injury related to their trauma[3]. Recently, a consecutive series of 3218 patients undergoing posterior lumbar-instrumented arthrodesis was reviewed by Koutsoumbelis *et al*[4]. In this series, 34% of SSIs demonstrated positive cultures for MRSA, indicating an increasing prevalence of this organism.

When addressing microbiological factors that contribute to SSIs, it is important to emphasize that meticulous adherence to aseptic technique is the key component of SSI prevention[5]. One intervention that the bulk of available evidence has suggested may decrease the rate of SSI after spinal surgery is the use of prophylactic antibiotics[6]. Antibiotic prophylaxis has brought the incidence of SSI following lumbar discectomy down to < 1%[1,7-12]. In fact, one report by Transfeldt *et al*[13] showed a decrease in the SSI rate from 7% to 3.6% following elective spinal arthrodesis with the use of routine antibiotic prophylaxis. When choosing an antibiotic, one with good efficacy against common strains of *S. aureus* and *S. epidermidis* should be used due to the higher frequency of infection with these bacteria. A first-generation cephalosporin such as cefazolin is popular, as it also quickly reaches peak serum concentrations and has a more benign side effect profile than other antibiotics. If a patient is at high risk for colonization with MRSA, we recommend combining vancomycin with cefazolin, as vancomycin alone has relatively low efficacy against non-methicillin resistant strains of *Staphylococcus* spp. Yet for those patients with allergies to penicillin or cephalosporins, vancomycin alone can be used. Risk factors for colonization with MRSA include antibiotic use within 3 mo before admission, hospitalization during the past 12 mo, diagnosis of skin or soft-tissue infection at admission, and human immunodeficiency virus infection[14,15]. Bacterial antibiotic resistance continues to be an evolving problem and these recommendations may need to be modified based on regional bacterial susceptibilities or if common pathogens in SSIs develop widespread resistance to these antibiotics in the future.

Patient/host factors

Several patient-related risk factors have been reported for SSIs including: diabetes mellitus, obesity, alcohol abuse, smoking, advanced age, corticosteroid use, malnutrition and hospitalization greater than one week[16-40]. Koutsoumbelis *et al*[4] also identified coronary artery disease, osteoporosis and chronic obstructive pulmonary disease as independent risk factors for SSIs. Although the exact mechanism by which these factors increase the likelihood of a SSI is not definitively known, it is clear that an inability of the host to heal the surgical wound and mount an inflammatory response sufficient to eradicate the infectious organisms leads to their growth. Obese patients have a large layer of adipose tissue with poor vascular perfusion that may become necrotic following wound closure, creating a nidus for infection[2,16,20,24,41,42]. Smoking and diabetes both predispose patients to infection through microvascular damage and subsequent induction of tissue ischemia[23,24,41-43]. Advancing age increases the likelihood of the presence of other comorbidities and is associated with immunosenescence, a phenomenon by which the immune response gradually wanes and becomes ineffective.

The pathology that patients present with also influences susceptibility to infection. Patients with traumatic spine injury, especially those with a concomitant neurological injury, have infection rates of up to 10%[2-4,16-40,43-47]. Such patients may have additional injuries to the viscera or appendicular skeleton and usually have a greater degree of soft-tissue injury than patients undergoing elective surgery, which contributes to tissue hypoxia. Trauma patients are in a catabolic state and are more likely to have protein-calorie malnutrition. Prolonged stays in intensive care units lead to increased exposure to antibiotic resistant bacteria, which may increase the severity of a SSI and make treatment more difficult. Those factors that cause trauma patients to have a higher risk of developing SSIs also apply to patients with spinal neoplasms. In addition, these patients may also undergo systemic chemotherapy or radiation to the surgical site, leading to immunosuppression and delayed healing, and consequently increasing their susceptibility to infection.

Modifiable risk factors should be mitigated preoperatively to minimize the risk of postoperative infection. A nutrition consult should be obtained in patients after significant polytrauma, with catabolic processes due to neoplasm, or otherwise at significant risk for malnutrition. Blood sugar should be closely controlled in diabetic patients.

Procedure-related factors

The length and complexity of the index surgical procedure has a significant impact on the incidence of SSIs.

Although the risk of a SSI is < 1% for lumbar discectomy, the risk is higher following spinal arthrodesis, particularly with posterior instrumentation. This is likely due to increased dead space, longer duration of surgery and the potential for adherence of biofilm to metal implants. Following elective thoracic or lumbar spinal arthrodesis, reported rates of SSI from individual surgeons or institutions ranges from 1.9% to 4.4% in the last ten years[41,42,48-50]. The most recent National Nosocomial Infections Surveillance report in 2004 cited the infection rate following spinal arthrodesis as 2.1%[51]. The risk of SSI is less common after anterior spinal arthrodesis and is not greater for a combined anterior/posterior arthrodesis than for a posterior arthrodesis alone[44], except for when it is a staged procedure done under separate anesthesia[48]. Devices such as an operating microscope or headlamp and loupe magnification can create a source of bacterial shedding onto the surgical field, although increased contamination from these devices has not been shown to directly increase infection risk[8,9,52-54]. There is also some limited evidence that minimally invasive surgery may decrease the risk of a SSI. A recent systematic review of single cohort studies comparing minimally invasive transforaminal interbody fusion (TLIF) to open TLIF showed a significant decrease in SSI rates from 4% to 0.6%[55-57]. In addition, it has recently been shown that the risk of returning to the operating room (OR) to treat a SSI increases along with the surgical invasiveness index of the primary spine surgery[58].

The study by Koutsoumbelis *et al*[4] reported an overall incidence of SSIs of 2.6%. Their study identified four procedure related risk factors: (1) longer duration of surgery; (2) intra-operative blood loss/need for transfusion; (3) incidental durotomy; and (4) greater than ten people in the OR, specifically cautioning against extraneous nurses. Previous studies have also identified increased operative time, multilevel surgery, revision surgery, and an increased number of people in the OR as important predisposing factors for a SSI[1,2,16,41,42,45,46,48,49]. However, this is the first time incidental durotomy has been identified as a risk factor for SSI[47]. It is unclear how and to what extent incidental durotomy and an increased number of people in the OR increase the likelihood of a SSI. Both may increase the risk of contamination of the surgical field directly, or be indicative of a longer and/or more complex surgical procedure.

Modifications to procedural technique can assist in the prevention of a SSI. It is important to frequently release retractors to prevent myonecrosis, avoid excessive use of electrocautery during subperiosteal dissection of muscle, and debride necrotic appearing muscle at the conclusion of the case. This will prevent the retention of devitalized necrotic tissue, which is a potential nidus for infection. Although the use of this technique in the lumbar spine has not yet been investigated, the addition of vancomycin powder to posterior cervical incisions prior to closure has been shown to decrease SSIs[59,60]. At our institution, patients undergoing multi-level decompression and/or posterior spinal arthrodesis routinely receive antibiotic irrigation and closed suction drains postoperatively. Existing investigations have not shown that these interventions provide a significant benefit, although they have been underpowered to detect a change in infection rate, a rare event[61-63]. Evidence for the use of vertical laminar flow systems to decrease the risk of SSI in the OR is limited[64].

Recently, Dipaola *et al*[65] created a predictive model to stratify patients with spinal SSIs into those needing single *vs* multiple irrigation and debridements. To develop the model, risk factors from all three categories (microbiological, patient/host and procedure related), were analyzed. It was found that positive MRSA cultures and concomitant infections at sites other than the spine or bacteremia were strong predictors of the need for multiple irrigation and debridements. In addition, diabetes, location of surgery in the posterior lumbar spine, presence of instrumentation and the use of bone graft material other than autogenous bone graft were also more likely to result in multiple irrigation and debridements. In the future, this predictive model may help stratify patients with SSIs, enabling surgeons to adapt their index surgery and SSI treatment strategies accordingly.

CLINICAL PRESENTATION AND DIAGNOSIS

The diagnosis of a SSI requires the synthesis of all available data, as there is no one pathognomonic sign or symptom to indicate its presence. The most common symptom of a SSI in the early postoperative period is increasing pain at the surgical site. Signs on exam include tenderness to palpation, peri-incisional erythema, induration and drainage. A particular concern is a patient with constitutional symptoms such as fever and chills, and in the case of a severe infection: hypotension, lethargy and confusion from sepsis. Such an infection is an absolute indication for emergent irrigation and debridement, but presents rarely. In the setting of a revision surgery, latent infection from organisms such as *Propionibacterium acnes* must always be considered and routine cultures sent, as the presentation may be limited to vague complaints of pain with evidence of hardware loosening or pseudoarthrosis.

Imaging

Except in the setting of latent infections or discitis, plain radiographs of the spine are not particularly useful to diagnose an early SSI. Patients with latent infections may have lucency around instrumentation, while those with discitis may show loss of disk height and end plate erosion. Along those lines, computed tomography (CT) can be used in these patients to assess bony destruction and implant loosening three-dimensionally. Bone scan is not useful in these patients, as it will commonly show increased uptake due to the reactive bone at the surgical site post-operatively[66]. Gadolinium enhanced magnetic resonance imaging (MRI) is the best radiologic modality to use when a SSI is suspected. Progressive marrow signal changes, rim enhancing fluid collections, ascending or descending epidural collections and bony destruction are all indicative of infection on MRI.

When interpreting MRI results, confounding factors such as time from index procedure should be taken into account, as tissue edema from a non-infectious cause can be confused with an infectious process. Infection typically occurs between three days and three months postoperatively and takes several days to become established. In the immediate post-operative period (< 6 wk), it has been shown that diffuse, spotty, linear intervertebral disk enhancement, with two thin bands paralleling the endplates, as well as annular enhancement at the surgical curette site are common findings and do not indicate that an infection is developing. Type 1 changes of adjacent endplates, such as decreased signal intensity on T1 imaging and edema of the vertebral marrow adjacent to the disc, are also common post-operatively. Vertebral osteomyelitis is typically recognized by endplate changes similar to these Type 1 changes, and is described as a diffuse, irregular area of non-anatomic high signal intensity in the disc. Contrast is valuable in differentiating between the two entities, as osteomyelitis shows circumferential enhancement of the disc, while the postoperative state will only produce subtle linear areas of enhancement[67,68].

Laboratory tests

Measurement of acute phase reactants is very useful when diagnosing an infection. C-reactive protein (CRP) has been shown to be more sensitive than erythrocyte sedimentation rate (ESR) for detecting a SSI, as CRP levels only stay elevated for two weeks postoperatively before decreasing, while it may take up to six weeks for ESR levels to normalize. For this reason, time since index surgery is important when interpreting levels of acute phase reactants. Persistent elevation of CRP is an early indicator of an infection. In addition, preoperative measurement of CRP levels in high-risk patients with associated medical co-morbidities that may confound a postoperative CRP measurement can be useful as a baseline for detection of early infection postoperatively[69]. White blood cell count, although routinely obtained, is an unreliable indicator of a SSI. It may remain normal despite a SSI or may be normally elevated in the postoperative period. When attempting to identify the causative organism in a SSI, intra-operative tissue cultures are the gold standard. Superficial cultures, from either the skin or drainage, are not reliable due to the likelihood of contamination by skin flora. Alternatively, some authors have proposed wound aspiration as a method for detecting early infections[70].

TREATMENT OF SSI

The timing and location of the infection dictates treatment. The timing of a SSI can be classified as early, late or latent, and location is either limited to the disc, or superficial or deep to the fascia.

Posterior spinal infections

Superficial extrafascial SSIs, such as cellulitis or subcutaneous abscesses, are usually managed with IV antibiotics and/or surgical incision and drainage, which can often be performed at the bedside. Subfascial wound infections rarely respond to antibiotic treatment alone and require surgical debridement and removal of all necrotic tissue with closure over drains. Epidural abscesses can be managed medically when small. However, surgical drainage is typically required for large collections, small collections that progress despite antibiotic therapy, and decompression of the dural sac in the event of a neurological deficit. Paraspinal epidural abscesses, such as a psoas abscess, may respond to medical treatment when small. However, CT-guided aspiration and drainage is often required for large collections[32]. A SSI in an immunocompromised host or with a particularly virulent organism may require multiple irrigation and debridements.

Patients with a SSI and spinal instrumentation present similarly to those without instrumentation, but pose unique challenges. The use of MRI in patients with instrumentation requires specialized protocols for suppression of metal artifact, such as the metal artifact reduction sequence described by Chang *et al*[71], without which the MRI is of limited value[72,73]. Thorough surgical debridement of all necrotic tissue and irrigation with large amounts of normal saline is crucial[74]. Loose bone graft material should be removed if unincorporated, as dead bone will only serve as a nidus for continued infection. Loose pedicle screws and other non-essential spinal instrumentation should be removed, but essential instrumentation should be maintained if possible to avoid the creation of instability or the loss of deformity correction. Interbody and posterior segmental instrumentation can usually be left in place early on, as several authors have reported high success rates using this hardware-preservation strategy in the management of early SSIs[1,4,75-78]. Patients with a late infection and solid fusion can have their instrumentation removed during surgical debridement to help clear the infection[79]. Unfortunately, these patients are at an increased risk of developing a pseudoarthrosis and must be monitored with serial imaging studies[80].

As multiple debridements are often necessary when treating a SSI, involving a plastic surgeon early on can facilitate optimal wound management[81,82]. The debridement of soft tissue required to treat a SSI may result in a significant soft tissue defect. Such defects may be definitively closed with a muscle flap, or heal by secondary intention using a vacuum-dressing. We recommend that patients who require multiple surgical debridements have antibiotic impregnated polymethylmethacrylate (PMMA) beads placed into the wound during early debridements, permitting high local antibiotic concentrations despite poor tissue vascularity. PMMA beads have been shown to decrease the development of infection after wound contamination, and have been documented to decrease both acute infection rates and osteomyelitis after compound limb fractures[83-85].

Postprocedure discitis

With a reported incidence ranging from 0.2% to 2.75%, postprocedure discitis is an infrequent complication of spine surgery[86-89]. A vague complaint of low back pain is commonly the only indication that a patient may be suffering from postprocedure discitis, which can lead to a delay in diagnosis. Especially concerning are those patients with a history of increasing low back pain following surgery. For these patients, bracing can be used for comfort. Image guided percutaneous aspiration of the disc to identify the causative organism and guide antibiotic treatment is very effective[90]. Most of these cases can be treated with six weeks of IV antibiotics, usually resulting in spontaneous fusion of the disk space[91-93].

Surgery is indicated in those patients whose infection has progressed on MRI despite appropriate antibiotic therapy, with deformity due to progressive destruction of the vertebral bodies, or with severe pain or neurological deficits due to progression of the infection into the spinal canal. For early postoperative discitis with minimal involvement of the vertebral bodies, percutaneous transforaminal endoscopic debridement is an effective and minimally invasive option that has been shown to bring immediate pain reduction and good clinical results[94]. Otherwise, anterior only or posterior only approaches for debridement and fusion may be sufficient, depending on the location of the infection and the extent of debridement and resulting instability[95-97]. Many surgeons prefer to use autologous bone graft as an interbody spacer to minimize the risk of recurrent infection. If performed, harvesting of the bone graft should be performed prior to opening the spinal wound to minimize the risk of graft donor site SSI. When performing a surgical discectomy, as much of the disk as possible should be removed to prevent recurrent infection, as the adult intervertebral disk is avascular.

Postoperative antibiotic therapy

Infectious disease specialists are routinely involved in the selection and monitoring of antibiotic therapy at our institution. For implanted spinal instrumentation, the protocol our institution uses is based on previous experience with SSIs following total joint replacement[98-100]. Intravenous antibiotics are chosen based on the type of causative organism and its sensitivity profile. Dosage is monitored by the trough serum bactericidal titer (SBT), which indicates the amount of bactericidal activity in the patient's serum at the trough level between antibiotic doses. The trough SBT should be maintained at a minimum of 1:2[101]. This ensures that at a trough level, there is at least twice the minimum concentration of antibiotic in the serum that is required for bactericidal activity. Using the SBT to monitor antibiotic therapy improves its efficacy, even in cases with resistant organisms. Antibiotics are continued for six weeks postoperatively, although recent recommendations advise eight weeks of total IV antibiotic therapy for patients with resistant organisms such as MRSA[102]. Patients are subsequently maintained on oral suppressive antibiotics. The patient's health status, success in achieving spinal fusion and causative organism influence the choice between lifetime oral antibiotic suppression to prevent recurrent infection and removal of instrumentation.

CONCLUSION

SSI is a common but challenging complication, particularly after instrumented spinal arthrodesis. Using meticulous aseptic technique, intra-operative irrigation, prophylactic antibiotics and optimizing patient factors preoperatively are key to preventing a SSI. In patients who still develop an infection despite efforts at prevention, timely diagnosis and treatment is critical. Instrumentation can be retained while still successfully clearing an early infection, although following fusion, instrumentation can be removed if lifetime oral antibiotic suppression is either not indicated or undesirable. Involving a plastic surgeon early on in the process is useful for closure of complex soft tissue defects.

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