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REVIEW ARTICLE

Postoperative infections of the lumbar spine: presentation and management

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Abstract
Purpose Postoperative surgical site infections (SSI) are a frequent complication following posterior lumbar spinal surgery. In this manuscript we review strategies for prevention, diagnosis and treatment of SSI.
Methods The literature was reviewed using the Pubmed database.
Results We identified fifty-nine relevant manuscripts almost exclusively composed of Level III and IV studies.
Conclusions Risk factors for SSI include: 1) factors related to the nature of the spinal pathology and the surgical procedure and 2) factors related to the systemic health of the patient. Staphylococcus aureus is the most common infectious organism in reported series. Proven methods to prevent SSI include prophylactic antibiotics, meticulous adherence to aseptic technique and frequent release of retractors to prevent myonecrosis. The presentation of SSI is varied depending on the virulence of the infectious organism. Frequently, increasing pain is the only presenting complaint and can lead to a delay in diagnosis. Magnetic resonance imaging and the use of C-reactive protein laboratory studies are useful to establish the diagnosis. Treatment of SSI is centered on surgical debridement of all necrotic tissue and obtaining intra-operative cultures to guide antibiotic therapy. We recommend the involvement of an infectious disease specialist and use of minimum serial bactericidal titers to monitor the efficacy of antibiotic treatment. In the most cases, SSI can be adequately treated while leaving spinal instrumentation in place. For severe SSI, repeat debridement, delayed closure and involvement of a plastic surgeon may be necessary.

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Introduction

Postoperative surgical site infection (SSI) in the lumbar spine is an unfortunately common and potentially devastating complication. It is associated with increased morbidity, the need for further surgery and even death. The emotional and monetary costs of treating these infections to both health care payers and patients are significant. Additionally, the increasing prevalence of antibiotic-resistant organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA) presents new challenges for both prevention and treatment of SSIs, especially in patients with spinal instrumentation. In this manuscript, we review the epidemiology of SSI with respect to both host and organism risk factors, the varying presentations of SSI, the challenge of diagnosis, and strategies for prevention and treatment.

Epidemiology

SSI is one of the most common complications following spinal surgery. Risk factors affecting the incidence of SSI can be broadly divided into two categories: (1) factors related to the nature of the spinal pathology and the surgical procedure and (2) factors related to the systemic health of the patient.

Surgical risk factors

The incidence of SSI varies significantly depending on the length and complexity of the index surgical procedure. With the use of modern antibiotic prophylaxis, the incidence of SSI following lumbar discectomy is <1% [1–4]. The use of an operating microscope or headlamp and loupe magnification creates a source of bacterial shedding onto the surgical field which may increase infection risk [2, 3, 5, 6]. The risk of infection is higher following spinal arthrodesis especially for cases with posterior instrumentation. In the most recent National Nosocomial Infections Surveillance (NNIS) report, the infection rate following spinal arthrodesis was cited as 2.1% in 2004 [7]. In the last ten years, reported rates of SSI from individual surgeons or institutions following elective thoracic or lumbar spinal arthrodesis range from 1.9 to 4.4% [8–12]. The incidence of SSI is less following minimally invasive surgery. A recent systematic review showed a significant decrease in SSI rates after minimally invasive transforaminal interbody fusion (TLIF) compared to open TLIF (0.6% versus 4%) [13]. SSI is uncommon after anterior spinal arthrodesis and the risk of SSI is not greater after combined anterior/posterior arthrodesis than posterior arthrodesis alone [14], except in the case of staged anterior/posterior arthrodesis done under separate anaesthesia [8].

Koutsoumbelis et al. recently reviewed a consecutive series of 3,218 patients undergoing posterior lumbar instrumented arthrodesis [15]. They reported an overall incidence of SSI of 2.6%. Procedure-related risk factors identified by their study included: (1) the presence of greater than ten people in the operating room (OR), specifically cautioning against the presence of extraneous nurses; (2) longer duration of surgery; (3) greater intra-operative blood loss/the need for transfusion; and (4) the presence of an incidental durotomy. These findings are consistent with previous studies that have identified multilevel surgery, increased operative time, revision surgery, and an increased number of people in the OR as important risk factors [4, 8–10, 12, 16–19]. Incidental durotomy, however, has not been identified as a risk factor for SSI by previous studies [20]. To what extent the underlying mechanism by which incidental durotomy and an increased number of people in the OR increase the risk of SSI remains unclear. Both of these factors may be a proxy for longer and/or more complex surgical procedures or a direct effect related to a greater risk of contamination of the surgical field.

Patient risk factors

Commonly reported patient-related risk factors for SSI include: smoking, diabetes mellitus, alcohol abuse, obesity, malnutrition, advanced age, pre-operative hospitalization greater than one week and corticosteroid use [16, 21–29]. Koutsoumbelis et al. identified chronic obstructive pulmonary disease (COPD), coronary artery disease and osteoporosis as independent risk factors for SSI. However, the underlying mechanism by which these factors contribute to SSI remains unknown. Smoking and diabetes have been shown to predispose patients to infection by inducing tissue ischemia and microvascular damage [10, 12, 27, 28, 30]. The thick layer of adipose tissue in the obese patient creates a large potential space following surgical wound closure which has poor vascular perfusion and may become necrotic [10, 12, 16, 17, 24, 28]. Age is certainly a surrogate for the presence of other comorbidities and is associated with the phenomenon of immunosenescence—a waning and ineffective immune response. Together these factors indicate an inability of the host to heal the surgical wound and mount a sufficient inflammatory response to eradicate infectious organisms.

Surgery for trauma or neoplasm

Traumatic spine injury has a well-documented infection risk especially in patients with concomitant neurological injury with reported rates of up to 10% [14–31]. This results from a combination of patient- and procedure-related risk factors which is also seen in patients undergoing surgery for neoplasms, especially those due to metastasis. Trauma patients are likely to have a greater degree of soft tissue injury than elective patients, which contributes to tissue hypoxia. Additionally, trauma patients may have additional injuries to the viscera or appendicular skeleton. They are more likely to spend time in an intensive care unit, which may expose them to antibiotic-resistant bacteria. Trauma induces a catabolic state and trauma patients experience increased protein-calorie malnutrition. The same risks also apply in the setting of neoplasm with the additional risk of potential delayed healing and immunosuppresion from radiation to the surgical site or systemic chemotherapy.

Bacteriology

Staphylococcus aureus is the most common organism causing SSI [4, 17]. Recently, however, MRSA has become increasingly prevalent with 34% of SSIs demonstrating positive cultures in the series by Koutsoumbelis et al. Other reported causative organisms include *Staphylococcus epidermidis*, *Enterococcus faecalis*, *Pseudomonas* spp., *Enterobacter cloacae*, and *Proteus mirabilis*. Gram-negative bacteria are more common in trauma patients and may result from hematogenous spread in the setting of urosepsis in patients with a neurological injury [31].

Prevention of SSI

Meticulous adherence to aseptic technique is the single most important component of SSI prevention. The use of prophylactic antibiotic therapy has significantly decreased the rate of SSI after spinal surgery [32]. In a report by Transfeldt and Lonstein, the use of routine antibiotic prophylaxis lowered the SSI rate following elective spinal arthrodesis from 7% to 3.6% [33]. A first-generation cephalosporin such as cefazolin is routinely used because it quickly reaches peak serum concentrations and has good efficacy against common strains of *S. aureus* and *S. epidermidis*. Vancomycin alone can be used for patients with allergies to penicillin or cephalosporins. For patients who are thought to be high risk for colonization with MRSA we recommend the use of vancomycin and cefazolin due to the relatively low efficacy of vancomycin against non-methicillin-resistant strains of *Staphylococcus spp*. Recently, the addition of vancomycin powder to posterior cervical incisions prior to closure has been shown to decrease SSI [34]. The use of this technique in the lumbar spine has not been investigated.

Frequent release of retractors to prevent myonecrosis and debridement of any necrotic appearing muscle at the end of the procedure is recommended. It is routine practice at our institution to use antibiotic irrigation and closed-suction drains postoperatively in all patients undergoing multilevel decompression and/or posterior spinal arthrodesis. Neither of these interventions has been shown to provide a significant benefit although the investigations performed to date have been underpowered to detect a change in a rare event such as infection rate [35–37]. There is limited evidence to suggest that use of vertical laminar flow systems in the OR decreases the incidence of SSI [38].

Clinical presentation and diagnosis of SSI

The overall diagnosis of SSI must be made using clinical judgment and taking into account all available information. No single test or finding is sufficient to make the diagnosis. SSIs can be defined based on their anatomic relationship to the fascia (superficial or deep), whether the infection is limited to the disc and based on the timing with which they present (early, late and latent). The timing and location of the infection dictates the course of treatment. In the early postoperative period, the most common presenting complaint of infection is increasing pain at the surgical site. Objective findings on examination include peri-incisional erythema, tenderness to palpation, induration and drainage. Constitutional symptoms such as fever or chills are especially concerning. Rarely, in the case of severe infection, patients may present with hypotension, lethargy and confusion from sepsis which is an absolute indication for emergent irrigation and debridement. In the setting of a latent infection such as those occurring from *P. acnes*, patients may have only vague complaints of pain with evidence of pseudarthrosis or hardware loosening. Consequently, infection must always be entertained as a possibility in the setting of revision surgery.

Laboratory studies

White blood cell count is an unreliable indicator of infection. The acute phase reactants are more useful for diagnosing infection but must be interpreted with respect to the time since the index surgery. Erythrocyte sedimentation rate (ESR) can remain elevated for up to six weeks after surgery. C-reactive protein (CRP) levels normalize within two weeks. Consequently, CRP has been shown to be a more sensitive indicator of the presence of SSI [39]. Superficial cultures, whether from the skin or drainage, do not reliably assist with identification of the causative organism. Wound aspiration has been proposed by some authors as a way to detect early infections [40]. However, intra-operative tissue cultures remain the gold standard for identification of the causative organism in SSI.

Imaging

Plain radiographs of the spine are rarely useful for the diagnosis of early infection. In the setting of discitis there may be evidence of loss of disc height and end plate erosion. In latent infections lucencies may be present around orthopedic hardware. Magnetic resonance imaging (MRI) is the most useful study to diagnose SSI. Gadolinium enhancement improves the diagnostic accuracy of MRI and should be used whenever infection is suspected. Findings must be interpreted based on the timing since the index procedure and other potentially confounding conditions since tissue oedema from non-infectious causes may mimic the appearance of infection. Rim enhancing fluid collections, ascending epidural collections, evidence of bony destruction, and progressive marrow signal changes are all suggestive of infection.

Management of SSI

Postprocedure discitis

Postoperative discitis occurs infrequently with a reported incidence ranging from 0.2% to 2.75% [39, 41]. The presentation of postoperative discitis is frequently limited to low back pain, which is non-specific, and can lead to a delay in diagnosis. A history of increasing low back pain following surgery is especially concerning. The majority of cases of postoperative discitis can be treated with six weeks of IV antibiotics with acceptable long-term results—usually spontaneous fusion of the disc space [42–44]. The use of image-guided percutaneous aspiration of the disc to identify the causative pathogen and guide antibiotic therapy is recommended and has been shown to be very effective [45]. Bracing has been used for patient comfort. Indications for surgery include progression of the infection on MRI despite optimal antibiotic therapy, progression of the infection into the spinal canal causing severe pain or neurological deficits and progressive destruction of the vertebral bodies leading to deformity. In cases where surgery is indicated, single-stage anterior and posterior spinal debridement and fusion is an effective treatment [46–48]. Since the adult intervertebral disc is avascular, surgical discectomy should attempt to remove as much of the disc as possible to prevent recurrent infection.

Posterior spinal infections without instrumentation

Subfascial wound infections following spinal surgery can manifest with increasing pain and/or constitutional symptoms. The infection will usually demonstrate evidence of a fluid collection on MRI with or without the presence of vertebral osteomyelitis. Such infections rarely respond to antibiotic therapy alone. Surgical debridement with removal of all necrotic tissue with surgical closure over drains is the appropriate treatment. Multiple irrigation and debridements may be necessary in the setting of a particularly virulent organism or an immunocompromised host.

Posterior spinal infections with instrumentation

The use of posterior spinal instrumentation both increases the risk of SSI and creates additional challenges for the treatment of infection. The presentation of SSI in the setting of spinal instrumentation is similar to that for posterior infections without instrumentation, although the presence of spinal instrumentation may limit the utility of MRI except in those centres with specialized protocols for suppression of metal artifact. Meticulous surgical debridement of all devitalized tissue is essential along with irrigation using copious amounts of normal saline. Intra-operative tissue culture is essential to tailor antibiotic therapy prior to the administration of antibiotics. Close blood sugar control in diabetic patients and a nutrition consult in patients at risk for malnutrition are recommended. Spinal instrumentation should be maintained if possible to avoid the loss of correction of deformity or the creation of instability when possible. Non-essential spinal instrumentation such as loose pedicle screws should be removed. In general, both interbody and posterior segmental instrumentation can be left in place in the setting of early postoperative infections [4, 15, 49, 50]. Delayed wound closure with vacuum-dressings and repeat irrigation and debridement are frequently used at our institution with excellent results. However, infection increases the risk of developing a pseudarthorosis and these patients must be closely monitored with serial imaging studies [51]. In cases of late infection with a solid fusion, instrumentation can be removed at the time of surgical debridement to facilitate clearance of the infection [52].

Postoperative antibiotic management

It is standard practice at our institution to involve infectious disease specialists in the selection and serial monitoring of antibiotic therapy. Our preferred protocol for treatment of infection in the setting of implanted spinal instrumentation is based on previous institutional experience developing successful treatments for SSI following total joint replacement [53–55]. The antibiotic regimen is designed and monitored by an infectious disease specialist and based on the type of infectious organism and its drug sensitivity profile. Intravenous antibiotics are administered in doses sufficient to attain a trough serum bactericidal titre (SBT) of at least 1:2 [56]. The SBT reflects the level of bactericidal activity against the pathogen in the patient's serum at the trough between antibiotic doses. Such monitoring enhances the effectiveness of antibiotic therapy even in infections from resistant organisms. Intravenous antibiotic therapy is continued for at least six weeks postoperatively. In cases of resistant organisms such as MRSA, recent recommendations suggest extending intravenous antibiotic therapy for eight weeks total [57]. Following completion of intravenous antibiotic therapy, we routinely maintain patients on oral suppressive antibiotics tailored to the infectious organism. The decision regarding removal of instrumentation versus lifetime oral antibiotic suppression is based on the causative pathogen, patient health status and presence of a fusion mass.

Complex wound management

Necessary debridement of necrotic tissue following SSI may result in a significant soft tissue defect. Depending on the nature of the defect, treatment may consist of healing by secondary intention using a vacuum-dressing or definitive closure with a muscle flap. We recommend the placement of antibiotic impregnated methylmethacrylate cement beads for situations with soft tissue defects where multiple surgical debridements are expected. This allows for high local antibiotic concentrations despite poor tissue vascularity. Multiple debridements are usually necessary and we recommend involvement of a plastic surgeon early in this process to facilitate optimal wound management [58, 59].

Conclusion

In summary, SSI presents a difficult problem especially following instrumented spinal arthrodesis. Prevention of infection using a meticulous aseptic technique, prophylactic antibiotics and intra-operative irrigation is essential. In those patients who develop SSI, prompt diagnosis and treatment allow for optimization of patient outcomes. It is usually possible to clear an early infection while retaining spinal instrumentation, although instrumentation can be removed following fusion if necessary. In cases with complex soft tissue defects, we recommend involvement of a plastic surgeon for wound closure.

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