INTRODUCTION

Infection is one of the most common causes of morbidity in the acute phase following lumbar spine surgery. Wound infections of the spine can have devastating consequences on the outcome after procedures such as a simple discectomy or a multilevel decompression and instrumentation fusion. Once identified, rapid and definitive treatment offers the best hope for restoring the patient to the normal recovery process. Prevention is clearly better than treatment for this unfortunate complication, which continues to occur relatively frequently even in the presence of aseptic techniques and prophylactic antibiotic agents. As our surgery-related ability to manage more complex spinal disorders improves, the unfortunate potential for wound complications increases because these procedures often require prolonged operations and multisegmental internal fixation.

Post procedural infections rates vary with the type of surgery and the anatomical site. Potential infectious complications include superficial wound infections, deep wound infections, discitis, epidural abscess, meningitis, and osteomyelitis.

The incidence of surgical site infection after decompressive laminectomy and fusion is quoted to be 3% or even lower, but the incidence may increase to as high as 12% with the addition of instrumentation. Post procedural discitis is a rare after any invasive spinal procedure. The majority of patients are managed adequately with organism-specific antibiotics and spinal immobilization with good long-term outcomes (21).

CLASSIFICATION

Surgical site infections are commonly subclassified as superficial or deep. Superficial infections are limited to the skin and subdermal/subcutaneous layer without fascial involvement. Deep infections occur below the lumbodorsal fascia for a posterior lumbar wound or below the ligamentum nuchae and fascial layer for posterior cervical wounds. Anteriorly, deep infections occur below the anterior abdominal fascia or below the platysma layer for the lumbar and cervical wounds, respectively. Deep infections may also involve the disks or the spinal column resulting in discitis, osteomyelitis, or epidural abscess. These infections can further be classified into acute (within 3 weeks of the procedure) or chronic/delayed (>4 weeks after the procedure) (1).

RISK FACTORS

SURGERY RELATED

More extensive surgeries, and surgeries with longer operative times, are associated with an increased risk for postoperative infection. For example, the risk for infection after lumbar discectomy is less than 1%, but this rate increases to 1.5% to 2% with decompression (19,26,43). The rate of infection for noninstrumented fusions has been reported to
range from less than 1% up to 5%, whereas the rate with the addition of instrumentation increases to 1% to 12% (21). Along with instrumentation, a posterior approach has been shown to be a risk factor for postoperative infection (22, 29, 32, 44). In a retrospective study, Levi and colleagues found a 3.8% infection rate in posterior instrumentation cases but no infections in anterior instrumentation cases.

Type of bone graft used for fusion—irradiated allograft, nonirradiated allograft, or autograft was not found to be a significant risk factor for infection (27). In addition, cervical spine operations have been shown to have a decreased risk for infection compared with lumbar operations (odds ratio [OR], 0.3) (30). Anterior cervical spine procedures demonstrate an extremely low postoperative infection rate, about 0.1% (23). When an infection occurs, it should be assumed, until proved otherwise, that there has been an iatrogenic esophageal injury; appropriate consultation should be obtained, and a workup done (10).

Other surgical risk factors for infection include extended preoperative hospitalization, larger number of levels to be fused, extension of fusion to sacrum, prolonged surgery, tumor resection, high volume of operating personnel, staged procedure, and revision procedure (26,29,30,44) (Table). Excessive blood loss has repeatedly been found to elevate the infection risk; patients with an initial postoperative hemoglobin level of less than 8 g/dL are 6 times (OR, 6.37) as likely to develop a surgical site infection (32). In addition, more extensive surgical procedures are at higher risk for postoperative infection (32,2,3). Veeravagu and colleagues (42) confirmed this finding in a review of 24,775 patients. They noted a progressively higher infection risk the longer the operation, relative to under 3 hours: 3 to 6 hours (OR, 1.33) and more than 6 hours (OR, 1.40).

**PATIENT RELATED**

Patient-related factors, or preoperative comorbidities, significantly influence the likelihood of developing postoperative spinal infections. Poor preoperative nutritional status may be one of the strongest risk factors, as malnourished patients are more than 15 times more likely to acquire an infection after spinal procedures (20). Given this significant risk, if a patient is to undergo an elective major spine reconstruction, a thorough nutritional workup should be undertaken with correction of these deficits before proceeding. Staged spinal surgeries have been shown to have an additive risk for malnutrition (6). Perioperatively, patients who have undergone large spine reconstructions should have an in-hospital nutrition consultation with initiation of enteral feeding, if possible, and total parenteral nutrition if unable to tolerate enteral feeds. Similarly, other immunocompromised states predispose patients to more frequent and more severe postoperative infections (26). Alcohol abuse, IV drug use, steroid use, malignant processes, rheumatoid arthritis, smoking, and diabetes mellitus have all been reported as risk factors for postoperative spinal infection (25,32,44). Furthermore, the immunocompromised state related to diabetes predisposes patients to becoming infected with uncommon organisms (4,37). Because of this significantly increased infection risk in patients with diabetes, perioperative glucose control is crucial, as elevated serum glucose levels both before surgery (>125 mg/dL) and after surgery (>200 mg/dL) are independent risk factors (OR, 3.3) (30).

Other patient risk factors associated with infection are obesity, previous infection, older age, higher American Society of Anesthesiologists class, and postoperative incontinence (26,30,32,42,44). Similarly, prior spinal surgery or local radiation to the operative field may also compromise local wound healing (44). Other less important factors contributing to the risk for postoperative spinal infections are history of trauma and presence of a neurologic deficit (23,35). Complete neurologic injuries predispose patients to other sources of infection, such as urinary tract infections, pneumonia, and decubitus ulcers, which can hematogenously seed the surgical site (7).

**CLINICAL PRESENTATION**

Increased pain and tenderness to palpation around the surgical site are common clinical symptoms of a postoperative spinal infection. Although some discomfort from the incision and the muscle dissection is common, clinicians should become more concerned about infection if the discomfort intensifies or returns after a discomfort-free period. Patients may present with systemic complaints of fever, chills, or malaise, but not always. A retrospective review of 2391 spinal procedures found that fewer than one-third of the patients with a postoperative wound infection were febrile at presentation (43). Conversely, most fevers that occur after spine surgery have no identifiable infectious focus (45). Wound discharge and wound dehiscence, or erythema, were the most common presenting problems, each occurring more than 90% of the time (43) Although rare, neurologic deficits may be seen secondary to direct compression of neural elements.
It is important to consider that tight fascial closures may allow deep-seated infections to fester without any obvious superficial manifestations. As a result, treating physicians must not dismiss this diagnosis, because an incision does not exhibit any drainage, erythema, or other clinical signs of superficial infection. Unfortunately, after surgery, there is often a delay (mean, 15 days; range, 5-80 days) for a wound infection to declare itself, so any clinical evidence of a spinal infection warrants close monitoring or even presumptive management (43).

DIAGNOSIS

Laboratory Studies

Postoperatively patients frequently complain of discomfort associated with a posterior lumbar incision and muscle dissection. When this pain increases or occurs after a period of comfort, postoperative wound infection may have developed. Patients typically present initially with signs and symptoms of an infection after a mean of 15 days from the index procedure, and 93% present with wound drainage (43). In most, however, no fever is present. Wound inflammation is common, and rarely is the wound benign in appearance. Because there are no pathognomonic symptoms or signs, laboratory studies are useful in helping the clinician to establish the correct diagnosis. The mean Erythrocyte sedimentation rate in patients in one study was 71 mm/hour (43). When faced with abnormal values, one should have knowledge of the normal postoperative course of recovery of these indices. In a study of patients who underwent uncomplicated spinal surgery, none of whom developed a postprocedural infection, the postoperative values for CRP and erythrocyte sedimentation rate were quantified (41). The CRP level peaked at 2 to 3 days postoperatively and normalized between Days 5 and 14. The erythrocyte sedimentation rate peaked on Day 5 but declined at a much more variable rate than CRP, often staying elevated at 21 to 42 days postoperatively. These indices are considered sensitive but not specific. They can be elevated by an infection at any site, but when combined with an inflamed or draining lumbar wound within the appropriate time frame, elevation in the CRP or erythrocyte sedimentation rate can aid in the diagnosis by indicating the presence of a postoperative wound infection.

DIAGNOSTIC IMAGING MODALITIES

Plain radiography, CT scanning, and MR imaging are often of limited value in the diagnosis of a postoperative wound infection in the setting of internal fixation. Plain radiography can assist in determining the presence of indirect indicators of a spinal infection such as early implant loosening, rapid loss of adjacent-level disc space height, or abnormal soft-tissue swelling. Plain radiography will also detect the presence of a retained foreign body in the spinal wound. Both CT and MR imaging can demonstrate whether a fluid collection exists. Some authors have strongly supported the immediate use of contrast-enhanced MR imaging when an epidural abscess is suspected (28). However, it is not usually possible to differentiate between a postoperative fluid collection in the form of a sterile seroma and a postoperative abscess. Some authors have reported success with CT and MR imaging in distinguishing between blood, purulent material, and granulation tissue (38). Unfortunately, the presence of instrumentation-related metal artifact often makes these advanced modalities of little value. Gadolinium-enhanced MR imaging is of value in detecting an early-onset postoperative discitis even in cases in which posterior hardware has been placed. One should note, however, that following operative manipulation of the disc space, an increase in postcontrast MR imaging signal intensity or edema may not be indicative of a infection but in fact may be a normal postoperative finding (Figure 2). Because there is no optimal imaging modality for detecting a postoperative wound infection, these studies should be used to provide additional information when formulating a diagnosis of a postoperative spinal infection.

Computed tomography (CT) scans show areas of early bony destruction and soft tissue collections with better anatomical detail than plain radiographs. Similar to plain films, early changes include that of erosive and destructive changes at the endplates and disk space narrowing (Figure 3). The image quality and the level of detail may be compromised in the presence of instrumentation-related scatter/artifact, particularly if stainless steel implants were used. CT guidance can also be used to obtain a tissue biopsy of postoperative discitis/osteomyelitis or needle aspiration of pus from abscess cavities to provide a microbiological diagnosis. The specimens should be sent for Gram stain and cultures to identify the organism and its susceptibilities before starting antimicrobial therapy.

Microbiology

For a clinical infection to occur at the surgical site, bacteria must be present at the operative/procedural site in substantial quantity (>10⁵ organisms). Three possible
sources of bacteria are direct inoculation at the time of surgery (8), soiling of the incision in the fresh postoperative phase (24), or through hematogenous seeding (14). Most postprocedural infections are a consequence of direct inoculation and thus meticulous operative technique is paramount.

Review of the literature indicates a fairly consistent source for postoperative infection. The primary pathogens in acute infections are the gram-positive cocci, specifically Staphylococcus aureus, Staphylococcus epidermidis, and β-hemolytic Streptococci. S aureus is the most common organism cultured from acute postoperative infections (21). Klebsiella pneumoniae, Escherichia coli, Pseudomonas aeruginosa, and Proteus species are the common gram-negative isolates from post-operative wounds (1). Delayed or chronic infections are usually caused by skin flora of low
virulence such as Propionibacterium acnes (15) and diphtheroids (21). Patients who abuse intravenous drugs have a higher incidence of infections with gram-negative rods (21). Infections with nosocomial organisms are more common in patients with a protracted hospital course or ICU stay (44).

Prophylactic antibiotics have been clearly established as an effective adjunct to decrease the chance of a surgical site infection. Keller and Pappas (19) reported a dramatic decrease in infection rates from 2.7% to 0% with the use of preoperative prophylactic antibiotics. Infection rates after lumbar disectomies dropped from 9.3% to 1% with the use of preoperative antibiotics (16). Another study showed that infection rates were significantly lower (4.3%) in patients treated with preoperative antibiotics v/s those treated with placebo (12.7%) before undergoing clean lumbar surgery (11). A laboratory study by Guiboux et al (13) showed that postoperative disk space infection in a rabbit model was effectively prevented by a single preoperative dose of intravenous cefazolin or vancomycin given within 1 hour before surgery, and no benefit was rendered in giving postoperative doses. Most spine surgeons recommend administering a first-generation cephalosporin (or clindamycin/vancomycin in patients with penicillin allergy) within 1 hour before the surgery. Because antibiotic levels have been shown to decrease with operative time (39,33) some surgeons recommend redosing patients after 4 hours of operative time. However, clinical studies comparing a single preoperative dose to multiple intraoperative doses of antibiotics fail to show any statistical difference (11). Because antibiotic-resistant infections have become an increasingly prevalent problem; many hospitals have increased efforts to monitor emerging patterns of antibiotic resistance and to regulate the use and duration of antibiotics for prophylactic purposes. Methicillin-resistant S aureus (MRSA) is the most common resistant organism isolated. Studies have shown that infections caused by resistant organisms may be associated with increased morbidity, mortality, and costs. Some risk factors associated with MRSA infections include previous hospitalization, intensive care unit (ICU) stay, indwelling catheters, before prolonged antibiotic therapy, advanced age, and exposure to patients colonized or infected with MRSA (5).

**TREATMENT**

Medical management of a suspected superficial postoperative spinal infection may be considered in the absence of a palpable abscess or fluid collection on imaging studies (17). It cannot be emphasized enough that management of any wound infection with antibiotics alone requires extreme vigilance on the part of the treating clinician in order to rule out any disease progression or involvement of deeper tissues. Response to medical management may be monitored by assessing the superficial appearance of the incision and by following ESR, CRP, and other laboratory studies. Furthermore, it is imperative that the treating clinician ensures adequate nutritional supplementation in all patients with a suspected spinal infection.

The mainstay of managing postoperative spinal infections is open irrigation and debridement. If there is sufficient clinical suspicion for a wound infection, this surgical intervention should be performed immediately, on a presumptive basis, and should not be delayed for confirmatory laboratory or imaging studies. The debridement itself should be extensive, including exposure of superficial tissues and exposure beyond the fascial layer. Removal of all necrotic and devitalized tissue, both in superficial layers and deeper muscle layers, is imperative. Strategies for managing any instrumentation and residual bone graft present in the operative field remains a matter of some controversy. Many surgeons leave spinal instrumentation in place, as the stability afforded by internal fixation not only is essential for proper management of the underlying spinal pathology
but also facilitates fusion and resultant eradication of any infection. However, implant removal is preferable in cases of clearly loosened instrumentation or delayed infection with solid fusion. In addition, instrumentation removal may be considered when infection does not resolve after multiple debridements (21). In grossly infected wounds, cement beads impregnated with tobramycin or vancomycin, and placed on a suture or wire can be used to obtain much higher doses of local antibiotics without systemic side effects. These beads are typically left in for approximately 3 days and then removed with repeat debridement (9). Loose bone graft in the surgical site is usually removed, whereas any material that adheres to the surrounding bony structures is often left in place.

Many surgeons, having completed irrigation and debridement, close the wound primarily over drains. Before closure, the skin edges should be clean and viable. Emphasis should be placed on obtaining a tight, layered closure to minimize dead space. Alternatively, a grossly infected wound may be left open for serial irrigation and debridement, until there is no evidence of contamination and cultures are negative, at which point delayed wound closure may be performed. More recently, various suction/irrigation and vacuum-assisted closure (VAC) systems have been described; these systems may be of potential use in managing these infections (21,26,34,46). Spine wounds that do not heal, despite adequate infection eradication and nutritional status, may require flap coverage (31).

Broad-spectrum antibiotics are typically initiated after surgery. The regimen may be tailored to the results of the intraoperative wound cultures. Antibiotic therapy is routinely continued for at least 6 weeks, and any subsequent changes in medical management are based on the clinical response and laboratory profile of each patient.

Management of postoperative discitis often begins conservatively. Most patients with a suspected diagnosis of discitis respond favorably to spinal immobilization with orthosis in conjunction with organism-specific antibiotics. If discitis is suspected on the basis of laboratory studies or imaging findings, blood cultures should be obtained in an effort to identify a pathogen and guide antibiotic therapy (18). If repeated blood cultures are negative, and if the suspicion for discitis remains high, CT-guided needle biopsy should be considered as a guide to antibiotic treatment. If neither measure identifies a pathogen, broad-spectrum antibiotics should be used (36). The duration of antibiotic therapy varies, but a commonly administered course consists of 6 weeks of IV therapy, followed by 6 weeks of oral antibiotics. White blood cell, ESR, and CRP values should be used to monitor the clinical response of the patient, particularly a patient with negative blood cultures.

If there is clinical evidence that the infection is worsening, or if symptoms do not resolve after 6 weeks of antibiotic treatment, open surgical intervention should be considered. Surgical debridement usually involves removal of the disk and aggressive anterior debridement of necrotic tissue and bone. Reconstruction consists of anterior autograft fusion without instrumentation and posterior stabilization with instrumentation. Reconstruction has been described using a structural autograft, allograft, or titanium cage with or without anterior plate fixation, and posterior stabilization with instrumentation (25,40). In addition, BMP-2 has shown promise in assisting with fusion in infection cases (31). However, whether this is because of the inflammatory nature of BMP-2 or the decreased time to fusion is not clear. Minimally invasive techniques, such as percutaneous disk biopsy and debridement with possible fusion, have been described (12). These procedures have been associated with favorable outcomes, though they are associated with vascular complications in the thoracic spine and are technically more difficult (12).

Sagittal reformatted CT after anterior debridement and strut grafting for the patient with postoperative osteomyelitis. The patient later underwent a staged posterior fusion with instrumentation

CONCLUSIONS

Although postoperative spinal infections are relatively uncommon, a surgeon should maintain a high level of suspicion for their occurrence and should be vigilant to reduce their incidence. Risk factors such as diabetes and malnutrition should be identified and minimized before proceeding with surgery. Prophylactic systemic antibiotics should be administered within 1 hour of incision on the basis of the patient’s allergies. During the operation, surgeons should be cognizant of the duration of the procedure, frequent irrigation, and traffic in and out of the room, redosing antibiotics, and good fascial closure. A high level of vigilance should be maintained during the perioperative period with close inspection of the wound. There should be a low threshold for obtaining further imaging studies and necessary laboratory indices in patients with a questionable infection. In patients with a clear infection, early and aggressive debridement of
the wound, including skin, muscle fascia, and bone, should be undertaken. The hardware and bone graft are often left in place with a course of culture-directed antibiotics. Resolution of the infection is followed clinically, radiographically and with laboratory indices.

REFERENCES


Table 1: Reported Risk Factors for Postoperative Spinal Infections

<table>
<thead>
<tr>
<th>Surgery related</th>
<th>Patient related</th>
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<tbody>
<tr>
<td>Staged procedure</td>
<td>Advanced age (&gt;60 y)</td>
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<tr>
<td>Revision procedure</td>
<td>Higher American Society of Anesthesiologists class</td>
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<tr>
<td>Prolonged operative time</td>
<td>Obesity (higher body mass index)</td>
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<td>High volume of moving operating room personnel</td>
<td>Smoking</td>
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<td>Instrumentation</td>
<td>Immunosuppression</td>
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<td>Posterior approach</td>
<td>Diabetes</td>
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<td>Lumbar spine</td>
<td>Perioperative glucose control</td>
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<td>Tumor resection</td>
<td>Rheumatoid arthritis</td>
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<td>Excessive blood loss</td>
<td>Previous surgical infection</td>
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<td>Infection at remote sites</td>
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<td>Previous spine surgery</td>
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<td>Alcohol abuse</td>
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<td>Steroid therapy</td>
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<td>Poor nutritional status</td>
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<td>Acute spine injury (trauma)</td>
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<td></td>
<td>Postoperative incontinence</td>
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<td></td>
<td>Complete neurologic deficit</td>
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<td>Prolonged preoperative hospitalization</td>
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Postoperative Infections of the Spine


