

Postoperative Infections of the Spine

Jesse E. Bible, MD, MHS, Debdut Biswas, MD, MHS, and Clint J. Devin, MD

Abstract

The incidence of postoperative infections after spinal surgery ranges from less than 1% to 15%. This rate can vary based on several surgical- and patient-related risk factors, such as the type and duration of the procedure, nutritional status, immunosuppression, and comorbidities of the patient. Most surgeons routinely administer intravenous antibiotics prophylactically, and may employ other measures in an effort to prevent postoperative infection. Multiple diagnostic modalities, in conjunction with examination findings, should be utilized in the assessment of possible postoperative spinal infections. In particular, wound discharge or erythema, and an elevation in the erythrocyte sedimentation rate and C-reactive protein beyond expected postoperative values should raise a clinician's level of suspicion for an infection. The diagnosis of a postoperative spine infection can be difficult to confirm with diagnostic imaging, given findings are not all that different from normal postoperative changes. When suspected, the preferred treatment for a postoperative spinal infection is open irrigation and aggressive debridement of all necrotic tissue and bone, followed by antibiotic treatment based on culture sensitivity.

All surgical interventions carry the risk for postoperative wound infection. Surgical site infections account for the most common type of nosocomial infection that affects patients after surgery.^{1,2} Although relatively uncommon, infections can have a dramatic social and financial impact. Postoperative infections often require management with prolonged-use intravenous (IV) antibiotics or operative debridement, which translates into a longer hospital stay for the patient and increased cost for both

the patient and the health care system.³⁻⁶ Postoperative spine infections, specifically, can have devastating sequelae, including pseudarthrosis, hardware failure, potential neurologic compromise, and other medical problems.

In this review, we focus on the risk factors, clinical presentation, and diagnosis of postoperative spinal infections. We also address strategies for prevention and management options.

INCIDENCE AND RISK FACTORS

For spine surgery, the rate of postoperative infections has been reported to range from less than 1% up to 15%.⁷⁻²¹ All postoperative infections have a broad range of reported incidence, as the different surveillance methods used to follow patients can produce varying rates of infection. In addition, the type of procedure involved in the analyses dramatically affects the rate of infection.

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.^{9,14,22} The rate of infection for noninstrumented fusions has been reported to range from less than 1% up to 5%,^{14,22} whereas the rate with the addition of instrumentation increases to 1% to 7%.^{7,8,11,12,14,16,17} Along with instrumentation, a posterior approach has been shown to be a risk factor for postoperative infection.^{5,11,15,23} In a retrospective study, Levi and colleagues¹¹ 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.²⁴ In addition, cervical spine operations have been shown to have a decreased risk for infection compared with lumbar operations (odds ratio [OR], 0.3).²⁰ Anterior cervical spine procedures demonstrate an extremely low postoperative infection rate, about 0.1%.²⁰ 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.²⁵

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.^{5,15,18-20,22,26-29} (Table). Excessive blood loss has repeatedly been found to elevate the infection risk; patients with an initial postoperative hemoglobin level

Dr. Bible is Orthopaedic Surgery Resident, Vanderbilt Orthopaedic Institute, Vanderbilt University School of Medicine, Nashville, Tennessee.

Dr. Biswas is Orthopaedic Surgery Resident, Department of Orthopedic Surgery, Rush University Medical Center, Chicago, Illinois.

Dr. Devin is Chief and Division Director, Vanderbilt Spine Center, and Assistant Professor of Orthopaedics and Rehabilitation, Vanderbilt Orthopaedic Institute, Vanderbilt University School of Medicine.

Address correspondence to: Jesse E. Bible, MD, MHS, Vanderbilt Orthopaedic Institute, Vanderbilt University School of Medicine, Medical Center East, South Tower, Suite 4200, Nashville, TN 37232-8774 (tel, 615-479-6034; fax, 615-936-0017; e-mail, jesse.bible@vanderbilt.edu).

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Figure 1. Disk and epidural abscess after discogram in 56-year-old patient.

of less than 8 g/dL are 6 times (OR, 6.37) as likely to develop a surgical site infection.^{23,30} In addition, more extensive surgical procedures are at higher risk for postoperative infection.^{23,31,32} Veeravagu and colleagues¹⁹ 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 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.³³ 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.^{34,35} 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.^{33,36} Similarly, other immunocompromised states predispose patients to more frequent and more severe postoperative infections.^{22,37} 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.^{15,22,23,26,38,39} Furthermore, the immunocompromised state related to diabetes predisposes patients to becoming infected with uncommon organisms.⁴⁰⁻⁴³ 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).²⁰

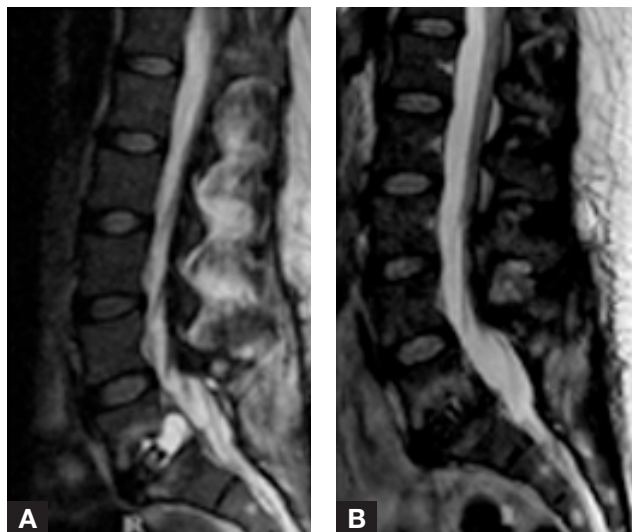


Figure 2. (A) Magnetic resonance imaging shows osteolysis, of concern for possible infection, in patient 6 weeks after transforaminal lumbar interbody fusion with bone morphogenetic protein 2. (B) By 4 months after surgery, osteolysis had resolved with resultant fusion.

Other patient risk factors associated with infection are obesity, previous infection, older age, higher American Society of Anesthesiologists class, and postoperative incontinence.^{5,15,18,19,22,23,26,28,39,44} Similarly, prior spinal surgery or local radiation to the operative field may also compromise local wound healing.¹⁵ Other less important factors contributing to the risk for postoperative spinal infections are history of trauma and presence of a neurologic deficit.^{45,46} 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.⁴⁷

MICROBIOLOGY

Experience reported elsewhere indicates that *Staphylococcus aureus* is the most common pathogen cultured from postoperative spinal infections, followed by *Staphylococcus epidermidis*.^{14,15} Most infections involve only *S aureus*, though infections with Gram-negative organisms in conjunction with Gram-positive organisms do occur at less frequent rates.^{14,15,21}

PROPHYLACTIC MEASURES

Antibiotics

Most surgeons routinely administer prophylactic antibiotics in patients undergoing spinal surgery, though the evidence supporting this practice is somewhat limited. Others have argued that prophylactic antibiotic therapy is unwarranted in certain spinal procedures and that unnecessary use of antibiotics may expedite the emergence of antibiotic-resistant bacteria strains.

Several reports have supported use of prophylactic antibiotics by demonstrating decreased rates of infection



Figure 3. Deep infection (A) was removed during debridement (B–D) in 49-year-old patient.

in patients undergoing neurosurgical procedures, including spinal operations. Malis and Savitz have repeatedly advocated use of prophylactic antibiotics during neurosurgical cases.⁴⁸⁻⁵¹ In a retrospective review, Horwitz and Curtin⁵² reported decreased rates of infection in patients receiving antibiotics compared with patients not receiving antibiotics before lumbar laminectomy.

Barker⁵³ reported a meta-analysis of 6 prospective randomized clinical trials of prophylactic antibiotic therapy during spine surgery. Although no individual trial demonstrated a statistically significant effect of prophylactic antibiotic therapy on infection rates, the pooled analysis showed an OR of 0.37 ($P < .001$), indicating efficacy for antibiotic prophylaxis. One of these studies, by Rubinstein and colleagues,⁵⁴ was the only randomized clinical trial focused exclusively on spinal surgery. The authors found a reduced rate of infection after “laminectomy or discectomy” in patients who received a single dose of cefazolin (4.3%) versus placebo (12.7%). Although the difference was not statistically significant, the study likely was not sufficiently powered, and significance likely would be reached with a larger study population.

First- or second-generation cephalosporins (eg, cefazolin, cefuroxime) are the antibiotics of choice, as they provide adequate coverage of Gram-positive organisms, including *S aureus* and *S epidermidis*, 2 of the most common causative agents. Patients colonized or infected with methicillin-resistant *S aureus* (MRSA) and patients with cephalosporin allergy should receive a combination of vancomycin and gentamycin. The addition of gentamycin not only increases bactericidal potential but specifically provides penetration to the disk, helping to prevent discitis.³¹ Patients who are at low risk for MRSA and are scheduled for high-risk procedures may benefit from MRSA screening in the preoperative period.

A single parenteral dose of antibiotics should be given during induction of anesthesia, approximately 30 minutes to 60 minutes before time of incision, to allow for adequate tissue penetration. For prolonged surgical

procedures, intraoperative doses of antibiotics (50% of the initial dose) should be administered at intervals 1 to 2 times the half-life of the medication: every 4 hours for cephalosporins and every 8 hours for vancomycin and gentamycin. These antibiotics should be used judiciously, particularly in patients with renal impairment. Continuing prophylactic antibiotics for an extended period after surgery is not recommended. Takahashi and colleagues⁵⁵ reported an inverse relationship with duration of postoperative antibiotics and infection incidence. Their findings also emphasize the importance of administering antibiotics before, or at time of, anesthesia. Compared with patients who received perioperative antibiotics, patients who received antibiotics only after surgery had the highest rate of infection, even though they received antibiotics over the longest period (7 days). Although many surgeons prefer to extend the duration of antibiotic use to “cover” wound drains or lines, this practice is not supported by any class I or II evidence and increases the risk for secondary infections with antibiotic-resistant organisms.

The recommendations for antibiotic prophylaxis for prevention of discitis are less established. No prospective randomized clinical trials have evaluated the efficacy of prophylactic antibiotics in patients at risk for developing discitis. The only requirement for antibiotic choice is in vitro coverage against staphylococci. Several pharmacokinetic studies have suggested that β -lactams have poor penetration into the disk space, whereas other antibiotics (aminoglycosides, clindamycin) achieve therapeutic concentrations in the disk space.⁵⁶⁻⁶¹ Surgeons may still use β -lactams based on their own positive outcomes but should administer such medications at maximal dosages. They may also use antibiotics that have been found to penetrate the disk space (gentamycin, clindamycin), despite the lack of clinical studies advocating their use.³¹

Irrigation and Drainage Systems

Despite advances in aseptic technique and innovations in airflow systems, operating theater contamination of a sur-

Table. Reported Risk Factors for Postoperative Spinal Infections**Surgery related**

Staged procedure
Revision procedure
Prolonged operative time
High volume of moving operating room personnel
Instrumentation
Posterior approach
Lumbar spine
Tumor resection
Excessive blood loss

Patient related

Advanced age (>60 y)
Higher American Society of Anesthesiologists class
Obesity (higher body mass index)
Smoking
Immunosuppression
Diabetes
Perioperative glucose control
Rheumatoid arthritis
Previous surgical infection
Infection at remote sites
Previous spine surgery
Alcohol abuse
Steroid therapy
Poor nutritional status
Acute spine injury (trauma)
Postoperative incontinence
Complete neurologic deficit
Prolonged preoperative hospitalization

gical wound remains a concern in all surgical procedures. In spine surgery, extensive and prolonged exposure of the posterior spinal structures places these procedures at increased risk for surgical site infection. Several surgeons use irrigation solutions and wound drainage systems in an effort to minimize the risk for infection.

In a randomized controlled trial, researchers compared the efficacy of prophylactic antibiotics versus wound irrigation with povidone-iodine in patients who underwent lumbar disk surgery.⁶² Povidone-iodine irrigation had a statistically significant benefit in terms of reduced incidence of postoperative surgical site infection. However, the study did not control for physical cleansing of wounds. Saline lavage has been reported to reduce the number of colony-forming units in wounds by approximately 30%.⁶³ Some authors have suggested wounds are effectively decontaminated after irrigation with dilute (40 ppm) aqueous elemental iodine.³¹ The effect that even this small amount of iodine has on tissues remains unclear. In vitro and animal studies have well described the inhibitory effects of iodine on osteoblasts and fibroblasts, while a prospective study of 244 cases found no significant difference in fusion rates and wound healing between iodine and saline irrigation.⁶⁴⁻⁶⁶

Several authors have evaluated the efficacy of antibiotic-containing saline solutions in the prevention of surgical site infections. Malis⁴⁸ reported on irrigation with saline that contained streptomycin and use of prophylactic IV vancomycin and gentamicin, and Savitz and colleagues⁶³ described irrigation with polymyxin

and bacitracin and prophylactic IV cefazolin. Both studies reported no postoperative infections, though the relative contribution of irrigation is difficult to ascertain, as both studies used prophylactic IV antibiotics.

The literature suggests that regular, frequent saline irrigation may have efficacy in preventing wound infection in spinal procedures, which require prolonged, extensive exposure. Surgeons may supplement irrigation solutions with iodine. Adding antibiotics to the irrigation solution, though common practice for many surgeons, lacks extensive support in the literature.³¹ However, preclinical animal studies have yielded promising results for reducing postoperative infections with use of intraoperative implantation with antibiotic microspheres or with injection of antibiotic directly into the tissue.^{36,67} In the only human study of prophylactic local antibiotics, adding vancomycin powder to standard systemic prophylaxis in elective spine surgery reduced infection rates from 2.6% to 0.2%.⁶⁸

Surgeons may place a closed-wound suction drain (Jackson-Pratt) in an effort to reduce the incidence of hematoma or infection at the surgical site, though this practice has minimal support in the literature. Payne and colleagues⁶⁹ reported that presence or absence of such a drain did not affect the postoperative infection rate, or the incidence of hematoma in patients who underwent single-level laminectomy. Brown and Brookfield⁷⁰ reported on use of closed-wound suction after multilevel decompression, decompression and fusion with and without instrumentation, and reoperation decompression in the lumbar spine. In their randomized study, they reported no infections or epidural hematomas in patients who did or did not receive drains. Although these studies suggest it may be reasonable to minimize drain use, the decision to use a closed-wound suction drain is at the surgeon's discretion.

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.¹⁴ Conversely, most fevers that occur after spine surgery have no identifiable infectious focus.⁷¹ Wound discharge and wound dehiscence, or erythema, were the most common presenting problems, each occurring more than 90% of the time.¹⁴ 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 simply because an incision does not exhibit any drainage, erythema, or other clinical signs of a 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.¹⁴

DIAGNOSTIC STUDIES

Laboratory Studies

Given the inconsistency in presenting signs and symptoms of postoperative spinal infections, laboratory studies may be extremely helpful in establishing the diagnosis. White blood cell counts may be elevated or within the normal range in cases of spinal infections. Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) level are both sensitive markers of infection, with CRP thought to be more specific.⁴⁰ These laboratory indicators are normally elevated after spinal procedures. ESR, on average, peaks 5 days after surgery and takes a slow, increasing course before normalizing.⁷² It often remains elevated longer than 21 days to 42 days after surgery. Along with taking a more predictable course, CRP increases more rapidly, peaking 2 days to 3 days after surgery, and normalizes sooner, within 5 days to 14 days.⁷³ Thus, these laboratory studies must be interpreted in light of the normal alterations known to accompany any type of surgical intervention. In any patient with a potentially infected wound, obtaining a baseline laboratory profile may provide additional information supporting this diagnosis. As these values would be expected to gradually return to normal in an unaffected individual over time, an upward trend or second rise should raise the level of suspicion for an untreated spinal infection.

Imaging

Plain radiographs of the operated spinal segments should be considered in any patient returning with symptoms suggestive of postoperative infection in order to rule out underlying abnormalities that might alternatively account for the clinical presentation. These abnormalities include early implant loosening, abnormal soft-tissue swelling, and retained foreign body. Other, more subtle radiographic findings are disk space narrowing and blurring of adjacent endplates after only 2 weeks of infection.⁷⁴ This occurs as proteolytic enzyme-producing pathogens, such as *S aureus*, spread into the disk and adjacent-vertebra endplates.⁷⁵

In the absence of radiographic findings, cross-sectional imaging, such as computed tomography (CT) and magnetic resonance imaging (MRI), may be indicated. CT provides excellent visualization of possible bony involvement but is inferior to MRI in evaluating infection in its early stages.⁷⁶ MRI becomes especially

helpful in assessing the spinal canal, including epidural abscesses (Figure 1). The T₁-weighted signal of epidural fat and connective tissue is commonly decreased, while T₂-weighted images are hyperintense. T₁-gadolinium sequences can illustrate the peripheral enhancement of an epidural mass.^{77,78} For discitis, decreased bony signal on T₁-weighted images and increased bony signal on T₂-weighted images can be seen. In addition, there can be gadolinium enhancement of vertebral endplates and disk space, with sensitivity and specificity over 90%.⁷⁹⁻⁸²

Even with these advanced imaging modalities, the diagnosis of a wound infection can be difficult to confirm, as deep perispinal fluid collections may not be able to be differentiated from normal postoperative changes. After surgery, there is some increased T₂-weighted signal and contrast uptake at the surgical site, and some non-specific peripheral contrast enhancement may also be seen. Artifact from instrumentation can further complicate visualization of the surrounding structures. There is an interesting new radiographic finding with use of bone morphogenetic protein 2 (BMP-2), a very powerful inflammatory agent that can cause osteolysis of the vertebral body, which is usually self-resolving (Figure 2). BMP-2 can appear as discitis or osteomyelitis of the vertebral body on imaging studies.⁸³ It can be differentiated from true infection in that infectious indices are often normal.

Cultures

Isolation of the infectious organism is paramount for accurate and appropriate management of the infection. Superficial wound cultures are usually not necessary and are of limited use in the postoperative patient population because they are at significant risk for contamination. Blood cultures should always be drawn when a systemic infection is suspected. If the etiology remains unclear or improvement is not seen, a needle biopsy of the affected area may be a reasonable option to access deep fluid loculations that cannot be differentiated from postoperative hematomas. Intraoperative cultures demonstrate the highest sensitivity and specificity for confirming presence of an active wound infection and identifying the pathogen involved. For this reason, in cases of operative intervention, a comprehensive set of wound cultures should be obtained at time of surgery.

MANAGEMENT

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.⁸⁴ 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 labora-

tory 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 debridements¹¹ (Figure 3). 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.⁸⁵ 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.^{11,22,86-88} Spine wounds that do not heal, despite adequate infection irradiation and nutritional status, may require flap coverage.⁸⁹

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.⁹⁰ 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.⁹¹ 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.⁹²⁻⁹⁴ In addition, BMP-2 has shown promise in assisting with fusion in infection cases.^{95,96} 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.^{97,98} These procedures have been associated with favorable outcomes, though they are associated with vascular complications in the thoracic spine and are technically more difficult.^{97,98}

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, 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.

AUTHORS' DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

REFERENCES

- Gaynes RP, Culver DH, Horan TC, Edwards JR, Richards C, Tolson JS. Surgical site infection (SSI) rates in the United States, 1992–1998: the National Nosocomial Infections Surveillance System basic SSI risk index. *Clin Infect Dis*. 2001;33(suppl 2):S69–S77.
- Horan TC, Culver DH, Gaynes RP, Jarvis WR, Edwards JR, Reid CR. Nosocomial infections in surgical patients in the United States, January 1986–June 1992. National Nosocomial Infections Surveillance (NNIS) System. *Infect Control Hosp Epidemiol*. 1993;14(2):73–80.
- Calderone RR, Garland DE, Capen DA, Oster H. Cost of medical care for postoperative spinal infections. *Orthop Clin North Am*. 1996;27(1):171–182.
- Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. *Infect Control Hosp Epidemiol*. 1999;20(11):725–730.
- Olsen MA, Mayfield J, Laurysen C, et al. Risk factors for surgical site infection in spinal surgery. *J Neurosurg*. 2003;98(2 suppl):149–155.
- Jarvis WR. Selected aspects of the socioeconomic impact of nosocomial infections: morbidity, mortality, cost, and prevention. *Infect Control Hosp Epidemiol*. 1996;17(8):552–557.
- Abbey DM, Turner DM, Warson JS, Wirt TC, Scalley RD. Treatment of postoperative wound infections following spinal fusion with instrumentation. *J Spinal Disord*. 1995;8(4):278–283.
- Glassman SD, Dimar JR, Puno RM, Johnson JR. Salvage of instrumental lumbar fusions complicated by surgical wound infection. *Spine*. 1996;21(18):2163–2169.
- Keller RB, Pappas AM. Infection after spinal fusion using internal fixation instrumentation. *Orthop Clin North Am*. 1972;3(1):99–111.
- Kostiuk JP, Israel J, Hall JE. Scoliosis surgery in adults. *Clin Orthop*. 1973;(93):225–234.
- Levi AD, Dickman CA, Sonntag VA. Management of postoperative infections after spinal instrumentation. *J Neurosurg*. 1997;86(6):975–980.
- Lonstein J, Winter R, Moe J, Gaines D. Wound infection with Harrington instrumentation and spine fusion for scoliosis. *Clin Orthop*. 1973;(96):222–233.
- Roberts FJ, Walsh A, Wing P, Dvorak M, Schweigel J. The influence of surveillance methods on surgical wound infection rates in a tertiary care spinal surgery service. *Spine*. 1998;23(3):366–370.
- Weinstein MA, McCabe JP, Cammisia FP Jr. Postoperative spinal wound infection: a review of 2,391 consecutive index procedures. *J Spinal Disord*. 2000;13(5):422–426.
- Wimmer C, Gluch H, Franzreb M, Ogon M. Predisposing factors for infection in spine surgery: a survey of 850 spinal procedures. *J Spinal Disord*. 1998;11(2):124–128.
- Hodges SD, Humphreys SC, Eck JC, Covington LA, Kurzynske NG. Low postoperative infection rates with instrumented lumbar fusion. *South Med J*. 1998;91(12):1132–1136.
- Picada R, Winter RB, Lonstein JE, et al. Postoperative deep wound infection in adults after posterior lumbosacral spine fusion with instrumentation: incidence and management. *J Spinal Disord*. 2000;13(1):42–45.
- Tenney JH, Vlahov D, Salcman M, Ducker TB. Wide variation in risk of wound infection following clean neurosurgery. Implications for perioperative antibiotic prophylaxis. *J Neurosurg*. 1985;62(2):243–247.
- Veeravagu A, Patil CG, Lad SP, Boakye M. Risk factors for postoperative spinal wound infections after spinal decompression and fusion surgeries. *Spine (Phila Pa 1976)*. 2009;34(17):1869–1872.
- Olsen MA, Nepple JJ, Riew KD, et al. Risk factors for surgical site infection following orthopaedic spinal operations. *J Bone Joint Surg Am*. 2008;90(1):62–69.
- Collins I, Wilson-MacDonald J, Chami G, et al. The diagnosis and management of infection following instrumented spinal fusion. *Eur Spine J*. 2008;17(3):445–450.
- Massie JB, Heller JG, Aitbol JJ, McPherson D, Garfin SR. Postoperative posterior spinal wound infections. *Clin Orthop*. 1992;(284):99–108.
- Pull ter Gunne AF, Cohen DB. Incidence, prevalence, and analysis of risk factors for surgical site infection following adult spinal surgery. *Spine (Phila Pa 1976)*. 2009;34(13):1422–1428.
- Mikhael MM, Huddleston PM, Nassr A. Postoperative culture positive surgical site infections after the use of irradiated allograft, nonirradiated allograft, or autograft for spinal fusion. *Spine (Phila Pa 1976)*. 2009;34(22):2466–2468.
- Fountas KN, Kapsalaki EZ, Nikolakakos LG, et al. Anterior cervical discectomy and fusion associated complications. *Spine (Phila Pa 1976)*. 2007;32(21):2310–2317.
- Fang A, Hu SS, Endres N, Bradford DS. Risk factors for infection after spinal surgery. *Spine*. 2005;30(12):1460–1465.
- Perry JW, Montgomerie JZ, Swank S, Gilmore DS, Maeder K. Wound infections following spinal fusion with posterior segmental spinal instrumentation. *Clin Infect Dis*. 1997;24(4):558–561.
- McPhee IB, Williams RP, Swanson CE. Factors influencing wound healing after surgery for metastatic disease of the spine. *Spine*. 1998;23(6):726–732.
- Schwender JD, Casnellie MT, Perra JH, et al. Perioperative complications in revision anterior lumbar spine surgery: incidence and risk factors. *Spine (Phila Pa 1976)*. 2009;34(1):87–90.
- Pull ter Gunne AF, Skolasky RL, Ross H, van Laarhoven CJ, Cohen DB. Influence of perioperative resuscitation status on postoperative spine surgery complications. *Spine J*. 2010;10(2):129–135.
- Brown EM, Pople IK, de Louvois J, et al; British Society for Antimicrobial Chemotherapy Working Party on Neurosurgical Infections. Spine update: prevention of postoperative infection in patients undergoing spinal surgery. *Spine*. 2004;29(8):938–945.
- Boston KM, Baraniuk S, O'Heron S, Murray KO. Risk factors for spinal surgical site infection, Houston, Texas. *Infect Control Hosp Epidemiol*. 2009;30(9):884–889.
- Klein JD, Hey LA, Yu CS, et al. Perioperative nutrition and postoperative complications in patients undergoing spinal surgery. *Spine*. 1996;21(22):2676–2682.
- Dick J, Boachie-Adjei O, Wilson M. One-stage versus two-stage anterior and posterior spinal reconstruction in adults. Comparison of outcomes including nutritional status, complications rates, hospital costs, and other factors. *Spine*. 1992;17(8 suppl):S310–S316.
- Mandelbaum BR, Tolo VT, McAfee PC, Burest P. Nutritional deficiencies after staged anterior and posterior spinal reconstructive surgery. *Clin Orthop*. 1988;(234):5–11.
- Hu SS, Fontaine F, Kelly B, Bradford DS. Nutritional depletion in staged spinal reconstructive surgery. The effect of total parenteral nutrition. *Spine (Phila Pa 1976)*. 1998;23(12):1401–1405.
- Cunningham ME, Girardi F, Papadopoulos EC, Cammisia FP. Spinal infections in patients with compromised immune systems. *Clin Orthop*. 2006;(444):73–82.
- Simpson JM, Silveri CP, Balderston RA, Simeone FA, An HS. The results of operations on the lumbar spine in patients who have diabetes mellitus. *J Bone Joint Surg Am*. 1993;75(12):1823–1829.
- Capen DA, Calderone RR, Green A. Perioperative risk factors for wound infections after lower back fusions. *Orthop Clin North Am*. 1996;27(1):83–86.
- Carragee EJ. Pyogenic vertebral osteomyelitis. *J Bone Joint Surg Am*. 1997;79(6):874–880.
- Gupta RK, Khan ZU, Nampoory MR, Mikhail MM, Johny KV. Cutaneous cryptococcosis in a diabetic renal transplant recipient. *J Med Microbiol*. 2004;53(pt 5):445–449.
- Khurram IM, Khan SA, Khwaja AA, et al. Risk factors for clinical infection in patients colonized with methicillin resistant *Staphylococcus aureus* (MRSA). *J Pak Med Assoc*. 2004;54(8):408–412.
- Simionescu R, Grover S, Shekar R, West BC. Necrotizing fasciitis caused by *Erysipelothrix rhusiopathiae*. *South Med J*. 2003;96(9):937–939.
- Andreshak TG, An HS, Hall J, Stein B. Lumbar spine surgery in the obese patient. *J Spinal Disord*. 1997;10(5):376–379.
- Lim MR, Lee JY, Vaccaro AR. Surgical infections in the traumatized spine. *Clin Orthop*. 2006;(444):114–119.
- Rechtine GR, Bono PL, Cahill D, Bolesta MJ, Chrin AM. Postoperative wound infection after instrumentation of thoracic and lumbar fractures. *J Orthop Trauma*. 2001;15(8):566–569.
- Dryden DM, Saunders LD, Rowe BH, et al. Utilization of health services following spinal cord injury: a 6-year follow-up study. *Spinal Cord*. 2004;42(9):513–525.
- Malis LI. Prevention of neurosurgical infection by intraoperative antibiotics. *Neurosurgery*. 1979;5(3):339–343.

49. Savitz MH, Malis LI. Prophylactic clindamycin for neurosurgical patients. *N Y State J Med*. 1976;76(1):64-67.
50. Savitz MH, Malis LI, Savitz SI. Efficacy of prophylactic antibiotic therapy in spinal surgery: a meta-analysis. *Neurosurgery*. 2003;53(1):243-244.
51. Savitz MH, Katz SS. Rationale for prophylactic antibiotics and neurosurgery. *Neurosurgery*. 1981;9(2):142-144.
52. Horwitz NH, Curtin JA. Prophylactic antibiotics and wound infections following laminectomy for lumbar disc herniation. *J Neurosurg*. 1975;43(6):727-731.
53. Barker FG II. Efficacy of prophylactic antibiotic therapy in spinal surgery: a meta-analysis. *Neurosurgery*. 2002;51(2):391-400.
54. Rubinstein E, Findler G, Amit P, Shaked I. Perioperative prophylactic cephalosporin in spinal surgery. A double-blind placebo-controlled trial. *J Bone Joint Surg Br*. 1994;76(1):99-102.
55. Takahashi H, Wada A, Iida Y, et al. Antimicrobial prophylaxis for spinal surgery. *J Orthop Sci*. 2009;14(1):40-44.
56. Fraser RD, Osti OL, Vernon-Roberts B. Iatrogenic discitis: the role of intravenous antibiotics in prevention and treatment. An experimental study. *Spine*. 1989;14(9):1025-1032.
57. Gibson MJ, Karpinski MR, Slack RC, Cowlishaw WA, Webb JK. The penetration of antibiotics into the normal intervertebral disc. *J Bone Joint Surg Br*. 1987;69(5):784-786.
58. Lang R, Folman Y, Ravid M, Bental T, Gepstein R. Penetration of ceftriaxone into the intervertebral disc. *J Bone Joint Surg Am*. 1994;76(5):689-691.
59. Rhoten RL, Murphy MA, Kafas IH, Hahn JF, Washington JA. Antibiotic penetration into cervical discs. *Neurosurgery*. 1995;37(3):418-421.
60. Riley LH III, Banovac K, Martinez OV, Eismont FJ. Tissue distribution of antibiotics in the intervertebral disc. *Spine*. 1994;19(23):2619-2625.
61. Tai CC, Want S, Quraishi NA, Batten J, Kalra M, Hughes SP. Antibiotic prophylaxis in surgery of the intervertebral disc. A comparison between gentamicin and cefuroxime. *J Bone Joint Surg Br*. 2002;84(7):1036-1039.
62. Strohecker J, Piotrowski WP, Lametschwandtner A. The intra-operative application of povidone-iodine in neurosurgery. *J Hosp Infect*. 1985;6(suppl A):123-125.
63. Savitz SI, Savitz MH, Goldstein HB, Mouracade CT, Malangone S. Topical irrigation with polymyxin and bacitracin for spinal surgery. *Surg Neurol*. 1998;50(3):208-212.
64. Chang FY, Chang MC, Wang ST, Yu WK, Liu CL, Chen TH. Can povidone-iodine solution be used safely in a spinal surgery? *Eur Spine J*. 2006;15(6):1005-1014.
65. Kaysinger KK, Nicholson NC, Ramp WK, Kellam JF. Toxic effects of wound irrigation solutions on cultured tibiae and osteoblasts. *J Orthop Trauma*. 1995;9(4):303-311.
66. Lineaweaver W, Howard R, Soucy D, et al. Topical antimicrobial toxicity. *Arch Surg*. 1985;120(3):267-270.
67. Stall AC, Becker E, Ludwig SC, Gelb D, Poelstra KA. Reduction of postoperative spinal implant infection using gentamicin microspheres. *Spine (Phila Pa 1976)*. 2009;34(5):479-483.
68. Sweet FA, Roh M, Silva C. Intra-wound application of vancomycin for prophylaxis in instrumented thoracolumbar fusions: efficacy, drug levels, and patient outcomes. *Spine (Phila Pa 1976)*. 2011 Feb 7. [Epub ahead of print]
69. Payne DH, Fischgrund JS, Herkowitz HN, Barry RL, Kurz LT, Montgomery DM. Efficacy of closed wound suction drainage after single-level lumbar laminectomy. *J Spinal Disord*. 1996;9(5):401-403.
70. Brown MD, Brookfield KF. A randomized study of closed wound suction drainage for extensive lumbar spine surgery. *Spine*. 2004;29(10):1066-1068.
71. Walid MS, Woodall MN, Nutter JP, Aijan M, Robinson JS Jr. Causes and risk factors for postoperative fever in spine surgery patients. *South Med J*. 2009;102(3):283-286.
72. Thelander U, Larsson S. Quantitation of C-reactive protein levels and erythrocyte sedimentation rate after spinal surgery. *Spine*. 1992;17(4):400-404.
73. Mok JM, Pekmezci M, Piper SL, et al. Use of C-reactive protein after spinal surgery: comparison with erythrocyte sedimentation rate as predictor of early postoperative infectious complications. *Spine (Phila Pa 1976)*. 2008;33(4):415-421.
74. Sapico FL, Montgomerie JZ. Vertebral osteomyelitis. *Infect Dis Clin North Am*. 1990;4(3):539-550.
75. Varma R, Lander P, Assaf A. Imaging of pyogenic infectious spondylodiscitis. *Radiol Clin North Am*. 2001;39(2):203-213.
76. Modic MT, Feiglin DH, Piraino DW, et al. Vertebral osteomyelitis: assessment using MR. *Radiology*. 1985;157(1):157-166.
77. Rigamonti D, Liem L, Sampath P, et al. Spinal epidural abscess: contemporary trends in etiology, evaluation, and management. *Surg Neurol*. 1999;52(2):189-196.
78. Sampath P, Rigamonti D. Spinal epidural abscess: a review of epidemiology, diagnosis, and treatment. *J Spinal Disord*. 1999;12(2):89-93.
79. Grane P, Josephsson A, Seferlis A, Tullberg T. Septic and aseptic post-operative discitis in the lumbar spine—evaluation by MR imaging. *Acta Radiol*. 1998;39(2):108-115.
80. Maiuri F, Iaconetta G, Gallicchio B, Manto A, Briganti F. Spondylodiscitis. Clinical and magnetic resonance diagnosis. *Spine (Phila Pa 1976)*. 1999;22(15):1741-1746.
81. Schulitz KP, Assheuer J. Discitis after procedures on the intervertebral disc. *Spine (Phila Pa 1976)*. 1994;19(10):1172-1177.
82. Van Goethem JW, Parizel PM, van den Hauwe L, Van de Kelft E, Verlooy J, De Schepper AM. The value of MRI in the diagnosis of postoperative spondylodiscitis. *Neuroradiology*. 2000;42(8):580-585.
83. Lewandowski KU, Nanson C, Calderon R. Vertebral osteolysis after posterior interbody lumbar fusion with recombinant human bone morphogenetic protein 2: a report of five cases. *Spine J*. 2007;7(5):609-614.
84. Hong HS, Chang MC, Liu CL, Chen TH. Is aggressive surgery necessary for acute postoperative deep spinal wound infection? *Spine (Phila Pa 1976)*. 2008;33(22):2473-2478.
85. Decoster TA, Bozorgnia S. Antibiotic beads. *J Am Acad Orthop Surg*. 2008;16(11):674-678.
86. Yuan-Innes MJ, Temple CL, Lacey MS. Vacuum-assisted wound closure: a new approach to spinal wounds with exposed hardware. *Spine*. 2001;26(3):E30-E33.
87. Beiner JM, Grauer J, Kwon BK, Vaccaro AR. Postoperative wound infections of the spine. *Neurosurg Focus*. 2003;15(3):E14.
88. Ploumis A, Mehbod AA, Dressel TD, Dykes DC, Transfeldt EE, Lonstein JE. Therapy of spinal wound infections using vacuum-assisted wound closure: risk factors leading to resistance to treatment. *J Spinal Disord Tech*. 2008;21(5):320-323.
89. O'Shaughnessy BA, Dumanian GA, Liu JC, Ganju A, Ondra SL. Pedicled omental flaps as an adjunct in the closure of complex spinal wounds. *Spine (Phila Pa 1976)*. 2007;32(26):3074-3080.
90. Jiménez-Mejías ME, de Dios Colmenero J, Sánchez-Lora FJ, et al. Postoperative spondylodiscitis: etiology, clinical findings, prognosis, and comparison with nonoperative pyogenic spondylodiscitis. *Clin Infect Dis*. 1999;29(2):339-345.
91. Rawlings CE III, Wilkins RH, Gallis HA, Goldner JL, Francis R. Postoperative intervertebral disc space infection. *Neurosurgery*. 1983;13(4):371-376.
92. Lu DC, Wang V, Chou D. The use of allograft or autograft and expandable titanium cages for the treatment of vertebral osteomyelitis. *Neurosurgery*. 2009;64(1):122-129.
93. Korovessis P, Repantis T, Iliopoulos P, Hadjipavlou A. Beneficial influence of titanium mesh cage on infection healing and spinal reconstruction in hematogenous septic spondylitis: a retrospective analysis of surgical outcome of twenty-five consecutive cases and review of literature. *Spine (Phila Pa 1976)*. 2008;33(21):E759-E767.
94. Silber JS, Anderson DG, Vaccaro AR, Anderson PA, McCormick P; NASS. Management of postprocedural discitis. *Spine J*. 2002;2(4):279-287.
95. O'Shaughnessy BA, Kuklo TR, Ondra SL. Surgical treatment of vertebral osteomyelitis with recombinant human bone morphogenetic protein-2. *Spine (Phila Pa 1976)*. 2008;33(5):E132-E139.
96. Allen RT, Lee YP, Stimson E, Garfin SR. Bone morphogenetic protein-2 (BMP-2) in the treatment of pyogenic vertebral osteomyelitis. *Spine (Phila Pa 1976)*. 2007;32(26):2996-3006.
97. Gebhard JS, Brugman JL. Percutaneous discectomy for the treatment of bacterial discitis. *Spine*. 1994;19(7):855-857.
98. Hadjipavlou AG, Crow WN, Borowski A, Mader JT, Adesokan A, Jensen RE. Percutaneous transpedicular discectomy and drainage in pyogenic spondylodiscitis. *Am J Orthop*. 1998;27(3):188-197.

This paper will be judged for the Resident Writer's Award.
