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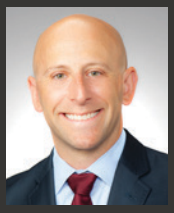
WINTER 2019

Diagnosis and Management of Postoperative Spine Infection



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Postoperative spine infections are a devastating surgical complication. Historical literature reports postoperative infection rates as high as 20 percent. With improved surgical techniques and the use of intrawound vancomycin powder, postoperative infection rates have dropped in recent years.[1-10] Importantly, patients who experience a postoperative spine infection have a poorer perceived outcome of their surgery even if it is ultimately successful. In an era of patient-reported outcomes (PROs) driving practice patterns, and an aging population undergoing increasing rates of high complexity spine surgery, infection remains a key target for quality improvement.[11-14] This article outlines contemporary standard of care practices for the diagnosis and treatment of postoperative spine infection with an emphasis on emerging concepts and broadly applicable surgical techniques.

Rate of Postoperative Infection

The rate of postoperative infection remains difficult to determine due to the diverse and heterogeneous nature of spine procedures. However, the trend is clear that higher rates occur with increasing complexity, length of surgery, and invasiveness of the procedure.[15,16] The use or absence of instrumentation appears to be a driver of infection, with instrumented cases having higher rates of infection. While numbers vary per report, working numbers with which to counsel patients remain at approximately one to two percent for uninstrumented cases, and approximately five percent for instrumented fusions based on prospective data.[17-19] Recent pooled average data is approximately 1.9 percent for all spine cases.[20] For thoracolumbar deformity cases, self-reported Scoliosis Research Society data reports an overall infection rate of 2.1 percent, while more recent International Spine Study Group (ISSG) data reports a 2.4 percent rate of deep infection.[5,21] These numbers, however, must be interpreted with caution due to inherent bias and systemic underreporting of infection data.[22]

Clearly defined modifiable and nonmodifiable risk factors for postoperative spine infection are well documented. Spinal trauma patients represent a unique population that has an increased risk of developing postoperative infections.

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The elevated infection risk for this population is primarily attributed to damage to the soft tissue envelope, leading to local tissue hypoxia with subsequent necrosis, edema, acidosis, and hematoma thus creating the ideal milieu for bacterial proliferation.[23] Trauma patients also are in a state of paradoxical systemic immunosuppression from the traumatic event, a state that is further thought to increase susceptibility to infection.[24] Comorbid factors such as age, nutritional status, body habitus, and other medical conditions cannot be controlled for in the same manner as they are in elective surgery, further compounding the risk of infection. Consequently, the rate of postoperative infection in this population is approximately two to three times higher than in nontrauma cases.[25-27]

Spinal surgeries for management of tumors also are associated with significantly higher rates of postoperative infections, with those who receive local radiation at particular risk.[28,29] It is generally recommended that patients not undergo surgery within six to 12 weeks of preoperative radiation, or receive postoperative radiation within three weeks of surgery in order to allow adequate soft tissue healing.[17]

Nonmodifiable risk factors must be evaluated and maximally treated prior to surgery. These include conditions such as rheumatoid arthritis, human immunodeficiency virus / acquired immunodeficiency syndrome (HIV/AIDS), psychiatric illness, substance abuse, and corticosteroid use, all of which have been linked to an elevated risk of infection. While age is not an independent risk factor for postoperative spine infection, age is correlated with increased medical comorbidity which is a known risk factor for infection.[17,30]

Modifiable risk factors include smoking, obesity, procedure length, catheter use, length of hospital stay, and malnutrition. Individuals with poorly controlled diabetes are at particular risk.[30] Anterior procedures and minimally invasive surgery (MIS) procedures appear to have correspondingly lower rates of postoperative infection, in most cases likely due to the preserved and robust soft tissue envelope left largely undisturbed.[17,22,31-33] In aggregate, modifiable and nonmodifiable risk factors are perhaps best summarized in the emerging concept of patient frailty, which appears to be positively correlated with elevated rates of postoperative infection in frail patients.[34]

Definition and Diagnosis of Postoperative Spine Infection

Importantly, there is no clearly stated set of diagnostic criteria that defines a postoperative spine infection. Increased pain, fever, and wound erythema are present in less than 30 percent of cases. The most reliable marker seems to be increased wound drainage at 10 to 14 days, which occurs in two-thirds of cases of postoperative spine infection (Figure 1).[22] For deep infection, often there is a pain-free period after surgery of one to two months, and subsequently increasing pain or development of new neurologic symptoms over several weeks. Pain is at times out of proportion to what would otherwise be expected. These findings are often associated with constitutional symptoms. Superficial wound infections, in contrast, typically present at one to two weeks postoperatively and are less frequently associated with constitutional symptoms. Superficial wound infections can most commonly be treated with wound care and oral antibiotics.[17]

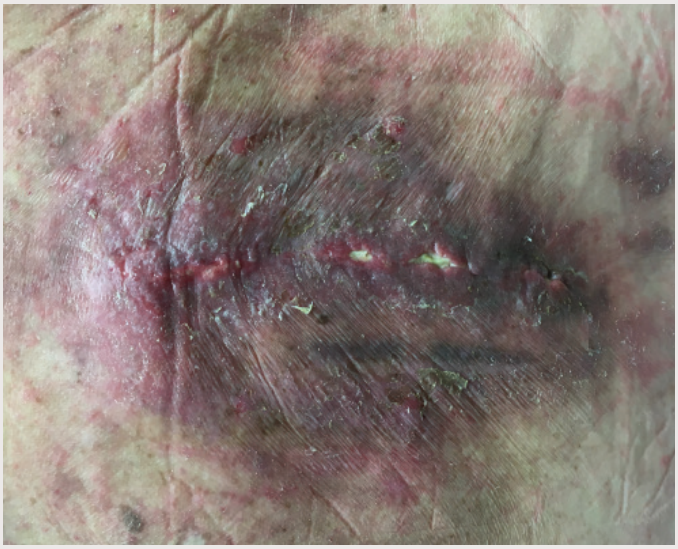

Figure 1. Macerated dorsal spine wound in the early postoperative period with increasing drainage.

If there is a concern for deep underlying infection, additional workup is warranted. Laboratory values are the first line of additional diagnostics in cases of suspected postoperative infection. Initial blood tests should consist of white blood cell count (WBC), erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP). Of commonly assessed laboratory values, CRP has the highest diagnostic sensitivity and specificity (82 percent and 86 percent, respectively) for the identification of a postoperative spine infection.[35,36] CRP is particularly useful for the diagnosis of postoperative spine infection as it normalizes quickly following spine surgery. In uninfected patients, it should return to baseline three to seven days postoperatively.[37] In contrast, ESR may not normalize for three to six weeks following an invasive procedure, decreasing diagnostic utility in the early postoperative period.[38] Less commonly assessed markers such as procalcitonin, serum amyloid A protein, and interleukin-6 (IL-6) also have been evaluated in the literature for the diagnosis of postoperative infection. These markers have been found to have high sensitivity and appear to be superior to CRP in several studies.[39-41]

The accurate identification of the infectious organism is a critical step in the treatment of postoperative spine infection. While some

authors advocate superficial wound cultures, these experience high rates of contamination with local skin flora and can complicate the diagnostic workup. If there is a fluid collection, early aspiration, however, may be beneficial for diagnosis.[42] Computed tomography (CT) or fluoroscopic guidance may be used to obtain a fine-needle aspiration — or preferably a core biopsy — of the affected area.[17] The most accurate cultures, however, are those obtained during surgery. Unfortunately, even when intraoperative cultures are obtained at the time of surgery, they are often negative in patients with established postoperative spine infections. The diagnostic sensitivity of cultures is further worsened since many patients receive antibiotics prior to obtaining intraoperative cultures.[22]

Tissue cultures remain the gold standard for infection diagnosis in spine surgery.[17] However, other subspecialty domains, particularly arthroplasty, have embraced novel molecular biology techniques that have proven particularly useful in the identification of culture-negative infections. These techniques can often identify infection even in presumptively aseptic revision settings. Implant sonication, polymerase chain reaction (PCR), and next-generation sequencing are available — if underutilized — diagnostic techniques with broad applicability to spine surgery.[43-46]

Indeed, the current state of diagnosis for postoperative spine infection is poorly defined. This lies in contrast to arthroplasty literature which has defined and frequently updated consensus-based diagnostic criteria for infection of a prosthetic joint. The initial definitions for periprosthetic joint infection (PJI) were published in 2011 and have been subsequently updated and validated in 2013 and 2018, respectively.[22,47-49]

Unfortunately, no similar consensus definition can be applied to the arena of spinal surgery. However, recently updated guidelines for the diagnosis of periprosthetic joint infection provide an excellent starting point to define postoperative or periprosthetic spine infection. Specifically, patients with a sinus tract communicating to the hardware or bone, or those with two positive cultures of the same organism, can likely be presumed infected. Similarly, those with an intraoperative constellation of positive histology, purulence, and/or a single positive culture can likely be presumed infected. These findings, however, do not necessarily help with the decision of whether or not to return to the operating room to treat a presumed infection. In that regard, elevated serum CRP, D-dimer, and ESR may be most helpful and are commonly assessed in the setting of infection. To the authors' knowledge, analysis of local fluid white blood cell count, leukocyte esterase, alpha-defensin, polymorphonuclear (PMN) cell percentage, and CRP have not been evaluated in the setting of postoperative spine infection. However, these markers may provide diagnostic value based on extrapolation of current arthroplasty literature.[48]

Imaging

Plain film radiographs are the first imaging that should be obtained as part of a diagnostic workup for suspected infection. It may take up to four weeks for radiographs to show evidence of infection. However, subtle bony lysis at the bone-prosthetic interface or implant loosening are early clues of infection. Infectious disc space changes may take longer to develop and are often challenging to differentiate from degenerative changes. More substantial bony changes such as osteolysis, endplate destruction, and deformity typically take two months or more. Paravertebral soft tissue swelling also is a strong indicator of potential abscess, particularly in the retropharyngeal space or paraspinal musculature.[17,50]

CT provides a more detailed view of bony anatomy and allows for earlier detection of infection-related bony changes when compared to plain radiographs. When IV contrast is used, CT also can provide clues to soft tissue collections that are not identifiable on plain radiographs and can be useful in patients who are not candidates for magnetic resonance imaging (MRI). While nuclear imaging modalities such as gallium, technetium, and indium bone scan have been demonstrated to have limited utility, positron emission tomography (PET) and PET-CT have an emerging role in the diagnosis of postoperative spine infections that may have otherwise equivocal imaging.[17,51-53]

MRI with and without contrast remains the gold standard used for clinical decision-making in the setting of postoperative spine infection. For the diagnosis of postoperative spine infection, it is both highly sensitive and highly specific (up to 93 percent and 96 percent, respectively). However, as with other modalities, it can be difficult to distinguish early nonpathologic postoperative changes from infections.[17,54-56] Of particular utility may be the recently described pedicle screw sign. This is defined as fluid collection outside the head of the pedicle screw represented by a high-intensity area extending more than 5 mm outside the lateral edge of the head of the screw in the T2-weighted axial plane (Figure 2, Page 4).[57] Metal artifact, particularly with stainless steel or cobalt, can further limit the diagnostic utility of MRI.[54-58]

Microbiology

Generally, three mechanisms are described for postoperative infections:

1. Direct inoculation during the procedure
2. Contamination during the early postoperative period
3. Hematogenous seeding

Of these three, direct inoculation during the surgery is most common.[17]

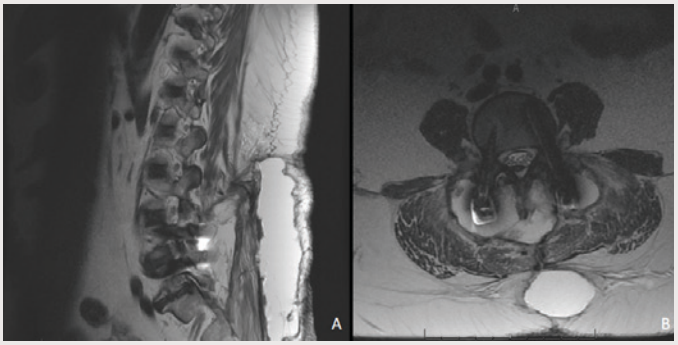

Figure 2. – A: Parasagittal T2-weighted MRI showing superficial and deep fluid collections. **B:** The pedicle screw sign can be seen with fluid collections extending more than 5 mm outside the lateral edge of the head of the pedicle screw in the axial plane. This wound should be presumed infected unless proven otherwise.

Gram-positive cocci are the most common pathogens responsible for acute postoperative spine infections. Of these, *Staphylococcus aureus* causes more than 50 percent of infections in some reports, with *Staphylococcus epidermidis* and *beta-hemolytic streptococci* as the next most common. Common gram-negative pathogens include *Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae, Enterobacter cloacae, Bacteroides,* and *Proteus species.* The anatomic location of the wound impacts the likelihood of gram-negative infection, with lumbosacral incisions having an increased risk of gram-negative infection due to fecal and urinary contamination. Additionally, in cases of patients who are immunosuppressed, fungal infection also is a risk.[17,59,60]

While vancomycin powder has reduced the overall rate of infection following spine surgery, there is a growing body of evidence that shows the traditional microbial profile of postoperative spine infections is changing. Due in large part to the use of in-wound vancomycin powder and associated killing of gram-positive organisms, there is significant selection pressure for gram-negative organisms. Thus, while the overall number of infections is greatly decreased, the proportion of gram-negative infections has increased.[22,61,62]

For late spine infections that present a year or more after spine surgery, low virulence organisms such as *Propionibacterium acnes* are the most common causative agents. These organisms are postulated to be present in normal skin flora and contaminate the wound via prolonged drainage and inflammation. Importantly, if *P. acnes* is suspected as an infectious agent, cultures need to be retained by the microbiology lab for two weeks.[63-65] At this postoperative time point, hematogenous spread of infection must also be considered. These infections are typically due to highly virulent organisms and are often present in patients with systemic illness, intravenous drug use, immunosuppression, and sepsis.[66]

Prevention

The easiest way to manage postoperative spine infection is prevention. Hospital and medical system factors play a role in the rate of postoperative infection. Preoperative nasal *Methicillin-Resistant Staphylococcus Aureus* (MRSA) colonization is associated with postoperative spinal MRSA. Preoperative screening and subsequent decolonization using topical antibiotics have been shown to reduce the rate of surgical site infection and are cost effective.[67,68] Case order and seasonality also impact the rate of surgical site infection (SSI) after spine surgery, with cases occurring later in the day having higher rates of infection, as well as those during the summer months.[69,70] When using implants in spine surgery, keeping the instrumentation covered if opened at the beginning of the case, or not opening until necessary, leads to lower colonization rates, which may lead to lower infection.[71]

Decision-making

Infection prevention starts with good patient selection. Obese patients are considered at high risk for developing postoperative infections. Specifically, it appears that the distribution of body mass is even more predictive of SSI than absolute body mass index (BMI), with MRI measurements of skin-to-lamina distance and thickness of the subcutaneous adipose layer being significant risk factors.[72] Those with an excessively thick layer of subcutaneous fat are at an elevated risk of postoperative spine infection and should be counseled accordingly. Surgery should not necessarily be delayed or canceled, as obese patients have a treatment effect associated with surgery that is at least equivalent to nonobese individuals. The risk is in large part due to inferior outcomes with nonoperative management in obese patients.[73] Additionally, new studies suggest that bariatric surgery before elective posterior lumbar fusion may mitigate the risk of medical complications and postoperative spine infection.[74]

While patients with diabetes have a higher risk of postoperative spine infection versus their nondiabetes counterparts, all people with diabetes are not the same. Insulin-dependent diabetic patients have a different risk profile versus noninsulin-dependent diabetics, with those requiring insulin experiencing both greater numbers of and more severe perioperative complications, including infection.[75] Similarly, elevated preoperative hemoglobin A1c (HbA1c) has been linked to an elevated infection risk, with patients having a HbA1c >7.0 percent at an elevated risk.[76]

Recent studies have shown that both cervical and lumbar spine surgery within three to six months following epidural steroid injection may be associated with an increased rate of postoperative infection. Thus, increasing the time interval between injection and spine surgery to at least three, or possibly six, months may decrease infection rates.[77,78]

Intraoperative Measures

For preoperative surgical skin antisepsis, spine surgeons continue to use both iodine- and chlorhexidine-based agents. While a small prospective series examined both chlorhexidine- and iodine-based agents and found no difference in antiseptic properties in the lumbar spine, the broader literature suggests the likely superiority of alcohol-based agents, specifically chlorhexidine-isopropyl alcohol.[79-81]

Preoperative weight-based antibiotic prophylaxis within 60-minutes prior to incision remains the standard of care for spine surgery with a demonstrated benefit in the reduction of postoperative infection.[82] Cefazolin is the antibiotic of choice, with clindamycin and vancomycin as acceptable options if cefazolin is not possible due to a contraindication.[81,83] There is currently no role for routine use of vancomycin alone. In patients known to be colonized with MRSA or at risk for MRSA colonization (such as patients with recent hospitalization, nursing home residents, and those on hemodialysis), vancomycin may be used in addition to cefazolin. Dual coverage is preferred as vancomycin is less effective than cefazolin for preventing SSI caused by *methicillin-sensitive Staphylococcus aureus* (MSSA).[83-87]

Antibiotic-containing irrigation has long been used in spinal surgery and multiple other surgical domains. The literature is mixed on their performance, as well as on the possible effects on bone and soft tissue healing, and if high- or low-pressure systems are preferred. Use of these agents in in vitro studies demonstrates reduced bacterial counts, however, there are no significant trials that clearly support the use of antibiotic irrigation in spinal surgery.[17] There is, however, mounting evidence that irrigation with dilute betadine may be beneficial prior to wound closure.[88,89] Additionally, betadine appears to be less toxic than other antimicrobial wound cleansers.[90-92]

Application of in-wound antibiotics has been popularized by the marked reductions achieved in postoperative infection rates across a variety of procedures in both adult and pediatric populations.[6,7,93-98] Antibiotics, most commonly vancomycin, are placed in the wound prior to closure at the conclusion of the case. They also may be mixed with the bone graft in the case of fusion-type procedures. Importantly, this does not appear to inhibit bony fusion.[99] Tobramycin and gentamicin also are popular options with enhanced gram-negative bacterial coverage.[100-103] Due to morbidity and the cost of postoperative spine infections, the use of these intraoperative adjuncts has proven highly cost-effective.[104] There are few known downsides, however, sterile seroma and circulatory collapse have been documented as case reports.[105,106] Early concerns about increased topical antibiotic use causing antibiotic resistance have not born out in the literature. This is postulated to be a result of supratherapeutic levels of antibiotics causing early wound bed sterilization.[107]

In contrast to other purported infection reducing techniques, use of iodine-impregnated adhesive drapes does not appear to reduce the rate of SSI.[108] Similarly, use of closed suction drainage appears to have no effect on infection rates.[109] Rather, drain use has been linked to increased transfusion rates.[110] Transfusion rates have been independently associated with increased rates of postoperative infection.[111,112] Thus, use of surgical drains should be judicious.

Perhaps most importantly, attention to detail and basic principles of sterile technique remain essential. General operating room behavior, which may create numerous opportunities for small violations in sterile technique, has been attributed to higher rates of surgical site infection. Indeed, current evidence suggests that positive intraoperative cultures occur in nearly one-third of primary deformity cases.[113] Thus, common sense actions such as appropriate hand washing, frequent glove changes, covering implants while not in use, and minimizing operating room traffic all contribute to lower rates of postoperative spine infection.[7,114-116]

Management of Postoperative Spine Infections

Successful treatment of postoperative spine infections requires timely and appropriate diagnosis, as well as coordinated medical and surgical management. The goal of treatment is the eradication of infection, which must be accomplished while maintaining vertebral column stability. The obligate requirement of stability differentiates treatment of postoperative spine infections from other postoperative and implant-associated infections, as implant removal may not be feasible.

The role of biofilm in postoperative spine infections is under-appreciated. Bacterial biofilms pose a significant challenge in treating periprosthetic spine infections as they provide bacteria with substantial protection against antimicrobial agents and the host immune response.[117] Most periprosthetic infections, including postoperative spine infections, are caused by biofilm-forming organisms.[118] Basic science and animal literature suggest that biofilms are established in vivo within hours to days.[119-123] Importantly, for periprosthetic infections caused by biofilm-forming organisms, there is no literature to support the opposite position that there is clinically significant periprosthetic infection without biofilm.

As antibiotics are unable to penetrate the protective bacterial glycocalyx layer of a biofilm, surgical debridement is thus essential to the eradication of biofilm-associated infections. However, knowing which tissue should be removed and which should remain is highly dependent on a surgeon's experience.[124,125] Conventional spine wisdom suggests that all dermal margins that appear infected should be excised, as well as all subcutaneous tissues including fascia that is in contact with the infectious or

necrotic material. If underlying deep fascial layers appear intact, some authors advocate limited subcutaneous debridement. However, there is usually some communication between superficial and deep surgical planes, and missing a deep infection is potentially disastrous.[17] While viable bone graft may be retained, any bone graft that is in contact with the infectious or necrotic tissue should also be removed (Figure 3).[17,64]

At this time, the need for repeated surgical debridement or hardware removal and exchange is driven by surgeon preference. Some authors recommend a "second look" irrigation and debridement at 48 to 72 hours after the initial debridement in all cases. However, this is not the norm in clinical spine practice.[17] To better risk stratify patients requiring repeated debridement, *Dipaola et al.* developed a postoperative infection treatment score for the spine (PITSS). The general message is that sick patients with highly virulent polymicrobial or MRSA infections with hardware and allograft are at high risk of infectious failure with single-stage irrigation and debridement.[126] While novel within the arena of spine surgery, critical analysis of this article indicates that the authors fail to appreciate the underlying reason for infectious failure is likely residual bacterial biofilm.

This concept is best explained by examination of literature relating to irrigation and debridement for acute PJI, and the debate about single- versus two-stage exchange for chronic PJI. In both clinical scenarios, the ability to eradicate tenacious bacterial biofilms appears essential to the reliable eradication of deep periprosthetic infections.[127,128] Nonetheless, both in spine and arthroplasty, the use of irrigation and debridement to treat infection likely persists because of the perceived radical option of two-stage exchange to achieve infection control. While host factors and virility of the organism play a role, the inability of parenteral antibiotics to penetrate the glycocalyx biofilm layer embedded on the implant and host tissue is thought to be the primary reason for the failure of this treatment option.[127]

Given that residual biofilm on both implant and host tissue is postulated to be the common mode of failure for management of deep periprosthetic infections, a technique to reliably identify biofilm in the operative settings holds promise for reducing the failure rate and consequent morbidity, mortality, and cost. Adequate debridement, however, is complicated by the inability to visualize most biofilms with the naked eye. To that end, methylene blue recently has shown promise as a biofilm disclosing agent in the orthopaedic literature in both in vitro and in vivo settings and may have utility for the treatment of deep spine infections (Figure 4).[129-132]

During the debridement of infections with instrumentation, implants should be inspected and replaced if there are obvious signs of loosening or failure. However, removal of infected instrumentation that remains well fixed is highly controversial. The literature on this topic is conflicted, with some authors

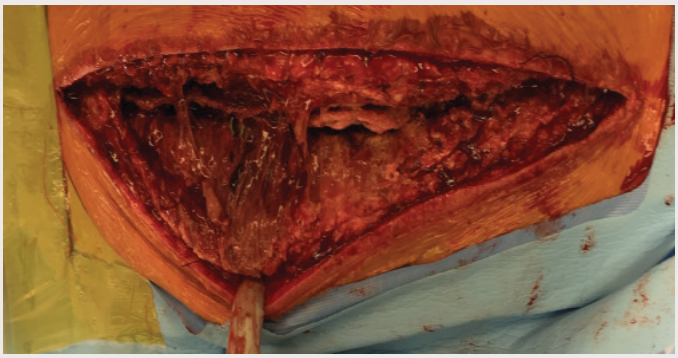

Figure 3. Postoperative infection with gross purulence and deep necrotic muscle.

reporting successful eradication of both anterior and posterior infections with retained instrumentation. However, a recent trend, particularly within the arena of spinal deformity surgery, is complete removal of all instrumentation independent of fixation or fusion status because of the difficulty of eliminating infection without removal.[133-137] Indeed, residual biofilm on spine implants is associated with infectious failure and the need for additional surgery. In this regard, there has been a significant shift towards hardware removal if a deep infection is suspected. A recent MRI-based study concluded that once vertebral osteomyelitis or intervertebral abscess were evident in MRI images, all the hardware should be removed.[138] If the hardware is not able to be removed, long-term antibiotic suppression may be required until fusion is achieved and the implants can be removed.

Adjunctive Surgical Techniques

Surgical techniques in addition to the application of in-wound antibiotic powder include the placement of antibiotic-containing beads. This can be done either as part of a single or multistage surgical debridement strategy. Use of antibiotic-containing polymethylmethacrylate (PMMA) bone cement or bioabsorbable

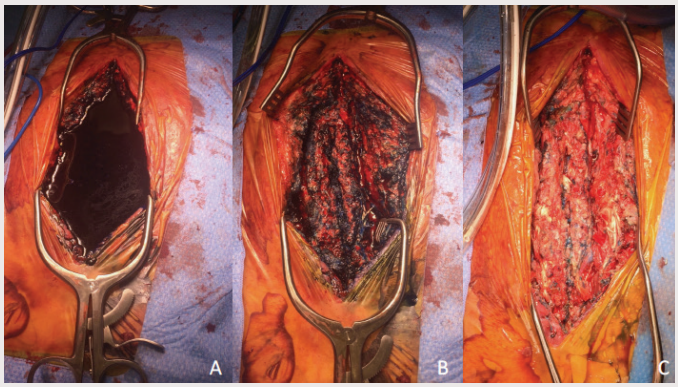

Figure 4. Visual description of methylene blue technique. **A**: Dilute methylene blue solution is instilled in the wound after opening the incision. **B**: Residual dye is removed, the wound is irrigated, and the remaining blue dye stains infected and necrotic tissue. **C**: Blue tissue is debrided leaving a healthy-appearing wound bed.

calcium sulfate beads are viable options. These products have prolonged elution characteristics versus powdered antibiotics alone and may provide longer-term local antibiotic delivery. These products are most commonly used with vancomycin, tobramycin, and/or gentamicin as they are heat stable. Other antibiotic options are available and should be based on preoperative culture data.[139-142] For difficult to treat fungal infections of the spine, amphotericin B and voriconazole are both heat stable and also may be added to bone cement.[143,144]

Achieving reliable fusion following postoperative spine infection is particularly challenging. Rates of pseudarthrosis and subsequent hardware failure are elevated. This may be due in part to the ability of bacteria to impair fusion, colonization of instrumentation, and impaired vascularity in fusion beds. Consequently, even the use of iliac crest bone graft (ICBG), long considered the standard of spinal fusion, cannot ensure reliable bony fusion. While the initial FDA-labeling of recombinant human bone morphogenetic protein-2 (rhBMP-2, Infuse, Medtronic) listed active infection as a contraindication, several series have successfully published on the use of BMP to successfully achieve bony fusion in the setting of difficult to treat infection.[145-147] While more research on this topic is needed, this may be a useful adjunct to achieve fusion in an inhospitable host environment.

Severe postoperative spinal infections may result in significant soft tissue defects that require complex wound management. Early involvement of plastic and reconstructive surgeons is essential in optimizing patient outcomes in these settings. Plastic surgeons should be involved prior to definitive spine management. Ultimately, these complex wounds may require flap coverage or healing by secondary intention. In both regards, vacuum-assisted closure (VAC) devices have been used with success. VAC technology is particularly helpful in closing complex wounds as the application of negative pressure assists in the development of granulation tissue, promotes angiogenesis, increases responsiveness to growth factors, and decreases bacterial levels. Recent literature also suggests that VACs may safely be placed directly on the dura even if there is no intervening soft tissue.[148-151]

Local, rotational, and free muscle and tissue flaps also may be used to bring increased vascularity and adequate soft tissue coverage while protecting instrumentation and allowing bony fusion.[152,153] Trapezius muscle flaps have historically been the gold standard for cervical and thoracic coverage, however, paraspinous muscle flaps have also gained in popularity.[154,155]

Medical Management

Even with optimal surgical management, culture-based parenteral antibiotic therapy remains a mainstay of treatment for post-operative spine infections. These are treated with a minimum of six weeks, and possibly three months, of intravenous antibiotics, followed by additional oral antibiotics. Oral regimens often include rifampin, which is thought to be beneficial in the treatment of biofilm-forming organisms.[156,157] Difficult to treat or recurrent infections may require longer-term or even lifetime antibiotic suppression.[158] Postoperative discitis and epidural abscess are typically treated initially with antibiotic regimens unless surgery is indicated for neurologic compromise or recalcitrant progressive infection.[17]

Conclusions

Spine infection rates likely range from one to five percent based on prospective data. Recent retrospective data puts aggregate rates for postoperative spine infection at approximately two percent. Rates vary by procedure and increase with surgical invasiveness. Modifiable and nonmodifiable risk factors should be maximally managed prior to surgery and attention should be paid to patient frailty. CRP represents the single best laboratory value to follow in the setting of postoperative spine infection. MRI with and without gadolinium contrast remains the imaging modality of choice to supplement plain film radiographs in the diagnosis of infection. Accurate and timely diagnosis of infectious organisms is crucial to long-term infection eradication and disease-free survival. Novel molecular biological techniques such as PCR and next-generation sequencing should be considered in the setting of culture-negative infection and suspicious aseptic revision surgery. Appropriate antibiotic therapy remains essential. Surgical debridement remains a mainstay in the treatment of postoperative spine infections and is essential for eradication of biofilm-associated infections with or without implant retention.

References

1. El-Gindi S, Aref S, Salama M, Andrew J. Infection of Intervertebral Discs After Operation. *J Bone Joint Surg Br.* 1976.
2. Pilgaard S. Discitis (Closed Space Infection) Following Removal of Lumbar Intervertebral Disc. *J Bone Joint Surg Am.* 1969.
3. Lindholm TS, Pylkkänen P. Discitis Following Removal of Intervertebral Disc. *Spine (Phila Pa 1976).* 1982.
4. Stolke D, Sollmann WP, Seifert V. Intra- and Postoperative Complications in Lumbar Disc Surgery. *Spine (Phila Pa 1976).* 1989.
5. Smith JS, Shaffrey CI, Sansur CA, Berven SH, Fu KMG, Broadstone PA, et al. Rates of Infection After Spine Surgery Based on 108,419 Procedures: A Report From the Scoliosis Research Society Morbidity and Mortality Committee. *Spine (Phila Pa 1976).* 2011.
6. Heller A, McIff TE, Lai SM, Burton DC. Intrawound Vancomycin Powder Decreases Staphylococcal Surgical Site Infections After Posterior Instrumented Spinal Arthrodesis. *J Spinal Disord Tech.* 2015.
7. Chiang HY, Herwaldt LA, Blevins AE, Cho E, Schweizer ML. Effectiveness of Local Vancomycin Powder to Decrease Surgical Site Infections: A Meta-Analysis. *Spine J.* 2014.
8. Caroom C, Tullar JM, Benton EG, Jones JR, Chaput CD. Intrawound Vancomycin Powder Reduces Surgical Site Infections in Posterior Cervical Fusion. *Spine (Phila Pa 1976).* 2013.
9. Evaniew N, Khan M, Drew B, Peterson D, Bhandari M, Ghert M. Intrawound Vancomycin to Prevent Infections After Spine Surgery: A Systematic Review and Meta-Analysis. *Eur Spine J.* 2015.
10. Khan NR, Thompson CJ, DeCuypere M, Angotti JM, Kalobwe E, Muhlbauer MS, et al. A Meta-Analysis of Spinal Surgical Site Infection and Vancomycin Powder. *J Neurosurg Spine.* 2014.

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