Hematogenous Pyogenic Spinal Infection: Current Perceptions

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As a result of reading this article, physicians should be able to:

1. Understand the importance of early diagnosis and treatment of spinal infection in an effort to avoid devastating and crippling complications such as paralysis, painful deformity, and death.

2. Understand current perceptions in the ongoing debate of whether operative or conventional treatment should be preferred and in which cases.

3. Understand the latest advances in the surgical treatment of spinal infection, their indications, and their effectiveness.

4. Understand the change in the traditionally held belief that in the presence of infection, the use of metal implants or grafts is not indicated.

Abstract

Controversy exists regarding optimal treatment for pyogenic spinal infection. The authors systematically reviewed peer-reviewed published clinical trials in the English language through 2009 on the clinical presentation, complications, and conservative and operative treatments of pyogenic spinal infection. The cornerstone of therapy for uncomplicated spondylodiskitis is intravenous antibiotics followed by oral antibiotics and bracing. Surgery is effective in complicated cases and improves sagittal balance, restores neurological impairment, and relieves severe pain. In cases of delayed diagnosis or surgery, potential early devastating and late crippling complications may occur. To the authors’ knowledge, no Level I studies compare operative vs conservative treatment of pyogenic spinal infection.

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The concept of spondylitis (osteoarticularitis of the vertebral body) originates from the theory that, in adulthood, bone infection starts in the subchondral bone as an osteomyelitic lesion and then spreads into the adjacent intervertebral disk. In the early stages, several of these entities may represent different phases of a wider spectrum of the same infectious process in a state of evolution, with spondylodiskitis being the major segment of the spectrum of spinal infections. When an epidural abscess complicates pyogenic infection of the spine, it is referred to as secondary epidural abscess. It is estimated that the incidence of spondylodiskitis in the general population is 1.8 cases per 10,000 hospital admissions, and the incidence of paraplegia represents 20.9 cases per 10,000 spinal cord injuries.

Common complications of spondylodiskitis are deformity, instability, and paravertebral or epidural abscess. The latter may result in back or neck pain, radiculopathy, paraparesis or paraplegia, severe morbidity, and mortality. Can these complications be prevented, and what are the best treatment options? Several conditions have been accepted as risk factors predisposing individuals to hematogenous spinal infection. To the authors’ knowledge, no scientific studies grade the degree of their virulence, but they can be graded into 3 categories. Category I includes the origin of the source of infection as a preceding infection, intravenous drug abuse, or diagnostic or operative procedures. Category II comprises predisposing medical conditions that render the host susceptible to infection, such as immunosuppressive host, diabetes mellitus, rheumatoid arthritis, and chronic steroid use. Category III comprises comorbidities (eg, organ failure, ankylosing spondylitis, and trauma).

The most frequent anatomical location of spondylodiskitis is the lumbar spine (49.5%), followed by the thoracic (25.8%) and cervical spines (10.8%) (Table 1). The most frequent anatomical site for thecal sac encroachment by epidural abscess is in the cervical spine (90%), followed by the thoracic (33%) and lumbar spines (23.6%). However, severe neurological complications (eg, paraparesis/paraplegia) can occur as a result of thecal sac compression more frequently in the thoracic (81.8%) and cervical (55.6%) spines as opposed to the lumbar spine (7.7%). Therefore, in case of cervical or thoracic infection, more caution should be exercised to assess the higher probability of secondary epidural abscess formation and prevent its grave neurological consequences.

Primary epidural abscess is reported to occur at rates ranging from 5.7% to 29%, whereas secondary epidural...
TREATMENT OF SPINAL INFECTIONS

Conservative Treatment

Spondylodiskitis is commonly managed conservatively with intravenous antibiotics and external support. However, surgical intervention is indicated when it is complicated with neurological impairment, abscess formation, infection recurrence, severe pain, segmental instability or local kyphosis, and absence of clinical response. Controversy exists about a common protocol for conservative treatment of spinal infections, but it is generally agreed that the administration of antibiotics is warranted.

However, the dosage, route, and duration of antibiotic therapy advocated by various investigators are imprecise. Some authors advocate 6 to 8 weeks of intravenous therapy alone, whereas others propose 6 to 8 weeks of parenteral therapy followed by 2 or more months of oral therapy, depending on clinical and laboratory response (erythrocyte sedimentation rate and C-reactive protein values).1,2,21,22,31,32

Even after adequate debridement and instrumentation, delayed recurrence of infection may occur because the primary infection is not completely eradicated or due to the occurrence of a de novo secondary infection.33 The contributing factor should be attributed to virulent microorganisms and resistance to local antibiotics.34 For example, patients who are hospitalized or have leg ulcers are at high risk for methicillin-resistant Staphylococcus aureus (MRSA), and elderly patients with recurrent urinary tract infections and intravenous drug users are at high risk for gram-negative bacilli. Generally, vancomycin or teicoplanin should be used to treat MRSA, and ciprofloxacin or third- or fourth-generation cephalosporin should be used to treat gram-negative bacilli.35,36

In general, patients who are immuno-compromised require longer treatment. When treatment is delayed for a mean of 6 to 7 weeks, 8 weeks is associated with an increased recurrence rate compared with treatment for 12 or more weeks.37 When treatment starts within 2 weeks of the onset of symptoms, a 6-week treatment is adequate.37 Obtaining a biopsy before antibiotic administration for culture and histology is crucial for administering the appropriate antibiotics.31,38

Conservative Versus Operative Treatment

Bony ankylosis after conservative treatment may take up to 2 years and occurs only in 35% of cases.39 Furthermore, most patients frequently report residual mechanical back pain.40,41 It is notable that 64% of patients treated conservatively reported mechanical back pain, as opposed to 26% of patients treated operatively.1

A retrospective analysis of 57 patients with epidural abscess treated with antibiotics alone (25 patients) or in combination with computed tomography–guided percutaneous needle aspiration (7 patients) and open surgical drainage (28 patients) concluded that an epidural abscess can be safely and effectively treated with antibiotics alone.42 However, the study had several limitations, ranging from patient selection to a lack of randomization. Furthermore, residual chronic pain from deformity, a major complication of spondylodiskitis, was not taken into account.42

A recent Level IV article reported uncertainty on the efficacy of conservative treatment.43 Nineteen patients with spondylodiskitis (8 complicated with an epidural abscess and 3 with a subdural abscess) were treated with antibiotics and bracing alone with a hospital stay of 58.2±22.0 days. The authors reported successful outcomes; however, 3 patients died of uncontrollable sepsis, and no objective outcome measures were used.43 Furthermore, the clinical presentations were not well documented, and it is not clear why the authors continued to treat patients with sepsis and paraplegia with antibiotics alone.

No prospective, randomized studies or sufficient data exist in the literature to compare the outcomes of conservative vs operative treatment. Furthermore, most of the patients who are referred for operative treatment are those with severe painful deformities and neurological complications for which surgery is the best treatment option.

Some authors noted a recurrence of infection as late as several years after operative treatment, ranging from 2% to 18%.1,30,40,44 However, the majority of published operative outcomes have not indicated late recurrences of deep infection.3,30,31,40,44-47

Inadequate published data exist on the long-term functional outcomes after pyogenic spinal infection.48 Most studies used heterogeneous, unreliable, and nonvalidated measure instruments, yielding data that are difficult to interpret. Poor functional outcome following pyogenic spinal infection is common at long-term follow-up, even in patients with apparent complete neurological recovery.
Operative Treatment

Although pyogenic spinal infection represents less than 4% of all bone infections, it can be a challenging condition to successfully manage operatively due to moribund patients, destructive lesions resulting in spinal deformity, profound local inflammatory response, and cord compression. Early accounts of surgery for spinal infection were associated with a significant morbidity rate and comparatively high incidence of recurrent infections. Improved methods of radiological diagnosis, safer operative and anesthetic techniques, and modern segmental spinal fixation systems have led to better overall operative outcomes.

It is widely agreed that radical and aggressive debridement of all unhealthy material is mandatory for successful results. All infected and necrotic tissues must be excised and abscesses evacuated. Surgery usually offers relief of severe pain, restoration of neurological impairment, and improvement or maintenance of sagittal balance.

Conventional Surgery

Several methods and operative approaches have been advocated, including an anterior approach alone, consisting of anterior decompression and bone grafting, that is occasionally enhanced with anterior stabilization; a posterior approach consisting of a laminectomy alone or further supported by transpedicular instrumentation; a combined anterior decompresion, bone grafting, or cages through a thoracotomy or retroperitoneal approach with posterior stabilization either as a staged or single procedure; and a posterior extracavitary approach, which can also achieve anterior decompression and posterior stabilization.

Anterior, Posterior, or Combined Approach

Some issues exist regarding operative approaches (eg, strategy of procedures for the best optimal treatment, type of instrumentation, and graft material). The decision to use an anterior or posterior approach is a matter of debate. Because the pathology of pyogenic vertebral osteomyelitis mainly affects the vertebral bodies and disk spaces, the anterior approach is adopted by many surgeons because it allows direct access to the infected focus and is convenient for debriding infection and reconstructing the defect with greater stability.

The majority of anterior surgical approaches are performed in patients with cervical lesions. In the lumbar and thoracic spines, anterior instrumentation to provide bone stability after grafting may be tenuous because the concomitant osteoporosis associated with infection renders the vertebrae structurally weak and may prevent adequate fixation. However, most surgeries are currently performed using a combined approach. A decrease exists in the incidence of infection recurrence and revision surgery with combined approaches compared with a single approach. The relatively larger invasiveness of combined anterior and posterior approach surgery has not been shown to worsen the morbidity and mortality of the procedure.

One- Versus 2-stage Surgery

Controversy remains on the subject of 1- vs 2-stage surgery. Two-stage surgery with a convalescence period bridging the 2 surgeries may have advantages, such as shorter operative times, less blood loss, and safety for patients with poorer general health. However, 1-stage surgery also has many advantages, such as lower complication rate, shorter hospital stay, and earlier mobilization.

In a small series of cases comparing anterior vs combined anterior and posterior instrumentation, Hee et al reported that the combined approach had better overall results in terms of postoperative complications, quicker fusion, and maintenance of kyphotic correction.

Combined surgical approaches in a sequential fashion have been shown to be a safe approach, even in moribund patients. Most authors agree that the benefits of a 1-stage procedure generally outweigh the perceived operative risks. However, a 1-stage procedure could be staged for severely unhealthy patients. Nevertheless, the possibility to perform limited invasive posterior, anterior, or combined stabilization should result in minimized intraoperative bleeding and postoperative complications.

Poor sagittal spinal correction has been documented following anterior debridement and fusion without instrumentation. In the past few years, improved correction of sagittal alignment has been noted with anterior strut grafting, structural allograft, and titanium mesh cages combined with posterior instrumentation.

Reported kyphosis correction ranges from 7.2° to 12.7°, with a 2.0° to 3.0° loss of correction with an average follow-up of 45 months.

Decompressive Laminecotomy

Decompressive laminectomy alone is indicated only for primary epidural abscess, which is usually complicated by paraparesis or paraplegia and associated with sepsis. The abscess is usually located in the posterior epidural space. Operative delay may lead to irreversible neurological deficit. Surgery is indicated even in moribund patients. For secondary epidural abscess, decompressive laminectomy alone is contraindicated, particularly in the cervical and thoracic spines, because this may render the spine unstable, predisposing to spinal dislocation and irreversible neurological deficit.

In this situation, the abscess is located anteriorly and may spread posteriorly. Surgery should be performed through an anterior approach for decompression and reconstruction, combined or not, with a posterior approach for additional stabilization and simultaneous correction of segmental kyphosis, if any.

Implants and Grafts

The loss of anterior spinal column structure integrity that follows operative debridement makes operative reconstruction mandatory to prevent potential insta-
bility and kyphotic deformity. Bone grafting with tricortical iliac autograft is often the surgeon’s first choice after debridement in septic spinal osteomyelitis.5,46,57,58 Segmental instrumentation to stabilize the spine in the presence of infection is no longer considered a controversial issue by some because the complication and recurrence rates are low and the success rates are high.49,59-61

Surgical outcomes have also focused on the type of anterior graft and the surgical reconstruction techniques. Various strut grafting options have been developed to prevent kyphotic collapse, which may occur after medical management of vertebral osteomyelitis or anterior debridement without grafting.19,20,22,25,60 More traditional tricortical autografts are now less commonly used in favor of more structural cortical bone ring allografts that exhibit good rates of fusion and infection eradication.59-62 Allograft could be used as an alternative63,64 because it avoids the donor-site morbidity and shortens the operative time. Furthermore, it has been shown that allograft incorporation is comparable with autograft for spinal osteomyelitis in combination with aggressive debridement, spinal instrumentation, and antibiotic therapy.54

Surgeons should keep in mind that allograft or even nonvascularized autograft, like any foreign material, may potentially promote biofilm formation65-67 and bacterial adherence and decrease antibiotic effectiveness. Moreover, allograft may provoke an immune response or may become a source for infection transmission.65-70

Recombinant human bone morphogenetic protein-2 (rhBMP-2) is an innovative osteoinductive substance that is increasingly being used to promote fusion.1,56,62,68 During anterior lumbar interbody fusion with tapered cages or allograft for degenerative disk conditions, the use of rhBMP-2 may theoretically result in fusion rates and functional outcomes that are superior to iliac crest autograft (eg, allograft/rhBMP-2 at 99% vs allograft/iliac crest autograft at 76%); however, this assumption emerged from studies in infected rat femurs.71 Recent evidence in animal models suggests that rhBMPs retain their osteoinductive properties during both acute and chronic infections.69,70 In 2007, several authors71,72 reported that rhBMP-2 use in combination with antibiotics and circumferential instrumented fusion provides a safe and highly effective treatment for medically nonrespon-sive pyogenic spondylitis with solid fusion and good clinical results but without adverse side effects, infection recurrence, or instrumentation failure.

Reconstruction With Titanium Mesh Cage

Because of the morbidity associated with harvesting large autografts, vertebral body replacement with titanium mesh cages filled with autogenous bone graft has emerged as a viable option for reconstructing a deficient anterior column.50,59,73 In 1991, the Harms group began using titanium mesh cages and rigid instrumentation for anterior column reconstruction in vertebral osteomyelitis.74 The titanium mesh cage, available in various diameters, is easily tailored to the needs of the surgery and, compared with tricortical autograft, possesses significant advantages (eg, the suitable shape for positioning between adjacent vertebral endplates).75,76 The fenestrations in the titanium mesh cage and its circular shape act as a bony conduit for the bone graft material.48,51

Furthermore, the use of a titanium mesh cage improves the alignment of the spine with fewer postoperative complications; permits earlier mobilization and faster fusion, even in the presence of active pyogenic vertebral osteomyelitis; and does not promote infection recurrence. Several reports have demonstrated the beneficial effects of titanium mesh cages as a reconstructive material following anterior decompression.7 A. Unfortunately, all are retrospective case series studies of Level IV evidence. Nevertheless, the clinical and radiological studies of titanium cages are convincing for the excellent outcomes in eradicating infection, providing stability with sustained correction of sagittal alignment with insignificant settling, and contributing to pain relief and neurological improvement.21,31,44,51,60 All of the authors advocate that anterior reconstruction with titanium cage in the thoracic and lumbar region should be followed by posterior stabilization, except in the cervical spine, where fixation with anterior plate is sufficient.21 A report of a smaller series (11 cases) provided evidence that structural allograft has similar properties to titanium cages.30

Minimally Invasive Surgery

The natural history of uncomplicated hematogenous pyogenic spondylodiskitis is self-limiting healing. However, a variable degree of bone destruction frequently occurs, predisposing the spine to painful kyphosis. Delayed treatment may result in serious neurological complications. Early debridement of these infections by percutaneous transpedicular discectomy has been shown to accelerate the natural process of healing and prevent progression to bone destruction and epidural abscess formation.77

The advantages of this minimally invasive procedure are ample drainage of infected material, sufficient tissue sample for histological and bacteriological testing, installation of the suction irrigation system, prompt relief of pain and suffering, early patient mobilization, and short hospitalization. These procedures should also be considered cost effective because most patients can be discharged on the second or third postoperative day, decreasing the prolonged hospital stay necessary for bed rest and analgesia control.77 Similar results have also been accomplished through percutaneous arthroscopic discectomy.19,78,79 The overall reported Level IV success rates of these procedures range from 76% to 87%.79 A common denominator of these procedures to achieve prompt healing is to either shave or penetrate the subchondral plate of the affected intervertebral disk.
Video-assisted thoracoscopic surgery was presented by Mückley et al\(^9\) for the management of pyogenic vertebral osteomyelitis. However, this procedure is technically demanding, and special instruments that are seldom used in other routine surgical procedures are needed.

Another less invasive treatment method involves the combination of anterior percutaneous suction irrigation and a posterior external fixator as advocated by Jeanneret and Magerl.\(^81\) However, the disadvantage of this method is the need for a second procedure in 50% of the patients and the incomplete correction of the kyphotic deformity.

Although these are retrospective Level IV noncomparative studies, the clinical outcomes are encouraging as to the safety and effectiveness of minimally invasive surgery, rendering it another useful option.

**Pyogenic Facial Arthropathy**

Hematogenous pyogenic facet joint infection is a rarely diagnosed condition, representing approximately 6% of all pyogenic spinal infections,\(^70\) and has not been widely addressed in most textbooks. Thirty cases have been reported,\(^42,81,82\) of which 27 were located in the lumbar spine and 3 were located in the subaxial cervical spine.\(^82,83\) Approximately 25% of lumbar facet joint infections are associated with epidural abscess formation,\(^83,84\) and approximately 30% of these are accompanied by a severe neurological deficit.\(^70\) In the cervical spine, 2 of 3 reported cases are associated with epidural abscess formation, and all 3 patients demonstrated a neurological deficit, ranging in severity from hemiparesis to unilateral upper extremity weakness. This suggests that infection of the cervical facet joints is associated with greater morbidity than infection of the lumbar facets.\(^70\) Pyogenic infection involving the C1–C2 facet joint\(^82,85\) was associated with osteomyelitis of the occipitatoaxial complex or the odontoid process, suggesting a secondary pathological entity as opposed to isolated hematogenous facet joint infection.

Treatment for this entity is based on Level IV studies. Uncomplicated cases involving the lumbar spine have been reported to respond successfully to computed tomography–guided or fluoroscopically guided percutaneous drainage followed by 2 weeks of appropriate intravenous antibiotics and 6 weeks of oral antibiotics.\(^30,83,86,87\) Otherwise, open decompression is advocated, but repeated irrigation and debridement is common in spinal infections.\(^1,35,70,88,89\)

Vacuum-assisted closure is a useful tool in the armamentarium of the spinal surgeon with patients susceptible to wound infections. It is usually applied for 3 to 4 days. It allows for retention of the instrumentation and maintenance of spinal correction.\(^90\)

Likewise, percutaneous drainage has not yet been attempted in the cervical spine due to the serious nature of cervical spine infections. This method of treatment has only been considered in cases with epidural abscess formation, neurological deficit, or sepsis.

**CONCLUSION**

Hematogenous pyogenic infection of the spine comprises a wide spectrum of infection that includes spondylitis, diskitis, and spondylodiskitis. The cornerstone of therapy for uncomplicated spondylodiskitis is intravenous antibiotics followed by oral antibiotics and bracing. Few reports exist in the literature comparing the effects of conservative vs operative treatment. Those that are available are retrospective and uncontrolled reviews; however, they tend to demonstrate that operative treatment gives better results in terms of relieving back pain (26% residual back pain) than conservative treatment (64% residual back pain).\(^1\)

It is important to keep in mind that, according to the literature, most patients who underwent surgery had failed conservative treatment or developed paraplegia. Paraplegia is often irreversible if surgery is not performed within the first 36 hours.\(^1,16\)

Physicians should not lose sight of the potential early devastating (eg, paralysis and mortality) and late crippling (eg, painful deformity and spinal stenosis) complications. These complications are usually the result of fulminant destructive spondylodiskitis with epidural abscess. Medical treatment is ineffective for paraplegia, which is irreversible. Furthermore, conservative treatment cannot address established painful deformities and neurological deficit.

**REFERENCES**

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