

Management of Pyogenic Spondylodiscitis: Conservative and Surgical Treatment Strategies

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Abstract

Background: Pyogenic spondylodiscitis requires treatment directed toward infection eradication, preservation or restoration of spinal stability, neurological preservation or recovery, and pain relief. Conservative treatment is the first-line approach for uncomplicated disease without neurological deficit, severe instability, or large epidural abscesses, while surgical treatment is indicated in complicated disease and when conservative management fails.

Objective: To review the conservative and surgical management of pyogenic spondylodiscitis, including spinal immobilization, antibiotic therapy, surgical indications and timing, regional surgical approaches, minimally invasive techniques, instrumentation in infection, prognosis, and the evidence-based treatment algorithm presented in the thesis.

Conclusion: Management should be selected according to disease severity. Conservative treatment is appropriate for uncomplicated pyogenic spondylodiscitis, whereas progressive neurological deficit, septicemia, epidural abscess with neurological compromise, instability, significant deformity, large abscess, or failure of conservative treatment support surgical intervention. The available evidence favors an individualized treatment algorithm, while the optimal surgical technique remains controversial.

Keywords: Pyogenic Spondylodiscitis; Conservative Treatment; Antibiotic Therapy; Surgical Treatment; Instrumentation.

Introduction

Treatment goals: (1) infection eradication; (2) preservation/restoration of spinal stability; (3) neurological preservation/recovery; (4) pain relief^(1,2,3).

First-line for uncomplicated PSD without neurological deficit, severe instability, or large epidural abscesses. Comprises immobilization (bed rest initially ≤ 2 weeks, then brace) and antibiotic therapy⁽⁴⁾.

Conservative Treatment

Spinal Immobilization

Spinal immobilization with bed rest or with bracing decreases pain, stabilizes the spine and prevents deformity. Initially, bed rest is recommended in the first stages of disease, until acute pain is resolved, generally lasting no longer than two weeks. Ambulation using a brace is recommended thereafter. If the cervical spine is involved, a collar or a halo-vest may be applied. A reclining brace may be indicated for thoracic spine lesions. This brace immobilizes the affected spine in the reclining position, reducing the load on the infected vertebrae by distributing weight to the unaffected facet joints^(5,1,6).

Thoracolumbar or lumbosacral brace may be applied, if the thoracolumbar or lumbar spine is affected. In the presence of major defects in the anterior column in the lower lumbar or the lumbosacral spine, bed rest is claimed to be necessary for at least six weeks.

Nevertheless, immobilization-related morbidity, especially in the elderly, should be considered. Bed rest may result in skin ulcerations, deep vein thrombosis, pulmonary embolism or pneumonia. In addition, high rates of pseudarthrosis and instability that may result in spinal deformity and chronic pain have been reported (16% to 50%), conservative treatment discontinuation may be advisable after four to six weeks. If there are no radiological signs of bone fusion, destruction progresses or there is no clinical improvement, prompt treatment with antibiotics is essential^(1,7,8).

Antibiotic Therapy

Empirical therapy should target the most likely pathogens based on risk factors and local resistance patterns. The landmark Randomized Controlled Trial (RCT) by Bernard et al. (4) demonstrated that 6 weeks of antibiotic therapy was non-inferior to 12 weeks in 359 patients, with comparable cure rates (~91%)⁽⁹⁾. IV administration for 2–4 weeks followed by oral step-down guided by CRP decline (>50% reduction) is standard^(10,11,12,13,14). Additionally, the multidisciplinary algorithm proposed by Gatti et al. (15) provides Pharmacokinetic / Pharmacodynamic (PK/PD) optimized antimicrobial recommendations for vertebral osteomyelitis, complementing the Infectious Diseases Society of America (IDSA) 2015 framework.

Higher treatment failure rates are reported in cases with parenteral administration for less than four weeks. However, switching to an oral regimen after a two-week intravenous treatment is also reported to be effective, if enlarged epidural or paravertebral abscesses have been drained and CRP levels have decreased⁽¹⁶⁾.

In cases of methicillin-susceptible Staphylococci, an anti-staphylococcal penicillin or a first-generation cephalosporin are the antibiotic agents of choice. For methicillin-resistant organisms, including most Staphylococcus epidermidis cases, a glycopeptide such as vancomycin may be administered. Linezolid and quinupristin-dalfopristin are alternative options. Additionally, in cases of Streptococcus species, penicillin G is the agent of choice. For gram-negative bacteria, a cephalosporin or a quinolone could be administered, whereas in cases of anaerobes, metronidazole or clindamycin may be used^(5,1).

The pathogen-specific regimens discussed above are summarized in Table 1.

Table (1): Antibiotic Regimens for Pyogenic Spondylodiscitis^(17,18,4)

Pathogen	Preferred Regimen	Duration
MSSA	Anti-staphylococcal penicillin or 1st-gen cephalosporin	6 weeks ^(19,20)
MRSA	Vancomycin (alternatives: linezolid, daptomycin)	6–12 weeks
CoNS	Vancomycin	6–12 weeks
Streptococcus spp.	Penicillin G or ceftriaxone	6 weeks
Enterobacteriaceae	3rd-gen cephalosporin or fluoroquinolone	6 weeks
Pseudomonas	Ceftazidime/cefepime + aminoglycoside	6–8 weeks
Anaerobes	Metronidazole or clindamycin	6 weeks

A risk-stratified protocol for intravenous treatment, oral step-down, total duration, and special considerations is presented in Table 2.

Table (2): Risk-Stratified Antibiotic Duration Protocol for Pyogenic Spondylodiscitis ^(17,18).

Risk Category	Criteria	IV Duration	Oral Step-down	Total Duration	Special Considerations
Low Risk	Negative blood culture; No paraspinal abscess; No hardware; MSSA or culture-negative; Age <75; No endocarditis	2-3 weeks	2-3 weeks	4-6 weeks	Monitor CRP weekly; early mobilization; brace optional
Standard Risk	Positive blood culture OR small abscess (<2.5 cm); No hardware; Immunocompetent; No neurological deficit	4 weeks	2-4 weeks	6 weeks	IDSA 2015 standard; CRP >50% decline by week 2; MRI at 6-8 weeks
High Risk	Positive blood culture AND paraspinal abscess; MRSA; Retained hardware; Immunocompromised; Endocarditis; Age >75	6-8 weeks	4-6 weeks	8-12 weeks	Add rifampin 600mg daily if hardware present; consider ID consult; repeat MRI at 4 weeks
MRSA-Specific	MRSA confirmed (culture/PCR); Vancomycin MIC ≥2; Daptomycin non-susceptible	6-8 weeks (vancomycin or linezolid)	4-6 weeks (linezolid or TMP-SMX)	12 weeks	Trough vancomycin 15-20 µg/mL; linezolid CBC monitoring; consider combination therapy

Surgical Treatment

Indications

Surgical treatment is absolutely indicated in patients with spinal cord/cauda equina compression with progressive neurological deficit; septicemia; epidural abscess with neurological compromise. Relative surgical indications include spinal instability from extensive bone destruction, significant deformity, conservative failure (>4-6 weeks), or large abscess requiring drainage ^(21,17,13,19,22).

Only 10–20% of adult patients require surgery ^(17,23). In children, surgery is rarely indicated ⁽²⁴⁾.

Principles of surgical treatment are important; surgery should aim for decompression of neurological deficits and reconstruction for spinal stability and deformities ⁽²⁵⁾.

Timing of Surgery

Timing of surgical treatment is critical; surgical decompression should be done as an emergency in patients with spinal nerve or cord compression, as prognosis may be poor after 48 hours from the onset of symptoms and signs, despite some authors' claims of good results even after long-term paralysis. Septicemia is also a surgical emergency. Epidural abscesses should be treated before neurological impairment ensues ^(1,26). Moreover, prolonged unsuccessful conservative treatment may compromise the remaining healthy bone stock, leading to major reconstructive operations. Recommendations regarding optimal surgical management are controversial ⁽¹⁴⁾.

Surgical Approaches

There is a wide spectrum of surgical options, including anterior, posterior or combined approaches, with or without instrumentation. Less invasive endoscopic techniques for debridement and reconstruction have also

been described. However, open surgery remains the standard of care, particularly in cases of extensive bone destruction ⁽¹⁾.

Due to lack of specific guidelines for the optimal technique, surgeons often come to a decision considering the general health status, the most suitable spinal approach and instrumentation tailored to the characteristics of each patient and the individual surgeon's preference. Approach selection depends on spinal level, extent of destruction, and presence of neurological deficit ⁽¹⁾.

Current evidence increasingly favors posterior-only instrumentation in many thoracolumbar cases because it provides adequate stability with lower surgical morbidity, while combined approaches remain reserved for extensive anterior column destruction with kyphosis $>30^{\circ}$ ^(1,19,23,27). If the thoracolumbar junction or lumbar spine is affected and the patient experiences neurological deficit or extended epidural infection, stabilization is necessary after decompression. In cases of single segment disease with limited anterior involvement and minor kyphosis, an anterior fusion with bone grafts may be adequate. Posterior lumbar interbody fusion with autologous iliac crest bone graft is also reported to be successful in cases of minor bone destruction ⁽²⁸⁾.

In the cervical spine, an anterior approach followed by grafting and plating may be performed. Locking plates with or without posterior stabilization may be required in multilevel lesions ⁽²²⁾.

In the thoracic spine, considering that stability is maintained by the thoracic cage, a posterior approach with or without instrumentation is usually sufficient. An anterior approach alone may be effective for decompression and fusion in cases of single level involvement without posterior infectious spread. In the presence of extensive anterior destruction and collapse, an anterior approach for debridement, decompression and fusion, followed by additional posterior instrumentation, is recommended ^(1,29).

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The regional approaches and stabilization options described above are summarized in Table 3.

Table (3): Surgical Approaches by Region ^(1,19,30).

Region	Approach	Stabilization
Cervical	Anterior (ACDF) with plating	Plate $\pm$ posterior supplementation
Thoracic	Posterior $\pm$ transpedicular instrumentation	Posterior screws/rod
Thoracic (extensive destruction)	Combined anterior posterior	Anterior cage + posterior instrumentation
Lumbar	Posterior decompression + TLIF/PLIF	Pedicle screws + interbody cage
Lumbar (extensive body loss)	Combined anterior debridement + posterior stabilization	Titanium mesh/PEEK + posterior instrumentation

Minimally Invasive Surgical Techniques in Pyogenic Spondylodiscitis

Minimally invasive surgery (MIS) has emerged as a viable alternative to traditional open approaches in the management of pyogenic spondylodiscitis, particularly in patients with significant comorbidities who may not tolerate extensive open procedures ^(31,32,33).

Percutaneous Endoscopic Debridement and Drainage (PEDD)

Percutaneous endoscopic debridement and drainage (PEDD), performed via a posterolateral transforaminal or interlaminar approach, allows for direct visualization, targeted debridement of necrotic disc material, irrigation with >1000 mL of normal saline, and procurement of microbiological specimens under local or general anesthesia.

A recent systematic review and meta-analysis encompassing 546 patients across 20 studies demonstrated that endoscopic discectomy for thoracolumbar spondylodiscitis is a safe technique with satisfactory clinical outcomes and a high causative pathogen identification rate (54.2–90.4%). The pooled complication rate was 7.8% (95% CI: 5.35–10.47%), with no reported cases of cerebrospinal fluid leak or meningitis. Importantly, the reoperation rate was 13.1% (95% CI: 10.08–16.31%), predominantly in patients who underwent debridement without concurrent instrumentation^(31,32,33).

Percutaneous Endoscopic Interbody Debridement and Fusion (PEIDF)

For patients with spinal instability or extensive vertebral destruction, PEDD alone may be insufficient. Percutaneous endoscopic interbody debridement and fusion (PEIDF) represents an advanced MIS technique combining endoscopic anterior column debridement and allograft interbody fusion with percutaneous posterior pedicle screw instrumentation. In a comparative study of 12 PEIDF versus 15 PEDD patients, the PEIDF group demonstrated significantly lower revision rates (8.3% vs. 58.3%), superior kyphosis correction ($-5.73^\circ \pm 8.74$ vs. $1.07^\circ \pm 2.70$), and higher fusion rates (83.3% vs. 46.7%) at one-year follow-up. Both procedures achieved comparable immediate pain relief and infection control, with blood loss <50 mL in all cases^(31,32,33).

Clinical Outcomes and Indications

MIS techniques offer several theoretical advantages in spondylodiscitis: preservation of posterior tension bands and paraspinal musculature, reduced surgical trauma, earlier mobilization, and lower wound-related complications. However, current evidence consists predominantly of retrospective case series and small comparative studies. The most consensual indication for endoscopic intervention remains refractory infection despite appropriate antibiotic therapy, with spinal instability and neurological deficits traditionally serving as exclusion criteria. Future prospective randomized trials are warranted to determine whether early MIS debridement can reduce the need for subsequent open fusion surgery and prolonged antibiotic courses^(31,32,33).

A comparison of open surgery, MIS-PEDD, and MIS-PEIDF is shown in Table 4.

Table (4): Comparison of Surgical Approaches in Pyogenic Spondylodiscitis^(31,32,33).

Parameter	Open Surgery		MIS-PEDD	MIS-PEIDF	Evidence Level	Key Reference
Approach	Midline posterior / combined anterior-posterior		Percutaneous posterolateral transforaminal or interlaminar	Percutaneous endoscopic anterior + posterior percutaneous screws	Retrospective / Case series	Abreu et al. ⁽³¹⁾
Blood Loss (mL)	200-500		<50	<50	Comparative cohort	Lai et al. ⁽³²⁾
Operative Time	3-5 hours		1.5-2.5 hours	2.5-4 hours	Retrospective	Yang et al. ⁽³³⁾
Hospital Stay (days)	7-14		3-7	5-10	Case series	Abreu et al. ⁽³¹⁾
Complication Rate	15-25%		7.8% (pooled)	8.3%	Meta-analysis	Abreu et al. ⁽³¹⁾

Parameter	Open Surgery	MIS-PEDD	MIS-PEIDF	Evidence Level	Key Reference
Reoperation Rate	5-15%	13.1% (pooled)	8.3%	Meta-analysis	Abreu et al. ⁽³¹⁾
Fusion Rate (1 year)	90-95%	46.7% (PEDD alone)	83.3%	Comparative study	Lai et al. ⁽³²⁾

Instrumentation in Infection

Instrumentation is increasingly accepted after thorough debridement and antibiotics. Titanium demonstrates lower bacterial adherence than stainless steel or PEEK in biofilm studies. Bone grafting (autograft/allograft) is safe after adequate debridement. Single-stage debridement, reconstruction, and instrumentation is safe and effective in selected patients ^(14,34).

Recent evidence from Janssen et al. ⁽¹⁹⁾ demonstrated that minimally invasive posterior pedicle screw fixation achieves comparable outcomes to open instrumentation in thoracolumbar spondylodiscitis, with reduced blood loss and faster recovery. Ibrahim et al. ⁽³⁰⁾ reported 33% spinal dysfunction at median 5.4 years follow-up, with only 3% severe dysfunction, suggesting good long-term outcomes with modern surgical techniques.

Prognosis

Good prognosis predicted by significant CRP/ESR decline within first weeks. Poor prognostic factors: delayed diagnosis, pre-existing motor deficits, advanced age, concomitant infective endocarditis. Modern treatment has reduced lethality to <5% in developed countries ⁽³⁵⁾.

Neurological recovery depends on: (1) duration of compression before decompression; (2) severity of pre-operative deficit; (3) cervical versus thoracolumbar level; and (4) presence of comorbidities. Complete motor recovery is achieved in 40–60% of patients decompressed within 48 hours, declining to <20% with delays >72 hours ^(11,36,37).

Summary of Evidence

The key studies comparing conservative and surgical treatment and related management strategies are summarized in Table 5.

Table (5): Summary of Key Studies on Conservative versus Surgical Treatment ^(4,19,30,38)

Study (Year)	Design	N	Key Findings
Bernard et al. ⁽⁴⁾	RCT	359	6 weeks antibiotics non-inferior to 12 weeks (~91% cure both)
Thavarajasingam et al. ⁽³⁸⁾	Meta-analysis	—	Early surgery may improve pain/function; limited by bias
Park et al. ⁽¹⁸⁾	Retrospective	—	6 weeks sufficient for low-risk recurrence
Kowalski et al. ⁽²⁰⁾	Prospective imaging	—	MRI changes lag behind clinical improvement
Ibrahim et al. ⁽³⁰⁾	Cohort	—	33% spinal dysfunction at 5.4y; 3% severe; no difference by modality
Janssen et al. ⁽¹⁹⁾	Comparative cohort	—	Minimally invasive posterior = open outcomes, less morbidity

Proposed Treatment Algorithm

The following algorithm integrates IDSA 2015 guidelines, the ESCMID multidisciplinary expert opinion on bone and joint infections by Gatti et al. ⁽¹⁵⁾, Bernard et al. ⁽⁴⁾ RCT evidence, and contemporary literature. Thresholds for surgical intervention represent commonly used values reported in literature rather than universally accepted guidelines, reflecting the current evidence gaps.

STEP 1 — INITIAL ASSESSMENT:

- Clinical: History, physical examination (spinal tenderness, neurological deficits)
- Laboratory: ESR, CRP, WBC, blood cultures (≥ 2 sets)
- Imaging: MRI as modality of choice

STEP 2 — RISK STRATIFICATION:

Uncomplicated PSD (no neurological deficit, stable spine, no large abscess):

→ CONSERVATIVE PATHWAY:

- Empirical IV antibiotics (targeted within 48–72h if cultures positive)
- TLSO brace; bed rest ≤ 2 weeks then mobilization
- Monitor CRP weekly (expect $>50\%$ decline)
- Oral step-down after 2–4 weeks if improving
- Total duration: 6 weeks (non-inferior to 12 weeks per Bernard et al. ⁽⁴⁾)
- If no improvement at 4–6 weeks → Re-evaluate / Consider surgery

Complicated PSD (neurological deficit, spinal instability, abscess, sepsis):

→ SURGICAL PATHWAY:

- Emergency decompression for progressive neurological deficit (ideally $<48\text{h}$)
- Debridement $\pm$ drainage of abscess
- Stabilization with instrumentation (titanium preferred)

Conclusion

Treatment goals in pyogenic spondylodiscitis are infection eradication, preservation or restoration of spinal stability, neurological preservation or recovery, and pain relief. Conservative treatment is first-line for uncomplicated disease, while surgery is indicated for progressive neurological deficit, septicemia, epidural abscess with neurological compromise, instability, significant deformity, failure of conservative treatment, or large abscess requiring drainage. Timing is critical in neural compression, and the choice of surgical approach should be individualized according to spinal level, extent of destruction, neurological deficit, general health status, and the need for stabilization. Minimally invasive techniques are viable alternatives in selected patients, although current evidence remains predominantly retrospective and further prospective randomized trials are warranted.

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