

Timing and prognosis of surgery for spinal epidural abscess: A review

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Abstract

Background: The nonsurgical versus surgical management of spinal epidural abscesses (SEAs) remains controversial. Even with the best preoperative screening for multiple risk factors, high nonoperative failure rates are attended by considerable morbidity (e.g., irreversible paralysis) and mortality. Therefore, the focus remains on early surgery.

Methods: Most papers promote early recognition of the clinical triad (e.g., fever [50%], spinal pain [92–100%], and neurological deficits [47%]) for SEA. They also identify SEA-related risk factors for choosing nonsurgical versus surgical approaches; advanced age (>65 or 80), diabetes (15–30%), cancer, intravenous drug abuse (25%), smoking (23%), elevated white blood cell count (>12.5), high C-reactive protein >115, positive blood cultures, magnetic resonance imaging/computed tomographic documented cord compression, and significant neurological deficits (e.g., 19–45%).

Results: Surgical options include: decompressions, open versus minimally invasive biopsy/culture/irrigation, or fusions. Up to 75% of SEA involve the thoracolumbar spine, and 50% are located ventrally. Wound cultures are positive in up to 78.8% of cases and are often (60%) correlated with positive blood cultures. The most typical offending organism is methicillin resistant *Staphylococcus aureus*, followed by methicillin sensitive *S. aureus*. Unfortunately, the failure rates for nonoperative treatment of SEA remain high (e.g., 41–42.5%), contributing to significant morbidity (22% risk of permanent paralysis), and mortality (3–25%).

Conclusion: The vast majority of studies advocated early surgery to achieve better outcomes for treating SEA; this avoids high failure rates (41–42.5%) for nonoperative therapy, and limits morbidity/mortality rates.

Key Words: Medical management, neurological deficit, open surgery: Minimally invasive surgery, paraplegia, spinal epidural abscess, surgical decompression, timing

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INTRODUCTION

The nonsurgical versus surgical management of spinal epidural abscesses (SEAs) remain controversial. Even the best preoperative screening for multiple risk factors (clinical, laboratory, and radiographic) may result in high nonoperative failure rates, with significant morbidity/mortality. Most SEA patients, ranging in age

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from their mid 50s to mid 60s, present with the classical triad of fever (50%), spinal pain (47.1–100%), and weakness (19–55.8%).^[1,8,24,27,29] Major clinical risk factors predisposing to SEA include; diabetes (15–35.8%), advanced age (>50, 65, or 80), renal disease (30.2%), vascular disease (31.3%), smoking 23%, cancer history (16%), intravenous (IV) drug abuse (10–39.1%), alcohol abuse (4%), sepsis (15–40%) (methicillin resistant *Staphylococcus aureus* [MRSA] or methicillin sensitive *S. aureus* [MSSA]), and positive cultures (59.3–70.7%) [Tables 1-3].^[9,12,24,26,29] Laboratory, diagnostic, and neurological criteria that prompt

early surgery include; elevated white blood cell count (WBC > 12.5) C-reactive protein (CRP) (>115), positive blood cultures, magnetic resonance imaging (MRI)/computed tomographic (CT) images of cord compression, and neurological deficits [e.g., 19– 45%].^[24,27]

The timing of SEA surgery is typically categorized as early if performed at/within <24 h (mean 11.2 h) or late if performed after >24 h (mean 59 h).^[3,11] SEA surgical options include direct open versus minimally invasive surgical (MIS) techniques (e.g., CT endoscopically guided, apical laminectomies, other) to achieve decompression

Table 1: Diagnosis and outcomes for series of >100 cases of SEAs

Author (reference) Pathology	Number of patients/SEA/pathology Average age Symptoms Risk factors	Surgical versus nonsurgical treatment other	Multiple factors: Location MRI findings organism	Outcomes Mortality recommendation
Moudgal <i>et al.</i> ^[19] 116 SEA	544 contaminated ESIs 153 fungal infections	116 surgery for SEA or phlegmon	Abscess, phlegmon, arachnoiditis, osteomyelitis	Mortality 5 died
Schoenfeld and Wahlquist ^[26] 30,274 SEA	30,274 SEA NIS 30% diabetes 19% paralysis Age >80 Liver/renal disease	30,274 surgery SEA	26% one or > complication	3% mortality
Shweikeh <i>et al.</i> ^[29] 106 SEA	106 SEA Average age 63.3 47.1% back pain 47.1% focal deficits 35.8% diabetes 31.3% vascular disease 30.2% renal disease	63 surgery and antibiotics Fusion 30.2% Diskectomy 22.2% Corpectomy 14.3%	75% thoracolumbar 50% ventral 70.7% MRSA/MSSA 6.6% Streptococcus	60.7% good 39.3% poor Early surgery <36-72 h after deficit
Shiban <i>et al.</i> ^[27] 33 SEA/113	113 spondylodiscitis Average age 65 92% pain 35% deficits	33 SEA (29%) Antibiotics; IV 14.4 days Oral 3.2 months	Lumbar 60% Thoracic 17% Cervical 18%	111 (98%) infection resolved 2 mortalities endocarditis-sepsis
Kim <i>et al.</i> ^[15] 355 SEA	355 patients Cord deficits Diabetes age >65 MRSA	127 nonsurgical 73 succeeded 54 (42.5%) failed	Excluded phlegmon	Nonoperative therapy SEA: No risk factors and close monitoring
Patel <i>et al.</i> ^[24] 128 SEA	128 SEA Average age 52.9 100% pain 50% fevers 47% weakness 39.1% IV drugs Medical treatment failure 21.9% diabetes CRP >115 WBC >12.5 + blood cultures	77 surgery (primary) and antibiotics 51 nonoperative 30 succeeded 21 (41%) failed Delayed surgery	54.7% lumbar 39.1% thoracic Average 3.85 levels 36% ventral 41% dorsal 23% 360 MSSA 40% MRSA 30%	Early surgery=Better outcomes SEA treated medically requires vigilance with high failure rate 41%
Roßbach <i>et al.</i> ^[25] 13/135 SEA	135 epidural infections 13 SEA (subset)	102 Group I: Asia E 33 Group II: Asia A-D	13/33 Group II: With SEA	SEA with deficits=Early surgery
Arko <i>et al.</i> ^[4] 1099 SEA	1099 SEA Average age 57.24 62.5% male	59.7% surgery 40.3% nonsurgical	63.6% MRSA/MSSA or 6.8% Streptococcus species	

MRSA: Methicillin resistant *Staphylococcus aureus*, MSSA: Methicillin sensitive *Staphylococcus aureus*, IV: Intravenous, CRP: C-reactive protein, WBC: White blood cell count, NIS: Nationwide Inpatient Sample, ESI: Epidural steroid injection, SEAs: Spinal epidural abscesses, MRI: Magnetic resonance imaging

Table 2: Diagnosis and outcomes for series of 40-<100 cases of SEA

Author (reference) Pathology	Number of patients/SEA/pathology Average age Symptoms Risk factors	Surgical versus nonsurgical treatment Successes/failures Other	Multiple factors: Location MRI findings organism	Outcomes Mortality
Doutchi <i>et al.</i> ^[9] 32%/50 SEA	50 osteomyelitis SEA 32% 40% deficit 24% diabetes 16% cancer 10% IV drugs 4% alcohol abuse	Surgery 41 Fusion 26% Drain abscess 32% Decompression 40%	Antibiotics 123 days	Time to diagnosis; average 36 days Postoperative 22% deficits
Ghobrial <i>et al.</i> ^[12] 40 cervical discitis/SEA	40 cervical SEA 25% IV drugs 15% DM 23% smokers	Surgery 65% 360 20% ventral 5% dorsal	30% C67 28% C56 5% C1/2 5% C7T1	Advocated early surgery
Shousha <i>et al.</i> ^[28] 50 SEA	50 SEA Group A versus B 20 (1994-1999) A 85% single segment 30 (2004-2009) B 43.3% multiple segments	50 surgery Deficits 40% versus 45% Sepsis 15% versus 40% Frequency SEA 60% versus 80%	Anterior surgery 35% versus 56.7% 8-12 weeks of antibiotics	Mortality 5% versus 10%
Ghobrial <i>et al.</i> ^[11] 87 SEA	87 SEA Early surgery <24 h Late surgery >24 h	Early surgery 85% preoperative deficit Late surgery 64% preoperative deficits	Most MRSA/MSSA (51=59.3%)	Early surgery <24 h=Better outcomes
Alton <i>et al.</i> ^[3] 62 cervical SEA	62 cervical SEA 3 groups Early surgery (24 h) Nonsurgical only Failed nonsurgical (average 7.02 days)	38 early surgery Motor improved 11.89 patients 24 nonsurgical 6 succeeded Motor improved 2.3 patients Nonsurgical 18 failed Delayed surgery Motor worse 15.89 patients	Medical failure rate 75% (18/24)	Recommend early surgery for all cervical SEA
Adogwa <i>et al.</i> ^[2] 82 SEA	82 SEA Average age 65 >50 years of age Baseline pain Paraplegia Dorsal SEA	30 surgery 52 nonsurgical Antibiotic/CT aspiration Positive blood cultures	Good outcomes Surgical 7/30 (23%) Nonsurgical 5/52 (10%)	Mortality 20% Surgical 9 (30%) Nonsurgical 11 (21%)
Connor <i>et al.</i> ^[8] 72 SEA	72 SEA Average age 51.4 67.5% pain 55.8% weakness 28.6% radiculopathy 5.2% myelopathy	48 (66.7%) surgery <82 h Average time admission to surgery 5.5 days	Lumbar 50.6% Thoracic 26% Cervical 23.4% MRSA 31.2% 78.8% surgical cultures positive	Outcomes 79.2% improved 8.3% same 12.5% worse

MRSA: Methicillin resistant *Staphylococcus aureus*, MSSA: Methicillin sensitive *Staphylococcus aureus*, SEA: Spinal epidural abscess, MRI: Magnetic resonance imaging, IV: Intravenous, DM: Diabetes mellitus

(40%) or drainage of abscesses (32%) (biopsy/culture/irrigation) with or without fusion (26%).^[9,12] Up to 75% of SEA involve the thoracolumbar spine and 50% are typically ventrally located (e.g., anterior surgery warranted 35–56.7% of cases).^[28,29] Open or MIS (e.g., biopsy/aspiration) surgery yield positive wound cultures in up to 78.8–90.5% of cases (not 100%).^[8,33,34] Early surgery typically achieves better outcomes for patients with

SEA, while those treated nonsurgically continue to exhibit unacceptably high failure rates (41–42.5%) accompanied by increased morbidity (up to 22% permanent paralysis) and mortality (rates from 1.8% to 25%).^[2,8,9,26,27,29]

This review provides an overview of the presentation, clinical, radiographic, and surgical management of SEA [Tables 1-4]. The vast majority of studies advocate early surgery, factoring in specific high risk factors while only

Table 3: Diagnosis and outcomes for series of 1-<40 cases of SEAs

Author (reference) Pathology	Number of patients	Surgical treatment	Course of treatment	Outcomes
French <i>et al.</i> ^[10] 19 SEA	19 SEA and/or epidural hematomas		Failure to operate within 48 h	Higher medicolegal risk
Yang <i>et al.</i> ^[33] 21 Not SEA	21 advanced lumbar infections Not SEA Significant deficits excluded	3 groups 3 surgery patients Debridement/fusions within 2 weeks Nonsurgery 18 antibiotics alone	Positive cultures 19 (90.5%) of 21 biopsies	Complications 1 delayed fusion L5S1 2 lumbar root paresthesias
Yang <i>et al.</i> ^[34] 32 SEA	32 spondylodiscitis subset SEA PEDI	32 nonsurgical 26 (81.3%) nonsurgery success 6 delayed surgery	28 (87.5%) positive bacterial cultures 27 (84.4%) relief of back pain	PEDI recommended; for those not responding to antibiotics alone
Talia <i>et al.</i> ^[30] 7 SEA	7 SEA 5 bacterial 2 TB	7 surgery Decompression and fusion antibiotics 12 months	6 thoracic 2 lumbar 1 cervical	No complications
Avanali <i>et al.</i> ^[5] 23 SEA	23 SEA	23 laminectomies		10 improved 2 normal 11 paraplegic
Lee <i>et al.</i> ^[17] 1 SEA	1 lumbar infection Nonsurgical	1 cervical SEA 3 days later Laminectomy	Delayed cervical SEA surgery	Remained quadriparetic
Hwang <i>et al.</i> ^[14] 1 SEA	1 SEA holocord	1 holocord Alternating unilateral Laminectomy	Excellent result	No deficit
Ohnishi <i>et al.</i> ^[22] 1 SEA cervical	1 cervical SEA Diabetes	1 nonsurgical First MRI: No cord compression Plegic 2 weeks later-Second MRI cord compression	First treated: Perperacillin and steroids No CSF studies	Eventual 360 fusion
Oh <i>et al.</i> ^[21] 1 SEA	1 cervical SEA	1 nonsurgical IV antibiotics	Strep viridens SEA/ endocarditis	No deficit
Hernández-Puiggròs <i>et al.</i> ^[13] 1 SEA	1 SEA thoracic	1 SEA epidural catheterization lung resection	6 days later infected treated antibiotics alone	No surgery No complications
Abd-El-Barr <i>et al.</i> ^[11] 2 SEA	2 holocord SEA C1/2-L5S1	2 focal apical laminectomy Irrigation with antibiotic/saline passing catheter	2 infections resolved No instability	Procedure: Focal apical laminectomy
Nicolosi and Pratt ^[20] 1 SEA	1 thoracic/lumbar SEA and lumbar osteomyelitis	1 L45 fusion Laminectomy T9-L1	Etiology: Calcaneal osteomyelitis	1 residual deficit Used cane/walker

PEDI: Percutaneous endoscopy dilute betadine solution irrigation, SEA: Spinal epidural abscess, TB: Tuberculosis, MRI: Magnetic resonance imaging, CSF: Cerebrospinal fluid, IV: Intravenous

the minority chose nonoperative intervention in their general absence.

SPINAL EPIDURAL ABSCESS DUE TO EPIDURAL STEROID INJECTIONS

Cervical meningomyelitis following lumbar epidural steroid injection: Case study

Lee *et al.* noted that the greater number of lumbar epidural steroid injection (ESI) are correlated with higher complication rates.^[17] They presented a 60-year-old diabetic male who developed an S1 epidural hematoma following multiple lumbar ESI; he was started on antibiotics with the initial diagnosis of an SEA. Three

days later, when he developed progressive upper and lower extremity weakness, the cervical MRI documented a cervical/brain stem SEA; despite debridement, he failed to neurologically improve.

Spinal and paraspinal fungal infections (abscess, phlegmon, arachnoiditis, and osteomyelitis) associated with the contaminated methylprednisolone epidural steroid injection

Moudgal *et al.* tracked patients who developed spinal or paraspinal fungal infections due to the injections of exserohilum-contaminated methylprednisolone (Michigan Department of Community Health, electronic medical records (EMRs), and MRI reports).^[19] Out of 544 patients receiving contaminated ESI, 153 (28%) were

Table 4: Summary of review articles

Author (reference) Pathology	Number of patients	Surgical treatment	Course of treatment	Outcomes Recommendations
Krishnamohan and Berger ^[16] SEA		20% Staphylococcus aureus originating from the skin and/ or soft tissues	Triad Fever Spinal pain Deficits	Early diagnosis MRI emphasized
Tuchman <i>et al.</i> ^[31] SEA	28 series (minimum of 30 patients) 26 of 28 retrospective	Antibiotics only Unable to have surgery Complete cord injury >48 h Little concern for ascending lesion	Few reasons for medical management alone in SEA	Advocated early surgery for good risk candidates Delayed deficits do not fully resolve even after prompt surgery
Arko <i>et al.</i> ^[4] SEA	Average age 57.24 62.5% male 1099 patients 12 articles	59.7% surgery 40.3% treated medically	Staphylococcus aureus (63.6%) and Streptococcus species (6.8%)	Advocate early surgery
Moritani <i>et al.</i> ^[18] SEA	4 types SEA	1. Epidural/paraspinal SEA + spondylodiscitis 2. Epidural/paraspinal SEA/ facet joint infection	3. Epidural/paraspinal SEA no spondylodiscitis or facet joint infection	4. Intradural abscess (subdural abscess, purulent meningitis and spinal cord abscess)
Verdú-López <i>et al.</i> ^[32] SEA and other infections	MIS percutaneous image guided techniques		To address pine infections	
Avilucea and Patel SNI 2012 SEA	General review	Early diagnosis of SEA	Early treatment	
Krishnamohan and Berger ^[16] SEA	Emphasized early diagnosis with MRI Triad Fever Spinal pain Neurological deficit	Location Thoracic Lumbar Cervical	Most common organism: <i>Staphylococcus aureus</i> (20%)	Early surgery yields best outcomes

SEA: Spinal epidural abscess, MIS: Minimally invasive surgery, MRI: Magnetic resonance imaging

diagnosed at one institution with probable/confirmed spinal/paraspinal fungal infection at the injection site; 41 had meningitis/spinal or paraspinal infection, while 112 had only spinal/paraspinal infection. MRI findings included; abscess, phlegmon, arachnoiditis, and osteomyelitis. Surgical debridement was performed for 116 patients who demonstrated epidural phlegmon and/or SEA; fungal infection was demonstrated in 78 patients (51%) (e.g., hyphae in tissues, positive polymerase chain reaction, or culture). The authors concluded that of the 153 patients who developed spinal/paraspinal fungal infection at the site of ESI contaminated with methylprednisolone, 116 (76%) required surgery plus treatment with antifungal agents; 5 ultimately expired.

TIMING OF SURGERY FOR SPINAL EPIDURAL ABSCESES

Optimal timing of surgery for spinal epidural abscess within 24 h

Utilizing meta-analyses, Ghobrial *et al.* focused on the optimal timing of surgery for SEA or other spinal infections (e.g., osteomyelitis, osteodiscitis, and spondylodiscitis).^[11]

They noted that 1 of 10,000 hospitalized patients has a SEA/other spinal infections with a mortality rate of up to 16%; their hypothesis was that patients undergoing early surgery had better outcomes. This study involved a retrospective analysis (2009–2011) of 87 patients who had early (evacuation within 24 h) versus delayed surgery (>24 h) for the treatment of SEA. They were all assigned American Spinal Injury Association (ASIA) Impairment Scale grades. Patients averaged 55.5 years of age. Of the 54 having early surgery (admission to incision, 11.2 h), 45 (85%) had neurological deficits, while of 33 undergoing late surgery (mean 59 h), 21 (64%) had neurological deficits. Notably, those in the delayed surgery groups were significantly older (>10 years; 59.6 vs. 51.8 years, $P = 0.01$). The two groups showed no significant differences regarding prior revision surgery, body mass index, IV (intravenous) drug abuse, smoking, prior radiation therapy, diabetes, chronic infection, and prior osteomyelitis. The most common organism isolated was MSSA ($n = 51$, 59.3%) and MRSA ($n = 18$: 21%). The authors concluded; surgery at <24 h correlated with a better neurological grade at discharge.

Preoperative neurological status best determined outcome for bacterial spinal epidural abscess

In their literature review of 40 SEA articles, Shweikeh *et al.* emphasized the import of early recognition of bacterial SEA as the preoperative neurological status determined the best postoperative outcome.^[29] Early surgery defined as within 36–72 h from onset of neurological deficits, was recommended as opposed to medical treatment alone. The latter correlated with high failure rates attributed to delayed surgery greater permanent morbidity.

EPIDEMIOLOGY, DIAGNOSIS, AND MANAGEMENT OF OSTEOMYELITIS AND/OR SPINAL EPIDURAL ABSCESES SUMMARIES OF STUDIES INVOLVING >100 CASES

Mortality, complications, and charges for spinal epidural abscesses in 30,274 patients from a Nationwide Inpatient Sample Study

Schoenfeld and Wahlquist looked at the Nationwide Inpatient Sample of 30,274 individuals (2006–2011) in order to predict the morbidity/mortality (in-hospital: Failure to rescue from a complication) and total charges for patients undergoing SEA surgery [Table 1].^[26] Patients averaged 57.4 years (± 14.7 years) of age, 63% were caucasian, 27% were underinsured, 30% had diabetes, and 19% presented with some degree of paralysis (19%). Other medical comorbid factors included; age over 80, liver disease, or renal failure. Notably, 26% of patients had one or more complications, and 3% died during their hospital stay. Of interest, the average total charge was \$159,782, but with a marked range from \$4008 to \$3,373,410 likely reflecting the prolonged hospitalizations required for the patients incurring marked increased morbidity.

Medical and surgical management of 1099 spinal epidural abscesses: A systematic review

Arko *et al.* noted that SEA have typically (particularly prior to 1999) been managed with emergent surgery/decompression and antibiotic therapy [Table 1].^[4] Here, utilizing PubMed Boolean search engines, they identified 12 articles that directly contrasted operative versus nonoperative treatment of SEA involving 1099 patients who had MRI studies obtained early in the clinical course. Patients averaged 57.24 years of age, 62.5% were male, and blood and wound cultures documented *S. aureus* (MRSA/MSSA: 63.6%) or *Streptococcus* species (6.8%). Surgery was performed in 59.7% of patients, while 40.3%, typically without neurological deficits, were treated with the antibiotics alone.

Independent risk factors help predict failure of nonoperative management of 355 spinal epidural abscesses

Kim *et al.* stipulated that medical management may be successful in a subset of patients with SEA and that all

do not require surgery [Table 1].^[15] Notably, they excluded postsurgical SEA or phlegmon without an abscess, as well as those with a complete spinal cord injury from SEA for longer than 48 h. Out of 355 patients with SEA who averaged 60 years of age, 127 were managed nonsurgically; 73 were successfully treated without surgery while another 54 failed nonsurgical therapy and required delayed surgery. The most significant risk factors that appeared to contribute to failed medical treatment included; preoperative incomplete or complete spinal cord deficits, age over 65, diabetes, and MRSA. Without such risk factors, nonoperative therapy for SEA “may be considered as the initial line of treatment with close monitoring.”

Hematogenous vertebral osteomyelitis (not spinal epidural abscess) caused by Gram-negative bacteria in 313 cases

In a study involving three tertiary-care centers over a 7 year period, Park *et al.* found that Gram Negative bacteria (GNB) were responsible for 65 (20.8%) of the 313 hematogenously spread cases of vertebral osteomyelitis (HVO).^[23] Those with GNB HVO included more diabetic females. Outcomes were similar for the GNB versus MSSA groups regarding in-hospital mortality (4.6% vs. 7.8%), recurrence (9.7% vs. 4.3%), and morbidity. They did recommend antibiotic therapy for ≥ 8 weeks for those in the GNB HVO group.

Surgical treatment of spondylodiscitis in 135 patients with the neurological deficits: Predicting clinical outcomes

Roßbach *et al.* successfully utilized preoperative neurological deficits in 135 patients with CT/MRI documented SEA (13 patients) or spondylodiscitis (122 patients) to predict clinical outcomes [Table 1].^[25] There were 102 Group I patients without neurological deficits (Frankel E) while the remaining 33 in Group II were in Frankel Grades A-D (e.g., 13 of 33 patients had a SEA). Twenty-eight of the 33 patients in poorer Frankel grades in Group II were treated surgically; for the 20 without a SEA, 11 improved and 9 remained unchanged while 4 of 13 with SEA died.

High failure rates with nonoperative management of 128 spinal epidural abscesses; utility of four major risk factors

Patel *et al.* retrospectively evaluated how multiple risk factors impacted outcomes of SEA managed medically or with antibiotics combined with surgery [Table 1].^[24] They looked at 128 consecutive patients who presented with spontaneous SEA averaging 52.9 years of age. Patients had bacterial SEA (radiographic/surgical confirmation); they excluded those thought to have SEA but with negative intraoperative findings/cultures. The patients were followed an average of 241 days. Chief complaints included; pain (100%), fevers (50%), and weakness (47%).

The location of lesions included; 54.7% lumbar, and 39.1% thoracic (average 3.85 disc levels). Lesions were located: 36% ventral, 41% dorsal, and 23% circumferentially. Major risk factors included; IV (intravenous) drug abuse (39.1%), and diabetes mellitus (DM) (21.9%). Pathogens included; MSSA (40%) and MRSA (30%). Primary surgery and antibiotics were utilized in 77 patients (Group 2). However, for those 51 managed nonoperatively, 30 were successfully treated while 21 patients (41%) failed medical management (e.g., demonstrated progressive motor deficit or increased pain and required delayed surgery) [Group 3]). Medical management failure correlated with four risk factors; DM, CRP >115, WBC >12.5, and positive blood cultures (bacteremia). The authors concluded; early surgery improves neurologic outcomes, whereas nonsurgical management has a high (41%) failure rate. Furthermore, four risk factors help predict those likely to become nonoperative failures.

Retrospective evaluation of surgically treated spondylodiscitis in 113 patients

Shiban *et al.* retrospectively analyzed 113 consecutive patients who had surgical decompression/instrumentation performed for spondylodiscitis (2006 and 2010) at one institution; SEA were noted in 33 patients (29%) [Table 1].^[27] Patients averaged 65 years of age. Infections involved the lumbar spine in 68 (60%), thoracic spine in 19 (17%), and cervical spine in 20 (18%) cases. Preoperatively, the patients typically exhibited both pain (92%) and neurological deficits (40 patients: 35%); postoperatively, deficits resolved in 20 patients, while 14 had partial recoveries, and 6 showed no improvement. Postoperative IV antibiotics (given for 14.4 ± 9.3 (mean \pm standard deviation [SD]) days) were followed by 3.2 ± 0.8 (mean \pm SD) months of oral therapy. They observed full resolution of infection in 111 (98%) cases; however, 2 died of septic shock attributed to endocarditis. The authors, therefore, recommended early surgery for newly diagnosed spinal infections including SEA.

Institutional series with bacterial spinal epidural abscesses in 106 patients

Shweikeh *et al.* evaluated bacterial SEA encountered at one institution over an 11-year period (2001–2012) utilizing the electronic medical record (EMR) while also reviewing the pertinent literature (e.g., PubMed 2000–2011) [Table 1].^[29] Their hospital-based series identified 106 patients with bacterial SEA averaging 63.3 ± 13.7 years of age; 65.1% of patients were male. Classic symptoms of SEA included; back pain (47.1%) and focal neurological deficits (47.1%). Furthermore, 75% were located in the thoracolumbar spine, with more than 50% found ventrally. Historical predisposing comorbid risk factors included; DM (35.8%), vascular disease (31.3%), and renal insufficiency/dialysis (30.2%). Organisms responsible for SEA included; *S. aureus* (MRSA/MSSA: 70.7%), and *Streptococcus* spp.

(6.6%). Both surgery and antibiotics were utilized to manage 63 (59.4%) patients. Surgical procedures included; spinal fusion (19 patients; 30.2%), discectomy (14 patients; 22.2%), and corpectomy (9 patients; 14.3%). Outcomes at 8.4 ± 26 weeks (range 0–192 weeks) were categorized as good (60.7%) or poor (39.3%).

SUMMARIES OF SPINAL EPIDURAL ABSCESS CASES INVOLVING 40 TO <100 CASES

Surgery versus medical management of 82 spinal epidural abscesses in patients 50 years of age or older

Adogwa *et al.* analyzed SEAs in 82 patients over the age of 50 treated at one institution (15 years) (1999 and 2013); 30 [37%] had surgery, while 52 [63%] were treated with antibiotics/CT-guided aspiration or antibiotics based on blood cultures alone.^[2] Patients averaged 65 ± 8.58 years of age and were followed for an average of 41.38 ± 86.48 weeks. Good outcomes were observed in 12 patients; in 7 patients (23%) with surgery versus 5 (10%) without surgery. The clinical status of 41 patients (50%) was unchanged (e.g., for 10 [33%] after undergoing surgery vs. 31 [60%] who were treated nonoperatively). Critically, 20 patients (25%) died; 9 (30%) were treated operatively versus 11 (21%) who were treated nonoperatively. Poor outcomes correlated with; increased baseline pain, paraplegia, or quadriplegia on initial presentation, and dorsally located SEA.

Operative versus nonoperative management of 72 spinal epidural abscess

Connor *et al.* retrospectively reviewed nonoperative versus operative treatment of SEA [Table 2].^[8] They identified 77 patients averaging 51.4 years of age who presented with axial pain (67.5% of cases), focal weakness (55.8%), radiculopathy (28.6%), and myelopathy (5.2%). SEA involved the lumbar 39 cases [50.6%], thoracic spine in 20 cases [26.0%], and cervical spine in 18 cases [23.4%], respectively. Surgical site interventional biopsy/cultures documented organisms in 52 cases (78.8%), and correlated with blood culture results in 36 (60.0%) cases. Peripheral blood cultures were negative in 32 (45.1%) of 71 patients. MRSA was found in 24 cases (31.2%). The mean duration between admission and surgery was 5.5 days (range 0–42 days; within 72 h in 66.7% of cases). Outcomes in 72 cases showed; 57 patients (79.2%), improved, 6 (8.3%) improved minimally, or 9 (12.5%) showed no improvement/worsening. More advanced patient age and more severe preoperative deficits significantly correlated with poorer outcomes.

Poorer outcomes for managing 62 cervical spinal epidural abscesses without versus with early surgery

Alton *et al.* retrospectively evaluated the risk factors associated with the neurological outcomes for 62 patients with cervical SEA treated either with antibiotics alone

(e.g. originally neurologically intact (Group 1) or with delayed deterioration (Group 3)) versus early surgery (Group 2) [Table 2].^[3] Using EMRs they tracked motor scores (MS) and neurological outcomes (ASIA score) for the patients in three treatment groups: medical treatment alone, failed medical management leading to subsequent surgery, and early surgery. Of the 62 patients in the series, 24 were initially managed medically; 6 in Group 1 were successfully managed medically alone (MS increased 2.3 points), while 18 (75%) in Group 3 failed medical treatment and required delayed surgery (time to odds ratio 7.02 days) with a net MS drop of 15.89 (SD 24.9). The remaining 38 patients successfully underwent early surgery (Group 2) (average time to surgery 24.4 h) with better outcomes (average MS increase 11.89 points). The authors concluded that for treating cervical SEA, early surgery resulted in better outcome/MS scores whereas nonsurgical management requiring delayed surgery correlated with high failure rates (75%) and poorer neurological outcomes (average MS drop of 15.89 points).

Epidemiology of vertebral osteomyelitis in 50 patients

Doutchi *et al.* evaluated the morbidity of vertebral osteomyelitis in 50 patients over a 5-year period [Table 2].^[9] Patients averaged 55 years of age; 84% were males. Comorbidities in 62% of patients included: DM (24%), malignancy (16%), IV drug use (10%) and alcoholism (4%). Etiologies of infection in 66% of cases involved postoperative (18%) versus hematogenous infection (48%) sources. Diagnoses were confirmed over an average of 36 days. One organism was present in 92% of cases Gram-positive bacteria [76% of cases], and Gram-negative bacteria [GNB] [18% of cases]. Antibiotics were administered over an average of 123 days. Surgery in 41 of 50 cases included; fusion (26%), drainage of abscesses (32%), or decompression alone (40%). Postoperatively, the patients complained of pain (24%), and demonstrated a 22% incidence of continued neurologic deficits (more with cervical disease). The authors concluded that despite the availability of better diagnostic studies and improved surgical techniques, too many patients exhibited significant, irreversible neurologic deficits attributed to osteomyelitis.

Management of 50 patients with cervical spondylodiscitis/spinal epidural abscesses plus literature review

Shousha *et al.* evaluated the surgical treatment (debridement/reconstruction and antibiotics for 8–12 postoperative weeks) and outcomes for 50 consecutive patients with cervical spondylodiscitis/SEA managed at one institution [Table 2].^[28] The first 20 (Group A) patients had surgery from 1994 to 1999 while 30 (Group B) patients were treated between 2004 and 2009. The average age for the patients in series A was 59.7; this

increased to 64.5 years of age in series B. The extent of neurological deficits remained similar (40–45%) for both groups. However, the percentage of sepsis for Groups A and B increased from 15% to 40%, while the incidence of clearly defined SEA increased from 60% to 80%. Notably SEA also increased from being monosegmental in Group A (85%), to involving 2–3 segments (43.3%) in Group B. There was also a trend favoring more anterior surgery in the latter group; (35%) in Group A, and 56.7% for Group B (56.7%). Patients followed an average of 2.8 years. The overall mortality increased from 5% to 10% in the two respective series.

Surgery for 40 cervical spinal epidural abscesses: Increased circumferential management

Ghobrial *et al.* retrospectively analyzed 40 consecutive patients from multiple studies (1997–2011) presenting with cervical SEA.^[12] In these studies, patients were progressively managed with single-stage anteroposterior decompressions and stabilization procedures rather than separate operations [Table 2].^[12] Clinical predisposing risk factors included; average age of 53, IV drug abuse in 10 patients (25%), 6 (15%) with diabetes, 6 (15%) with cancer, 2 with prior neck irradiation, and 9 (23%) who were smokers. Discitis predominantly occurred at C6/C7 in 12 (30%) patients, and at C5/C6 in 11 (28%) patients. Most patients were ASIA score D (20 patients (50%)), followed by ASIA score E (9 patients (28%)). MRI studies documented that 17 (43%) SEA was dorsal, 12 were ventral (30%) while 11 were circumferential (28%). Most were managed with 360 procedures (e.g., anterior followed by posterior decompression/fusion [$n = 26$, 65%]), while 8 (20%) had a ventral, and 6 had dorsal approaches (15%). Fusion was achieved in 39 of 40 (97.5%) patients. The authors concluded that for cervical SEA, acute evacuation/decompression, and shifting to staged treatment did not increase complications rates.

SUMMARIES OF STUDIES INVOLVING I TO <40 CASES OF SPINAL EPIDURAL ABSCESSSES

Treatment of primary pyogenic spinal epidural abscess: Import of timing of surgery in 23 patients

Avanali *et al.* noted that SEA, even when diagnosed and treated in a timely fashion, often leads to irretrievable neurological deficits [Table 3].^[5] They evaluated the results for 23 patients whose SEA were diagnosed later in the course of their disease.; only 2 had a normal neurological function, 11 were plegic while the remaining 10 experienced some improvement in function.

Safety of instrumentation/fusion with surgical debridement of osteomyelitis for spinal epidural abscesses in 7 cases

Following radical debridement, Talia *et al.* evaluated the safety/efficacy of single-stage instrumentation/

fusion (6 thoracic, 2 lumbar, and 1 cervical infections) in 9 patients (5 diabetics) with spinal infections (e.g., vertebral osteomyelitis or SEA).^[30] Seven patients had bacterial infections (predominantly *S. aureus*) while 2 had tuberculosis. All were treated with antibiotics for up to 12 postoperative months, and neither developed complications or the need to remove of instrumentation.

Cervical osteomyelitis/thoracic myelitis and meningitis in a diabetic patient

Ohnishi *et al.* reported on a 45-year-old male with untreated diabetes, who presented paraparetic after 2 weeks of fever, back pain, and what was diagnosed as flu/gastroenteritis [Table 3].^[22] With the original diagnosis of infectious meningitis/myelitis, he was presumptively given piperacillin and steroids (e.g., no cerebrospinal fluid [CSF] study). At the next institutions, with a high fever and full-blown paraplegia, he underwent a lumbar puncture that revealed a yellowish CSF, characterized by polynucleosis, and hypoglycorrhachia but with a negative Gram-stain/culture. The MRI scan showed a cervical SEA without cord compression, but there was no pathology involving the thoracolumbar region. He was treated with broad-spectrum antibiotics. Two weeks later, now with a progressive quadriparesis, the MRI newly demonstrated a cervical SEA with cord compression; he immediately underwent operative debridement and was treated with an additional antibiotic for; one month later, he underwent a secondary 360° fusion 1-month later.

Infectious spondylodiscitis, epidural phlegmon, and psoas abscess in a diabetic

In a 63-year-old diabetic male with back pain, hyperpyrexia, and right calcaneal osteomyelitis, Nicolosi and Pratt reported hematogenous spread of MRSA resulting in a right psoas muscle abscess, L4–L5 osteomyelitis, and an SEA extending from T9–S1 [Table 3].^[20] Following spinal surgery to drain the T9–L1 SEA and a decompression/fusion at L4–L5, he demonstrated partial recovery from his preoperative paraparesis (e.g., required a walker/cane to perform activities of daily living).

Cervical spinal epidural abscess due to bacterial endocarditis with streptococcus viridans: Single case study

Oh *et al.* presented a patient with a cervical SEA due to streptococcus viridans endocarditis that was successfully treated with IV antibiotics for 8 weeks without sequelae [Table 3].^[21]

Successful antibiotic treatment alone of thoracic spinal epidural abscess after epidural catheterization; single case study

Hernández-Puiggròs *et al.* presented the case of a thoracic epidural abscess forming following epidural catheter placement for a patient undergoing lobar lung

resection. Six days after surgery the patient complained of “pulsatile” back pain accompanied by purulence at the catheter site [Table 3].^[13] The thoracic MRI documented a SEA that was successfully treated with antibiotics. This treatment was chosen after a consensus decision among neurosurgery, infectious diseases, and anesthesia services. In this case, the abscess fully resolved without complications.

DRAINAGE OF SPINAL EPIDURAL ABSCESES WITH MINIMALLY INVASIVE SURGERY

Minimally invasive surgery endoscopy to treat 32 cases of lumbar infectious spondylitis

In 32 patients with lumbar single-level infectious spondylodiscitis, postoperative infectious spondylodiscitis, and SEA, Yang *et al.* evaluated the efficacy of percutaneous endoscopic epidural debridement using “dilute betadine solution irrigation (percutaneous endoscopy dilute betadine solution irrigation [PEDI])” (2005 to July 2010) [Table 3].^[34] Positive bacterial cultures were identified in 28 (87.5%) of 32 biopsy specimens, and directed the use of appropriate antibiotic therapy. Postprocedure, 27 (84.4%) reported satisfactory relief of back pain, and 26 (81.3%) recovered uneventfully utilizing antibiotic therapy alone. They recommended PEDI for those not adequately responding to antibiotics alone, and as an alternative to major open surgery. Notably, however, 3 developed transient paresthesias in the affected lumbar segment.

Percutaneous endoscopic lavage/drainage for 21 patients with lumbar infectious spondylodiscitis

Yang *et al.* retrospectively assessed the safety/efficacy of percutaneous endoscopic lavage and drainage (PELD) for 21 patients with infectious spondylitis to help determine whether MIS (PELD) would suffice and avoid open surgery [Table 3].^[33] Those with significant neurological deficits and significant instability were excluded. Pathology for the three treatment groups included: paraspinal abscesses, postoperative recurrent infection, and multilevel infections. Positive bacterial cultures were found in 19 (90.5%) of 21 biopsies; 18 were effectively treated with antibiotics alone. Nevertheless, in 3 patients with multilevel infections, anterior debridement/fusions were warranted within 2 weeks following PELD. The overall infection rate was controlled in 86% of cases. One patient with SEA and spondylolytic spondylolisthesis at L5–S1 required an instrumented fusion 5 months later. Two patients developed transient paraesthesias in the affected lumbar segment.

Minimally invasive spine surgery in spinal infections

Verdú-López *et al.* noted that new MIS techniques might address spine infections.^[32] Specifically, using

percutaneous image guided techniques, (e.g., endoscopic, microsurgical techniques with/without tubular retractors), some of these procedures are touted as safe and effective, resulting in reduced morbidity and enhanced patient recovery.

Holocord spinal epidural abscess treated with alternating unilateral approach (skip laminectomy): Single case study

In a 51 year old with bilateral lower extremity weakness attributed to a C4–S1 holocord SEA, Hwang *et al.* utilized a unilateral level-skipping laminectomy technique that effectively preserved stability [Table 3].^[14]

Holocord spinal epidural abscesses treated with “apical laminectomies:” 2 case studies

Abd-El-Barr *et al.* (JNS 2015) reported 2 cases in which apical laminectomies (e.g., an alternative to skip laminectomies) provided irrigation/drainage of extensive C1–C2 to L5–S1 SEA [Table 3].^[11] First, a pediatric feeding tube was placed epidurally in the mid thoracic spine (apical laminectomy). The catheter was then both directed cephalad toward the mid cervical, and subsequently caudally toward the mid lumbar laminectomy sites. Advantages of this method included; avoiding extensive laminectomies and the increased morbidity due to prolonged/extensive surgery with the inherent increased risk of instability and estimated blood loss. SEAs were clinically and radiographically cleared in both patients. Furthermore, neither developed instability within 12 postoperative months.

REVIEW ARTICLES [TABLE 4]

Treatment algorithm for timing of surgery versus nonsurgical management for spinal epidural abscesses

Tuchman *et al.* emphasized that although the typical treatment for SEA includes emergency surgery and protracted antibiotic therapy, some series with very carefully selected patients have successfully utilized antibiotic treatment alone [Table 4].^[31] They reviewed the SEA literature (e.g., PubMed) to determine both the optimal timing for SEA surgery and to determine which patients could be safely triaged to nonoperative therapy only. They identified 28 case series (each included a minimum of 30 patients) that discussed treatment and outcome; 26 were retrospective studies. Based on these studies, the authors developed the following evidence-based algorithm for nonoperative/antibiotic management alone of the patients with SEA. This algorithm included; those unable to have surgery, complete spinal cord injuries >48 h old with “low clinical or radiographic concern for ascending lesions,” and the patients who were neurologically stable without significant risk factors for failed medical therapy. Notably,

all of these patients had to be closely monitored for potential neurological worsening and were informed: “Delayed neurological deterioration may not fully resolve even after prompt surgical treatment.” Overall, they concluded, “good surgical candidates should receive their operation as soon as possible because the rate of clinical deterioration with SEA is notoriously unpredictable.” They further noted that when “neurological injury becomes irreversible is unknown, supporting emergency surgery in those patients with acute findings.”

Epidural infection: Is it an abscess?

Avilucea and Patel assessed the literature/PubMed regarding organisms identified, and the diagnosis/management of SEA [Table 4].^[6] Notably, it is difficult to establish this diagnosis before the triad of back pain, fever, and neurological deficit appear. Being familiar with other risk factors and obtaining diagnostic information earlier (e.g., lab studies, MRI) are critical and help direct whether medical versus surgical management will be warranted. Most problematic is the late diagnosis of SEA and irretrievable neurological deficits.

Vertebral osteomyelitis and spinal epidural abscess: Evidence-based review

Boody *et al.* noted that spinal infections are typically associated with significant morbidity and mortality rates.^[7] Despite newer treatment protocols offering prompt diagnosis (e.g., identification of risk factors, laboratory studies, MRI, CT imaging studies), medical and surgical management strategies have not markedly improved patients’ outcomes. This study reviewed the recent literature and latest evidence-based recommendations for treating vertebral osteomyelitis and SEA, the two most common primary spinal infections.

A review of spinal epidural abscesses: Early diagnosis with magnetic resonance imaging studies

Krishnamohan and Berger emphasized that for SEA, early diagnosis with MRI studies, and surgical management yielded the best outcomes [Table 4].^[16] Nevertheless, diagnostic delays were common and few randomized controlled trials clearly identified optimal treatment strategies. They noted that most SEA were located in the thoracic followed by the lumbar and cervical regions. Patients typically presented with the triad of fever, spinal pain, and neurological deficits; the severity of the latter best determined final outcomes. The most typical organism responsible for SEA was *S. aureus* (20%).

Pyogenic and nonpyogenic spinal infections diagnosed with diffusion-weighted magnetic resonance imaging: Abscesses and pus collections

Although Moritani *et al.* noted that conventional MRI is typically utilized to diagnose SEA, in fact, diffusion-weighted imaging (DWI) provides earlier and

more accurate detection of abscess and pus collections within the spine along with an excellent means of following the efficacy of treatment.^[18] They reviewed the 4 diagnoses readily established utilizing MRI/DWIs: “(1) Epidural/paraspinal abscess with spondylodiscitis, (2) epidural/paraspinal abscess with facet joint infection, (3) epidural/paraspinal abscess without concomitant spondylodiscitis or facet joint infection, and (4) intradural abscess (subdural abscess, purulent meningitis, and spinal cord abscess).” Critical differential diagnoses for these infectious processes included; “epidural, subdural, or subarachnoid hemorrhage, CSF leak, disc herniation, synovial cyst, granulation tissue, intra- or extradural tumor, and postsurgical fluid collections.” Furthermore, DWI may be helpful both in diagnosing and treating these infections.

MEDICOLEGAL CASES INVOLVING SPINAL EPIDURAL HEMATOMA AND SPINAL EPIDURAL ABSCESS FAVORING EARLY SURGERY

French *et al.* discussed the fact that spinal epidural hematoma and SEA, although infrequently encountered constitute neurosurgical emergencies.^[10] This retrospective study looked at risk factors that might predict adverse outcomes. Utilizing the LexisNexis Academic legal search database, 19 cases filed concerning spinal epidural hematomas and SEA were identified. There was a significant correlation between time to surgery of more than 48 h and unfavorable verdicts for the provider. Of interest, the “degree of permanent neurologic impairment did not appear to affect the verdicts;” indeed 58% of cases did not present with an initial deficit, including loss of bowel or bladder control. The recommendation was for early diagnosis and surgery for epidural hematomas and SEA.

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