Global Spine Journal
2018, Vol. 8(4S) 85S-95S

DOI: 10.1177/2192568218763323
journals.sagepub.com/home/gsj

Lumbar Epidural Abscesses: A Systematic Review

Charles N. de Leeuw, PhD[1,2], Patrick R. Fann, BSc[1,2], Joseph E. Tanenbaum, BA[1,2], Avery L. Buchholz, MD, MPH[3], Brett A. Freedman, MD[4], Michael P. Steinmetz, MD[1], and Thomas E. Mroz, MD[1]

Abstract

Study Design: Systematic review.

Objectives: Spinal epidural abscesses (SEAs) are rare, but when missed or when diagnosis is delayed, SEA can lead to permanent neurological impairment or death. Limited information exists on the optimal treatment modalities for SEA, especially in the lumbar spine. We synthesize the current literature to identify the clinical features, diagnosis, management, and outcomes of lumbar SEA.

Methods: Queries in 4 databases—EMBASE, MEDLINE, Scopus, and Web of Science—were performed using comprehensive search terms to locate published literature on lumbar SEA.

Results: Ten articles reporting results for 600 cases of lumbar SEA were included, published between 2000 and 2017. Negative prognostic factors included diabetes, older age, methicillin-resistant *Staphylococcus aureus*, immune compromise, and more severe disease at presentation. Early first-line surgically treated patients responded better, specifically in terms of motor recovery, than those undergoing medical management or failing medical treatment, despite generally worse initial presentation. Elevated C-reactive protein, leukocytosis, and positive blood cultures predicted medical management failure.

Conclusions: This systematic review provides guidance to neurological and orthopedic spine surgeons seeking the best treatment for lumbar-localized SEA. This study is limited by a dearth of high-quality publications to support evidenced-based management recommendations. Surgical treatment appears to provide better outcomes than medical treatment alone, especially in those who present with a motor deficit. Further investigation is needed to confirm this finding. What is clear is that early recognition and treatment remains crucial to minimizing morbidity and mortality of SEA.

Keywords

lumbar, lumbar epidural abscess, epidural abscess, spine abscess, SEA, EDA, systematic review, medical management, surgical management, outcomes

Introduction

Spinal epidural abscess (SEA) is a severe medical condition that can result from progression of vertebral osteomyelitis, hematogeneous spread (eg, septicemia/bacteremia or overlying skin infection), and/or spinal procedures.[1] SEA can lead to significant morbidity and mortality, especially if not diagnosed and treated early in the disease course. Possible serious sequelae include permanent neurological deficits such as paralysis, and even death.[2,3] The incidence of SEA is increasing, potentially due to increases in longevity, increased volume of spinal

[1] Cleveland Clinic, Cleveland, OH, USA
[2] Case Western Reserve University, Cleveland, OH, USA
[3] Medical University of South Carolina, Charleston, SC, USA
[4] Mayo Clinic, Rochester, MN, USA

Corresponding Author:
Charles N. de Leeuw, Center for Spine Health, Department of Neurosurgery, Neurological Institute, The Cleveland Clinic, 9500 Euclid Avenue, S-80, Cleveland, OH 44195, USA.
Email: cnd17@case.edu

procedures,[4] high prevalence of intravenous drug abuse, and increased prevalence of diabetes. Despite this, SEA remains a relatively rare disease with an incidence of approximately 0.2 to 2 cases per 10 000 hospital admissions.[1,2]

Clinical presentation of lumbar SEA is vague and varied with the most important factor in preventing morbidity and mortality continuing to be the consideration of SEA in the differential diagnosis. This is most important for patients who present with back pain, fever, neurological deficits, and/or radiculopathy.[1,3] Patients with SEA typically present along a 4-stage process: stage 1 is back pain in the localized area, stage 2 is radicular pain from that area (often involving the lower limbs in lumbar SEA), stage 3 is neurological deficits, and stage 4 is paralysis.[3]

The gold standard for identification of SEA is gadolinium-enhanced magnetic resonance imaging (MRI).[1,4] Lumbar spine infections are most often pyogenic, brucellar, or fungal.[4] Tuberculous infections generally affect the thoracic spine or thoracolumbar junction and have a predilection for the anterior spinal column. Spinal epidural abscesses typically only occur as a late manifestation except in miliary tuberculosis, which can directly seed the epidural space. A meta-analysis indicates that the lumbar region (38.9%) is the second most common site for an SEA, after the thoracic region (50.4%).[1]

Treatment modalities for SEA include both medical and surgical options, with patients who fail medical treatment or present with progressive or profound neurologic deficit provided surgical intervention. The optimal treatment modality for lumbar SEA is currently unknown. The patient characteristics that predict outcomes following different treatment modalities are similarly unclear.

To our knowledge, there are no systematic reviews on outcomes following treatment of lumbar SEA. The lack of systematic reviews is in part due to limited published data on subsets of SEA patients, including lumbar-localized SEA. While much of the information presented in the present study on lumbar SEA is consistent with SEA in general, this review aims to clarify the current clinical knowledge of lumbar SEA specifically.

Methods

Search Strategy

Four databases were used for the literature search—EMBASE, MEDLINE, Scopus, and Web of Science—utilizing the following search terms: ("spin*" AND "epidural" AND ("abscess*" OR "infect*" OR "pyogenic") AND ("lumbar" OR "L1" OR "L2" OR "L3" OR "L4" OR "L5")). Publications were limited to articles on humans and those in the English language with a search period ending on July 20, 2017 (Figure 1).

Inclusion and Exclusion Criteria

Original clinical articles were included if they reported findings and results related to lumbar epidural abscess presence and treatment. This included retrospective and prospective observational studies. Case reports and case series were excluded, including any studies with $n \leq 10$.

Articles on Pott's disease and tuberculosis were excluded, as were cases of isolated discitis, osteomyelitis, and spondylitis in which lumbar epidural abscesses were not specifically identified. Similarly, pyogenic spinal infections as an umbrella term and those only relating to specific microorganisms that may cause SEA without specific mention of lumbar SEA were also excluded. Articles that did not specify the spinal column level(s) involved were excluded as were systematic reviews, editorials, commentaries, and technical notes.

Data Collection

Two reviewers (CNdL and PRF) independently assessed all studies as described below. A third author (JET) served as an arbiter when there was disagreement between the 2 primary reviewers. JET also screened all accepted articles to ensure they complied with the eligibility criteria presented above.

From the articles obtained from the initial database searches, duplicates were removed automatically using the EndNote software package and manually by comparing authors, publication date, and titles. The titles of the remaining publications were then reviewed independently by the 2 primary reviewers (CNdL and PRF) to select articles relevant to lumbar SEA. Subsequently, the abstracts of the selected articles were reviewed for eligibility within this study. Finally, full-text analysis resulted in retaining the 10 publications used for this study. Data extraction was performed independently using a standardized template and 2 reviewers (CNdL and PRF), with differences subsequently reconciled by JET. The final list of articles was assessed using the Oxford Center for Evidence Based Medicine (OCEBM; http://www.cebm.net/index.aspx?o=5653; v2.1) for level of evidence.

Results

The initial search yielded 2638 articles, of which 1185 duplicates were removed, resulting in 1453 entries. A large portion of these articles (n = 240, or 16.5%) were related to: Pott's disease or tuberculosis (n = 43), and isolated SEA-related conditions (n = 197) such as vertebral osteomyelitis, spondylitis, discitis, and pyogenic spinal infections in general. After title review, this list was narrowed to 250 articles. Subsequently, publications were screened based on their abstract for full-text review. Forty-one articles were retained and the full text was independently analyzed. A further 31 articles were excluded at this stage, resulting in a total of 10 articles that were included in the final study (Figure 1). Eight studies were retrospective observational studies (n = 245 total lumbar SEA patients), 1 was a meta-analysis (n = 287), and 1 was a case-control study (n = 68 lumbar SEA vs n = 68 controls). Thus, a total of 600 cases of lumbar SEA from 10 articles were included in our analysis. Publication dates of included articles ranged from 2000 to 2017. Common themes identified included (1) clinical

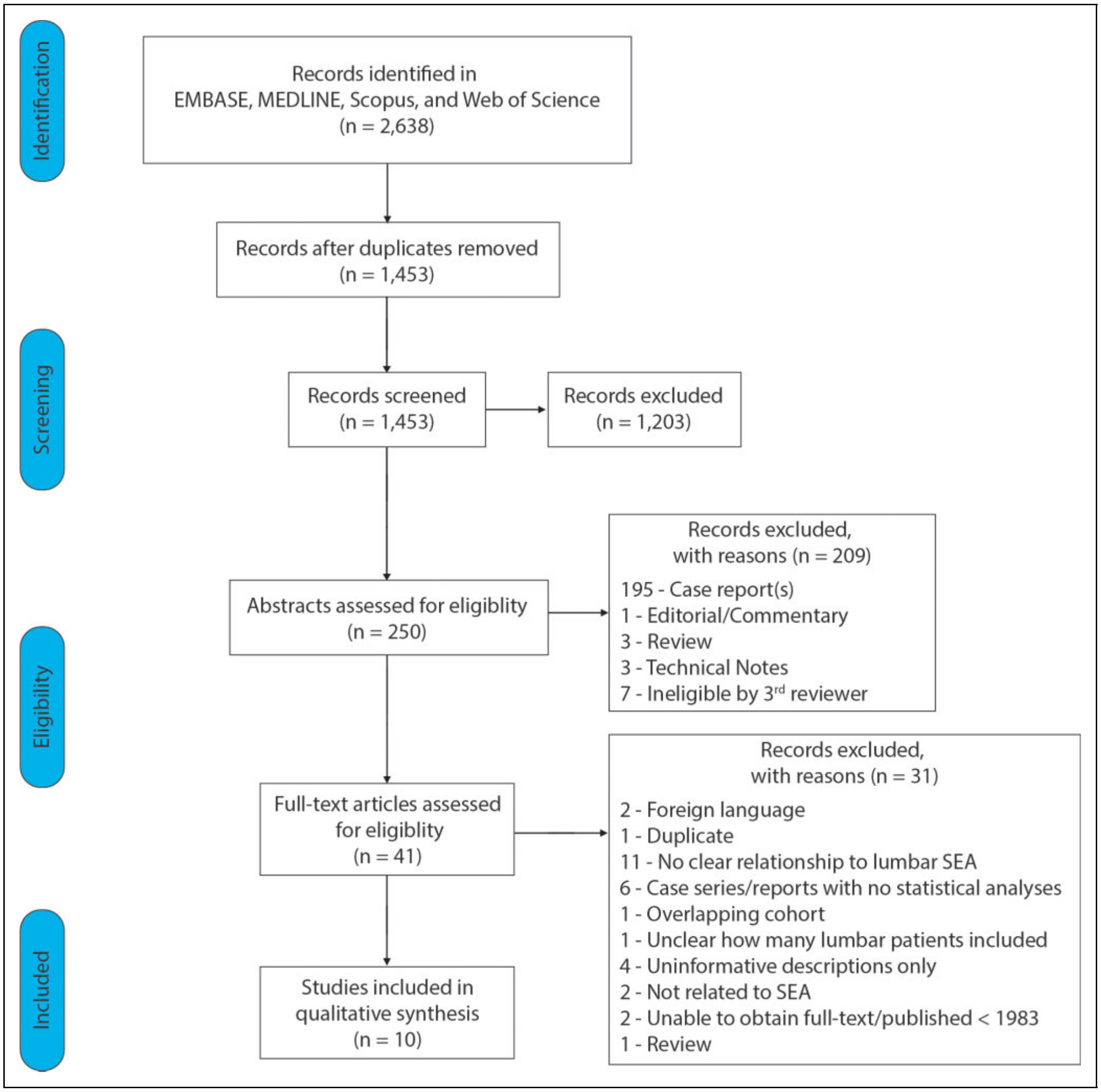

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) flow diagram for study selection algorithm and inclusion.

presentation including risk factors or special populations and (2) the medical and surgical management of SEA and associated outcomes. Study characteristics are reported in Table 1.

Clinical Presentation, Risk Factors, or Special Populations

Five of the 10 (50%) included studies documented detailed analyses of clinical presentation, risk factors, or special populations beyond simple demographics. The expanded clinical features reported in these 5 articles are presented in tabular form in Table 2.[1,5-8]

In 2000, Reihsaus et al conducted an extensive meta-analysis on SEA, covering 915 patients described in the literature between 1954 and 1997.[1] Two hundred and eighty-seven of these patients had SEA in the lumbar spine (38.9%; N = 738 with localization data). Reported presenting symptoms included: back pain (71% of N = 871 patients), fever (66%), paraparesis or paraplegia (31%), muscle weakness (26%), incontinence (24%), spinal irritation (20%), local tenderness (17%), and sensory deficit (13%). The authors found that cervical SEA, compared to thoracic or lumbar SEA, was more likely to lead to paraparesis or paraplegia. However, the occurrence of lumbar and thoracic SEAs was more common, likely due to the extension of the epidural space and the extradural venous plexus. Patients with more severe neurological deficits and those patients whose deficits had been present for a longer period of time prior to surgery were more likely to have a poor outcome. The proportion of SEA patients that make a full recovery remained relatively stable throughout the authors' study period at 41% to 46%.

Hadjipavlou et al (n = 13 lumbar SEA patients of N = 35 SEA patients) found that primary SEA (5.7%) is relatively rare

Table 1. Characteristics of the Included Studies.

First Author	Number of Patients (N)	Type of Study	OCEBM Level of Evidence	Disease Classification(s)	Data for Lumbar SEA (n/N)	Causative/Isolated Organisms (All Patients)	Population Demographics: Age, y	Gender	Location	Time period
Chen et al (2008)	31	Retrospective case study	Level 4	Diagnosed w/infective spondylitis, infective spondylodiscitis, vertebral osteomyelitis, or epidural abscess	19/31	*S aureus* only	20-90 (median = 55)	25 males and 6 females	Taipei, Taiwan	01/2002 to 12/2006
Connor et al (2013)	77 (72 w/outcomes)	Retrospective case study	Level 4	SEA	39/77	*C albicans*, *E faecalis*, *M tuberculosis*, *O anthropi*, *P intermedia*, *S aureus*, *S bovis*, *S epidermidis*, *S oralis*, *S pneumoniae*	17-78 (median = 51.4)	48 males and 29 females	Shreveport, LA, USA	07/1998 to 05/2009
Hadjipavlou et al (2000)	101	Retrospective case study	Level 4	Hematogenous pyogenic spinal infection	13/35 Epidural abscesses	Anaerobes, *Citrobacter*, *Diphtheroids*, *E coli*, *Enterobacter*, *Enterococcus* Gr D, *P aeruginosa*, *Providencia* sp, *Proteus mir*, *Staphylococcus* sp, *Streptococcus* sp, *Stento malo*	8-71 (mean = 46)	76 males and 25 females	Galveston, TX, USA	01/1986 to 03/1996
Huang et al (2012)	29	Retrospective case study	Level 4	*S aureus* SEA	22/29	*S aureus* only	27-81 (mean = 58)	21 males and 8 females	Kaohsiung, Taiwan	2003 to 2008
Löhr et al (2005)	27	Retrospective case study	Level 4	SEA operated by dorsal approach	15/27	*Bacteroides fragilis*, *Klebseilla oxytoca*, *S aureus*, *Streptococcus* sp	11-80 (mean = 58.5)	14 males and 13 females	Cologne, Germany	1992 to 2002
Patel et al (2014)	128	Retrospective case study	Level 4	Consecutive, spontaneous SEA	70/128	*E coli*, multiple, other, *S aureus*, *S milleri*, *Streptococcus* sp	22-83 (mean = 52.9)	79 males and 49 females	Seattle, WA, USA	01/2005 to 09/2011
Reihsaus et al (2000)	915	Meta-analysis	Level 1	SEA	287/738	Numerous bacterial species, minor numbers of fungi and parasites	10 days to 87 years	520 males, 289 females, and 106 unknown	Worldwide	1954 to 1997
Shifrin et al (2017)	68	Retrospective case-control study	Level 3	Lumbar SEA	68/68	Not reported	SEA: mean = 57.4	SEA: 46 males and 22 females	Boston, MA, USA	01/2000 to 08/2014
							Control: mean = 57.6	Control: 43 males and 25 females		
Uchida et al (2010)	37	Retrospective case study	Level 4	Sustained epidural abscess associated with pyogenic spondylodiscitis of the lumbar spine	37/37	*E coli*, *P aeruginosa*, *S aureus*, *S epidermidis*, *Streptococcus* sp	37-89 (mean = 63.8)	21 males and 16 females	Japan/China	1991 to 2007
Wu et al (2011)	41	Retrospective cohort study	Level 4	SEA	ESRD: 10/12	*C albicans*, *Enteroccocus*, *Salmonella choleraesuis*, *S aureus*, *Streptococcus* group D, *S viridans*	ESRD: mean = 57.3	ESRD: 5 males and 7 females	Taipei, Taiwan	2003 to 2006
					Non-ESRD: 20/29		Non-ESRD: mean = 64.2	Non-ESRD: 19 males and 12 females		

Abbreviations: OCEBM, Oxford Center for Evidence Based Medicine; SEA, spinal epidural abscess; ESRD, end-stage renal disease.

Table 2. Clinical Presentation, Risk Factors, or Special Populations.

First Author	Data for Lumbar SEA (n/N)	Medical Versus Surgical Treatment (of Total N)	Treatment Modalities	Outcomes
Hadjipavlou et al (2000)	13/35 epidural abscesses	42.6% vs 57.4%	Antibiotics to all patients (mostly including clindamycin and oxofloxacin), unless blood-brain barrier compromise, then vancomycin and ceftazidime. Surgical interventions included CT-guided drainage, percutaneous transpedicular discectomy, laminectomy, corpectomy, and fusion.	For pyogenic spinal infection, 64.3% of medically treated patients continued to have disabling back pain, compared to only 26.3% of surgically treated patients.
Huang et al (2012)	22/29	44.8% vs 55.2%	Antibiograms were performed and treatment with oxacillin, teicoplanin, vancomycin, or linezolid. Surgical technique not specified.	Surgical and medical treatment combined, 72.4% had a good outcome and 27.6% a poor outcome. SEAs with MSSA had a better outcome than those with MRSA. All of the MRSA cases were sensitive to vancomycin, SMX-TMP, and teicoplanin.
Reihsaus et al (2000)	287/738	11.3% vs 88.7% (N = 639)	Antibiotic and surgical management	Outcome summary (N = 589): Complete recovery 38% to 43%; Neurological deficits 21% to 26%; Paresis/paralysis 15% to 27%; Death 14% to 16%
Shifrin et al (2017)	68/68	Not specified	Not specified	Not reported
Wu et al (2011)	ESRD: 10/12 Non-ESRD: 20/29	ESRD: 41.6% vs 58.4%; non-ESRD: 58.6% vs 41.4%	Antibiotics at diagnosis and anterior laminectomy with suction-irrigation.	Survival and number of required surgical interventions were similar between ESRD and non-ESRD patients.

Abbreviations: CT, computed tomography; SEA, spinal epidural abscess; MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*; ESRD, end-stage renal disease.

compared to secondary SEA (77.1%), with a third category of epidural inflammation and granulation in 17.1% of cases.[5] The authors defined primary SEA as epidural abscess in the absence of pyogenic infection, and secondary SEA as a complication of pyogenic infection of the spine and/or disc. Furthermore, the location of secondary SEA was most often lumbar (36.3%), then thoracic (33.3%), and lastly cervical (27.2%). Lumbar epidural abscess was the least likely to become a complication of spondylodiscitis (90% of cervical spondylodiscitis vs 33.3% of thoracic spondylodiscitis vs 23.6% of lumbar spondylodiscitis; $P < .001$).[5] In addition, serious neurological deficits (ie, paraplegia or paraparesis) resulting from secondary SEA were also the least likely to occur as a consequence of lumbar SEA (60% of thoracic SEA vs 33.3% of cervical SEA vs 6.7% of lumbar SEA; $P < .001$). Similarly, the likelihood of serious neurological complications due to thecal sac compression was also the least likely in the lumbar spine (81.8% thoracic vs 55.6% cervical vs 7.7% lumbar; $P < .001$).

Potential diagnostic indicators of lumbar SEA were specifically addressed by Shifrin et al (n = 68 lumbar SEA patients) in a case-control study.[6] Using a multivariable logistic regression model for unenhanced MRI features comparing lumbar SEA patients to controls, the authors found paraspinal edema (odds ratio [OR] = 39.0), psoas edema (OR = 4.90), disk signal (OR = 13.9), and bone marrow edema (OR = 118) to have predictive value of epidural collection (univariate $P < .001$, each). After multivariable correction, the findings for paraspinal edema ($P < .001$) and bone marrow edema were still significant ($P = .006$), whereas a statistical trend was also found for psoas edema ($P = .065$) and disk signal ($P = .069$).

Wu et al (n = 30 lumbar SEA patients of N = 41 total) assessed end-stage renal disease (ESRD) comorbidity in the context of SEA.[7] ESRD SEA patients were more likely to be younger (57 years of age vs 64 years of age; $P = .029$) and have a positive history of diabetes mellitus (66.7% vs 27.6%; $P = .034$) and hypertension (100% vs 44.8%; $P < .001$) than non-ESRD SEA patients. ESRD patients were also more likely to present with sensory deficits (41.7% vs 6.9%; $P = .016$) and abdominal pain (50% vs 3.4%; $P < .001$). Laboratory findings indicated a lower mean hematocrit (27.1% vs 33.7%; $P < .001$) in ESRD patients and an elevated erythrocyte sedimentation rate (108 mm/h vs 81 mm/h; $P < .014$). There was a statistical trend toward increased numbers of patients undergoing surgical interventions in the ESRD SEA group: 16.7% versus 0% of non-ESRD patients ($P = .081$). There was no difference in gender, body mass index, presence of back pain, leg pain, unsteady gait, paraplegia, mobility/bedridden, or somnolence between the 2 cohorts. Bladder dysfunction, headache, neck stiffness, and nausea or vomiting were all comparatively rare in all included SEA patients (all features present at <20%). ESRD and non-ESRD patients did not differ on the affected spinal levels, pathogenic organisms involved, white blood cell count (WBC) or C-reactive protein (CRP) laboratory values. Despite these clinical differences and the need for a greater number of surgical interventions on average in ESRD patients, there was a no significant difference in overall survival at 30, 60, or 90 days between ESRD patients with SEA and non-ESRD patients with SEA.

Huang et al (n = 22 lumbar SEA patients of N = 29 total) analyzed prognostic factors in SEA.[8] Poor outcomes were defined as patients with a modified 20-point Barthel Index score of <12, or patients who had died. Patients who had a good outcome were more likely to be younger (mean of 53 years vs 71.5; $P = .015$) with fewer individuals over the age of 70 specifically (n = 2 vs n = 5; $P = .008$). There was a trend for females to have better outcomes than males (8/8 vs 13/21; $P = .066$). Furthermore, underlying diabetes mellitus was associated with a poor outcome (6/8 vs 3/21; $P = .004$), as was adrenal insufficiency (3/8 vs 0/21; $P = .015$). Patients who were infected with methicillin-sensitive *Staphylococcus aureus* (MSSA) were more likely to have a good outcome than those infected with methicillin-resistant *Staphylococcus aureus* (MRSA: 15/17 good outcome vs 2/17 poor outcome; MRSA: 6/12 good outcome vs 6/12 poor outcome; $P = .038$).

Medical and Surgical Management

Treatment and outcomes were described in detail in 5 articles (50%). A comparison between medical treatment and surgery was made in 4 of 10 (40%) of the included articles,[1,9-12] while Löhr et al[13] solely reported outcomes for operative approaches utilized in SEA (Table 3).

Chen et al (n = 19 lumbar SEA patients of N = 31 total) found that the strongest predictor of poor outcomes among patients with epidural abscess[10] was increased Charlson comorbidity score.[14,15] Patients who were treated with medical management alone were less likely to have preoperative neurological deficits (20.0% vs 63.6%; $P = .02$) and more likely to have greater than 2 vertebral levels involved preoperatively (35.0% vs 0%; $P = .03$).[10] In addition, the median length of hospital stay for patients treated medically versus surgically was shorter (45.5 days vs 58 days; $P = .02$). Chen et al defined poor outcomes as "marked residual weakness, stage 4 conditions and recurrence or worsening clinical symptoms after discharge, or mortality due to infection." With respect to comorbidities, patients treated medically had fewer compared to those treated surgically, as demonstrated by chronic renal failure (8% vs 50%; $P = .04$), malignancy (4% vs 50%; $P < .001$), and a Charlson score >1 (12% vs 100%; $P < .001$). However, there was no difference in good versus poor outcomes in the medical group compared to the surgical group (80% good outcome vs 81.8%; $P = 1.00$).

Contrary to Chen et al, Uchida et al identified a clear advantage of surgical management over medical management in terms of length of stay and time to normalization of CRP.[9] In their article (n = 37 lumbar SEA patients), they analyzed nonoperative (ie, conservative) versus operative management of lumbar SEA associated with pyogenic spondylodiscitis. The authors found that hospital stay was significantly decreased among surgically treated patients (43.0 days vs 79.4 days; $P < .05$) and that CRP levels normalized faster after surgical treatment (4.8 weeks vs 7.6 weeks; $P < .05$).

In a retrospective analysis by Connor et al (n = 39 lumbar SEA patients of N = 77 total) SEA was more common in males (62.3%; $P = .06$) with a trend for localization to the lumbar spine (50.6% vs 26.0% thoracic and 23.4% cervical; $P = .1$). Most of the operative (45.6%) and nonoperative (65.0%) patients had lumbar involvement.[12] Patients who recovered from SEA were younger than those who did not show improvement (49.6 years vs 57.0 years; $P = .04$). Patients who underwent operative treatment had presented with greater focal weakness (64.9% vs 30.0%; $P = .009$). With respect to infectious etiology, there was a trend in having a previous comorbid focus of infection (38.6% vs 15.0%; $P = .059$). Furthermore, compared to nonoperative patients, those who received surgery were more often culture-positive (blood or surgical site) for *Staphylococcus aureus* (MRSA or MSSA) infections than either culture-positive for other organisms or culture-negative (operative vs nonoperative; negative: 14% vs 40.0%; MRSA and MSSA combined: 71.9% vs 30.0%; other organisms: 14.0% vs 30.0%; $P = .010$).

When compared to the entire cohort, operative group patients who had a preoperative focal weakness were more likely to have improved or resolved outcomes (64.9% vs 35.1%; $P = .012$). However, there was no such association in the nonoperative group ($P = .193$). Surgical patients were primarily treated with simple decompression via posterior laminectomy (82.5%), augmented by discectomy (8.8%), or posterolateral pedicle screw fixation (1.8%).

A study by Patel et al compared medical and surgical management in SEA (n = 70 lumbar SEA patients of N = 128 total).[11] The authors found that while surgical patients often had lower baseline ASIA (American Spinal Injury Association) motor function level subscores (range of 0 to 100; assessing the main upper and lower extremity muscle groups) than those treated medically (medical: 97.86 vs surgical: 80.32), they showed a significant improvement in motor score, whereas medical patients' ASIA motor function level subscores indicated deterioration (change of +9.52 for surgical vs −5.92 for medical; $P < .05$). Patients who failed medical treatment and subsequently underwent surgery had a significantly worse change from baseline of −14.86. Perhaps even more surprisingly, the 21 patients who failed medical treatment had a much higher baseline ASIA score (99.86). Importantly, elevated CRP >115 mg/L (OR = 4.7; $P = .045$), a WBC count of $>12.5 \times 10^9$/L (OR = 3.3; $P = .045$), and a positive blood culture (OR = 3.5; $P = .035$) were all predictive of medical management failure. In addition, there was a trend toward a history of diabetes predicting failure of medical treatment (OR = 3.8; $P = .057$). The authors generated a regression model that indicated that patients who had 3+ risk factors had a 76.9% risk of medical failure (decline in neurological function or increased/intolerable pain), requiring eventual surgical treatment, whereas those with 1 or 2 had 35.4% to 40.2% risk, and those

Table 3. Medical and Surgical Management.

First Author	Data for Lumbar SEA (n/N)	Medical versus Surgical Treatment (of Total N)	Medical Treatment	Medical Notes	Surgical Technique	Surgical Notes	Posttreatment Outcomes
Chen et al (2008)	19/31	64.5% vs 35.5%	Antibiotics (not specified)	Medical treatment useful for patients with minimal neurological deficits.	Laminectomy; not specified.	Urgent surgical intervention necessary in patients who have marked motor deficits or rapid deterioration.	Renal failure, malignancy, and Charlson score >1 significantly predictive of residual weakness, recurrence/worsening of symptoms, stage 4 symptoms, or mortality.
Connor et al (2013)	39/77	30.0% vs 70.0%	Antibiotics (not specified)	Initial treatment should include broad-spectrum coverage including MSSA and other *Staphylococcus* species. Patients may have a negative tissue culture if treated with antibiotics for >1 day prior. Blood and tissue culture results correlate, suggesting blood culture may be sufficient.	Decompression of affected vertebral segments. Majority via posterior laminectomy. Some augmented with discectomy, and one with posterolateral pedicle screw fixation. Anterior and anterolateral approach in a small subset of patients with discectomy and fusion, or corpectomy and fusion.	MRSA and MSSA more frequently isolated in operative patients than nonoperative.	Preoperative weakness is a positive predictor for a positive outcome; but there was no difference in the degree of improvement between operative and nonoperative patients. Neurological status prior to intervention was the strongest predictor of outcome. Decompressive surgery affects outcomes in patients with focal weakness, but not in other subsets.
Löhr et al (2005)	15/27	0% vs 100%	—	—	Dorsal approach: laminectomy or interlaminar. Drainage systems used in all patients.	Laminectomy in n = 13 with 1-4 adjacent levels, or interlaminar in n = 14 with 1-5 levels. The interlaminar procedure was preferred in 80% of lumbar SEA patients. Two patients with laminectomy dorsal to spondylodiscitis developed progressive kyphosis.	No difference in recurrence rate and outcome between suction-irrigation and usual outflow drainage. Postoperative MRI was positive for residual or recurrent SEA prior to reoperation. Patients with no neurological deficits prior to surgery, and those with paraplegia, did not have a change in status. 75% of patients who were nonambulatory prior to surgery improved.

(continued)

Table 3. (continued)

First Author	Data for Lumbar SEA (n/N)	Medical versus Surgical Treatment (of Total N)	Medical Treatment	Medical Notes	Surgical Technique	Surgical Notes	Posttreatment Outcomes
Patel et al (2014)	70/128	39.8% vs 60.2%	Antibiotics (not specified)	Four significant predictors of medical treatment failure: (1) diabetes; (2) CRP >115 mg/L; (3) WBC > 12.5×10^9/L; (4) positive blood cultures.	Laminectomy, laminotomies, anterior cervical discectomy/fusion, corpectomy, and posterior spinal instrument fusion.	Delayed surgical patients (ie, medical treatment failure), did not improve to the same extent as immediate surgical treatment.	41% of medically treated patients had to undergo surgical intervention. Although final ASIA motor scores were similar in medically vs surgically treatment patients, medical patients deteriorated while surgical patients improved to that score.
Uchida et al (2010)	37/37	37.0% vs 73.0%	Antibiotics (not specified)	Patients who are good candidates for medical treatment: (1) organism identified; (2) neurologically stable; (3) MRI readily accessible; (4) surgical consult available; (5) patient is a compromised host; (6) high surgical risk; (7) good response to 2-day antibiotic trial	Mini-incisional percutaneous suction drainage with antibiotic irrigation (n = 2), mini-incisional curettage (n = 4), and major open surgery (n = 21)	Left-sided retroperitoneal approach and anterior debridement in 10 cases, with autologous bone grafting (iliac crest). Psoas abscess via anterior extraperitoneal approach; paravertebral with additional incision over back. Extensive curettage curettage and spinal reconstruction with bone grafting recommended in multilevel involvement with paravertebral suppuration.	Hospital stay was much longer in the medical treatment group. Normalization of CRP was shorter in the surgical group. No difference was observed in low back pain score after follow-up. Medical patients requiring subsequent surgical treatment often had a circular ring-like enhancement on Gd-enhanced T1-weighted MRI, linear dural enhancement, poor antibiotic response, and were a compromised host. Intervertebral disk height was preserved and kyphosis prevented in the surgical group.

Abbreviations: SEA, spinal epidural abscess; MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*; MRI, magnetic resonance imaging; ASIA, American Spinal Injury Association; CRP, C-reactive protein.

with none only had 8.3% risk of failure with conservative management.

None of the included studies rigorously compared different surgical approaches and their efficacy in treating lumbar SEA. Although a very small sample, Löhr et al described some differences in operative approaches in SEA.[13] Interlaminar fenestration was performed primarily in lumbar SEA patients (80% of n = 15 total patients), whereas laminectomy was performed primarily in thoracic (87.5% of n = 8 total patients) and cervical (75% of n = 4 total patients) SEA patients in their cohort. In 2 patients, laminectomy dorsal to the spondylodiscitis resulted in a progressive kyphosis requiring further stabilization. In contrast, this did not occur in interlaminar approaches dorsal to spondylitis (n = 4), nor in laminectomies nonadjacent to spondylitis (n = 2), or in patients without spondylitis (n = 9).

Discussion

Lumbar SEA requires timely diagnosis and treatment to prevent adverse outcomes. In order to understand the typical presentation and treatments for lumbar SEA, this systematic review summarizes what is known from the literature and highlights gaps in our collective knowledge. The included studies were grouped into either those describing the clinical presentation, risk factors, or special populations, and those studies comparing medical and surgical management of lumbar SEA. The optimal management strategy for lumbar SEA remains unclear. The literature on lumbar SEAs currently lack scientifically rigorous analyses of different treatment modalities. As the United States continues to transition toward value-based reimbursement and an increasing emphasis on health care quality, it is increasingly important to conduct multicenter studies of complex conditions such as lumbar SEA.

Clinical Presentation, Risk Factors, or Special Populations

Although primary lumbar SEAs are rare, secondary SEAs are commonly located in the lumbar spine.[5] Despite this common localization of secondary SEAs to the lumbar spine, compared to other spinal regions, lumbar SEAs are less likely to cause complications in spondylodiscitis, result in neurological deficits, or lead to symptomatic neural compression.[5] When MRI images demonstrate paraspinal edema, bone marrow edema, and increased disk signal, surgeons should consider lumbar SEA as the diagnosis.[6] In any patient presenting with back or radicular pain, fever, and neurological deficits, it is critical to consider SEA as part of the differential diagnosis.[4,16] Even when diagnosed in a timely fashion, a full recovery is expected in only ∼40% of patients that receive early treatment.[1]

ESRD patients are at particular risk for developing SEA due to their immunocompromised state.[7] ESRD patients also tend to have a history of diabetes and hypertension, which puts patients at increased risk for SEA. The incidence of surgical intervention for lumbar SEA is greater in ESRD patients than patients with normal renal function. However, survival outcomes are similar between the 2 groups. While this study provides insight into considerations with SEA, it remains unknown what other comorbidities may alter the treatment and management of SEA and the interplay between other disease processes and prognostic factors in lumbar SEA.

Patients infected with MRSA were more likely to have a worse outcome than patients who had MSSA or other causative bacteria.[1,8] Similarly, diabetes and advanced age was identified as a negative prognostic factor by several authors.[1,4,7,8,11,13] Combined, this data suggests patients with stronger immune systems, that is, younger individuals, or those without comorbid immune-related disorders, such as diabetes, are more likely to have a good prognosis.[13]

Medical and Surgical Management

Two studies compared the length of hospital stay in medically treated compared to surgically treated patients.[9,10] Chen et al[10] found that the median length of hospital stay was shorter for medically treated patients, whereas Uchida et al[9] found median length of stay was shorter for surgically treated patients. It is unclear whether this disagreement is due to local policy and treatment algorithms or if there is another explanation. Further work on elucidating this difference is needed to better understand the recovery times associated with each treatment modality, especially in a value-based assessment of care.

Several studies found that surgically treated patients likely presented with more severe disease: patients were more likely to have a neurological deficit,[10,12] more likely to have a positive result for MSSA/MRSA,[12] and had a history of previous infection.[12] Moreover, patients with diabetes, elevated CRP, increased WBC, and a positive blood culture were at much higher risk of failing medical therapy.[11] Interestingly, some patient characteristics such as a history of alcohol abuse[12] and having greater than 2 spinal levels affected[10] may predispose physicians to manage lumbar SEA medically. Further studies are needed to determine whether patients with more complex disease would benefit from earlier surgical intervention or which specific patient characteristics are associated with worse surgical outcomes among lumbar SEA patients.

Although SEA patients treated surgically often present with worse physical symptoms, such as worse ASIA motor level subscores[11] and more significant neurological deficits,[10,12] there were few significant differences in treatment success and outcomes compared to medically treated patients.[10,11] However, the most important predictor of final neurological status may still be the initial evaluation immediately preceding surgery.[3] The quality of the evidence in support of surgery as a primary recommendation is hindered by the lack of prospective clinical trials comparing medical versus surgical interventions in lumbar SEA patients.[3,17] Given the relative rarity of this condition and ethical concerns regarding random allocation of patients to treatment options for lumbar SEA, we may never have high-level evidence to support treatment recommendations. Until this can be negotiated, surgeons are left to rely on systematic and retrospective reviews such as the one contained herein to inform their practice in the management of this rare but serious spinal condition.

Limited evidence suggests that an interlaminar approach may offer equal or better results than laminectomy in lumbar SEA, in part due to the destabilizing effect that laminectomies can have on the spine. Further large-scale comparisons of the surgical approach are warranted.

Limitations and Future Study

This study was limited by several factors. The relative dearth of literature on SEAs, and lumbar SEA in particular, presents a challenge in obtaining high-quality studies to ascertain consensus. Specifically, while lumbar spinal levels were well represented in several studies on SEA, there are very few studies that focus on lumbar SEA only. As a result, the diagnostic and prognostic factors, treatment paradigms, and outcomes could not be analyzed using rigorous statistical meta-analysis, as many of the reported results refer to the entire group of patients. Furthermore, the majority of studies we identified initially were case reports or case series, with high inherent bias. Therefore, we recommend that medical centers collaborate on prospective studies that will offer stronger data to assess specific unresolved issues in the management of lumbar SEA, such as presenting symptoms and prognostic factors that favor medical management or surgery, and best operative approaches, for when surgery is indicated. Another important limitation is the exclusion of discitis and osteomyelitis, both of which commonly occur in association with SEA. The authors believed inclusion of such studies would add more heterogeneity to the included literature, further subtracting from the ability to make conclusions. Last, there is likely a reporting bias whereby surgical and medical management has not received equal exposure in the literature, and which may well have changed throughout the years, thus further complicating definitive clinical guidelines, barring large-scale, multicenter evaluations. Thus, at present there is still a very individualistic approach to treatment modality for the patient.

Conclusion

SEA is a rare but potentially devastating occurrence that has a well-defined natural history and risk factors. Currently, the decision for medical versus surgical treatment appears largely predicated on the patient's neurological status. However, other factors such as comorbidities, hospital resources, and surgeon preference also influence the treatment. This review represents a first step in identifying gaps in our knowledge of lumbar SEA and a summary of findings to date. This information will help guide clinical practice in the management of lumbar SEA, and identification of research study needs, with the ultimate goal of reducing and preventing the devastating outcomes that can occur as a result of lumbar SEA.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This Supplement was supported by funding from AOSpine North America.

ORCID iD

Charles N. de Leeuw, PhD http://orcid.org/0000-0001-9413-2095

References

1. Reihsaus E, Waldbaur H, Seeling W. Spinal epidural abscess: a meta-analysis of 915 patients. *Neurosurg Rev*. 2000;23:175-204.
2. Baker AS, Ojemann RG, Swartz MN, Richardson EP Jr. Spinal epidural abscess. *N Engl J Med*. 1975;293:463-468.
3. Darouiche RO. Spinal epidural abscess. *N Engl J Med*. 2006;355: 2012-2020.
4. Duarte RM, Vaccaro AR. Spinal infection: state of the art and management algorithm. *Eur Spine J*. 2013;22:2787-2799.
5. Hadjipavlou AG, Mader JT, Necessary JT, Muffoletto AJ. Hematogenous pyogenic spinal infections and their surgical management. *Spine (Phila Pa 1976)*. 2000;25:1668-1679.
6. Shifrin A, Lu Q, Lev MH, Meehan TM, Hu R. Paraspinal edema is the most sensitive feature of lumbar spinal epidural abscess on unenhanced MRI. *AJR Am J Roentgenol*. 2017;209:176-181.
7. Wu MY, Fu TS, Chang CH, et al. Aggressive surgical intervention in end-stage renal disease patients with spinal epidural abscess. *Ren Fail*. 2011;33:582-586.
8. Huang PY, Chen SF, Chang WN, et al. Spinal epidural abscess in adults caused by *Staphylococcus aureus*: clinical characteristics and prognostic factors. *Clin Neurol Neurosurg*. 2012;114: 572-576.
9. Uchida K, Nakajima H, Yayama T, et al. Epidural abscess associated with pyogenic spondylodiscitis of the lumbar spine; evaluation of a new MRI staging classification and imaging findings as indicators of surgical management: a retrospective study of 37 patients. *Arch Orthop Trauma Surg*. 2010;130:111-118.
10. Chen WC, Wang JL, Wang JT, Chen YC, Chang SC. Spinal epidural abscess due to *Staphylococcus aureus*: clinical manifestations and outcomes. *J Microbiol Immunol Infect*. 2008;41: 215-221.
11. Patel AR, Alton TB, Bransford RJ, Lee MJ, Bellabarba CB, Chapman JR. Spinal epidural abscesses: risk factors, medical versus surgical management, a retrospective review of 128 cases. *Spine J*. 2014;14:326-330.
12. Connor DE Jr, Chittiboina P, Caldito G, Nanda A. Comparison of operative and nonoperative management of spinal epidural abscess: a retrospective review of clinical and laboratory predictors of neurological outcome. *J Neurosurg Spine*. 2013;19: 119-127.
13. Löhr M, Reithmeier T, Ernestus RI, Ebel H, Klug N. Spinal epidural abscess: prognostic factors and comparison of different surgical treatment strategies. *Acta Neurochir (Wein)*. 2005;147: 159-166.

14. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40:373-383.
15. Sharabiani MT, Aylin P, Bottle A. Systematic review of comorbidity indices for administrative data. *Med Care*. 2012;50:1109-1118.
16. Curry WT Jr, Hoh BL, Amin-Hanjani S, Eskandar EN. Spinal epidural abscess: clinical presentation, management, and outcome. *Surg Neurol*. 2005;63:364-371.
17. Darouiche RO, Hamill RJ, Greenberg SB, Weathers SW, Musher DM. Bacterial spinal epidural abscess. Review of 43 cases and literature survey. *Medicine (Baltimore)*. 1992;71:369-385.