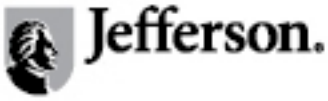

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Etiology and Surgical Management of Cervical Spinal Epidural Abscess (SEA):: A Systematic Review.

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Etiology and Surgical Management of Cervical Spinal Epidural Abscess (SEA): A Systematic Review

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Abstract

Study Design: Systematic analysis and review.

Objective: Evaluation of the presentation, etiology, management strategies (including both surgical and nonsurgical options), and neurological functional outcomes in patients with cervical spinal epidural abscess (SEA).

Methods: The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria were used to create a framework based on which articles pertaining to cervical SEA were chosen for review following a search of the Ovid and PubMed databases using the search terms "epidural abscess" and "cervical." Included studies needed to have at least 4 patients aged 18 years or older, and to have been published within the past 20 years.

Results: Database searches yielded 521 potential articles in PubMed and 974 potential articles in Ovid. After review, 11 studies were ultimately identified for inclusion in this systematic review. Surgery appears to be a well-tolerated management strategy with limited complications for patients with cervical SEA. However, the quantity of data comparing medical and surgical treatment of cervical SEA is limited and the bulk of the data is derived from low quality studies.

Conclusion: Data reporting was heterogeneous among studies making it difficult to draw discrete conclusions. Early surgical intervention may be appropriate in selected patients with cervical epidural abscess, but it is not clear what distinguishes these patients from those who are successfully managed nonoperatively.

Keywords

epidural abscess, cervical spine, neurological deficit

Introduction

Spinal epidural abscesses (SEAs) are a rare, heterogeneous, and potentially life-altering disorder. Historically, the incidence of SEA was cited between 0.2 and 1.2 cases per 10 000 hospital admissions.[1-3] However, that number is believed to have increased since 1988 as one study suggested the incidence may be closer to 12.5 cases per 10 000 admissions with the increase largely attributed to a rise in intravenous drug use (IVDU).[4] SEA is localized to the cervical spine in only 18% to 36% of SEA admissions, a lower rate than infection in the lumbar or thoracic spine.[5-11] Despite the lower incidence, cervical SEA is often associated with worse neurological functional outcomes and a higher risk of morbidity and mortality.[4,10,12-14] This suggests that the cervical location may be a unique disorder when compared with thoracic or lumbar infection, potentially due to dynamic motion, the cervical spinal cord, or a combination of both. Remarkably, most of the literature pertaining to spinal epidural abscesses combines

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cervical, thoracic, and lumbar abscesses. The goal of this article is to synthesize existing cervical spine-specific data to better understand common presenting symptoms, etiology, surgical and nonsurgical management strategies, and how neurological outcomes are influenced by management decisions and the preoperative functional status of patients with cervical SEA.

Methods

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework was used for the construction of this systematic analysis and review.[15] The specific objectives were to determine the common initial symptoms of cervical SEA, the incidence of neurological deficit at the time of presentation, the optimal work-up for suspected cervical SEA, including utility of radiographic and laboratory-based diagnostic testing, the risk factors and causative organisms commonly found in patients, and how treatment strategies including operative and non-operative management influenced patient functional outcomes. A search of the PubMed and Ovid databases was conducted using the MeSH headings "epidural abscess" AND "cervical." Eligibility criteria included case series with greater than 4 patients aged 18 yeras or older, availability in English language, and publication within the past 20 years. Papers not meeting these requirements were excluded. Using the PubMed and Ovid search results, review authors GS, YM, and SS independently screened titles and abstracts to identify articles potentially meeting inclusion criteria. Full text was subsequently reviewed for all articles deemed to meet inclusion standards; any disagreements regarding inclusion versus exclusion were discussed and resolved through majority opinion.

Following identification of articles for inclusion, relevant data was extracted using a standardized form (Table 1). The following data points were collected: authors, date of publication, number of patients, symptoms at presentation, method for evaluating neurological function, method for establishing diagnosis of SEA, risk factors for SEA, causative organism, management strategy including surgical and non-surgical options, surgical approach (where relevant), neurological outcomes, and complications. When any of these data points could not be assessed, "Not Recorded" (NR) was entered. The quality of evidence from each article was assessed using the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) guidelines.[16] The GRADE guidelines were also used for evaluating risk of bias within included studies.[17] Judgments were made by 2 separate authors and adjudicated by a third author when disagreement arose.

Given the heterogeneity among studies with regards to the data points of interest, it was determined quantitative consolidation of data would be ineffective and a narrative synthesis would be more suitable. The framework for the narrative was arranged to discuss the disease course of cervical SEA beginning with presentation and work-up, assessment of risk factors, moving to treatment options, and concluding with outcomes and complications.

Results

The search terms "epidural abscess" AND "cervical" yielded a total of 521 articles in PubMed and 974 results in the Ovid database. Fifty-seven potential articles were identified based on title, abstract, and date of publication; 27 were excluded for absence of cervical spine-specific data; 12 were excluded for not distinguishing between outcomes for patients with SEA versus osteomyelitis; 6 were excluded for having too few cervical patients; 1 was excluded for including patients younger than 18 years. Final analysis included 11 articles that met the inclusion criteria (Table 1).

All the studies collected were observational and, based on GRADE guidelines, begin with an initial evidence quality rating of "Low."[16] Eight studies lacked an internal control (all were case series); this was deemed a crucial limitation in assessing risk of bias and they were subsequently downgraded to a "Very Low" rating. Of the 3 remaining studies, 1 (Fukuda) was downgraded for absence of a standardized measurement tool, 1 (Alton) remained "Low" quality, and 1 (Ju) was upgraded to "Moderate" for strong statistical evidence in favor of their conclusions (Table 2).

Clinical Presentation

Common presenting symptoms for SEA in the cervical, thoracic, or lumbar spine include back pain, weakness, sensory changes, and fever.[11,18] Severe, rapidly progressive neck pain, nuchal rigidity, and fever are common in cervical SEA, but they are not specific findings.[19-21] The largest studies of cervical SEA found 45% to 77% of patients have some degree of neurological impairment at the time of presentation, ranging from mild monoparesis to tetraplegia.[20,21] Epidural abscess located ventral to the spinal cord may be significantly more likely to cause upper extremity weakness; however, cervical abscess location does not appear to be correlated with worse functional and neurologic outcomes.[10]

Workup

Once clinical suspicion for an epidural abscess is established, evaluation continues with an analysis of blood work. Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are elevated in the majority of cases, but leukocytosis is a less reliable indicator.[19,21] Data exploring the specificity and sensitivity of ESR and CRP values are absent with regard to cervical SEA; but among all patients with SEA, ESR was found to be greater than 22 mm/h in 94%[11] and has also been observed to have a sensitivity and specificity of 100% and 67%, respectively, in the presence of at least 1 risk factor (diabetes, IVDU, immunocompromised, chronic liver/kidney disease, other site of infection).[22]

Definitive diagnosis of SEA relies on imaging, either a contrast-enhanced magnetic resonance imaging (MRI) imaging or computed tomography (CT) myelogram in those who are unable to obtain a cervical MRI (Figures 1 and 2).[10-12,19-21,23-26]

Table 1. Summary of Included Studies.

Author	Year	Number Patients	Presenting Symptoms	Presenting Deficit	Evaluation Tools	Risk Factors	Organisms	Location	Surgical Management	Medical Management	Antibiotics	Outcomes	Complications
Alton	2015	62	Neck pain Weakness Numbness	Medical AIS: 96 Surgical AIS: 72.4	AIS motor score, MRI, ESR, CRP	DM, IVDU, hepatitis	MRSA, MSSA, *Streptococcus milleri*	Dorsal 21 Ventral 28 Both 13	38 (early) 56 (total)	24 (initial)-antibiotics; 6 (final)	NR	Medical AIS: 84.7 Surgical AIS: 84.3 No significant difference	NR
Böstrom	2008	8	NR	Frankel A: 1 Frankel B: 2 Frankel C: 2 Frankel D: 2 Frankel E: 1	Frankel grade	NR	NR	Dorsal 3 Ventral 4 Both 1	2 ACD 1 laminectomy 2 hemilaminectomy	3 CT-guided aspiration and antibiotics	NR	6 improved; 1 unchanged; 1 died	NR
Fukuda	2014	4	NR	NR	Frankel grade, CRP	NR	NR	NR	NR	4 CT-guided aspiration, bed rest, serial CRP	NR	4 failed medical treatment	NR
Ghobrial	2015	40	Weakness Neck pain	16 with deficit by ASIA scale	ASIA, MRI, CRP	IVDU	*Staphylococcus aureus*	Dorsal 17 Ventral 12 Both 11	26 anterior-posterior; 8 anterior; 6 posterior	0	Vancomycin/ cefepime	40% better; 58% stable; 2% worse	1 pseudarthrosis
Ju	2015	65	NR	NR	MRI, CT	NR	NR	NR	NR	NR	NR	NR	NR
Muzii	2006	8	Fever, pain, weakness	Tetraparesis Tetraplegia	MRI, ESR, CRP	DM, IVDU	*S aureus, S milleri*	NR	8 ACD with irrigation	0	NR	6 full recovery; 2 paraparesis	1 asymptomatic kyphosis
Soehle	2002	8	NR	NR	Unique grading scheme	NR	NR	6 anterior 2 posterior	8 treated with surgery; approach not specified	0	NR	NR	NR
Young	2001	6	Paralysis	Tetraplegia	MRI	IVDU	*S aureus*	NR	6 anterior corpectomy; 4 plated	0	NR	4 ambulatory; 2 tetraplegic	NR
Mondorf	2009	5	Weakness, neck pain	Paresis	NR	NR	*S. aureus*	NR	5 ACDF with PEEK cage	0	Meropenem	2 full recovery; 3 improved	NR
Wang	2010	5	NR	NR	MRI, CT, AIS motor score	NR	NR	NR	4 anterior corpectomy 1 laminectomy	0	NR	3 significant improvement; 2 no better	NR
Gonzalez-Lopez	2009	4	NR	Paresis, radiculopathy, plegia	MRI, CT, Heusner scale	Liver disease	NR	NR	4; strategy not specified	0	NR	1 full recovery; 2 poor outcome; 1 died	NR

Abbreviations: ACDF, anterior cervical decompression and fusion; ASIA, American Spinal Injury Association; AIS, ASIA Impairment Scale; CRP, C-reactive protein; CT, computed tomography; DM, diabetes mellitus; ESR, erythrocyte sedimentation rate; IVDU, intravenous drug use; MRI, magnetic resonance imaging; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *Staphylococcus aureus*; NR, not reported; PEEK, polyetheretherketone.

Table 2. GRADE Quality of Evidence Evaluation.

Author	Internal Control (Risk of Bias)	Outcome Measurement Tool (Risk of Bias)	GRADE
Alton	Yes (medical vs surgical)	AIS motor score	Low Observational study with internal control and standardized outcome measures
Böstrom	No	Frankel grade	Very low Case series without internal control
Fukuda	Y (medical vs surgical)	Treatment failure at clinician discretion	Very low Observational study without standardized outcome measure
Ghobrial	N	ASIA grade	Very low Case series without internal control
Gonzalez-Lopez	N	Nonstandard tool (full vs poor recovery)	Very low Case series without internal control and without standardized outcome measure
Ju	Y (skip vs no skip lesion)	Imaging data (MRI and CT myelography)	Moderate Observational study with robust statistical data
Mondorf	N	Nonstandard tool (normal, improved)	Very low Case series without internal control and without standardized outcome measure
Muzii	N	Nonstandard tool (recovery, paresis)	Very low Case series without internal control and without standardized outcome measure
Soehle	N	Nonstandard tool (plegia, nonambulatory, ambulatory, no deficit)	Very low Case series without internal control and without standardized outcome measure
Wang	N	Nonstandard tool (significant vs poor improvement)	Very low Case series without internal control and without standardized outcome measure
Young	N	Nonstandard tool (ambulatory vs plegia)	Very low Case series without internal control and without standardized outcome measure

Abbreviations: ASIA, American Spinal Injury Association; AIS, ASIA Impairment Scale; CT, computed tomography; MRI, magnetic resonance imaging.

Figure 1. T2-weighted sagittal and axial magnetic resonance imaging of dorsal cervical epidural abscess.

MRI has a reported overall diagnostic sensitivity of 91% for SEA in any location, but there is no data evaluating cervical-specific SEA.[27] On advanced imaging, epidural abscesses may be dorsal to the spinal cord (34%-43% of cases), ventral to the spinal cord (30%-45% of cases), or circumferential (21%-28%).[20,21] Smaller series suggest that 75% to 77% of abscesses are located ventral or ventrolateral and 23% to 25% are dorsal or dorsolateral to the spinal

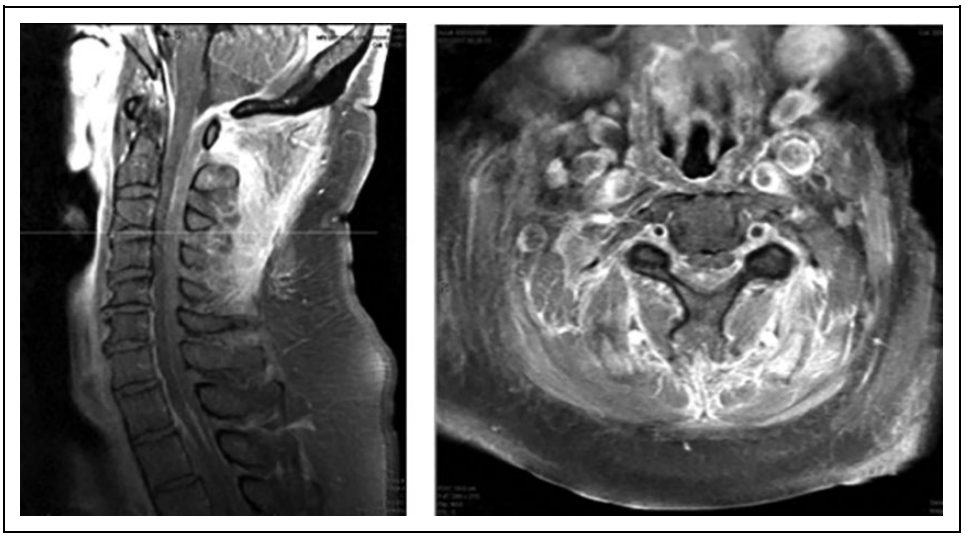

Figure 2. Postcontrast sagittal and axial magnetic resonance imaging of dorsal cervical epidural abscess.

cord, but this discrepancy may be a consequence of variation in classification schemes.[10,12] The C5-6 and C6-7 levels are the most commonly affected levels of the cervical spine while C1-2 is the least commonly affected (7%).[20] Imaging of the entire spine should be considered in any patient suspected of SEA since the incidence of concurrent but noncontiguous infectious lesions has been reported to be as high as 47%.[25] Patients with noncontiguous SEA are more likely to have had symptoms for at least 7 days prior to presentation, an ESR greater than 95 mm/h, and a concomitant infection outside the spine and paraspinal region.[25]

Risk Factors and Causative Organisms

Common comorbidities among patients with cervical SEA are similar to those of thoracic and lumbar SEA, including intravenous drug use (25%), diabetes (15%), and obesity (13%).[20,21,26] Additional risk factors include immunosuppression from chronic steroid use or malignancy. Risk factors which may be preferentially associated with cervical SEA include pharyngeal abscess and a history of neck radiation.[19,20]

Sources of infection include hematogenous spread from an infected joint outside the spine, direct spread from oral and/or pharyngeal infections, spread from a urinary tract infection, and bacterial endocarditis; however many patients will not have a definitive source of infection identified.[19] *Staphylococcus aureus* is the most commonly identified organism in cervical SEA and is found in nearly three-quarters of patients; methicillin-susceptible *Staph aureus* is observed more frequently than methicillin-resistant *Staph aureus* (58% vs 13%).[19,20,26,28]

Management and Outcomes

Management strategies for cervical SEA include systemic antibiotic administration, CT-guided aspiration of abscess plus antibiotics, and surgical abscess evacuation plus antibiotic therapy (Figure 3). Unfortunately, there are no randomized, controlled trials comparing these different options. The largest study comparing treatment options for cervical SEA was a retrospective review of 62 patients in which the authors compared medical treatment (systemic antibiotic therapy tailored to blood culture results) with open surgical techniques.[21] However, surgical approaches were at the discretion of the treating surgeon and not standardized. All patients were assessed at presentation with the 100-point ASIA (American Spinal Injury Association) Impairment Scale (AIS) for motor functioning: medical patients had an initial score of 96 while surgical patients had a score of 72.4.[21] This was a significant difference and shows that there may have been a bias toward

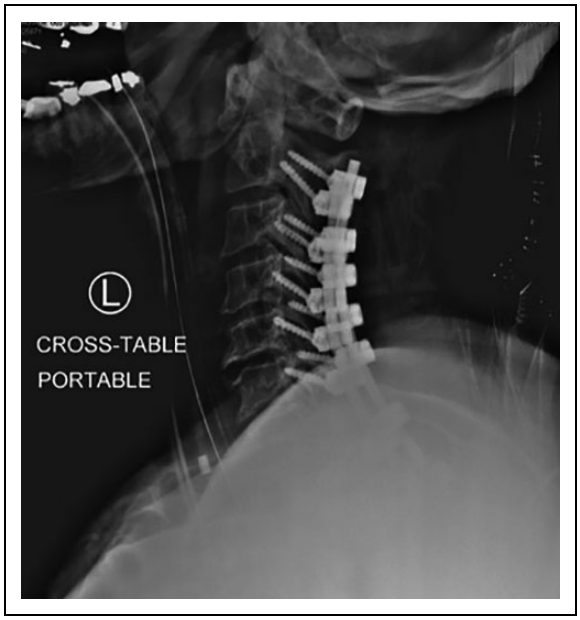

Figure 3. Postoperative radiograph following posterior C2-T1 decompression and fusion for cervical epidural abscess.

preferentially operating on patients who presented with neurological deficits. Postoperative motor scores were not significantly different between groups: 84.7 for the medical and 84.3 for the surgical. These results were based on an intention-to-treat analysis, however 18 of the 24 patients from the medical group ultimately went on to have surgical treatment. Those 18 patients were deemed to have failed medical therapy based on worsening motor scores. At presentation, the average AIS motor score (AIS-MS) among those who failed medical management was 99.2, but subsequently declined to 59.4.[21] After surgery, these patients had an average improvement in AIS-MS to a final score of 83.3, significantly lower than their presentation score.[21] Surgical treatment strategies for both the early and delayed surgical group included anterior cervical discectomy, corpectomy, posterior cervical decompression with or without fusion, and combined anterior and posterior procedures, but there was no analysis of outcome based on surgical approach. Despite the authors' bias toward early surgery for patients with neurological deficit in the setting of cervical SEA, their results suggest that there might be benefit in early surgical treatment, despite the overall outcomes being similar.

Two additional, albeit smaller, studies also compared outcomes between surgical and nonsurgical treatment. In their retrospective study, Fukuda et al[24] assessed outcomes of nonoperative therapy for SEA consisting of antibiotics, bed rest, and bracing. They observed that all 4 patients with cervical epidural abscess failed nonoperative therapy, defined as persistently elevated CRP, progressive neurological deficit and/or spinal instability with worsening kyphosis; all 4 went on to require surgical treatment.[24] Three of 8 patients in the Böstrom series were treated with CT-guided aspiration of their abscess and subsequent antibiotics: 1 remained a Frankel grade E after the procedure while the other 2 improved from a Frankel grade D to E.[23] While 2 studies (Fukuda and Soehle) did monitor treatment response with CRP,[10,24] neither preoperative laboratory values (ESR, CRP, WBC, etc) nor medical comorbidities have not been found to correlate with failure of medical therapy.[21]

Cervical SEA is a heterogeneous disorder, patient presentation can vary from isolated focal abscess to osteomyelitis-discitis with structural deformity. The goals of surgery for patients with SEA are decompression of the neural elements, debridement of the infection, identification of a causative organism(s) for targeted antimicrobial therapy, and stabilization of the spine. Surgical strategies to achieve these aims should be patient-specific and can range from an isolated decompression (e.g., hemilaminectomy) to the more complex combined anterior-posterior procedure. One study of 56 surgical patients found an average improvement of almost 12 points on the AIS motor score; however there was no discussion of outcome based on surgical approach or treatment.[21] Another study observed 52% of patients with a neurological deficit improved by 1 ASIA grade following surgery, while 45% remained unchanged and only 1 patient (3%) worsened after surgery.[20] Interestingly, neither study addressed how outcome is influenced by the relationship between surgical approach and abscess location; while they both observed a surgical benefit, one study performed 5 anterior-posterior procedures in the setting of 13 combined ventral-dorsal abscess where the other performed 26 anterior-posterior procedures despite only 11 patients having ventral and dorsal abscess.[20,21] Of note, the study with the higher number of anterior-posterior procedures did not specify whether they were required for abscess evacuation, spinal stabilization, or both.[20]

Only one study provided specific details linking abscess location, surgical approach, and outcomes. Of 5 cervical patients with neurological deficits on presentation in the Böstrom series, 2 had ventral abscesses and subsequently underwent anterior surgery, both improved by 2 Frankel grades. Three additional patients had dorsal abscesses treated with posterior surgery; 2 had no functional deficits (Frankel grade E) and remained neurologically intact while the remaining patient, who was a Frankel grade A on arrival, died.[23] This cohort is too small to make any conclusions about outcome based on the relationship between abscess location and surgical approach and it also neglected to discuss of the role of identifying spinal deformity/instability and the degree of cord compression in treatment decision making; both of these are important points neglected in the other studies also included in this review.

Other smaller, limited studies noted similar benefits of surgery in the treatment of surgical SEA patients. Muzii et al[19] treated 6 patients who presented with a neurological deficit and epidural abscess using anterior cervical decompression and irrigation of the epidural space with antibiotic fluid via a silicone catheter. Four went on to a full recovery while two had persistent paraparesis.[19] A similar rate of recovery was seen in 6 tetraplegic patients who underwent an anterior corpectomy with catheter irrigation for cervical SEA: four were able to ambulate independently while two remained tetraparetic.[26] Neither study discussed the location of abscess.[19,26] Recovery of function was also seen in all 5 patients who underwent anterior cervical decompression and fusion (ACDF) for evacuation of cervical SEA[28] as well as in 60% of patients who underwent either an anterior corpectomy or posterior laminectomy for cervical SEA in Wang's series.[14] Only 1 patient (25%) in the surgical series by Gonzalez-Lopez et al[29] had a good outcome (defined as full recovery) while 2 had poor outcomes (persistent deficit) and 1 died.

Interestingly, of the 3 patients who did poorly or died (75%) in the Gonzalez-Lopez series, 2 presented as a Heusner stage 4 (paralysis) and 1 was a Heusner stage 3 (weakness); the one patient who did well only had radiculopathy at presentation (Heusner stage 2).[29,30] While in this series it was suggested that poor neurological status at presentation might be a predictor for poor outcomes, this was not supported across all studies. In the study by Alton et al,[21] the group undergoing delayed surgery had a preoperative AIS MS of 59.4, the preoperative AIS MS of the early surgery group was 72.4, but final motor scores for each group were 83.3 and 84.3, respectively.[21] Similarly, Young et al[26] observed full recovery in 4 patients who had been tetraplegic for less than 24 hours; however, the 2 who

had been tetraplegic for more than 24 hours had persistent deficits. It is difficult to determine the role that timing of surgery may play in prognosis. For example, Muzii et al[19] observed full recovery in a patient with tetraparesis for 2 weeks; however, another patient with progressive weakness leading to tetraparesis over "several days" had persistent neurological deficits. From the existing literature, it is difficult to definitively identify predictors of outcome; furthermore, our understanding of the natural history of cervical SEA is also influenced by the tendency of surgeons to operate more expediently than for those abscesses located in other locations along the spine.[31]

Complications

There is limited data available regarding the rate of complications among patients with cervical SEA from either medical, surgical, or timing of treatment. Several studies either did not include or did not define that which constituted a surgical complication. Among those studies which did report complications, they appear to be uncommon. The incidence of repeat surgery for recurrent or persistent infection is reported between 0% and 2.5%; however, there is limited follow-up in these series, which makes it difficult to assess the durability of therapy.[20,21] In addition, the patient population affected by SEA tends to be inconsistent in their care patterns. One study observed that, despite the increased complexity and operative time of combined anterior-posterior procedures, these patients were not at any increased risk of complication when compared with anterior-only or posterior-only procedures.[20] In 2 small studies, neither placement of anterior hardware nor anterior interbody PEEK (polyetheretherketone) spacer appeared to be associated with an increased risk of persistent or recurrent infection.[26,28] Similarly, the rate of pseudarthrosis requiring revision surgery was also cited at only 2.5%.[20] For those patients undergoing anterior evacuation of SEA without fusion, no complications were reported; however, 1 out of 8 patients (12.5%) was found to have a mild, asymptomatic kyphosis on follow-up imaging.[19] No study discussed delayed instability requiring surgery; however, it is unclear if this is an error of omission or actually an event with incidence near zero as follow-up was variable between studies. Mortality among patients with cervical SEA was cited at 12.5% to 25% in 2 small, retrospective studies; both studies had 1 patient die, both of whom presented with significant neurologic compromise.[23,29] There was no discussion of the incidence of other known morbidities such as swallowing dysfunction, laryngeal nerve injury, or persistent iliac crest pain following autograft harvest among any of the included studies.

Discussion

The incidence of spontaneous SEA appears to be increasing across North America, and this increase is driven in large part by rising rates of intravenous drug use and obesity.[11] While there is an abundance of literature on spinal epidural abscesses, there is limited data focusing on cervical SEA and no high-level evidence. A majority of the literature pertaining to cervical SEA is grouped with thoracic and lumbar SEA, limiting cervical spine-specific conclusions.

Presenting symptoms for cervical SEA are vague, nonspecific, and overlap with those for thoracic and lumbar lesions, including neck/back pain, radicular symptoms, and neurological deficit.[5,7,18,32,33] Risk factors and causative organisms are similar between cervical, thoracic, and lumbar SEA.[5,7,18,33,34] However, while some studies have suggested that anatomic location of SEA does not significantly influence patient outcomes,[7,18,34] the disparity in morbidity and mortality based on location suggests the contrary as evidenced by other studies showing cervical abscesses are associated with worse outcomes, particularly due to neurologic deficits.[10,29] Pooled data in retrospective studies have reported a 30% to 52% failure rate for nonoperative management of SEA where failure is defined as progressive neurological impairment. However, there may be a selection bias in that successfully treated medical cases are most likely under reported.[5,32,34] The quantity of cases failing medical therapy increased to 75% to 100% when looking at cervical SEA-specific data in 2 limited, retrospective studies.[21,24] Contrary to the reports of these 2 small series, other series have observed no significant difference in final neurological outcome when comparing surgically and nonsurgically treated patients.[21,35] The simplicity of this conclusion overshadows the fact that nonoperatively managed patients tend to have better neurological exams at presentation, and tend to lose function while operatively treated patients tend to improve but have significant deficits at baseline.[5,18,21] While retrospective reviews of management strategy in patients with cervical SEA are often biased in favor of surgical intervention, potentially obscuring the true efficacy of nonoperative treatments, surgical intervention is generally reported to be safe and efficacious.[7,34,36] Unfortunately, an assessment of the decision making behind surgical intervention is often lacking but in practice must factor in both spinal cord compression and instability as a consequence of the infection.

The timing of surgical management of cervical SEA also remains an elusive question. Outcomes are worse in patients for whom treatment is delayed until the development of a neurological deficit[5,7,37,38] However, the pace of symptom progression from back pain to nerve root pain, weakness, and paralysis is variable from patient to patient, and there is a limited understanding of whom will develop symptomatic progression with nonoperative therapy.[30,37,39-41] Studies analyzing the impact of surgical timing on outcomes have not offered any additional clarification as patients with cervical SEA tend to preferentially undergo early surgery.[31] Lastly, the concept of "early" or "urgent" surgical intervention is either not clearly defined or ranges from 12 to 72 hours from a variable starting point that includes presentation to the hospital or imaging-based confirmation of diagnosis.[5,7,21,26,31,32,37]

Conclusion

Data pertaining specifically to cervical SEA is limited in quantity and the quality of the existing literature is low. That which

is available is diffusely heterogeneous, further hindering efforts to synthesize and generate larger data sets. Despite the limitations in our understanding of the optimal treatment strategy, the available research suggests that earlier surgical intervention may provide a neurological benefit in some patients with cervical SEA but there is a difficulty in identifying this population. However, there are inherent risks with operative treatment and thus medical management is also a possible option.

Declaration of Conflicting Interests

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