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Clinical Study

Clinical outcomes of percutaneous suction aspiration and drainage for the treatment of infective spondylodiscitis with paravertebral or epidural abscess

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Abstract

BACKGROUND CONTEXT: Patients with infective spondylodiscitis who failed conservative treatment are generally indicated for open surgery. However, some patients are poor candidates for standard surgery, hence the need to evaluate less invasive approaches. Good outcomes were previously reported for percutaneous suction aspiration and drainage (PSAD) in the treatment of infective spondylodiscitis resistant to conservative therapy. We recently extended the surgical approach of PSAD to allow drainage of paravertebral or epidural abscesses in patients with progressive infective spondylodiscitis.

PURPOSE: To evaluate the clinical outcomes of PSAD for infective spondylodiscitis with paravertebral or epidural abscess.

DESIGN: Retrospective case series.

PATIENT SAMPLE: Patients with infective spondylodiscitis and associated epidural or paravertebral abscess treated using PSAD at our institution, between 1998 and 2014.

OUTCOME MEASURES: Serum levels of C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and imaging data obtained via plain radiography, computed tomography, and magnetic resonance imaging were analyzed. Serum measurements were taken preoperatively and at several time points postoperatively. Clinical outcomes were evaluated using the modified MacNab criteria for overall functional mobility.

METHODS: Data were obtained from the patients' case notes, radiological images, and medical records. Student *t* test was used to assess the relevance of changes in serum levels of CRP and ESR at each evaluated time point, as well as the change in sagittal Cobb angle between the preoperative state and the state at final follow-up.

RESULTS: Fifty-two patients (31 men and 21 women; average age, 70.6 years) were included in our analysis. The median (range) CRP levels and ESR values at the time of diagnosis were 6.86 (0.04–20.15) mg/dL and 78.8 (26–120) mm/h, respectively. At 1 year postoperatively, these values had decreased to 0.18 (0.0–1.2) mg/dL and 13.8 (4–28) mm/h for CRP and ESR, respectively. At final follow-up, bone union was observed in 80.8% (42 of 52) of patients, with instability identified in five patients. Regarding functional mobility, excellent outcomes were obtained in 26.9% (14 of 52) of patients, whereas good, fair, and poor outcomes were noted in 42.3% (22 of 52), 3.9% (2 of 52), and 26.9% (14 of 52) of patients, respectively. Overall, treatment was considered effective in 69.2% (36 of 52) of patients.

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MT and YK participated in the study conception and design, the acquisition of data, the interpretation of data, and drafting of the manuscript. GM participated in the analysis and interpretation of the data. SK, GM, NK, and SN participated in critical revision.

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CONCLUSIONS: Percutaneous suction aspiration and drainage can serve as an effective alternative to open surgery for the treatment of patients with progressive infective spondylodiscitis and associated paravertebral or epidural abscess.

Keywords: Clinical outcome; C-reactive protein; Epidural abscess; Erythrocyte sedimentation rate; Infective spondylodiscitis; Paravertebral abscess; Percutaneous drainage; Percutaneous suction aspiration

Introduction

Although infective spondylodiscitis is a relatively rare disease, its incidence has recently increased [1–4], particularly in elderly individuals susceptible to illnesses that induce an immunosuppressive state. The risk of infective spondylodiscitis in elderly individuals is further increased by the fact that such individuals are more likely to use immunosuppressants [5–9] or require implantation of devices such as central vein catheters [10], which can cause hematogenous infections. Moreover, the use of computed tomography and magnetic resonance imaging has improved the diagnostic rate of infective spondylodiscitis [11–13], which is reflected in the recently increased incidence of this disease.

Generally, patients with infective spondylodiscitis undergo an initial course of conservative treatment that includes rest, external immobilization (bracing), and antibiotic medication [11,14,15]. Surgical intervention is recommended if conservative treatment fails and for infection control, progressive neurologic deficits, or progressive deformities [11,14–16]. Among the available surgical options, anterior spinal fusion is the most commonly used [16,17], as the anterior vertebral components (ie, the disc and vertebral body) are often determined to be the initial site of infection [18]. However, anterior spinal fusion is associated with a complication rate of 15% [19] and a mortality rate of 4%–5% [20]. In addition, some patients with poor general status are poor candidates for standard surgery, hence there is a need to develop and evaluate less invasive approaches for the treatment of infective spondylodiscitis.

Percutaneous suction aspiration and drainage (PSAD) is a minimally invasive technique that provides an alternative to open surgery for the treatment of infective spondylodiscitis, with good clinical outcomes having been reported by Nagata et al. for the first 23 cases managed using PSAD [21]. The advantages of PSAD, compared with anterior spinal fusion, include the use of local rather than general anesthesia, less postoperative pain, and early postoperative ambulation [21,22]. However, in PSAD, curettage is only possible within the disc space, which makes it challenging to drain paravertebral or epidural abscesses. However, Hanaoka et al. reported effective drainage and complete resolution of epidural and iliopsoas abscesses in four patients treated using a minimally invasive technique similar to PSAD [14]. Based on this evidence, we extended the PSAD technique to include drainage of epidural or paravertebral abscesses in patients with infective spondylodiscitis and poor general health status. In the present case series study, we aimed to conduct a retrospective analysis of the clinical outcomes of PSAD in such patients.

Materials and methods

Participants

This was a single-center, retrospective case series study performed at the hospital affiliated with our university. The study was conducted after obtaining institutional review board approval and in accordance with STARD guidelines for diagnostic test studies (Supplementary File 1). The requirement for informed patient consent was waived on account of the retrospective nature of the study. Consecutive patients treated between 1998 and 2014 using PSAD for infective spondylodiscitis with epidural or paravertebral abscesses were identified in the database maintained by our hospital. The following inclusion criteria were applied: clinical symptoms, including lumbar pain or pyrexia; elevated serum levels of inflammatory markers including C-reactive protein (CRP) levels and erythrocyte sedimentation rate (ESR); magnetic resonance imaging evidence of T2 signal intensity changes within a vertebral body end plate or intervertebral disc, and findings indicative of abscess formation in an epidural space or close to the involved vertebral body; failure of a 6-week conservative treatment course (rest, corset bracing, antibiotic treatment); no apparent paralysis or, if present, poor general health status as a contraindication to general anesthesia and surgery; postoperative follow-up ≥1 year; and age ≥20 years. Eligible patients were screened for the following exclusion criteria: infective spondylodiscitis caused by postoperative infection; surgical intervention other than PSAD, such as laminectomy; multilevel involvement; and tuberculous or mycotic spondylitis.

Fifty-two consecutive patients met our inclusion and exclusion criteria and were thus included in our study sample (31 men and 21 women; average age 70.1 years; age range, 29–92 years). The patients were followed up for a mean of 31.4 months (range, 12–130 months). The relevant demographic data of the patients included in our sample group are summarized in Table 1.

Surgical intervention

The surgical approach was similar to that used for percutaneous discectomy performed for the treatment of intervertebral disc herniation [23]. The patient was placed in a lateral decubitus or prone position on the operative table.

Table 1
Patient demographic data

No.	Sex	Age (y)	Infection site	ASA-PS	DM	CRF	LC	Malignancy	Use of immunosuppressant	Charlson comorbidity index	Preoperative duration of symptom	Kulowski classification	Griffiths classification	Semiquantative method (upper/lower)	Epidural abscess	Paravertebral abscess
1	F	65	L3–L4	1	No	No	Yes	Yes	No	5	18	Acute	I	Grade 0/0	Yes	No
2	M	77	L3–L4	3	Yes	No	No	No	No	2	1	Acute	II	Grade 1/2	No	Yes
3	F	70	L2–L3	3	No	No	No	No	No	0	3	Acute	I	Grade 0/0	No	Yes
4	M	80	L2–L3	2	No	No	No	Yes	No	2	33	Acute	II	Grade 1/1	No	Yes
5	M	59	L3–L4	1	No	No	No	No	No	0	21	Acute	I	Grade 0/0	Yes	Yes
6	M	58	L3–L4	3	Yes	No	Yes	No	No	5	8	Acute	I	Grade 0/0	Yes	No
7	M	52	L2–L3	1	No	No	No	No	No	0	3	Subacute	I	Grade 1/0	Yes	No
8	M	65	L2–L3	3	Yes	No	No	No	No	5	0	Acute	II	Grade 0/0	No	Yes
9	M	63	T12–L1	2	No	No	No	No	No	1	11	Acute	II	Grade 1/0	No	Yes
10	F	59	L4–L5	3	Yes	No	No	No	No	2	5	Subacute	II	Grade 1/0	Yes	No
11	F	62	L2–L3	3	Yes	No	No	No	No	1	8	Subacute	II	Grade 1/2	Yes	Yes
12	F	63	T9–T10	3	Yes	No	No	No	No	1	13	Subacute	II	Grade 0/0	Yes	No
13	M	87	L3–L4	2	No	No	No	No	No	0	4	Acute	I	Grade 0/0	No	Yes
14	F	48	L3–L4	1	No	No	No	No	No	1	2	Acute	I	Grade 0/0	No	Yes
15	M	84	L3–L4	3	No	No	No	No	No	1	6	Acute	I	Grade 1/0	Yes	No
16	M	72	L3–L4	3	No	No	No	Yes	No	0	34	Acute	I	Grade 1/1	Yes	Yes
17	M	85	L1–L2	3	Yes	No	No	Yes	No	3	6	latent	II	Grade 1/0	Yes	Yes
18	F	70	L3–L4	2	No	No	No	Yes	No	8	1	Subacute	I	Grade 1/0	No	Yes
19	F	76	T12–L1	3	Yes	No	No	No	Yes	1	2	Acute	II	Grade 1/2	Yes	Yes
20	M	75	L3–L4	3	Yes	No	No	No	No	1	10	Subacute	II	Grade 0/0	Yes	Yes
21	M	65	L1–L2	3	Yes	No	No	No	No	4	4	Latent	III	Grade 1/0	Yes	No
22	M	69	L3–L4	2	No	No	No	No	No	1	10	Acute	II	Grade 0/0	No	Yes
23	F	85	T12–L1	3	No	No	No	No	No	1	11	Acute	I	Grade 0/0	No	Yes
24	F	81	L3–L4	2	No	No	No	No	No	0	2	Acute	I	Grade 0/0	Yes	No
25	M	70	L3–L4	2	No	No	No	No	No	0	7	Subacute	I	Grade 0/1	Yes	No
26	M	77	L2–L3	3	No	No	Yes	No	No	3	7	Latent	II	Grade 0/0	Yes	Yes
27	M	45	L3–L4	1	Yes	No	No	No	No	1	0	Acute	II	Grade 3/3	No	Yes
28	M	58	L2–L3	2	Yes	Yes	No	No	No	4	3	Subacute	II	Grade 0/0	Yes	Yes
29	M	74	T6–T7	2	Yes	Yes	No	Yes	No	5	8	Subacute	II	Grade 2/0	No	Yes
30	F	60	L3–L4	2	No	No	No	No	Yes	0	8	Acute	II	Grade 0/2	No	Yes
31	F	86	L2–L3	2	No	No	No	No	No	0	1	Acute	II	Grade 1/0	Yes	Yes
32	M	78	L4–L5	2	Yes	No	No	Yes	No	4	0	Subacute	II	Grade 0/1	Yes	Yes
33	M	66	L2–L3	3	Yes	No	Yes	Yes	No	6	0	Subacute	II	Grade 0/1	No	Yes
34	F	80	L3–L4	2	No	No	No	No	Yes	1	1	Subacute	II	Grade 0/2	No	Yes
35	M	60	L2–L3	4	No	Yes	No	Yes	No	4	3	Subacute	II	Grade 2/3	Yes	Yes
36	M	75	L3–L4	3	No	No	No	Yes	No	2	1	Subacute	II	Grade 0/0	Yes	Yes
37	F	67	L4–L5	4	Yes	No	No	No	No	3	41	Acute	II	Grade 0/0	Yes	Yes
38	M	67	T9–T10	1	No	No	No	Yes	No	3	32	Acute	II	Grade 0/2	Yes	Yes
39	F	29	L4–L5	1	No	No	No	No	Yes	0	21	Acute	II	Grade 0/0	No	Yes
40	M	75	L4–L5	2	No	No	No	Yes	No	2	2	Subacute	II	Grade 0/0	Yes	No
41	F	89	L4–L5	2	Yes	No	No	No	No	3	61	Latent	II	Grade 0/1	No	Yes
42	M	79	L1–L2	2	No	No	No	No	No	0	10	Subacute	II	Grade 1/0	No	Yes
43	M	77	L4–L5	1	Yes	No	No	No	No	1	3	Acute	II	Grade 1/1	Yes	yes
44	F	87	L1–L2	2	No	No	No	No	Yes	0	1	Latent	III	Grade 1/1	Yes	No
45	M	65	L2–L3	3	Yes	No	No	No	No	3	80	Latent	III	Grade 0/0	Yes	Yes
46	M	73	L2–L3	3	No	No	No	No	Yes	1	6	Acute	I	Grade 1/2	Yes	Yes
47	M	77	L1–L2	3	Yes	No	No	No	No	1	1	Acute	I	Grade 1/2	No	Yes
48	F	53	L3–L4	3	No	Yes	No	No	Yes	4	2	Subacute	II	Grade 0/0	Yes	Yes
49	M	65	L4–L5	2	No	No	No	No	No	0	5	Acute	II	Grade 1/1	No	Yes
50	F	81	L4–L5	2	Yes	No	No	No	No	3	18	Acute	I	Grade 0/0	Yes	Yes
51	F	69	T6–T7	2	Yes	No	No	No	No	3	3	Latent	III	Grade 0/3	No	Yes
52	F	92	L2–L3	2	No	No	No	No	No	1	7	Acute	II	Grade 3/0	No	Yes

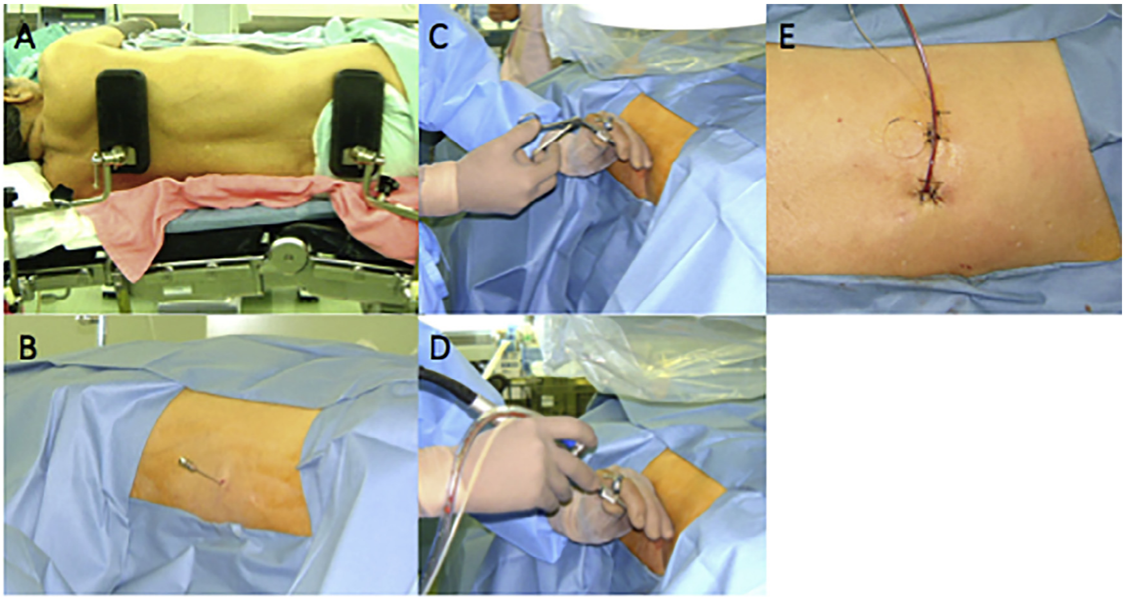

Fig. 1. (A) The patient was placed in a lateral decubitus or prone position on the operative table. (B) A Mayer instrument was inserted toward the intervertebral disc under real-time fluoroscopic guidance. (C) The affected intervertebral disc was curetted with several rongeurs as much as possible. (D) The end plate of the vertebral body was removed using a motor-driven shaver. (E) An epidural catheter and a suction tube were inserted into the affected disc space and fixed to the skin.

After applying local anesthesia, a Mayer instrument was inserted toward the intervertebral disc under real-time fluoroscopic guidance. The affected intervertebral disc was curetted with several rongeurs as much as possible, and the end plate of the vertebral body was removed using a motor-driven shaver. The removed tissue was sent for bacteriological and histologic examinations. The disc space and its surrounding region were irrigated with a large volume (1,000–2,000 mL) of normal saline. An epidural catheter and a suction tube (outer diameter, 3.3 mm) were inserted into the affected disc space and fixed to the skin. The epidural tube was used for intermittent irrigation postoperatively, and the suction tube was used for drainage postoperatively (Fig. 1).

Irrigation was maintained at 50–100 mL/d until the inflammation had subsided. The inflow tube, followed by the outflow tube, was removed at ≥1 week postoperatively. Patients were permitted to ambulate freely and independently as soon as possible after the procedure, with external immobilization using a flexible corset for 3 months after the procedure.

Preoperative antibiotics were administered. In 12 of the 52 patients included in the study, the antibiotic was specific to the causative organism, whose sensitivity spectrum had been identified using the preoperative samples. Cephazolin was used in patients for whom the causative agent or its antibiotic sensitivity spectrum was not known. In 24 cases, the causative organism was identified anew in the tissue cultures obtained intraoperatively, and the antibiotic therapy regimen was modified postoperatively to account for the corresponding sensitivity profile. If the CRP levels decreased to <1.0 mg/dL, the antibiotic administration route was changed from parenteral to per-oral (parenteral administration period, 27.1±22.9 days), and the regimen was continued for at least 3 more months in all patients.

Outcome measures

Blood examination

Changes in serum inflammatory markers (CRP, ESR) were assessed preoperatively and then postoperatively at 2, 4, and 8 weeks, as well as at 3, 6, and 12 months after the operation.

Radiological evaluation

The progression of local spinal deformity was assessed on plain radiographs obtained preoperatively and at the final follow-up. The sagittal Cobb angle was measured as the angle formed by the intersection of a line drawn perpendicular to the superior end plate of the vertebral body above the affected disc with the perpendicular to the inferior end plate of the vertebral body below the affected disc. The Cobb angle was used to quantify the degree of focal kyphosis (from the thoracic vertebrae to L2–L3) and lordosis (L3–L4, L4–L5).

The presence of bone union and instability at final follow-up was also evaluated from plain radiographs obtained at the final follow-up. Bone union was defined as evidence of interbody fusion, with end plate calcification or bridging. Intervertebral instability was defined as a greater than 10-degree change of the angle formed by the superior and inferior disc space of the index level between the flexion and the extension radiographs [24].

Functional evaluation

The modified Frankel score and the modified MacNab criteria [25] were assessed. The modified Frankel score was assessed pre- and postoperatively. The modified MacNab criteria were classified functional mobility outcomes postoperatively as follows: excellent, if the patient was free of pain, with no restriction in mobility, and able to return to normal work and leisure activities; good, if the patient had occasional non-radicular pain but with relief from presenting symptoms and able to return to altered work and leisure activities; fair, if the patient showed some improved functional capacity but with persisting impairments in normal work and leisure activities, and was therefore unable to return to work (if relevant); and poor, if the patient continued to exhibit objective symptoms involving the root cause, with additional surgical intervention needed at the same vertebral level, irrespective of the number of repeated surgeries or length of postoperative follow-up. The success rate was calculated as the number of cases with excellent or good outcomes, with treatment failure calculated as the number of cases with fair or poor outcomes.

Analysis of poor prognosis factors

Patients with good outcomes were classified into the "satisfactory results group," whereas those with poor outcomes comprised the "unsatisfactory results group." Statistical analyses were carried out by comparing various parameters between two groups.

Statistical analysis

Changes in serum levels of CRP and ESR at each evaluated time point were assessed using the Student *t* test. The same approach (i.e., Student *t* test) was applied to assess the change in sagittal Cobb angle between the preoperative state and the state at final follow-up. A p value of <0.05 was considered to indicate statistical significance.

When analyzing the poor prognosis factors, comparisons of categorical and continuous data between the two above-described groups were performed using the Fisher exact test and Wilcoxon rank sum test as appropriate. Multivariate assessments of selected risk factors were performed using a logistic regression analysis. Variables with p values <.20 in the univariate model were included in the multivariate model. The significance of the multivariate model was set at p<.05. All analyses were performed using JMP version 11.0.0 (SAS Institute Inc., Cary, NC, USA).

Results

The operative time was 63.1±32.1 minutes (range, 27–195 minutes), with a blood loss volume of 13±33.7 g (range, 0–110 g). Causative organisms of the infection were identified in 36 patients (69.2%), by blood culture only (one patient, 1.9%), by tissue culture only (24 patients, 44.2%), or by both blood and tissue culture (11 patients, 21.3%). The microbiological characteristics of the cases for which the causative agent was identified in pre- or intraoperative samples are presented in Table 2. The most common bacterium identified was methicillin-resistant *Staphylococcus aureus* (10 patients), followed by methicillin-resistant *Staphylococci* in six patients, methicillin-sensitive *S. aureus* in five patients, collagenase-negative *Staphylococci* in four patients, and *Escherichia coli* in three patients. Infections with antibiotic-resistant bacteria were present in 21 patients, which accounted for 40.4% (21 of 52 patients) of the study sample, and in 58.3% (21 of 36) of patients in whom the causative organism was identified. The recurrence rate among our study group was 7.7% (4 of 52 patients), with infective spondylodiscitis recurring at 5 months, 1 year, 1 year and 3 months, and 3 years and 6 months. Additional treatment required in each of these four cases was as follows: conservative treatment, anterior curettage and fixation, posterolateral fusion, and percutaneous pedicle screw (PPS) fixation.

Table 2
Parameters related to PSAD

Identifying of causative organism (number (%))	
Blood culture only	1 (1.9)
Tissue culture only	24 (44.2)
Both	11 (21.3)
Negative	16 (30.8)
Causative organism (number (%))	
MRSA	10 (19.2)
MRS	6 (11.5)
MSSA	5 (9.6)
CNS	4 (7.7)
Escherichia coli	3 (5.8)
others	11 (21.6)
Drug-resistant bacteria	21 (40.4)
Operation time (min)*	63.1±32.1 (27–195)
Estimated blood loss (g)*	13±33.7 (0–110)
Complication	Nerve root irritation: 1 Lumbar artery tear: 1
Postoperative duration of suction (d)*	14.1±5.9 (3–31)
Postoperative duration of drainage (d)*	15.3±6.6 (4–40)
Recurrence (number (%))	4 (7.7)

* The values are presented as the mean and the standard deviation (min-MAX).

Blood examination

The median (range) CRP levels and ESR values at the time of diagnosis were 6.86 (0.04–20.15) mg/dL and 78.8 (26–120) mm/h, respectively. At 1 year postoperatively, the median (range) CRP levels and ESR values were 0.18 (0.0–1.2) mg/dL and 13.8 (4–28) mm/h, respectively, indicative of a significant postoperative decrease in the levels of inflammatory markers (p<.01 compared with preoperative levels; Fig. 2).

Radiological evaluation

In the affected vertebrae, 25 cases were affected at the physiological lordosis levels, and 27 cases were affected at the

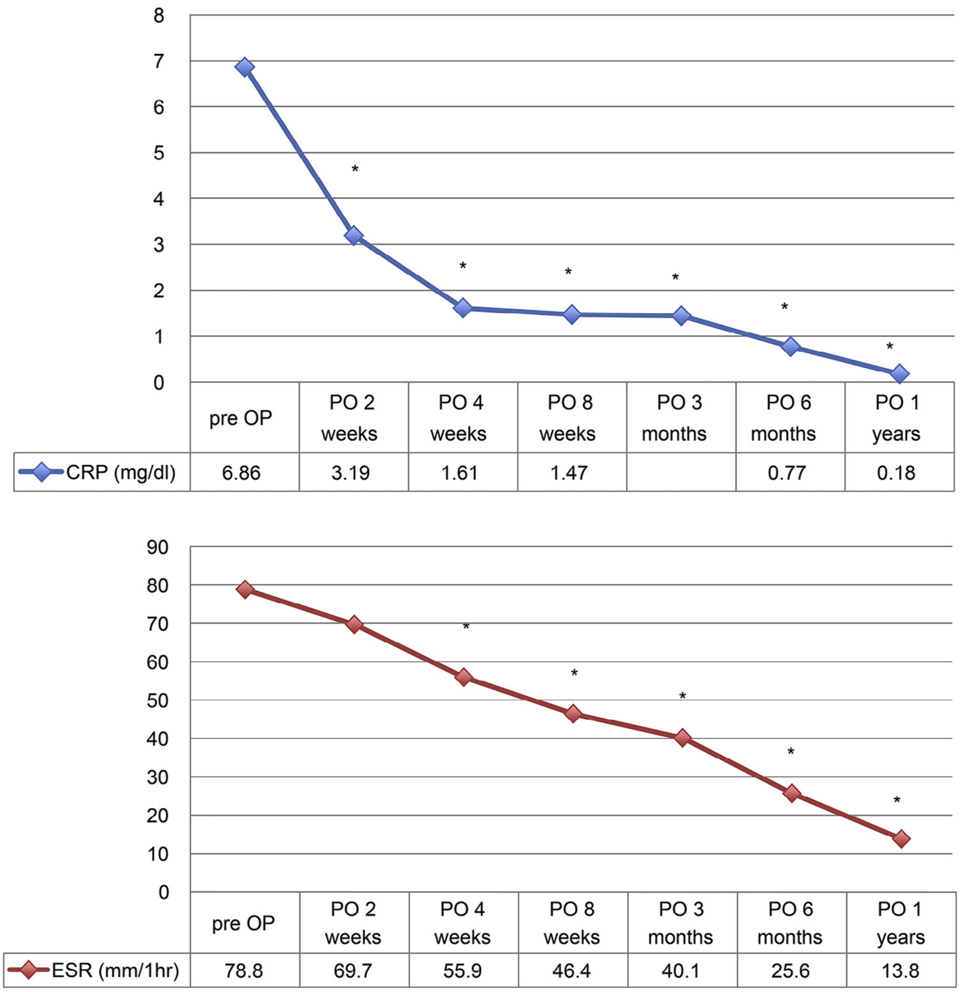

Fig. 2. Changes in serologic values after percutaneous suction aspiration and drainage (PSAD) in 52 patients with pyogenic spondylitis and associated paravertebral or epidural abscess. (Top) C-reactive protein (CRP). (Bottom) Erythrocyte sedimentation rate (ESR). OP, operation; PO, postoperative; *p<.05 compared with before PSAD, evaluated using Student *t* test.

physiological kyphosis levels. Lordosis decreased in 16 cases, and 13 of these cases had at least 5° of lordosis reduction. Moreover, kyphosis progressed in 13 cases, and 10 of these cases had at least 5° of kyphosis progression (Table 3). Overall, there was a progression of the local spinal deformity, with the angles of focal kyphosis changing from a mean of 7.5° preoperatively to a mean of 3.2° at the final follow-up (p=.02; Fig. 3, Top), and with the lordosis angle changing from a mean of 4.4° preoperatively to a mean of 9.7° at the final follow-up visit (p=.04; Fig. 3, Bottom).

Table 3
Radiographic findings after PSAD at final follow-up

Findings	Number (%) of patients
Decreased lordosis	16 (30.8)
Decreased lordosis (>5°)	13 (25.0)
Increased kyphosis	13 (25.0)
Increased kyphosis (>5°)	10 (19.2)
Bone union	42 (80.7)
Interbody fusion	25 (48.1)
End plate calcification	16 (30.8)
Bridging	1 (1.9)
Instability	5 (9.6)

At final follow-up, bone union was observed in 42 patients, with interbody fusion in 25 patients, end plate calcification in 16 patients, and bridge formation in one patient. Among the 10 patients in whom bone union was not achieved, marked bone destruction was observed in eight cases and pseudoarthrosis in two cases. Segmental instability was identified in five patients in whom bone union was not obtained (Table 3).

Functional evaluation

The modified Frankel score was C2 in 12 patients, D1 in 5, D2 in 2, D3 in 3, and E in 30 patients preoperatively, whereas it was C2 in 3 patients, D1 in 5, D2 in 4, D3 in 5, and E in 35 patients postoperatively (Table 4).

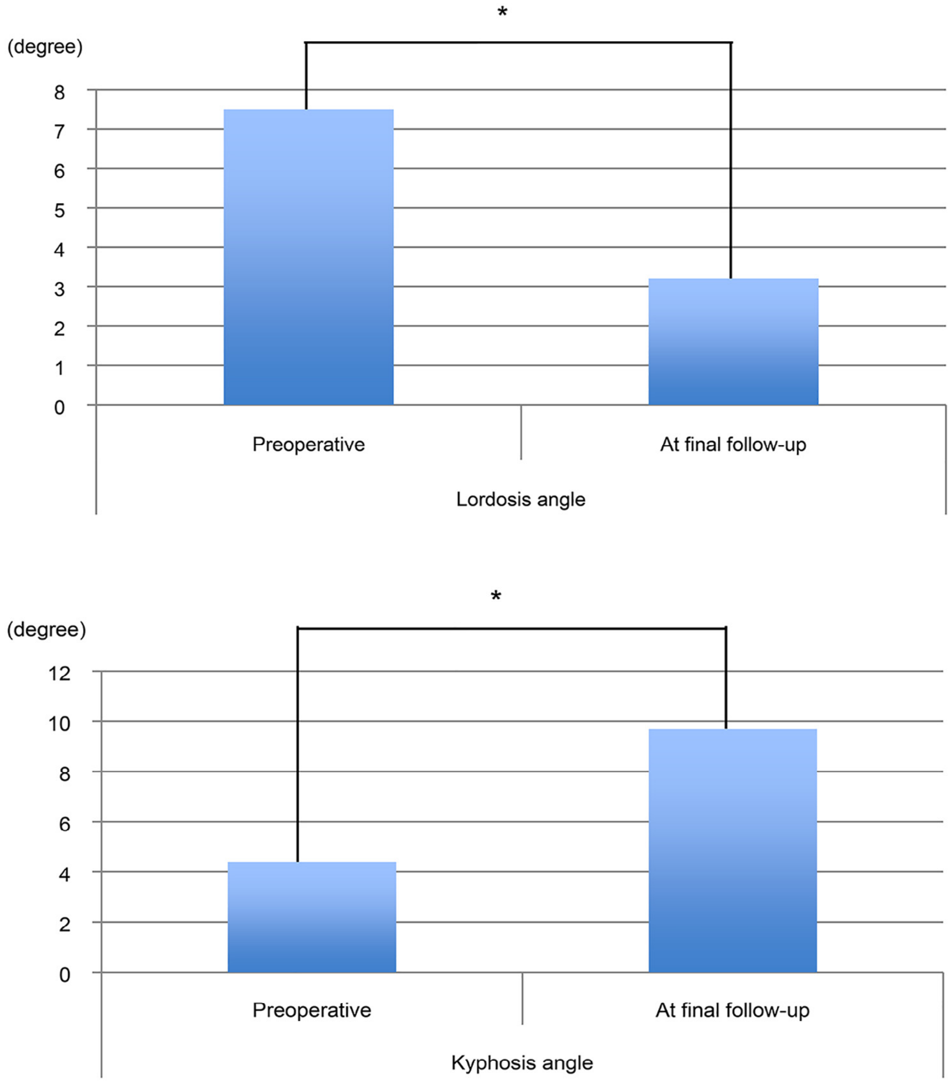

Fig. 3. Changes in the local sagittal angle of the spine, measured on plain radiographs before and after percutaneous suction aspiration and drainage (PSAD) for pyogenic spondylitis and associated paravertebral or epidural abscess. (Top) Angle of focal lordosis. (Bottom) Angle of focal kyphosis. *p<.05 compared with before PSAD, evaluated using Student *t* test.

Table 4
Functional evaluations

	Postoperative					
Modified Frankel score	C2	D1	D2	D3	E	
Preoperative	C2	3	5	2	2	
	D1			1	1	2
	D2			1	1	
	D3					3
	E					30
Modified MacNab criteria	Number (%)					
Excellent	14 (26.9)					
Good	22 (42.3)					
Fair	2 (3.8)					
Poor	14 (26.9)					

Clinical outcomes were excellent in 14 cases, good in 22, fair in 2, and poor in 14. The overall success rate, as shown in Table 3, was 69.1% (36 of 52 patients), with a failure rate of 30.8% (16 of 52 patients) (Table 4).

Analysis of poor prognosis factors

The results of the univariate and multivariate analyses of factors associated with treatment failure in this study are shown in Tables 5 and 6, respectively. Drug-resistant bacteria and immunosuppressant use were associated with an increased risk of failure in the univariate analysis (p<.01, p=0.18, respectively). In the multivariate analysis, drug-resistant bacteria remained associated with an increased risk of treatment failure (p<.01; Figs. 4 and 5).

Table 5
Univariate analysis of risk factors associated with PSAD failure

Variables	Satisfactory group (n=36)	Unsatisfactory group (n=16)	p Value
Age*	69.8±15.0	70.7±11.1	.44
Sex (male)	23	8	.38
ASA-PS*	2.4±0.8	2.3±0.9	.58
Charlson score*	1.9±1.8	2.0±1.9	.9
Diabetes mellitus	16	6	.76
Systemic malignancy	8	4	1.00
Hepatic failure	3	1	1.00
Immunosuppressant use	3	4	.18
End-stage renal disease	3	1	1.00
Kulowski classification: acute	21	7	.38
Griffiths classification: Stage II	20	12	.23
Drug-resistant bacteria	9	12	<.01

* The values are presented as the mean and the standard deviation.

Table 6
Multivariate analysis of risk factors associated with PSAD failure

Variables	Odds ratio	95% C.I.	p Value
Drug-resistant bacteria	8.1	2.03–32.2	<.01
Immunosuppressant use	2.16	0.34–13.5	.41

Discussion

Surgical treatment is generally indicated for the treatment of infective spondylodiscitis after failure of conservative treatment [11,14–16]. Although anterior spinal fusion is most commonly performed [16,17], this procedure is generally difficult in elderly patients, who tend to be in poor general condition, which increases the risk of complications related to general anesthesia and the surgical intervention, including injury to the aorta or vena cava [19,20]. Moreover, elderly patients often have difficulty with postoperative mobilization, which increases the risk of deep vein thrombosis and pulmonary embolism [26]. Therefore, minimally invasive procedures are recommended for elderly patients as well as for those with poor general health status.

In 1990, Gill et al. [27] described the use of percutaneous curettage as a minimally invasive treatment for infective spondylodiscitis. Later, in 1998, Nagata et al. [21] reported favorable therapeutic outcomes in 23 patients with early infective spondylodiscitis treated using PSAD alone; a similar report was published by Ando et al. in 2010 [22] and included 45 patients. Other minimally invasive treatment procedures have also been reported to be effective for the treatment of early infective spondylodiscitis. Specifically, Hadjipavlou et al. [28] used percutaneous transpedicular discectomy and drainage, whereas Ito et al. [29] used posterolateral endoscopic surgery. However, in both of these case series studies, the disease process was in its early phase, with the site of infection located around a vertebral disc in more than 50% of cases. In our extensive search of the literature, we identified only two reports of the effectiveness of minimally invasive surgical procedures for the treatment of infective spondylodiscitis with an epidural or paravertebral abscess. In their case series of four patients, Hanaoka et al. [14] reported a success rate of 100% for percutaneous drainage and continuous irrigation. On the other hand, in their case series of 12 patients, Tofuku et al. [30] reported a success rate of 83.3% (10 of 12 patients) of using continuous irrigation for the treatment infective spondylodiscitis and associated iliopsoas muscle abscess. Our case series study included 52 patients with infective spondylodiscitis and associated epidural or paravertebral abscess, and reported a success rate of 69.1% (36 of 52 patients). The discrepancy between our present findings and those of Hanaoka et al. [14] and Tofuku et al. [30] with respect to success rates is likely related to the fact that, in our study sample, there was a higher rate of infection with antibiotic-resistant bacteria (40.4% vs. 25%).

The rate identification of the causal organism is generally reported at 50% from blood cultures [9] and 70% from tissue cultures [11]. In our study, the identification rate was 23.1% from blood cultures (12 patients) and 67.3% from tissue cultures (35 patients). The lower identification rate from blood cultures is likely explained by our use of antimicrobials during the period of conservative treatment before surgery. Our rate of identification from tissue cultures, which was similar to previously reported rates, indicates that bacteria could not be eliminated from tissues by antimicrobial drug treatment alone because of the relatively low antimicrobial drug concentration in the vertebral disc and nucleus pulposus compared with blood serum levels [31]. This was demonstrated well by Walters et al. [31], who infected the vertebral discs of sheep (ie, in vivo) with *S. aureus*. The sheep had been administered cephazolin and were subsequently identified to have higher drug concentrations in the blood than in the annulus fibrous, with no correlation between drug concentration in the blood and that in the nucleus pulposus. This result shows that, once an infection reaches the nucleus pulposus, antibiotics may not reach the site of infection, even with an increase in the dose or concentration of antibiotics. Such infections are, therefore, difficult to treat with antibiotics alone. In such cases, PSAD is a reasonable surgical intervention, as the infected tissue can be removed by curettage and antibiotics can be injected directly at the site of infection.

Elevated ESR and CRP levels were seen in >90% of patients with spondylodiscitis. Lestini and Bell suggested that CRP is superior to ESR in terms of evaluating spinal fusion of the spinal infection, as these parameters rise more quickly and are less influenced by other plasma factors [32]. Indeed, we noted that, whereas CRP levels decreased significantly at 2 weeks postoperatively, ESR did not decrease significantly from one time point to another. However, both values had recovered to normal levels at the last follow-up.

Plain radiography findings at final follow-up revealed a bone union rate of 80.7% (42 of 52 patients), with a significant exacerbation of both focal kyphosis and lordosis. Pee

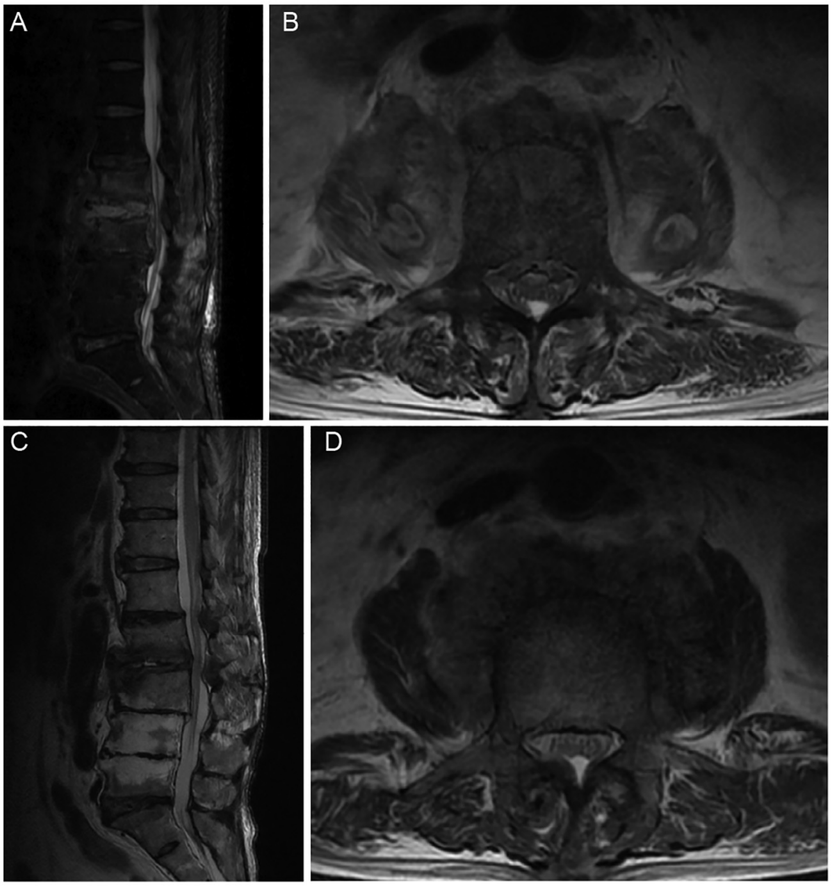

Fig. 4. An 80-year-old man (Patient 4) had severe low back pain and right leg pain. His associated medical illness was breast cancer treated with chemotherapy. The causative organism was methicillin-sensitive *Staphylococcus aureus*. T2 sagittal (A) and axial (B) MR images demonstrated L2–L3 vertebral bony destruction and abnormal intervertebral disc signal changes with epidural and iliopsoas mass formation. Percutaneous suction aspiration and drainage (PSAD) was performed, and the inflow tube was retained after PSAD for 14 days, and the outflow tube was retained for 15 days. Laminectomy was not performed. His low back pain and leg pain decreased immediately after PSAD, and MRI showed that the epidural and iliopsoas abscesses disappeared at 12 weeks postoperatively (C, D).

et al. reported a union rate of 91.3% (21 of 23 patients), with a mean change in segmental lordosis of 4.5±9.0° for each anterior debridement procedure and fusion with the autologous iliac bone strut, followed by PPS fixation in 23 patients with infective spondylodiscitis [33]. Because this surgical procedure involves using a bone graft in the curetted disc space, it is natural that the union rate was higher than that noted in our study. On the other hand, Ito et al. treated infective spondylodiscitis by performing posterolateral endoscopic surgery, which is a minimally invasive surgery, and reported bone union in 13 of 15 patients (86.7%) along with a mean kyphotic deformation of 12° [29]. Both PSAD and posterolateral endoscopic surgery involve curettage of the vertebral disc and surrounding tissues, which results in a hollow area after surgery. There are concerns that this may result in kyphotic deformation even when bone union occurs. The reason why PSAD is inferior to posterolateral endoscopic surgery in terms of bone union is thought to be that curettage of the end plate cannot be performed completely because it is performed under indirect vision using fluoroscopic guidance, and it cannot be confirmed under direct vision as is possible with endoscopic surgery. However, it may play a role in preventing progression of spinal deformity.

In our present study, instability after PSAD was present in five cases (9.6%), which may indicate persistent pain not likely to subside in the future. Lin et al. reported treating 20 patients with infective spondylodiscitis by performing anterior curettage and interbody fusion followed by PPS fixation, with no cases of recurrence and favorable clinical outcomes [34]. Therefore, PPS fixation, which is a minimally invasive surgery, can be considered as an additional surgical option for patients whose pain persists after the infection subsides.

Overall, we determined that paralysis did not necessarily progress after PSAD. Even nine of the 12 patients with a Frankel classification of C2 had recovery of paralysis after PSAD. Moreover, the patients with a Frankel classification of C2 who underwent PSAD all had more than three American Society of Anesthesiolosists-Physical Status classification,

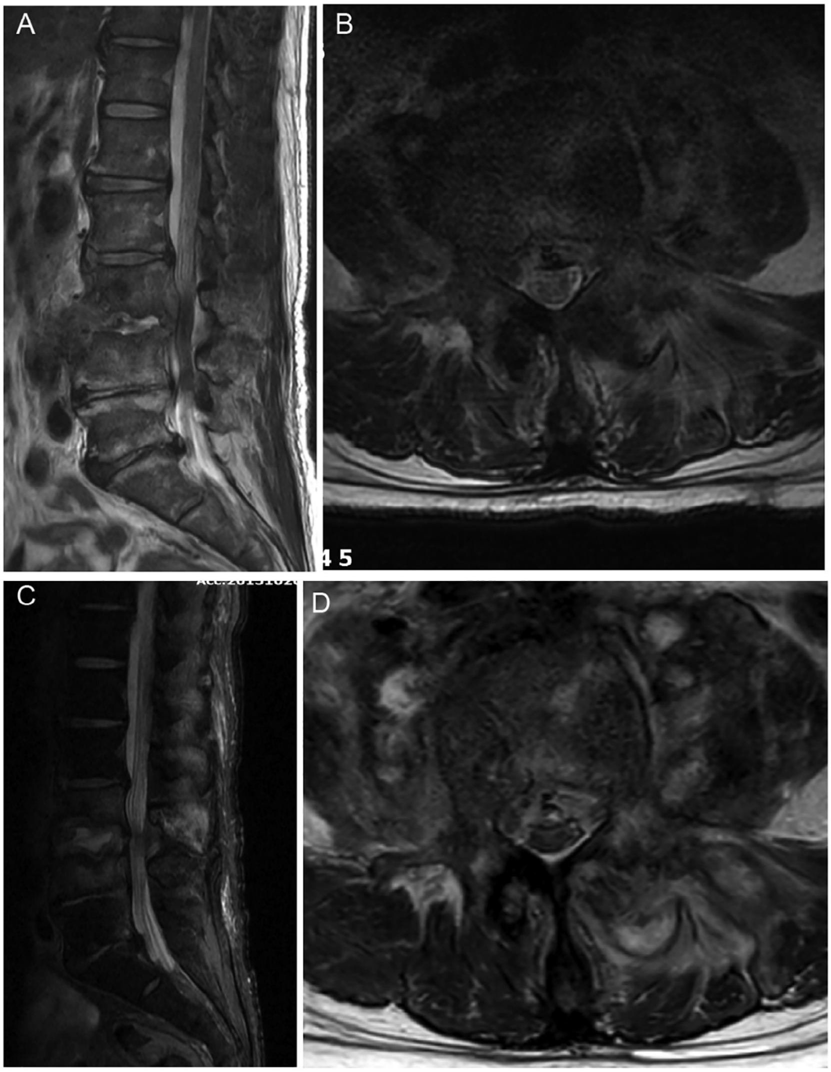

Fig. 5. A 65-year-old man (Patient 49) had severe low back pain. He had no comorbidity, but the causative organism was methicillin-resistant *Staphylococcus aureus*. T2 sagittal (A) and axial (B) MR images demonstrated L3–L4 vertebral bony destruction and intervertebral disc abnormal signal changes with iliopsoas mass formation. Percutaneous suction aspiration and drainage (PSAD) was performed, and the inflow tube was retained after PSAD for 18 days, and the outflow tube was retained for 19 days. However, the low back pain was not improved, and fever occurred frequently. MRI showed an epidural abscess and aggravation of an iliopsoas abscess (C, D).

so their general status was poor. Although Hadjipavlou et al. reported that patients with drop foot and sciatica because of an epidural abscess recovered after percutaneous transpedicular discectomy, he also insisted that this technique should be performed in cases without neurologic deficits [28]. Nagata et al. and Ando et al. also advocated that the indication for PSAD was an early stage of infective spondylodiscitis without epidural abscess [21,22]. However, 75% of the cases (9 of 12) recovered from palsy in the current study. From the above results, we suggest that PSAD should be strongly considered for patients with paralysis because of an epidural abscess who cannot undergo general anesthesia because of their poor general condition.

In this study, 21 patients (40.4%) were found to harbor drug-resistant bacteria. Shiban et al. reported the importance of performing a staged operation and instrumentation, as well as optimal debridement to ensure complete healing of spinal infections involving drug-resistant bacteria [35]. Therefore, if the PSAD is ineffective and the causative organism is identified as a drug-resistant bacterium, spinal fusion such as a PPS fixation should be performed.

Even if PSAD is able to calm down the infection, instability and kyphosis deformity may progress depending on the case. In such cases, PSAD can provide radical treatment if an additional operation for other symptoms is not needed. However, it is necessary to add spinal fixation when symptoms such as low back pain or motion pain remain. In these cases, we believe PSAD plays a role in the initial treatment to calm down the infection. Moreover, when the causative organism is proved to be a resistant bacterium, spinal fixation might be necessary in addition to the curettage of the intervertebral disc space by PSAD.

Although the clinical application of our findings is limited by the retrospective nature of our study and the absence of a control group, there is some evidence to support our conclusions. The next step would be to corroborate the conclusions from our present investigation via a prospective randomized study.

Conclusions

Percutaneous suction aspiration and drainage was effective in 69.1% (36 of 52) of patients with infective spondylodiscitis and associated epidural or paravertebral abscess, and we suggest that PSAD should be strongly considered for patients with paralysis because of an epidural abscess who cannot undergo general anesthesia because of a poor general condition. It might be necessary to add spinal fixation, such as PPS fixation, when low back pain or motion pain remains after PSAD and the causative organism is identified as a drug-resistant bacterium preoperatively.

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References

[1] Kehrer M, Pedersen C, Jensen TG, Lassen AT. Increasing incidence of pyogenic spondylodiscitis: a 14-year population-based study. J Infect 2014;68:313–20.

[2] Lora-Tamayo J, Euba G, Narváez JA, Murillo O, Verdaguer R, Sobrino B, et al. Changing trends in the epidemiology of pyogenic vertebral osteomyelitis: the impact of cases with no microbiologic diagnosis. Semin Arthritis Rheum 2011;41:247–55.

[3] Jensen AG, Espersen F, Skinhøj P, Rosdahl VT, Frimodt-Møller N. Increasing frequency of vertebral osteomyelitis following *Staphylococcus aureus* bacteraemia in Denmark 1980–1990. J Infect 1997;34:113–18.

[4] Hutchinson C, Hanger C, Wilkinson T, Sainsbury R, Pithie A. Spontaneous spinal infections in older people. Intern Med J 2009;39:845–8.

[5] Eismont F, Bohlman HH, Soni PL, Goldberg VM, Freehafer AA. Pyogenic and fungal vertebral osteomyelitis with paralysis. J Bone Joint Surg Am 1983;65:19–29.

[6] Carragee EJ. Pyogenic vertebral osteomyelitis. J Bone Joint Surg Am 1997;79:874–80.

[7] McHenry MC, Easley KA, Locker GA. Vertebral osteomyelitis: long-term outcome for 253 patients from 7 Cleveland-area hospitals. Clin Infect Dis 2002;34:1342–50.

[8] Gupta A, Kowalski TJ, Osmon DR, Enzler M, Steckelberg JM, Huddleston PM, et al. Long-term outcome of pyogenic vertebral osteomyelitis: a cohort study of 260 patients. Open Forum Infect Dis 2014;1:ofu107.

[9] Govender S. Spinal infections. J Bone Joint Surg Br 2005;87:1454–8.

[10] Torda AJ, Gottlieb T, Bradbury R. Pyogenic vertebral osteomyelitis: analysis of 20 cases and review. Clin Infect Dis 1995;20:320–8.

[11] Skaf GS, Domloj NT, Fehlings MG, Bouclaous CH, Sabbagh AS, Kanafani ZA, et al. Pyogenic spondylodiscitis: an overview. J Infect Public Health 2010;3:5–16.

[12] Gasbarrini AL, Bertoldi E, Mazzetti M, Fini L, Terzi S, Gonella F, et al. Clinical features, diagnostic and therapeutic approaches to haematogenous vertebral osteomyelitis. Eur Rev Med Pharmacol Sci 2005;9:53–6.

[13] Dagirmanjian A, Schils J, McHenry MC. MR imaging of spinal infections. Magn Reson Imaging Clin N Am 1999;7:525–38.

[14] Hanaoka N, Kawasaki Y, Sakai T, Nakamura T, Nanamori K, Nakamura E, et al. Percutaneous drainage and continuous irrigation in patients with severe pyogenic spondylitis, abscess formation, and marked bone destruction. J Neurosurg Spine 2006;4:374–9.

[15] Madhavan K, Vanni S, Williams SK. Direct lateral retroperitoneal approach for the surgical treatment of lumbar discitis and osteomyelitis. Neurosurg Focus 2014;37:E5.

[16] Przybylski GJ, Sharan AD. Single-stage autogenous bone grafting and internal fixation in the surgical management of pyogenic discitis and vertebral osteomyelitis. J Neurosurg 2001;94:1–7.

[17] Nasto LA, Colangelo D, Mazzotta V, Di Meco E, Neri V, Nasto RA, et al. Is posterior percutaneous screw-rod instrumentation a safe and effective alternative approach to TLSO rigid bracing for single-level pyogenic spondylodiscitis? Results of a retrospective cohort analysis. Spine J 2014;14:1139–46.

[18] Uchida K, Nakajima H, Yayama T, Sato R, Kobayashi S, Chen KB, 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: 111–18.

[19] Ruf M, Stoltze D, Merk HR, Ames M, Harms J. Treatment of vertebral osteomyelitis by radical debridement and stabilization using titanium mesh cages. Spine 2007;32:E275–80.

[20] Dimar JR, Carreon LY, Glassman SD, Campbell MJ, Hartman MJ, Johnson JR. Treatment of pyogenic vertebral osteomyelitis with anterior debridement and fusion followed by delayed posterior spinal fusion. Spine 2004;29:326–32.

[21] Nagata K, Ohashi T, Ariyoshi M, Sonoda K, Imoto H, Inoue A. Percutaneous suction aspiration and drainage for pyogenic spondylitis. Spine 1998;23:1600–6.

[22] Ando N, Sato K, Mitsukawa M, Yamada K, Wakioka T, Nagata K. Surgical results of percutaneous suction aspiration and drainage for pyogenic spondylitis. Kurume Med J 2010;57:43–9.

[23] Maroon JC, Onik G. Percutaneous automated discectomy: a new method for lumbar disc removal. J Neurosurg 1987;66:143–6.

[24] Eun SS, Lee SH, Sabal LA. Long-term follow-up results of percutaneous endoscopic lumbar discectomy. Pain Physician 2016;19:E1161–6.

[25] Macnab I. Negative disc exploration: an analysis of the causes of nerve-root involvement in sixty-eight patients. J Bone Joint Surg Am 1971;53:891–903.

[26] Ramcharan K, Conyette L, Mohammed B, Narine R. Low back pain in a diabetic on chronic haemodialysis: pyogenic spondylodiscitis. BMJ Case Rep 2014;2014:bcr2014204128.

[27] Gill K, Blumenthal SL. Automated percutaneous discectomy: long-term clinical experience with the Nucleotome® system. Acta Orthop Scand 1993;64:30–3.

[28] Hadjipavlou AG, Katonis PK, Gaitanis IN, Muffoletto AJ, Tzermiadianos MN, Crow W. Percutaneous transpedicular discectomy and drainage in pyogenic spondylodiscitis. Eur Spine J 2004;13: 707–13.

[29] Ito M, Abumi K, Kotani Y, Kadoya K, Minami A. Clinical outcome of posterolateral endoscopic surgery for pyogenic spondylodiscitis: results of 15 patients with serious comorbid conditions. Spine 2007;32:200–6.

[30] Tofuku K, Koga H, Yone K, Komiya S. Continuous irrigation in pyogenic spondylitis accompanied by iliopsoas abscess. Spine 2007;32:E382–7.

[31] Walters R, Rahmat R, Fraser R, Moore R. Preventing and treating discitis: cephazolin penetration in ovine lumbar intervertebral disc. Eur Spine J 2006;15:1397–403.

[32] Lestini WF, Bell GR. Spinal infection: patient evaluation. Semin Spine Surg 1996;8:81–94.
[33] Pee YH, Park JD, Choi YG, Lee SH. Anterior debridement and fusion followed by posterior pedicle screw fixation in pyogenic spondylodiscitis: autologous iliac bone strut versus cage. J Neurosurg Spine 2008;8:405–12.
[34] Lin TY, Tsai TT, Lu ML, Niu CC, Hsieh MK, Fu TS, et al. Comparison of two-stage open versus percutaneous pedicle screw fixation in treating pyogenic spondylodiscitis. BMC Musculoskelet Disord 2014;15:443.
[35] Shiban E, Janssen I, Wostrack M, Krieg SM, Horanin M, Stoffel M, et al. Spondylodiscitis by drug-multiresistant bacteria: a single-center experience of 25 cases. Spine J 2014;14:2826–34.