Laminotomy with Continuous Irrigation in Patients with Pyogenic Spondylitis in Thoracic and Lumbar Spine

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Objective: Pyogenic spondylitis often results in acute neurological deterioration requiring adequate surgical intervention and appropriate antibiotic treatment. The purpose of this study was to conduct an analysis of the clinical effect of continuous irrigation via laminotomy in a series of patients with pyogenic spondylitis in thoracic and lumbar spine.

Methods: The authors conducted a retrospective investigation of 31 consecutive patients with pyogenic thoracic and lumbar spondylitis who underwent continuous irrigation through laminotomy from 2004 to 2008. The study included 22 men and 9 women, ranging in age from 38 to 78 years (mean 58.1 years). The average follow-up duration was 13.4 months (range, 8-34 months). We performed debridement and abscess removal after simple laminotomy, and then washed out epidural and disc space using a continuous irrigation system. Broad spectrum antibiotics were administered empirically and changed according to the subsequent culture result. Clinical outcomes were based on the low back outcome scale (LBOS), visual analogue scale (VAS) score, and Frankel grade at the last follow-up. Radiological assessment involved plain radiographs, including functional views.

Results: Common predisposing factors included local injection for pain therapy, diabetes mellitus, chronic renal failure, and liver cirrhosis. Causative microorganisms were identified in 22 cases (70.9%): Staphylococcus aureus and Streptococcus spp. were the main organisms. After surgery, LBOS, VAS score, and Frankel grade showed significant improvement in most patients. Spinal stability was maintained during the follow-up period, making secondary reconstructive surgery unnecessary for all patients, except one.

Conclusion: Simple laminotomy with continuous irrigation by insertion of a catheter into intervertebral disc space or epidural space was minimally invasive and effective in the treatment of pyogenic spondylitis. This procedure could be a beneficial treatment option in patients with thoracolumbar spondylitis combined with minimal or moderate destructive change of vertebrae.

Key Words: Irrigation · Laminotomy · Pyogenic · Spondylitis · Thoracolumbar.

INTRODUCTION

Spinal infection is a threatening inflammatory disease of the vertebral body, extending to the epidural space, posterior elements, and paravertebral soft tissues. This disease has various presentations, including spondylitis, discitis, spondylodiscitis and epidural abscess. In particular, vertebral osteomyelitis and epidural abscess often result in acute neurologic deterioration and require a combination of surgical and conservative therapy. The rate of occurrence of spinal infection has increased in the past few decades, particularly among immunocompromised patients with severe underlying disease, such as diabetes mellitus, malignant tumor, chronic renal disease, and chronic liver disease.\(^{16,17,27}\). The number of iatrogenic spinal infections after spinal injections for pain therapy has also increased. Thus, spinal infection is a more serious condition than previously recognized. Accurate diagnosis and immediate and adequate treatment are critical for prevention of severe neurologic injury. Despite advancement in techniques for use in early diagnosis and appropriate antibiotic treatment, treatment of spinal infection is still a major surgical challenge.

Conservative treatment with antibiotics and immobilization is appropriate in cases of early-stage pyogenic spondylodiscitis, and has been found to be effective in 60% to 95% of cases of vertebral osteomyelitis.\(^{11,38,26,39}\). However, surgery may be required under the following circumstances: failure to obtain necessary culture material during closed biopsy sampling; presence of a clinically significant abscess; cases refractory to prolonged nonoperative treatment, in which the erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) level remains high or pain persists; cases in which spinal cord compression...
cause neurological deficits; and in cases in which there is severe bony destruction or significant spinal deformity. Surgical strategies must provide adequate neural decompression, spinal stabilization, and clearance of infectious tissue. Surgical treatment often involves anterior debridement and structural anterior or column reconstruction with/without instrumentation. However, a less invasive operative procedure might be desirable in some cases of pyogenic spondylitis and abscess, particularly in an immunocompromised host and in elderly patients who are in generally poor condition.

We report on the surgical outcome of thirty-two patients with spontaneous thoracic and lumbar pyogenic spondylitis with/without epidural abscess. We performed debridement and abscess removal by simple laminotomy, followed by washing out via a postoperative continuous irrigation system.

**MATERIALS AND METHODS**

**Patient population**

We conducted a review of 113 patients with acute spinal infection who underwent spinal surgery in our department from January 2004 to August 2008. Of the 113 cases, 31 patients with pyogenic spondylitis with/without epidural abscess on the thoracic and lumbar area were treated with continuous irrigation through laminotomy. Patients with tuberculous spondylitis and postoperative spinal infections were excluded from this study. Diagnosis of pyogenic spondylitis was based on history, clinical presentation, radiologic findings, and hematologic examinations, including white blood cell (WBC) counts, ESR, and CRP. A retrospective review of medical records and radiological findings was performed. Laboratory records, physical examination, and interview at discharge or the last follow-up visit were assessed.

**Surgical technique**

Surgical indications were lasting intractable pain despite appropriate treatment, failure of full course antibiotic treatment, and neurological impairment by thecal sac compression. We chose a simple debridement and removal of abscess via simple laminotomy followed by continuous irrigation as the initial surgical procedure, because many patients of them were immunocompromised hosts with poor general condition.

After general anesthesia, the infected spinal level was checked with a portable X-ray. Hemipartial laminotomy was performed through a conventional posterior approach at a single or multiple infected vertebral levels. Under the microscopic guidance, infected tissue including visible pus, granulomatous tissue, and specimens for microbiological studies were taken at the same time. In case that definite evidence of discitis was revealed through preoperative magnetic resonance imaging (MRI), we removed infected discs. However, we only removed just as we could hold on to disc forceps such as removal of ruptured disc. All specimens were tested for gram staining, aerobic and anaerobic culture and sensitivity, fungal culture, and acid-fast staining and tuberculous culture. After massive irrigation with antibiotic-mixed saline, inflow irrigation tips (Hemovac PP 400 c, 1.6 mm) was inserted into the affected epidural or intervertebral disc space and outflow tip (Hemovac PS 400 L, 2.8 mm) was placed in the epidural space. Both drains were passed through the skin with the outflow drain to the downward direction and the inflow drain exiting from the upward direction. Careful attention was paid to securing the catheters at their skin entry or exit points. Irrigation was initiated with normal saline containing first generation cephalosporin (1 g/L normal saline). The antibiotic agent was then selected relative to the gram stain and culture results, and delivered a high concentration of antibiotic therapy specific for the infecting organism directly to the wound site. The inflow rate of irrigation was initially started at 88 mL/hour. This rate was selected for delivery of a 1,000 mL/24 hour shift. The inflow line was driven by a syringe pump, while the outflow arm worked by orthostatic force of hemovac only. The inflow rate was titrated, if necessary, to match output. Input and output volumes, as well as hourly assessment of neurological signs, were initially required until steady-state between inflow and outflow volume were achieved. In order to avoid the risk of input/output imbalances, the input/output volume was promptly recorded per 4 hour closely. If the outflow drain volume was less than the inflow volume, inflow irrigation was halted and outflow was maintained. We considered the period which infected materials were washed away was enough based on color and volume of drained fluid. However, irrigation system was placed for 3 to 5 days and then removed to prevent secondary infection from prolonged indwelling catheter. Drainage tubes were kept in place for an additional day to ensure that a minimum amount of irrigation fluid remained within the wound. Drainage tips were saved for microbiological culture. Average operation time was less than 1.5 hours. Intraoperative blood loss was minimal, and none of the patients required blood transfusion.

**Antibiotic choice-empirical and targeted therapy**

At first, empirical antibiotic therapy was delivered intravenously in high doses, and adjustments were subsequently made as dictated by the results of antimicrobial susceptibility testing. When no pathogen was isolated, “best guess” bactericidal antimicrobial treatment, such as cefazolin or vancomycin was selected according to the etiological setting, because acupuncture was the most common cause of pyogenic spondylitis in this study, and these two antimicrobial agents are known to be effective drugs to staphylococci and streptococci of gram-positive bacteria that are common on normal human skin. Yoon et al. reported that cefazolin or vancomycin was effective in patients in whom the causative micro-organism was not identified. Intravenous antibiotic therapy was maintained for a mean period of 4 to 7 weeks, until patients showed improvement of clinical symptoms and laboratory findings. An additional 2- to 6-week course of oral antibiotic treatment was added. Response to treat-
ment was closely monitored by blood studies (ESR, CRP, and WBC counts) and radiological studies during the follow-up period.

Bracing was necessary for patient comfort, maintenance of stability, and prevention of deformity until occurrence of bony ankylosis.

Postoperative evaluation
Clinical outcomes were graded according to the low back outcome scale (LBOS), visual analogue scale (VAS) score, and Frankel grading system for neurological outcomes at the last follow-up. Postoperative lateral plain radiographs with dynamic views and MRI were obtained during follow-up. Change of segmental lordosis of the infected vertebral level was assessed from the Cobb angle, which was measured using preoperative and last follow-up plain radiography. SPSS statistical software (version 15.0, Chicago, IL, USA) was used for statistical analysis of the data. The paired t-test was used for statistical analysis and statistical monitoring by blood studies (ESR, CRP, and WBC counts) and radiological studies during the follow-up period.

| No. | Age/Sex | Comorbidity | Acupuncture Hx. | Organism | Complication | Pre Op. ESR/CRP | Discharge ESR/CRP | FS (pre/post) | LBOS (pre/post) | VAS |
|-----|---------|-------------|-----------------|----------|--------------|-----------------|------------------|---------------|----------------|-----|
| 1   | 74/M    | (-)         | (-)             | No growth | (-)          | 70/20           | 45/0.325         | 3/5           | 8/2            | 57  |
| 2   | 69/M    | (-)         | (-)             | Staphylococcus aureus | (-)   | 99/11.5      | 65/3.41          | 3/5           | 55  | 7/4 |
| 3   | 59/M    | Chronic     | (+)             | No growth | (-)          | 119/14.5        | 46/0.7           | 3/5           | 67  | 6/3 |
| 4   | 71/M    | (-)         | (+)             | No growth | (-)          | 143/21.3        | 148/0.9          | 4/5           | 61  | 8/4 |
| 5   | 66/M    | (-)         | (+)             | Staphylococcus simulans | (-)   | 127/6.8      | 60/0.29          | 4/5           | 69  | 6/4 |
| 6   | 74/F    | LC,         | (-)             | Staphylococcus haemolyticus | Infective endocarditis | 59/8.20 | 120/6.0 | 3/4 | 53  | 8/4 |
| 7   | 62/M    | LC, HCC.    | (+)             | Staphylococcus epidermidis | (-)   | 19/0.6       | 7/0.27           | 3/5           | 47  | 8/4 |
| 8   | 46/M    | DM          | (+)             | Staphylococcus aureus | (-)   | 7/27.5       | 30/0.58          | 3/5           | 69  | 6/2 |
| 9   | 62/M    | ESRD        | (-)             | No growth | (-)          | 69/16.6        | 14/4.29          | 4/5           | 68  | 5/2 |
| 10  | 70/M    | (-)         | (-)             | Staphylococcus aureus | (-)   | 31/6.3       | 18/0.313         | 4/5           | 62  | 7/4 |
| 11  | 70/F    | DM          | (-)             | No growth | (-)          | 115/6.6        | 26/0.3           | 5/5           | 73  | 6/2 |
| 12  | 47/M    | DM          | (+)             | No growth | (-)          | 123/2.98       | 127/0.9          | 4/5           | 69  | 7/4 |
| 13  | 60/M    | ESRD        | (-)             | No growth | (-)          | 84/14.9        | 25/2.98          | 3/5           | 51  | 8/3 |
| 14  | 70/F    | (-)         | (+)             | Staphylococcus aureus | (-)   | 70/19.1      | 69/0.316         | 4/5           | 62  | 6/3 |
| 15  | 67/F    | DM          | (-)             | Staphylococcus aureus | (-)   | 82/13.6      | 47/0.714         | 4/5           | 58  | 7/3 |
| 16  | 56/M    | LC, alcoholism | (+)             | Staphylococcus epidermidis | (-)   | 120/2.4      | 60/0.316         | 4/5           | 71  | 5/3 |
| 17  | 38/M    | (-)         | (-)             | Streptococcus gordonii | (-)   | 64/6.45      | 15/1.58          | 4/5           | 74  | 6/3 |
| 18  | 48/M    | LC, DM, hepatitis | (-)             | Streptococcus alactolyticus | (-)   | 28/3.2       | 11/0.319         | 5/5           | 74  | 5/2 |
| 19  | 41/M    | DM          | (-)             | Streptococcus viridans | (-)   | 93/2.6       | 52/0.319         | 5/5           | 72  | 5/2 |
| 20  | 52/M    | DM          | (-)             | Pseudomonas | (-)   | 107/6.23     | 22/0.319         | 2/4           | 51  | 8/3 |
| 21  | 58/M    | (-)         | (+)             | Staphylococcus epidermidis | (-)   | 86/13.95     | 62/1.11          | 3/4           | 60  | 7/3 |
| 22  | 77/F    | DM, pneumonia | (-)             | No growth | (-)          | 91/14.1       | 82/0.339         | 2/4           | 52  | 8/4 |
| 23  | 64/M    | (-)         | (+)             | Staphylococcus aureus | (-)   | 99/26.4      | 58/0.456         | 5/5           | 58  | 6/2 |
| 24  | 65/F    | DM, ESRD    | (-)             | Staphylococcus epidermidis | (-)   | 51/6.58      | 9/0.319          | 3/5           | 52  | 7/4 |
| 25  | 66/M    | DM, gastric ca | (+)             | Staphylococcus aureus | (-)   | 120/3.91     | 67/6.85          | 2/4           | 32  | 8/6 |
| 26  | 56/M    | DM          | (+)             | Escherichia coli | (-)   | 70/14.2      | 21/19.5          | 5/5           | 68  | 6/2 |
| 27  | 66/M    | (-)         | (+)             | Erysipellothrix rhusiopathiae | Wound dehiscence | 41/16.7       | 49/0.614         | 4/5           | 52  | 7/3 |
| 28  | 57/M    | (-)         | (-)             | Staphylococcus aureus | Pul.edema | 66/17.20     | 60/0.743         | 5/5           | 69  | 5/2 |
| 29  | 63/M    | LC          | (-)             | Streptococcus agalactiae | Pul.edema | 33/9.1       | 33/3.96          | 1/4           | 29  | 5/2 |
| 30  | 51/M    | (-)         | (-)             | No growth | (-)          | 74/0.8        | 76/0.803         | 4/4           | 67  | 8/3 |
| 31  | 78/F    | DM          | (+)             | Streptococcus constellatus | Pneumonia | 95/8.3       | 119/0.756        | 2/3           | 20  | 8/4 |

ESR: erythrocyte sedimentation rate, CRP: C-reactive protein, LBOS: low back outcome scale, VAS: Visual Analogue Scale
RESULTS

Characteristics of patients

The study included 23 men and 9 women. The mean age was 58.1 years (range, 38–78 years). Postoperative follow-up periods ranged from 8 months to 34 months, with an average of 13.4 months.

Underlying disease, clinical outcomes, cultured organisms, complications, and laboratory findings in all patients are summarized in Table 1. Most patients (96.8%) complained of localized pain around the infection site, such as back pain. Paraparesis was observed in 14 patients (45.2%), radiating pain in 11 patients (35.5%), buttock pain in 6 patients (19.4%), sensory change in 2 patients (6.5%), febrile sensation in 1 patient (3.2%), and voiding difficulty in 1 patient (3.2%). Clinical signs and symptoms are shown in Table 2. Comorbidity and probable etiology of the infection are summarized in Table 3. Immunologically compromised patients were affected in more than half of the cases. Diabetes mellitus was a risk factor in 12 patients. Other risk factors included the following: chronic renal failure (3 patients), liver cirrhosis (3 patients), alcoholism (3 patients), pneumonia (2 patients), and malignant tumor (1 patient). Previous iatrogenic injections in the vicinity of or into the spinal canal (local pain therapy, epidural anesthesia) were the most common, responsible for 45.2% of infections.

Identification of the pathogen from the sample collected by the procedure was possible in 22 patients (Table 4). Causative organisms included the following: *Staphylococcus aureus* (8, 25.8%), *Streptococci* (5, 16.1%), *Staphylococcus epidermidis* (4, 12.9%), other *Staphylococci* (2, 6.5%), and *Pseudomonas aeruginosa* (1), *E. coli* (1), and *Erysipelothrix* (1). The pathogen was not identified in 9 cases (29%). Postoperative complications developed in 5 patients (16.1%); pulmonary edema in 3 patients, infective endocarditis in 1 patient, and wound dehiscence in 1 patient. Four patients made a complete recovery, and 1 patient of infective endocarditis was transferred to the department of cardiothoracic surgery.

Distribution and number of spinal infections

The most common location was the L4-5 and L5-S1 vertebra level in 10 patients each, followed by L2-3 and L3-4 in 7 patients each, L1-2 in 4 patients, T8-9 in 1 patient, T10-11 in 1 patient, and T11-12 in 1 patient. The number of infected vertebral bodies varied from one to three. Two levels of vertebral body infection were identified in 19 patients (61.3%), followed by one level in 6 patients (19.4%) and three levels in 6 patients (19.4%).

Laboratory findings

WBC counts (nl<10,000×10⁹/L), ESR (nl<0-20 mm/hr) and CRP (nl<0-0.5 mg/dL) were determined for all patients. Except for 1 patient, all patients showed elevated CRP. In addition, ESR was elevated in 93.5% of patients, and WBC counts were elevated in 58% of patients. Before surgery, the average of ESR and CRP was 79.2 mm/hr and 11.1 mg/dL. At discharge, 23 patients (74.2%) showed decrease in ESR and 29 patients (93.5%) showed decrease in CRP. The average ESR and CRP showed a significant decrease to 54.7 mm/hr and 1.96 mg/dL, respectively.

Clinical and radiological outcome

Low back pain was relieved at discharge in all cases. The mean VAS score was decreased from 6.6 to 3.1. Functional outcome for LBOS was found to be “Excellent” in 13 patients (41.9%), “Good” in 16 patients (51.6%), “Fair” in 1 patient (3.2%), and “Poor” in 1 patient. LBOS was found to be “Excellent” in 13 patients (41.9%), “Good” in 16 patients (51.6%), “Fair” in 1 patient (3.2%), and “Poor” in 1 patient. LBOS was found to be “Excellent” in 13 patients (41.9%), “Good” in 16 patients (51.6%), “Fair” in 1 patient (3.2%), and “Poor” in 1 patient. LBOS was found to be “Excellent” in 13 patients (41.9%), “Good” in 16 patients (51.6%), “Fair” in 1 patient (3.2%), and “Poor” in 1 patient.
A summary of neurological outcomes is provided in Table 5. Preoperatively, one of 31 patients was classified as Frankel grade A, 4 as grade B, 9 as grade C, 11 as grade D, and 6 as grade E. Twenty-four of 26 patients who had a neurologic deficit showed improvement on the last follow up, at least in terms of Frankel grade. Only one patient with grade D showed no change. Two patients had worsening clinical features and laboratory findings, as well as abnormal MRI findings in admission state. Two of them had recurrent epidural abscesses at previous operative sites and required revision surgery, which involved drain replacement and subsequent clearing of recurrent infection. The same organism was detected in the reoccurred case. Development of a psoas abscess was observed in one patient on the follow-up MRI, and was treated with a retroperitoneal approach and abscess removal.

For assessment of the kyphotic deformity, Cobb’s angle was measured between the endplates above and below the infected vertebrae. At the last follow-up, kyphotic angles showed an increase in 16 patients. Among them, one patient underwent additional procedures including vertebral corpectomy and fusion with fixation due to a severe progressive bony defect and deformity after surgery. However, no statistical significance was observed between the overall preoperative and final kyphotic angles \( (p=0.129) \).

**ILLUSTRATIVE CASES**

A 67-year-old woman with non-insulin-dependent diabetes mellitus presented with back pain and paraparesis. She had undergone local injection for pain relief, including facet joint block and nerve root block several months earlier at another hospital. Blood examination revealed elevated WBC counts, ESR, and CRP levels. MRI scans demonstrated L2-L3 vertebral body collapse with epidural mass formation, and irregular signal change at the L2-L3 disc space. Gadolinium enhanced T1 and T2-weighted sagittal scans revealed osteomyelitic change and a central epidural abscess with severe dural sac compression at the L2-L3 levels (Fig. 1). T1-weighted enhanced sagittal and axial MRI scans showed extensive epidural abscess at the L2-L3 levels, spondylodiscitis at the L2-L3 intervertebral disc space, and inflammatory change of the paraspinal soft tissue (Fig. 2). Emergent evacuation of the epidural abscess and intervertebral infected tissue was implemented via a left L2 small laminotomy with decompression of the dural sac and nerve root. At the same time, a continuous irrigation system was applied. An input catheter was inserted into the L2-L3 intervertebral disc space and output drainage tube located in the epidural space at the same level (Fig. 3). *Pseudomonas aeruginosa* was indentified in tissue culture. Cycin and ceftazidime were given intravenously. After surgery, bilateral motor weakness in the legs showed gradual improvement, and the low back outcome scale revealed from “Fair” to “Good”, and Frankel grade improved from grade C to
grade D with a useful leg motor. Also, previously elevated ESR and CRP were normalized at discharge, and the final follow-up radiographs showed no further kyphotic change and good alignment compared with that of preoperative radiographs (Fig. 4).

**DISCUSSION**

Due to an increment of susceptible population and the availability of more effective diagnostic tools, the incidence of pyogenic spondylitis has risen. It can cause rapid deterioration leading to early neurologic deterioration. Early diagnosis of infection and prompt initiation of the appropriate antibiotic therapy against the cultured organisms are crucial in ensuring successful treatment and prevention of further morbidity. *Staphylococcus aureus* is the most commonly recognized causative organism accounting for 42-84% of organisms isolated in previous studies. In this study, the most of causative organisms were *Staphylococcus species* and *Streptococcus species*. In the current study, negative cultures were obtained in 9 cases (28%), similar to 20-30% of other report. Predisposing factors that compromise the immune system render the host more susceptible to pyogenic spondylitis. Diabetes, end-stage renal failure, liver cirrhosis, alcoholism, and other chronic diseases were the most common predisposing systemic conditions. Direct inoculation following spinal surgery, lumbar puncture, or epidural procedures is most commonly etiology and accounts for up to 25-30% of cases in some spondylodiscitis series. In this study, the incidence of spondylitis from an intra- or paraspinal injection was remarkably high, originating in 15 patients. An increase in the number of elderly patients with chronic lower back pain has resulted in an increase in the use of local injection for pain therapy. Due to the extensive intra-extraspinal venous network with missing valves and, therefore, changeable flow directions, there might be a hematogenous spread from paraspinal tissues into the epidural space. Although the incidence of pyogenic spondylitis and epidural abscess after epidural analgesia has been reported, there are no comparable data available regarding its frequency after paravertebral injections for local pain therapy. However, back pain leading to a local injection for pain therapy could already be a sign of an evolving infection; therefore, exact epidemiological data on this issue might be difficult to obtain.

Any substantial delay in diagnosis or management can have a detrimental effect on the overall clinical outcome. A high index of suspicion is warranted in the patient who presents with spinal pain or a neurologic deficit in conjunction with fever or an elevated ESR or CRP. In the presence of neurologic dysfunction, MRI should be obtained immediately. Surgical intervention is usually indicated in patients who are unresponsive to antibiotic therapy and in patients who show progressive spinal deformity or instability, epidural abscesses, or neurological impairment. Goals of surgery include eradication of the infection focus, restoration of neurological function, restoration of spinal stability, and relief of pain. The choice of a specific approach and technique depend primarily on the location of the abscess within the spinal canal, spinal stability, and the patient’s general condition. Favorable results have been reported with regard to anterior decompression and fusion in spondylodiscitis complicated by severe deformity, neurologic deficit, epidural abscess, and granulation tissue causing neural tissue compression. It allows direct access to the infected tissue, adequate debridement, and stabilization of the spine by bone grafting. Autologous iliac bone strut or titanium mesh cages were used after vertebral corpectomy, followed by single-stage or 2-stage posterior instrumentation. However, use of spinal instrumentation at the site of infection is still controversial. All foreign materials, including metallic implants, allograft, and autografts have a potential association with decreased antibiotic effectiveness and increased bacterial adherence and biofilm formation. Although spinal reconstruction with instrumentation can correct deformities and lead to robust fixation, the rate of complications was significant due to the long operative time, greater blood loss, more extensive disruption of normal tissue, more extensive wound cavity with larger potential dead space and hematoma, and prolonged and more extensive retraction, contributing to tissue ischemia. Carragee reported complication rates of 47% of their 17 patients after spinal instrumentation surgery in patients with pyogenic spinal infections. Complications included instrument failure, wound dehiscence, cardiac arrest, or inability of weaning of ventilator. Nonetheless, patient mortalities occurred during the early postoperative period due to hepatic failure, intracranial infarction, and septic shock. Moreover, in patients with serious comorbid conditions, invasive reconstruction surgery might not be desirable due to associated high complication rates. Non-invasive techniques, including percutaneous drainage or endoscopic surgery, have been introduced. These approaches have the advantages of being a minimally invasive procedure that is performed under local anesthesia, and requires a small incision. In general, percutaneous or endoscopic surgery is indicated for patients with lesions lo-
calized to one intervertebral region, little vertebral body destruction resulting in mild spinal alignment abnormality, and no serious paralytic symptoms\textsuperscript{20}. These techniques have advantages such as low rate of postoperatively developed instability or deformity, and low complication rate due to poor general condition. But, these techniques are contraindicated for patients with multilevel disease, excessive neural compression or marked bony destruction with kyphotic deformities. Also, these techniques have a higher rate of recurrence due to the difficulty of irrigation and debridement of infective structures during the procedure. Although percutaneous or endoscopic surgery can be very effective methods for early stage of spondylitis, it is inappropriate treatment for severe spondylitis. In comparison of percutaneous or endoscopic surgery, simple unilateral laminotomy of one or two levels has the advantages of sufficient canal decompression and direct extensive debridement of infected sites. Rath et al.\textsuperscript{21} reported extensive laminectomy without stabilization developed secondary neurological impairment due to spinal instability. These patients may require further operative treatment for stabilization. Besides, some study also reported instability of the spinal column following excision of a lamina dorsal to a spondylodiscitis\textsuperscript{31,40}. In our series, however, there were no patients with instability or deformity who underwent operation. Because of the risk of impending anterior column instability due to spondylitis, we performed single- or multilevel unilateral laminotomy rather than extended laminectomy. It was performed through a conventional posterior approach at a single or multiple infected vertebral levels. Also, this procedure did not cause kyphotic deformity after surgery, with no statistical difference in the measurement of Cobb’s angle on last follow-up plain radiograph. Except one patient, none of the patients required additional fusion and fixation. He developed severely progressive bony defect and deformity, and underwent two level lumbar corpectomy with internal fixation. The microorganism was not identified in this patient, and antibiotic therapy failed. Due to concern for insufficient debridement of the infected disc material and vertebral bodies, we combined continuous irrigation using drainage tubes for inflow and outflow. Picada et al.\textsuperscript{11} reported pyogenic spondylodiscitis that was achieved a clean wound through a protocol of aggressive debridement a secondary closure over a clean wound. These patients underwent average 2.7 times of debridements. Repeat debridements may be needed in case of secondary closure, leading to an increase of medical expenses and possible aggravation of general condition. The advantage of the close irrigation-suction system includes the avoidance of a secondary wound closure. Several recent studies have reported favorable results following application of continuous irrigation for pyogenic spondylitis and epidural abscess\textsuperscript{9,12,19,37,38,40}. Satoshi et al. studied relationship between CRP and duration of irrigation to investigate treatment effect of spondylitis\textsuperscript{10}. They reported that the duration of irrigation and period for CRP normalization was inversely proportional. Irrigation system has better effects on pyogenic spondylitis treatment. Lange et al.\textsuperscript{20} reported greater success of the inflow/outflow method on the outcome in comparison with a conventional suction drainage. Continuous irrigation enables to ongoing removal of necrotic or residual infectious debris of the spinal canal and simultaneous local administration of antibiotics directly to the wound site. It is possible that ongoing removal of necrotic or devitalized tissue and the byproducts of infection may aid local host defenses and intravenous antibiotic agents in surmounting the infection in the wound cavity. But, this technique should be performed carefully due to the risk of congestion of irrigation flow and mismatching of inflow and outflow.

When patients’ clinical symptoms were improved and preoperative symptoms were not evident, we discharged patients, even if their CRP levels were above normal limits. Follow up laboratory studies revealed decline of CRP level in patients with above normal CRP levels. Carrage\textsuperscript{6} reported favorable outcome in 40% of cases with a persistently elevated ESR. Moreover, Yoon et al.\textsuperscript{42} emphasized that ESR and CRP values at the fourth week after antibiotic treatment were noteworthy as predictive marker for the effectiveness of treatment. Thus, the values of ESR and CRP cannot be represented as an absolute value for predictors of cure or recurrence. In other study, laboratory studies such as leukocyte count and ESR apparently were not sensitive tests in the diagnosis of spondylodiscitis\textsuperscript{11}. Therefore, we did not consider the normal return of ESR as full recovery and postoperative radiographic studies including MRI were not conducted after antibiotic treatment if clinical and laboratory parameters were favorable.

Despite the small number of patients and relative short follow-up period, this technique has shown to allow adequate debridement resulting in favorable clinical outcome in patients with pyogenic spondylitis with/without epidural abscess. Spinal stability was maintained after decompression and use of instrumentation was not necessary in most patients. However, the effectiveness of this procedure for extensive destruction of multiple vertebral bodies due to spinal infections might be limited which will require further clinical investigation.

**CONCLUSION**

Pyogenic spondylitis can be successfully treated with preservation of spinal stability using laminotomy and a continuous irrigation system. It can be particularly useful in patients who are in poor general condition, such as immunocompromised and elderly patients, with reduction of the need for instrumental reconstruction and fusion. We suggest that this surgical procedure can be a beneficial treatment option for minimal or moderate destructive change of vertebrae in patients with thoracic and lumbar spinal infection.

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