Vacuum Sealing Drainage for Primary Thoracolumbar Spondylodiscitis: A Technical Note

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Primary spinal infection is a challenge for neurosurgeons. Here, for the first time, we introduced the vacuum sealing drainage (VSD) sponge into the intervertebral space for the primary thoracolumbar infection treatment. This study included 6 bedridden patients with thoracolumbar spondylodiscitis without deformity formation. All 6 patients were treated with the VSD in our hospital from June 30, 2018, to August 31, 2019. All 6 cases of thoracolumbar infection achieved clinical cure at 3-month follow-up, and no surgical-related mortalities occurred in our series. One patient died of acute cerebral infarction 5 months after surgery, and the remaining 5 patients completed a 12-month follow-up without recurrence. The JOA score of all 6 cases improved significantly after VSD treatment. VSD is feasible for safe and effective treatment for primary thoracolumbar infection. The short-term follow-up effect is definite.

1. Introduction

Spinal infection is a disease with some descriptions accompanying human evolution [1, 2]. There are several types of spinal infections, and when the infection affects only the intervertebral discs, the term used to describe the condition is usually discitis. If the infection invades the endplates of the vertebral body, the infection is more correctly designated as vertebral osteomyelitis or spondylitis. However, in many cases, at the time of diagnosis, the infection has damaged both structures; therefore, this condition is often diagnosed as spondylodiscitis [3]. The literature reports that the incidence of spinal infection in the general population is 2.4/100000, and the incidence rate increases significantly with age, and the incidence of spinal infection in people over 50 years old increases to 6.5/100000, mainly due to reduced immunity [4]. At the same time, comorbidities including diabetes, uremia, urinary tract infection, pulmonary infection, and body surface infection are also important reasons for the increased incidence [5, 6].

The conservative treatment of spinal infections is challenging. Although antibiotic therapy is crucial and necessary in treating spinal infections, acquiring pathogenic microorganisms in spinal infections is more challenging than other bone infections [7]. As a result, most spinal infections are treated with antibiotics based on clinical experience alone [8]. In addition, the inadequate blood supply to the disc tissue renders antibiotic therapy ineffective [8]. Chandra et al. reported that conservative treatment of spinal infections with comorbidities is inefficient and requires surgical treatment, including neurological symptoms, lumbar instability, kyphosis, spinal abscess, infection involving more than 4 vertebrae, and infection involving the intervertebral disc [3, 9]. According to literature, conservative treatment is frequently ineffective for spinal infections, and approximately 50% of patients require surgery [10–12].

Presently, the surgical treatment of spinal infection consists mainly of the classic approach of lesion excision combined with internal fixation, which is more traumatic and cannot be tolerated by patients with a spinal infection.
| Sequence | Gender | Age | The number of days in hospital | Infection site | BMI | Subjective global assessment (SGA) | Comorbidity | Bedridden time (months) | Prehospital pathogenic microorganisms | C-reactive protein (mg/L) | Time to return to normal (days) | Complication | Preoperative JOA | 3 months after surgery JOA |
|----------|--------|-----|-------------------------------|----------------|-----|----------------------------------|-------------|------------------------|--------------------------------------|--------------------------|-----------------------------|--------------|----------------|-----------------------------|
| 1        | Female | 50  | 51                           | L2-4, spondylodiscitis without deformity | 23.2 | B | (1) Right renal abscess  
(2) 4 years after removal of carbuncle on lower back  
(3) Diabetes mellitus type 2 | | 4 | Escherichia coli | 24.6 | 52 | Stress gastritis occurred 2 months after the operation | | 9 | 24 |
| 2        | Male   | 60  | 44                           | L4/5, spondylodiscitis without deformity | 16.5 | C | (1) Cervical spondylotic myelopathy complicated with incomplete paralysis  
(2) Diabetes mellitus type 2  
(3) Hypertension  
(4) Stiff knees | | 24 | Escherichia coli | 94.25 | 40 | Died from cerebral infarction 5 months after surgery | | 8 | 17 |
| 3        | Female | 54  | 35                           | L2-4, spondylodiscitis without deformity | 16.2 | C | (1) Chronic renal insufficiency (uremia stage)  
(2) Chronic pneumonia  
(3) Hypertension | | 3 | N/A | 82.4 | 74 | N/A | 7 | 18 |
| 4        | Female | 46  | 87                           | L5/S1, spondylodiscitis without deformity | 18.9 | C | (1) Rheumatoid arthritis  
(2) Anaphylactic shock  
(3) Cardiac insufficiency grade 4 | | 4 | N/A | 112 | 63 | Anaphylactic shock during plasma transfusion | | 8 | 20 |
| 5        | Female | 61  | 24                           | T8/9, spondylodiscitis without deformity | 22.5 | B | (1) Diabetes mellitus type 2  
(2) Osteoporosis  
(3) Rheumatoid arthritis | | 3 | N/A | 19.5 | 20 | N/A | 12 | 28 |
The number of days in hospital & Infection site & BMI & Subjective global assessment (SGA) & Comorbidity & Bedridden time (months) & Prehospital pathogenic microorganisms & C-reactive protein (mg/L) & Time to return to normal (days) & Complication & Preoperative JOA & 3 months after surgery JOA

| Sequence | Gender | Age | The number of days in hospital | Infection site | BMI | Subjective global assessment (SGA) | Comorbidity | Bedridden time (months) | Prehospital pathogenic microorganisms | C-reactive protein (mg/L) | Time to return to normal (days) | Complication | Preoperative JOA | 3 months after surgery JOA |
|----------|--------|-----|--------------------------------|----------------|-----|-----------------------------------|-------------|------------------------|----------------------------------------|--------------------------|----------------------------------|--------------|-----------------|---------------------------|
| 6        | Female | 76  | 25                             | T12/L1, spondylodiscitis without deformity | 25.7 | B | (4) Common peroneal nerve injury | 3           | N/A                    | 26.9                                   | 25           | N/A                | 15           | 23              |

Clinical status of 6 patients. JOA: Japanese Orthopaedic Association Scores; T: thoracic vertebra; L: lumbar vertebra; S: sacral vertebrae.
due to their physical state. Since the 1990s, it has been universally accepted that vacuum sealing drainage (VSD), also known as Negative Pressure Wound Therapy (NPWT), provides therapeutic effects for soft tissue infections, bone infections of the extremities, and chronic refractory wounds. Nonetheless, the clinical impact of VSD on spontaneous spondylodiscitis has not been investigated.

This study presents an all-new surgical paradigm for primary thoracolumbar infection patients with severe comorbidities. In this surgical paradigm, we, for the first time, apply VSD to treat primary spinal infection with intervertebral pus. The VSD treatment has proven feasible and effective for serious spondylodiscitis based on the short- and medium-term follow-up outcomes.

2. Materials and Methods

2.1. Patient Selection. The inclusion criteria were as follows: clinically diagnosed with lumbar spine infection with no spinal cord injury, with severe comorbidities, bedridden for more than three months, and accepted VSD treatment. From June 30, 2018, to August 31, 2019, 6 patients were
enrolled in this study, including 1 male and 5 females, aged 57.7 ± 7.83. All 6 patients had severe comorbidities and were incapacitated with bedridden for 5.5 ± 6.17 months, including one with renal abscess, one with cervical spondylotic myelopathy and incomplete paralysis, one with renal failure, two with renal failure with rheumatoid arthritis (stage 4), and one with fibula total nerve damage. All 6 patients were diagnosed with spinal infection and received antibiotics for 2 ± 0.67 months before admission. All 6 cases had low back pain symptoms at the consultation time, and 3 cases were accompanied by fever. As for the pathogenic microorganisms, 1 case of hospital blood culture was Escherichia coli, 1 case had a history of renal abscess due to Escherichia coli infection 4 months ago, and the remaining cases were unknown. Table 1 summarizes the patient features.

2.2. Surgical Procedure. Percutaneous pedicle screws and rods were placed on healthy vertebrae spanning the level of infection under C-arm guidance. Then, part of the lateral facet joint was excised, and the superior border of the lower pedicle was exposed through the intervertebral foramina approach through the working channel. Subsequently, the lumbar annulus was dissected, and the disc infection was removed entirely. Rinse repeatedly with hydrogen peroxide, bromine, and saline solution. The VSD sponge is placed in the intervertebral disc space. The wound was sealed with negative pressure (Figure 1).

About 7 days after placing the VSD sponge, the VSD sponge was removed entirely, and the intervertebral space was scraped with a spatula and a curette and repeatedly rinsed for debridement. The formation of granulation tissue on the wound surface was closely observed. Then, place a new VSD sponge in the intervertebral space. The VSD changes are performed weekly under general anaesthesia in the operating room or under local anaesthesia at the bedside. When fresh granulation grows on the intervertebral space endplate, it is time for bone grafting.

Use a particular iliac bone extraction instrument with a minimally invasive incision, and take an appropriate amount of iliac bone according to the bone defect. After the VSD sponge was removed, the intervertebral space was scratched, and the iliac bone was implanted after irrigation. The wound was sutured and sterile bandaged.

2.3. Postoperative Management and Follow-Up. All patients were administered intravenous susceptibility (based on the findings of drug susceptibility testing) or broad-spectrum antibiotics (cefuroxime sodium, 1.5 g, q8 h) until C-reactive protein and ESR readings returned to normal levels. Then, continue intravenous or oral antibiotics for 8 weeks [13]. Postoperative computed tomography (CT) and C-reactive protein were performed to evaluate the spinal fusion and infection. Follow-up was conducted 12 months postoperatively. The normal value of C-reactive protein and the new bone formation confirmed by CT in the intervertebral space were evaluated as a clinical cure. The JOA scores were measured in all cases before and 3 months after surgery to evaluate the changes in the neurological status of patients before and after surgery.

3. Results

Table 2 summarizes the surgical procedure and results. This series of patients includes 1 male and 5 females. The hospital stay was 44.3 ± 16.44 days. All 6 cases of thoracolumbar infection achieved clinical cure at 3-month follow-up, and no surgical-related mortalities occurred in our series.

The total operation time was 283 ± 53 min, and the total blood loss was 240.8 ± 29.44 mL.

All 6 patients completed the 12-month follow-up except for 1 patient who died of acute cerebral infarction 5 months after surgery due to bedridden and noncompliance with antithrombotic therapy after discharge from hospital. Among the 6 patients, 1 suffered anaphylactic shock from plasma infusion during hospitalisation and recovered after rescue; 1 suffered from stress gastritis and recovered after symptomatic treatment for 6 days. Furthermore, JOA scores improved significantly in all 6 patients at 3-month follow-up, demonstrating the effectiveness of this surgical paradigm (Figure 2).

4. Discussion

The challenge of spinal infection is that it is difficult to achieve complete debridement and adequate drainage of paravertebral abscesses with traditional surgery, requiring postoperative antibiotic treatment. However, it is difficult
Figure 2: The patient with a primary spinal infection was clinically cured after 6 months of follow-up. (a, b) Surgical site after surgery. (c, d) The L2/3 had been completely fused at the 6-month follow-up.
| Reference       | Age (years) | Number of cases | Postoperative ESR (mm/h) | Operation name                                      | Operation time (minutes) | Bleeding volume (mL) | Complication                                                                 | Follow-up time       |
|-----------------|-------------|-----------------|--------------------------|----------------------------------------------------|--------------------------|---------------------|-----------------------------------------------------------------------------|-----------------------|
| Fu et al. [22]  | 59.9 ± 12.1 | 31              | 50.8 ± 29.3 days back to normal | Anterior decompression and internal fixation         | N/A                      | 585 ± 428            | 1 case died from renal failure and fungal infection; 4 cases of unplanned second surgery | More than 2 years     |
| Fu et al. [22]  | 56.5 ± 14.4 | 37              | 38.4 ± 21.6 days back to normal | Foraminal focus debridement and drainage            | N/A                      | <50                 | 5 cases underwent debridement and internal fixation again                  | More than 2 years     |
| Qian et al. [24]| 43.8 ± 11.5 | 37              | The average value of 3 months decreased to normal  | Thoracolumbar lesion removal and bone grafting and internal fixation | 223.5 ± 41.7 (minutes)  | 812.6 ± 309.2        | 2 cases of lung infection; 4 cases of incision infection                  | Reach the clinical cure standard after 12 months |
| Qian et al. [24]| 45.3 ± 12.6 | 37              | The 3-month average dropped to 36                  | Thoracic and lumbar spine internal fixation with simple posterior approach | 87.4 ± 18.9 (minutes)    | 104.7 ± 25.0         | N/A                                                                        | Reach the clinical cure standard after 12 months |
| Lai et al. [25] | 42.3 ± 9.8  | 32              | 1-month average 28.5                                      | Debridement and internal fixation                   | 105.7 ± 16.3 (minutes)  | 206.5 ± 39.2         | N/A                                                                        | Average 12 months     |
| Jin and Wang [26]| 39.07 ± 18.30 | 54           | Decreased to normal in 24 weeks                        | Single-segment fixation for debridement              | 4.05 ± 0.59 (hours)     | 750.3 ± 51.35       | N/A                                                                        | 58.09 ± 17.01 months  |
| Jin and Wang [26]| 41.98 ± 15.20 | 52            | Decreased to normal in 24 weeks                        | Debridement and short-segment fixation               | 6.13 ± 0.81 (hours)     | 1150.6 ± 60.23       | N/A                                                                        | 58.09 ± 17.01 months  |
| Shen et al. [27]| 42.3 ± 10.1 | 30              | 3 months after operation 11.5 ± 3.3                    | Simple posterior debridement and internal fixation   | 140.2 ± 20.4 (minutes)  | 641.2 ± 148.2        | 3 cases of cerebrospinal fluid leakage; 2 cases of superficial infection | 36.5 ± 9.2            |
| Shen et al. [27]| 38.5 ± 12.1 | 30              | 3 months after operation 10.8 ± 1.3                    | Anterior and posterior combined lesion removal and internal fixation | 248.4 ± 50.2 (minutes)  | 850.2 ± 200.5        | 6 cases of cerebrospinal fluid leakage; 5 cases of superficial infection | 34.6 ± 10.2           |
| Chen et al. [28]| 65.6 ± 9.73 | 41              | 3 months after operation 33.46 ± 27.51                  | Single-space intervertebral foraminoscopy to clean up the lesion | N/A                     | N/A                 | 1 case of kyphosis                                                           | Average 42.46 months  |
| Zeng et al. [29] | 31.7        | 56              | N/A                                                     | Anterior debridement and single rod internal fixation | 203.66 ± 43.12 (minutes) | 530.45 ± 121.63     | 2 cases of recurrence; 1 case of injury to the pleura; 1 case of drug-induced hepatits; 8 cases of broken nails | Average 37.5 months   |
for antibiotics to reach sequestrum and bloodless tissues due to the inadequate blood supply. Notably, the intervertebral disc, a structure frequently linked with spinal infections, is supplied by endplate arterioles in adolescence but develops avascular in age [8]. Low blood antibiotic levels in dead, pus-filled, and avascular tissues result in the formation of drug-resistant bacteria and bacterial biofilms, which are essential for the recurrence of postoperative infections [14]. Literature indicates that the recurrence rate will be significantly reduced if all infected lesions are entirely eliminated [14, 15]. Evidence shows that complete debridement substantially reduces the rate of infection recurrence. However, due to the specificity of the spine structure, extensive debridement of extremity bone infections is contraindicated. Although VSD has been reported in the literature for other sites and spinal SSI infections, in this study, for the first time, we applied VSD to the treatment of primary spinal infections with intervertebral pus. By removing exudate, necrotic tissue, and bacteria using VSD, a microenvironment favorable to bacterial development is destroyed [16]. Additionally, VSD increases the formation of granulation tissue, which is highly antimicrobial and good for wound healing [17]. Simultaneously, VSD fills the postdebridement void and avoids hematoma development, facilitating autologous iliac bone grafting.

Although spine surgeons have a general consensus about the surgical indications for spinal infections, not all infected patients are tolerant of conventional surgical treatments. First, elderly patients with comorbidities have a much higher incidence of severe postoperative complications than general patients [18, 19]. On the other hand, most patients with spinal infections require debridement, spinal internal fixation, and conventional surgery with autologous iliac bone grafting. The extended operation time and significant blood loss of this traditional surgery will significantly reduce systemic immunity, which is not conducive to postoperative recovery and infection control. This surgical approach usually results in higher complication and recurrence rates. We summarize the traditional surgical modalities reported in the literature in Table 3. The results showed that minimally invasive implantation of VSDs significantly reduces operative time, blood loss, and complications. Therefore, minimally invasive VSD is a feasible approach for patients with clear surgical indications but severe comorbidities who cannot afford surgery [20].

Antibiotic treatment is required for all spinal infections. However, identifying pathogenic microorganisms is necessary to determine the most effective antibiotic. After repeated collection of blood, intraoperative tissue, abscess, and postoperative pathogen drainage, it was challenging to get pathogenic microorganisms from 4 patients in this series. These negative results may be caused by prehospital antibiotic administration or blood and specimen collection methods [21]. It has been claimed that metagenomics is utilised to promptly and accurately discover harmful microbes, although this use must be proven in clinics.

The benefits of VSD for patients with poor surgical tolerance are as follows. First, the intervertebral space installation of the VSD sponge is minimally invasive. This method is less invasive, causes less bleeding, and is suitable for patients with severe comorbidities [22, 23]. Second, this is a staged paradigm of precise individualised treatment, which provides a buffer opportunity for patients with severe comorbidities and determines whether further surgical treatment is required based on the treatment effect. Compared with the conventional surgery in Table 3, this new surgical paradigm significantly reduced the total blood loss and resulted in a faster postoperative recovery without increasing the total operative time [22, 24–29].

In conclusion, the VSD is safe and effectively treats spinal infections with severe comorbidities. Short- and medium-term follow-up demonstrated its efficacy. To our knowledge, this is the first time that VSD has been applied to treating the primary spinal infection with intervertebral pus. In long-term follow-up, complications and recurrence need to be further studied. Furthermore, this surgical paradigm requires further prospective controlled studies.

**Data Availability**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Ethical Approval**

All protocols involving human subjects were approved by the Ethics Committee of the 960th Hospital of PLA (approval no. KYLL201843).

**Consent**

All patients were asked to sign an informed consent statement for publication.

**Conflicts of Interest**

The authors declare that they have no competing interests.

**Authors’ Contributions**

HX and ZQ contributed substantially to data acquisition, analysis, and interpretation. ZQ was responsible for the conception and design of the study and the drafting and writing of this manuscript. YY and WQ were surgical assistants. All authors had read and approved the final manuscript. All authors confirm the authenticity of all the raw data.

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