Research Article

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Adjacent Segment Infection After Posterior Lumbar Fusion Surgery.

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ABSTRACT

Study Design: Retrospective study.
Objectives: Adjacent segment infection after posterior lumbar fusion for noninfectious spinal surgery is rare. The incidence, etiology, and treatment of adjacent segment infections are rarely reported, and the objective of this study was to investigate the incidence, risk factors, diagnosis, and treatment of adjacent segment infection(ASI) in patients undergoing posterior lumbar fusion surgery for noninfectious spinal surgery.
Methods: This retrospective study included patients who underwent lumbar decompression fusion surgery for the treatment of noninfectious lumbar spine diseases between 2008–2020. Clinical data collected from the First People's Hospital of Yunnan Province included sex, age, comorbidities, visual analog scale (VAS) scores, Oswestry disability index (ODI) scores, and adjacent segment infections (ASIs).
Results: A total of 6,325 patients undergoing posterior lumbar fusion surgery for noninfectious spinal surgery met the inclusion criteria. Seven patients (0.11%) developed ASIs. Five patients underwent posterior debridement, autologous iliac bone grafting, and prolonged internal fixation. Two patients were cured with combined anti-infectious therapy. Before the operation, the VAS score was 8.57 ± 0.98, the ODI score was 42.86 ± 3.85, the last follow-up VAS score was 2.0 ± 0.82, and the ODI score was 13.29 ± 2.92. At the last follow-up, all patients had an ASI segment that achieved bony fusion, and posterior lumbar fusion surgery for noninfectious lumbar spine diseases was associated with a 0.11% risk of ASI.
Conclusions: Surgeons should be aware of the risk factors for site infection to be able to avoid its occurrence. Early diagnosis is based on the patient's symptoms, signs, laboratory tests, MRI examination.Timely application of sensitive antibiotics, intervertebral space debridement, autologous iliac bone graft fusion, and prolonged internal fixation are effective treatment measures.

Keywords: Adjacent segment infection, Surgical site infection, Posterior lumbar fusion surgery, Spinal infection, Treatment, Etiology, Risk factor.

INTRODUCTION

Posterior lumbar fusion is an effective treatment for lumbar spinal disease, including spinal stenosis, disc herniation, spondylolisthesis, and spine instability. Lumbar fusion involves posterior lumbar interbody fusion(PLIF), transforaminal lumbar interbody fusion (TLIF), extreme lateral interbody fusion (XLIF), anterior lumbar interbody fusion (ALIF), and oblique lumbar interbody fusion OLIF. Posterior lumbar fusion surgery is one of the most frequently performed spinal surgeries (1).

The incidence of postoperative complications has gradually increased with the increase in lumbar fusion surgeries. Surgical site infection (spinal) is a well-known complication after spinal surgery that is difficult to treat, with an incidence of 2–13% (2).

Surgical site infections occur mainly at the surgical site, and infections that occur in segments adjacent to the surgery are very rare. Adjacent segment infection (ASI) after surgery for

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spondylodiscitis was a rare complication (1.94%) in a large cohort study (3). Siam et al. (3) reported 23 cases of ASI after spondylodiscitis surgery. However, all these ASI cases occurred after surgical treatment of spondylodiscitis. In uninfected spinal surgeries, the incidence of this complication is rare.

This article reported seven cases of ASI after posterior lumbar fusion surgery for uninfected spinal diseases. To the best of the authors' knowledge, these are the most reported cases. This article retrospectively analyzed the diagnosis, comorbidities, time of postoperative infection of adjacent segments, treatment methods, and follow-up results of the participants, with seven patients achieving satisfactory results. This article describes a strategy for the treatment of ASIs after posterior lumbar fusion surgery in patients with noninfectious spines.

MATERIALS AND METHODS

A retrospective analysis was performed on 6,325 patients undergoing posterior lumbar fusion surgery between January 2008 and January 2020. The inclusion criteria were 1) patients undergoing posterior lumbar fusion surgery for treat noninfectious lumbar spine diseases;2) Lumbar fusion involves PLIF, TLIF.Patients undergoing XLIF, ALIF, OLIF, intervertebral foraminoscopy surgery, patients with spinal trauma, infections and tumors were excluded.

Seven patients with ASIs after posterior lumbar fusion surgery were included in this study: four males and three females between the ages of 43 and 69 years (average: 58.86 ± 8.99 years old), with the following preoperative diagnoses: lumbar spinal stenosis, lumbar disc herniation,spondylolisthesis, including four cases of diabetes, three cases of hypertension, two cases of diabetes mellitus combined with hypertension, one case of long-term oral analgesia with a duodenal ulcer with bleeding, and one case of rheumatoid arthritis with a long-term history of oral steroids(**Table1**). The participants had normal infection indicators before surgery and no contraindications to surgery.

Table 1. Demographic characteristics, comorbidities, primary presentation, and outcomes of the study population.

Patient	Age/ sex	Risk factors Complications	ASI Level	Time of ASI occurrence (month)	WBC (109/L)	ESR (mm/h)	CRP (mg/L)	Bacterial culture	VAS preop	ODI preop	VAS postop	ODI postop
1	63/M	DM	L12	1.3	12.87	70	34.6	-	9	42	2	14
2	56/F	Hp,Parkinson's disease,upper end plate rupture,	L23	35	10.21	52	9.78	Staphylococcus epidermidis	9	46	1	9
3	69/M	Hp, DM, Upper-end plate rupture	L34	12	9.84	46	49.4	Worthlerii, epidermis, hemolyticus Staphylococcus	8	47	2	14
4	67/M	Duodenal ulcer with bleeding, Fall pneumonia	L23	24	7.09	27	110.5	Red string erythrococcus	8	44	2	13
5	61/F	Hp,DM	L45	2	14.63	38	78.6	Colibacillus	9	40	3	17
6	43/M	DM	L34	0.7	11.08	25	65.7	-	7	36	1	10
7	53/F	rheumatoid arthritis, osteoporosis, Long-term oral corticosteroids	L34	1	10.78	101	65.0	-	10	45	3	16

Abbreviations:

Hp(hypertension), DM(diabetes),

Clinical data collected from the First People's Hospital of Yunnan Province included sex, age, comorbidities, visual analog scale (VAS) scores, Oswestry disability index (ODI) scores, and adjacent segment infections (ASIs).

Seven days after surgery and at the last follow-up, body temperature was recorded, WBC count, ESR, and CRP were detected,

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and anterior-posterior and lateral lumbar radiographs and CT scans were obtained.

The VAS and ODI scores at the second surgery and last follow-up were recorded.

The preoperative and postoperative MRI scans were recorded before discharge.

During the study period, seven cases of ASI occurred, of which one was transferred from another hospital, and all of which occurred proximally to the surgical segment rather than the surgical site. All patients signed informed consent forms.

All seven patients were followed up between 12 and 36 months postoperatively (average: 19.75 ± 8.33 months). The clinical symptoms, signs, laboratory tests, MRI, microbiological tests, and treatment strategies of the seven patients were analyzed.

RESULTS

Patients were readmitted to the hospital after posterior lumbar fusion surgery for fever, recurrent low back pain, radiation pain in the lower extremities, and numbness in the limbs. Laboratory tests showed an elevated white blood cell (WBC) count, C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR). Postoperative radiographs showed no loosening of the internal fixation in the lumbar spine, narrowing of the intervertebral space near the adjacent lumbar fusion segment, an irregular endplate, and no sinus tract at the surgical site.

MRI showed that the signal of the vertebral body of the proximal adjacent segment was uneven, the corresponding endplate was irregular, there were low signals on T1-weighted imaging, an irregular endplate, uneven signals on T2-weighted imaging of the vertebral body and intervertebral space in the adjacent segment, punctate high signals in the intervertebral space, and moderately high signals of the vertebral body and intervertebral space in the proximal junction area on the fat suppression sequence. An MRI scan revealed significant strengthening of the vertebral body, intervertebral space, and surrounding soft tissues at the proximal junction.

Posterior lumbar decompression fusion internal fixation was performed under general anesthesia and intubation, with three cases of single-segment (L4–L5, two cases; L5–S1, one case) and four cases of multi-segment (three cases of two segments, one case of three segments) fusion. The time for postoperative onset of ASI ranged from 0.7 months to 35.0 months, with an average of 10.86 ± 13.71 months.

All seven patients were successfully discharged after treatment, including five patients who underwent surgical treatment as well as two patients diagnosed early who underwent anti-infective treatment and were successfully treated conservatively.

Four patients underwent posterior surgery for infection segment lesion removal, intervertebral iliac bone graft fusion, extended internal fixation, intervertebral disc tissue bacterial culture, and a drug susceptibility test. Bacteria were detected in three cases, and intravenous antibiotics for 4 weeks according to drug susceptibility results and oral antibiotic treatment for 8 weeks after discharge were given, and the patients were bedridden for 1 month. One month later, protective brace immobilization was performed.

One patient underwent surgery for transforaminal lesion removal, bacterial culture, catheter irrigation, and drainage. Postoperative antibiotics according to drug sensitivity results, bed rest, and brace protection were given, and postoperative symptoms were significantly relieved. However, the patient had an aggravated kyphosis deformity and could not stand or walk. In the second stage, posterior lumbar debridement, iliac bone grafting, prolonged internal fixation to rebuild spinal stability, and antibiotics according to drug sensitivity results were administered intravenously for 4 weeks after surgery and orally for 8 weeks after discharge.

The other two patients were treated conservatively with absolute bed rest, external brace fixation, and anti-infective therapy with dual antibiotics (cefoperazone sodium sulbactam sodium plus vancomycin).

At the last follow-up, the patients had no fever, recurrence, low back pain, or neurological deficits of the lower extremities, and X-rays and CT scans showed good fusion of adjacent infected surgical segments with the iliac mass continuum to the upper and lower endplates.

Seven days after surgery, the WBC count, ESR, and CRP levels decreased compared to the preoperative period, and the WBC count, ESR, and CRP levels were normal at the last follow-up.

Before the operation, the VAS was 8.57 ± 0.98, the ODI score was 42.86 ± 3.85, the last follow-up VAS was 2.0 ± 0.82, and the ODI score was 13.29 ± 2.92.

Typical cases

Case 1

A 56-year-old female patient with lumbar spinal stenosis and hypertension underwent TLIF surgery for lumbar spinal stenosis in our hospital 3 years ago, with a lumbar segment of 3–5. Three years after surgery, the patient experienced low back pain. Radiography showed a lumbar 23 intervertebral space stenosis (**Figure 1**), and MRI imaging revealed a lumbar 23 intervertebral space stenosis and paravertebral abscess formation (**Figure 2**). A CT scan showed lumbar 23 intervertebral space stenosis, lumbar 2 vertebral body bone destruction, and lumbar 3 pedicle screws breakthrough the upper endplate into the lumbar 23 intervertebral space (**Figure 3**). Laboratory test results were WBC, 10.21 × 109/L; ESR, 52 mm/h; and CRP, 9.78 mg/L; tuberculosis infection T-cell test result(-), diagnosis: adjacent segment infection (L2/3). Debridement, lumbar 23-space iliac bone graft fusion, and prolonged internal fixation were performed. Postoperative

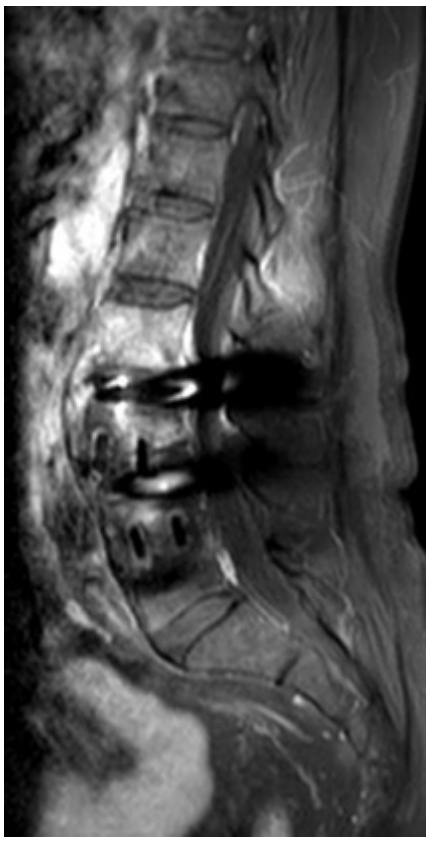
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radiography showed good positioning of the lumbar internal fixation and good bone graft fusion of the 23-segment lumbar segment (**Figure 4**). Postoperatively, the patient was given intravenous antibiotics based on sensitivity for 4 weeks, along with oral antibiotics for 8 weeks. The last follow-up of the patient's low back pain symptoms, blood WBC count, ESR, and CRP normal, postoperative VAS, and ODI score significantly improved compared to that preoperatively.

Figure 1: The primary operation postoperative anterior-posterior and lateral lumbar radiographs.



Figure 2: MRI before the second operation, showing lumbar 23 intervertebral space stenosis and paravertebral abscess formation.



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Figure 3: CT scan showing lumbar 23 intervertebral space stenosis, lumbar 2 vertebral body bone destruction, and lumbar 3 pedicle screws breakthrough the upper endplate into the lumbar 23 intervertebral space.

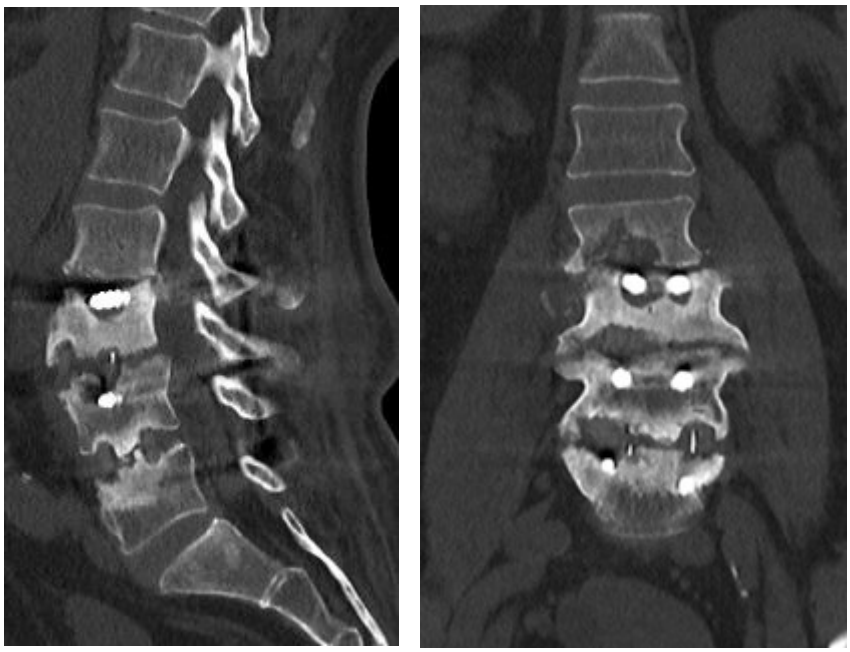


Figure 4: Postoperative X-ray showed that the position of lumbar internal fixation and bone graft fusion of the lumbar 23-segment was good.



DISCUSSION

Surgical site infection after posterior lumbar fusion is a common complication that is difficult to treat. ASI after posterior lumbar fusion surgery is a rare complication with a low incidence. The treatment of this condition is challenging. Patients often need prolonged use of antibiotics, have increased hospital stays and hospital costs, require multiple unplanned surgeries, and suffer a significant psychological burden on themselves, their families, and their doctors.

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Through a large retrospective case analysis, we found that the incidence was approximately 0.11%.

The first case of ASI after spinal surgery was reported in 2006. Kulkarni et al. reported a case of adjacent-level discitis after anterior cervical discectomy and fusion (ACDF) (4). Xin et al. reported a case of ASI after lumbar fusion in 2018 (5). In 2016, Siam et al. reported that the incidence of ASIs after surgical treatment of spondylodiscitis was 1.9% (3). The most commonly involved segments in ASIs were the lumbar (64%) and thoracic (20%) vertebrae [6]. However, the incidence of ASIs after posterior lumbar fusion surgery has not yet been reported.

Etiology

Currently, the etiology of ASIs after lumbar fusion surgery remains unclear. According to Xin et al., the following are the main possibilities (6): 1. the pathogen adheres to the surface of the pedicle screw, and 2. pedicle screws or location markers penetrate the upper endplate of the vertebral body; or 3. there is rupture of the posterior annulus of the adjacent intervertebral disc, and 4. hematogenous pathogens enter the outer layer through the blood supply vessels. For our cases ,three of our patients had upper endplate injuries proximal to the intervertebral space, which may have contributed to the occurrence of postoperative ASI.

Risk factors for surgical site infection are also risk factors for ASI.

Fei et al. (7) conducted a meta-analysis of surgical site infection after spinal surgery, and the results showed that diabetes, prolonged operation time (>3 hours), body mass index >35, number of fixed segments ≥7, and posterior spinal surgery were independent risk factors for increased risk of SSI after spinal surgery. Dubory et al. (8) performed a retrospective analysis of multicenter spinal surgical site infection, in which age factors (old age), diabetes, and long surgical time were risk factors for predicted SSI. In our cases, it was found that old age, multiple medical diseases, and long-term oral corticosteroids are also risk factors for ASI.

Adjacent segment degeneration

Adjacent segment degeneration is likely to be the driving factor behind adjacent intervertebral space infection. After lumbar fusion, with the increase in fusion segments, the stress on adjacent segments increases, making them prone to adjacent segment degeneration, and 90% of which occurs at the proximal end of the fusion segment. The ASIs in this group of cases all occurred proximally to the surgical segment and did not occur at the distal end.

The causes of adjacent segment degeneration are not fully understood but are related to overweight, age, osteoporosis, increased stress after intraoperative fusion of segments, and injury to the posterior ligament complex.

During surgery, attention should be paid to protecting the supraspinous and interspinous ligaments and facet joint capsules to minimize the degeneration of adjacent segments. Adjacent segment degeneration can easily cause superior intervertebral space instability, intervertebral disk degeneration, fibrous ring rupture, and decreased nucleus pulposus moisture, all of which reduce the ability of the intervertebral space to resist infection.

As long as infectious diseases of the lumbar spine are stabilized, the condition of many patients can be controlled, and spontaneous fusion will occur locally, thus leading to the resolution of the disease.

Local spread

After the pedicle screws were inserted during surgery, some bacteria may infiltrate the internal fixation site. Since the pedicle screws were close to the upper endplate, bacteria easily enter the upper intervertebral space through the upper endplate and cause infection.

Hematogenous infection

Hematogenous infection of the intervertebral disc, along with local intervertebral disc degeneration and instability, cause bacteria to easily accumulate, resulting in intervertebral space infection. The areas around and inside the vertebrae are rich in arteriovenous blood vessels. Close to the vertebral body endplate, terminal vascular network bacterial emboli can form at the edge of the vertebral body, and the epivertebral body edge can form a focus of infection. Intervertebral disc infections are mostly secondary to infections of the vertebral body or endplate. Factors such as disc degeneration lead to the dilation of blood vessels, and hematogenous bacterial infections then occur in the intervertebral discs.

Invasive manipulation or surgery

During surgery, the upper endplate is pierced and enters the intervertebral space during the insertion of the positioning pins and screws, causing an infection in the intervertebral space. Although the position of the screws were not seen in the postoperative review film, intraoperative fluoroscopy showed that the position of the upper screws were poor when the positioning needles were inserted, thus piercing the upper endplate and entering the upper intervertebral space. Puncture injury to the endplate into the intervertebral space is rare in the lower intervertebral space; thus, lower intervertebral space infection is rare.

Comorbidities

Previous underlying diseases, in our cases, were accompanied by rheumatoid arthritis, diabetes, hypoproteinemia, and long-term oral immunosuppressants, which led to the patient's poor preoperative state, making surgery less optimal to

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perform. However, the increase in the intensity of symptoms of low back pain and lower extremity radiation pain may necessitate long-term oral pain medication, causing digestive tract symptoms, negatively affecting the overall nutritional status of these patients, and causing decreased immune defenses, which predisposes these patients to infection adjacent to the intervertebral space.

Other factors

Environmental factors during surgery, strict aseptic technique, hand washing, skin disinfection, and clothing can also affect the incidence of infection. An inappropriate operating room system, frequent opening and closing of doors, excessive entry and exit, masks, and curtains are examples. Surgical factors include surgical techniques, a gentle operation, and reduced tissue damage and necrosis. Blood transfusions and allogeneic bone have always been used, because the longer the implants are exposed to air, the higher the chance of infection. Postoperative residual hematoma and necrotic foci, excessive use of an electric knife, suture knots, foreign body residue, bone wax, gelatin sponge, long operative times, and bleeding may also cause infection. Time until the removal of the drainage tubes for more than 48 hours is also a risk factor for susceptibility to postoperative infections. Surgical method, posterior approach, long operation time, extensive exposure of the posterior tissue, paravertebral muscle rupture, and hemorrhage all constitute risk factors for postoperative ASI, and these risk factors should be avoided as much as possible in clinical practice to minimize this risk.

Diagnosis

The diagnosis of infection in the adjacent segment after lumbar spine surgery depends on a combination of clinical symptoms, signs, laboratory tests, imaging tests, and microbiological examinations. After lumbar spine surgery, the patient may experience recurrent wound pain, with or without pain in the lower extremities, accompanied by fever, localized redness, swelling, and exudation from the wound. Laboratory tests usually show elevated blood leukocytes, ESR, CRP, and procalcitonin (PCT)levels; lumbar spine radiological examination shows narrowing of the adjacent segment intervertebral space; lumbar MRI shows a high signal in the adjacent segment intervertebral space after lumbar spine surgery; and the intervertebral space signal is significantly changed compared with the preoperative period. However, the change in lumbar MRI signals remains the most accurate basis for confirming ASI.

Blood cultures, secretion cultures, and biopsies are important methods for identifying pathogenic bacteria. Studies have shown that the main pathogens causing infection after spinal surgery are gram-positive bacteria (69.3%), followed by gram-negative bacteria (21.5%) and viruses (9). Staphylococcus aureus is the most common pathogen that causes postoperative spinal infections (10). Other pathogens mainly include Streptococcus, Staphylococcus epidermidis, coagulase-negative Staphylococcus, and Pseudomonas aeruginosa (11). Methicillin-resistant Staphylococcus aureus accounts for 45–61% of S. aureus isolates in patients with spinal infections. Regardless of the detection method used, bacterial culture results may be negative. Hariharan (12) and Gitajn (13), et al. showed that about 9–17% of patients with post-traumatic fracture infections have negative bacterial cultures. Agostino et al. (9) analyzed the influence of different methods on the bacterial detection rate after spinal infection. The results showed that the bacterial growth rate of the intervertebral disc biopsy was the highest, with a positivity rate of 90%. On the other hand, the positivity rate of CT-guided fine-needle aspiration was 76.1%, and the positivity rate of blood culture was only 45.2%. Nagashima et al. (10) obtained a bacterial detection rate of 41–90% using CT-guided percutaneous biopsy of the infected site. If a psoas abscess is present, the bacterial detection rate significantly increases (14). In general, the detection rate of bacteria in patients with spinal infections is 67–100%. Studies have shown that the use of antibiotics before a biopsy reduces the detection rate of bacteria. Antibiotics can be stopped for 1–2 weeks before a biopsy, but their detection rate may still be low (11, 14).

Due to the lack of specificity in the clinical manifestations of ASI after lumbar fusion surgery, it is difficult for doctors to make a definitive diagnosis as early as possible. However, we suggest that the 2015 Infectious Disease Society of America (IDSA) clinical practice guidelines for the diagnosis and treatment of native vertebral osteomyelitis in adults can be used as a reference for the diagnosis of ASIs after lumbar fusion surgery. Additionally, MRI has important diagnostic value. In the seven cases above, there were clinical symptoms, including fever and new back pain; elevated ESR and CRP levels; and an MRI showing an abnormal signal shadow.

Treatment

The treatment for surgical site infection also includes treatment for ASIs, which mainly includes conservative and surgical treatment. Conservative treatment primarily involves antibiotics and orthosis (11). Currently, owing to the lack of high-quality research evidence on spinal infections, the optimal duration of antibiotic treatment remains controversial. Some scholars suggest using only 6–8 weeks of non-intestinal antibiotics, while others suggest continued use of oral antibiotics for 2 months or longer (10, 11, 15). The 2015 IDSA guidelines recommend that empiric antibiotics should not be used in patients with stable hemodynamics and a normal neurological examination before pathogen isolation. For patients with hemodynamic instability, septicemia, septic shock, or progressive neurological symptoms, it is

recommended to use empirical antibiotics immediately (16). Patients with spinal cord or cauda equina compression, biomechanical instability, pain that is difficult to alleviate, difficulty in antibiotic treatment, prolonged high CRP and ESR, negative cultures, or epidural abscesses require surgery (17). Autotransplantation of self-supporting bone after radical debridement is considered the gold standard surgical treatment for spinal infection [10,11]. In five cases, the authors used radical debridement, posterior lumbar decompression, and fusion, while another patient was treated conservatively with antibiotics. All the patients showed good results.

Limitations

Adjacent segment infection after lumbar fusion surgery for noninfectious disease is a rare complication with a low incidence, and the 7 cases reported in this article are the most common cases in the current literature. We hope that in the future, there will be multi-center studies that can provide us with more cases for analyzing the etiology of its occurrence, how to diagnose it early, and effective treatment measures.

CONCLUSION

In summary, ASIs are rare. Currently, no guidelines are available for its diagnosis and treatment. Doctors should analyze patients' specific problems and choose the corresponding treatment plan, which should be based on guiding principles and clinical experience of spinal infection. Surgeons should pay attention to the risk factors for surgical site infection, avoid iatrogenic injury to the upper intraoperative endplate, and focus on preventing the degeneration of adjacent segments. When ASI occurs, an early diagnosis is made based on the patient's symptoms, signs, laboratory examinations, and MRI examination. Antibiotics based on drug sensitivity tests should be given early to prevent further infection of the intervertebral space lesions, and iliac bone graft fusion with internal fixation should be performed.

Conflict of Interest

The authors declare no conflicts of interest.

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