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Emergency 1-stage anterior approach for cervical spine infection complicated by epidural abscess

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Abstract

It was a retrospective analysis.

The aim of the study was to explore the safety and reliability of emergency 1-stage radical debridement and reconstruction using titanium mesh filled with autologous bone for patients with cervical spine infection complicated by epidural abscess.

At present, cervical spine infection complicated by epidural abscess is known as a severe spine disease. Recently, case report of this disease is showing quite an increasing tendency, particularly in economically undeveloped areas and countries. Regarding the treatment of this disease, 1-stage radical debridement and reconstruction has been widely adopted; however, emergency 1-stage anterior approach surgery without medication is considered as a relatively taboo, since it is generally acknowledged that such operation would possibly cause unexpected infection. Nevertheless, regular elective surgery may require longer time for preparation. In addition, long hour compression and stimulation of the abscess may leave the patients with irreversible spinal neural impairment. However, our department has finished 14 cases of cervical spine infection complicated with epidural abscess without 1 single case of postoperative infection.

A retrospective study was conducted on 14 patients (9 males and 5 females; average age 57.4 years) who were diagnosed with cervical spine infection complicated by epidural abscess from January 2005 to December 2014. All the patients were admitted to hospital with varying degrees of neurological function losses, and then underwent 1-stage anterior focal debridement and reconstruction using titanium mesh within 24 hours after admission. They received postoperative standard antibiotic chemotherapy for 10 to 12 weeks. They were followed up for 18 to 36 months, an average of 27.4 months. X-ray, computed tomography (CT), and MRI (magnetic resonance imaging (MRI) were used to determine the fusion state and vertebral stability. American Spinal Injury Association (ASIA) international standards for neurological classification were adopted, white blood cell count (WBC), erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) were evaluated to infection activity, and Japanese Orthopaedic Association (JOA) and visual analog scale (VAS) criteria were used to judge clinical efficacy.

All the 14 patients had no postoperative spread of infection. No recurrence of infection was found during the last follow-up. ASIA grade, VAS score, and JOA score were significantly improved ($P < .05$) after the operation. WBC, ESR, and CRP became normal after the operation ($P < .05$). Postoperative follow-up imaging results showed no significant loss of cervical curvature, collapse of the grafted bone or implant displacement but good spinal canal volume.

Emergency 1-stage radical debridement and reconstruction using titanium mesh filled with autologous bone, combined with antibiotic chemotherapy, is a safe and effective surgical therapy for cervical infection complicated by epidural abscess.

Abbreviations: ASIA = American Spinal Injury Association, CRP = C-reactive protein, CT = computed tomography, ESR = erythrocyte sedimentation rate, JOA = Japanese Orthopaedic Association, MRI = magnetic resonance imaging, P.O = per os, SPSS = Statistical Program for Social Sciences, TB = tubercle bacillus, T-SPOT-TB = T-SPOT-TB is an ex vivo enzyme-linked immunospot (ELISPOT) assay that uses overlapping peptide panels to stimulate IFN-γ secretion by ESAT-6 and CFP-10-specific T cells, VAS = visual analog scale, WBC = white blood cell count.

Keywords: anterior cervical surgery, cervical spine, epidural abscess, purulent infection

1. Introduction

The incidence of purulent spine infection is low, and purulent cervical spine infections only account for 3% to 11% of spine infections.[1,2] However, there are more and more patients being diagnosed with cervical spine infection because of the abuse of antibiotics and the high detection rate resulted with the popularization of MRI. It is difficult to control cervical spine infection once it occurs. The cervical spinal cord occupies quite a space in the cervical vertebral column, and the cervical spine has a large range of motion; thus, even a small epidural abscess in the cervical vertebral column can easily stimulate the spinal cord as well as the nerve root. Suppose the purulent secretion breaks through the posterior longitudinal ligament and compresses the spinal cord, which often leads to paralysis, a delay of treatment may cause lifelong paralysis or even death. Misdiagnosis or undiagnosis are prone to happen in the early stage of cervical

Editor: Kenneth Casey.

Funded: This work was funded by Key Discipline Construction Project of East Hospital of Shanghai.

The authors have no conflicts of interest to disclose.

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Medicine (2017) 96:26(e7301)

Received: 19 April 2017 / Received in final form: 17 May 2017 / Accepted: 22 May 2017

http://dx.doi.org/10.1097/MD.0000000000007301

spine infection since the development of the infection is insidious. Cervical spine infection can be primary or secondary. Clinicians usually do not pay much attention to primary spine infection, particularly primary purulent cervical spine infection, since the incidence is low. Therefore, the diagnosis of purulent cervical spine infection mainly relies on imaging and the culture of the specimen which is sampled postoperatively.[3] Anterior focal debridement, bone graft for fusion and internal fixation have been widely recognized as the therapy for cervical spine infection complicated by epidural abscess. However, if the patient also has a neurological deficit, the determination of operation time is still controversial.[4,5]

2. Clinical data and methods

2.1. Patients information

This Retrospective study was carried out by the spine Surgery Department (Shanghai East Hospital, Tongji University medical school affiliated, Shanghai, China). All of the potential risks of surgery (including death and other surgical complications) were explained clearly, and written consents were obtained from all patients before surgery. All authors had access to the study data and had reviewed and are fully aware of the final manuscript.14 patients with cervical spine infection complicated by epidural abscess underwent 1-stage thorough debridement and reconstruction using titanium mesh filled with autologous bone within 24 hours after admission during January 2005 and December 2014. They were 9 males and 5 females with an age ranging from 41 to 65 years (average age, 57.4 years). On admission, all the 14 patients had spinal cord and nerve root compression as well as neck and shoulder pain accompanied by incomplete quadriplegia (1 with ASIA B quadriplegia, 3 with ASIA C quadriplegia and 10 with ASIA D quadriplegia). Among these patients, 7 had varying degrees of radicular pains in the upper limbs. The average VAS (visual analog scale) score for preoperative pain was (7.58 ± 1.77). The average JOA (Japanese Orthopedic Association) score was (8.81 ± 1.26). All the patients had high temperature of 38.3–39.7°C, an average of (38.9 ± 0.87) °C. Average erythrocyte sedimentation rate (ESR)[6] was (63.36 ± 7.89) mm/h (normal range 0–15 mm/h), average C-reactive protein (CRP)[6,7] level was (73.49 ± 21.25) mg/L (normal range 0–3 mg/L) and average white blood cell (WBC)[6] count was (16,200 ± 4100) /mm3 (normal range 4500–11,000/mm^3). Preoperative frontal and lateral radiographs as well as CT and MRI images of the cervical spine in all the patients showed epidural abscess formation and damaged vertebra, which were involved with 2 segments in 12 patients (C4 and C5 in 4 patients, C5 and C6 in 5 patients, and C6 and C7 in 3 patients) and 3 segments (C4–C6) in 2 patients. 6 patients developed upper respiratory infection within 1 month before admission, 1 suffered an insect bite within 2 weeks before admission, 1 had a history of intravenous drug use, 1 developed skin and soft tissue infections within 3 weeks before admission, 2 underwent a tooth extraction and developed gingiva infection within 1 month before admission and 3 had cervical spine infection complicated by epidural abscess for unknown reason.

2.2. Surgery and treatment

In order to perform decompression surgery as early as possible after admission to save the spinal cord and help the antibiotic reach its highest plasma concentration in a short time, a consultation was held with pharmacy department, we gave the patients T-SPOT-TB test (T-SPOT-TB test is an ex vivo enzyme-linked immunospot (ELISPOT) assay that uses overlapping peptide panels to stimulate IFN-γ secretion by ESAT-6 and CFP-10-specific T cells.) as well as radiographic tests to rule out the possibility of spinal TB (tubercle bacillus). If the surgery was performed within 12 hours after admission, then first drug administration was completed within 6 hours after admission, and patients were put on second drug administration 1 hour before surgery. If the surgery was performed 12 hours after admission, then for every 6 hours, additional antibiotics were added to the drug administration. Generally, second-generation cephalosporin plus ciprofloxacin were given IV drip. After thorough preoperative preparations, all the patients underwent endotracheal intubation under general anesthesia. Usually, the patient was placed in a supine position. The injured vertebra was localized with a G-arm x-ray machine. A transverse incision was made in the right side of the neck (Smith-Robinson approach). Blunt dissection was performed from the space between cervical vessel sheath and tracheoesophageal sheath to prevertebral fascia to expose the diseased vertebra and vertebral disc. Caspar vertebral body retractor was installed between the first vertebrae higher than and the 1 lower than the diseased vertebra. Radical resection of affected vertebral disc, vertebra tissue and posterior longitudinal ligament was performed. Varying degrees of posterior longitudinal ligament edemas were found in all the cases. Pus was found to have broken through the posterior longitudinal ligament in 3 patients, where a focal pustule wrapped in a layer of membrane was formed in front of the spinal dura mater. Therefore, during the operation, a comprehensive removal of local inflammatory posterior longitudinal ligament was necessary, and all the lesion tissues needed to be submitted for bacterial culture, drug antimicrobial susceptibility testing and pathological examination. Following repeated washing with gentamicin solution diluted in 0.9% sodium chloride solution (normal saline), the length of the vertebral body discectomy area was measured. The titanium mesh filled with fresh iliac bone was placed in the vertebral body groove. The vertebral body retractor was taken out. A titanium plate with proper length was installed. The wound was repeatedly and thoroughly washed with 1% hydrogen peroxide, diluted povidone iodine solution (povidone iodine: 0.9% sodium chloride solution = 1: 2) and 0.9% sodium chloride solution. Gentamicin 3–4 g and a drainage tube were put in the wound.

If a positive result of postoperative specimen culture was found, the antibiotic was switched into another according to drug resistance testing. Usually, antibiotic administration was kept for another 10–12 weeks after the operation. The patients were given Quinolones and cephalosporin IV as well as rifampicin P.O. (per os) according to drug resistance testing, during which the changes in WBC, CRP and ESR were monitored continuously to maintain control of infection. After WBC, CRP, and ESR test came out normal, the medication mentioned above was switch into cephalosporin plus rifampicin P.O.

2.3. Follow-up

Postoperative radiographs were evaluated to ensure the implant position in the cervical spine was accurate. All the patients were followed up for 18 to 36 months after the operation. Radiography was employed to find out the position of the implant and possible failures. Meanwhile, CT scan was performed to observe the fusion of the grafted bone. MRI was done every 12 months to observe the spinal canal and check

Table 1

ASIA grades of the patients preoperatively and during the follow-ups within 3 months after the operation (n = cases).

Preoperative grade	Number of cases	Grade 7 Days after the postoperative					The last follow-up
		A	B	C	D	E	
A	0	0	0	0	0	0	0
B	1	0	1	0	0	0	0
C	3	0	0	1	2	0	0
D	10	0	0	0	4	6	1
E	0	0	0	0	0	0	13
Total	14	0	1	1	6	6	14

ASIA = American Spinal Injury Association.

possible recurrence of infection. ASIA international standards for neurological classification as well as JOA and VAS criteria were used for patients' function evaluation. WBC, ESR, and CRP were tested to evaluate infection activity. Statistical analysis was performed using the SPSS (Statistical Program for Social Sciences) 17.0 software (SPSS). Measurement data was expressed as $x \pm s$. Paired *t*-tests were used to compare pre- and post- operation data. Results were considered to be statistically significant if the *P* value was less than 0.05.

3. Results

All the patients had the operation done successfully and were followed up for 18 to 36 months, an average of 27.4 months. The neck and shoulder pain was obviously alleviated and the body temperature went normal gradually in all patients within 1 week after the operation. 14 patients had a neurological deficit. The ASIA grade of 13 patients was rated as E 3 months after the operation (Table 1). The VAS score was found to gradually drop 7 days and 3 months after the operation. The average VAS score was (7.58 ± 1.77) preoperatively and (2.33 ± 1.21) 3 months after the operation ($P < .05$). The average JOA score was (8.81 ± 1.26) preoperatively and (13.36 ± 2.35) 3 months after the operation ($P < .05$) (Table 2). Relevant indexes of laboratory tests were monitored simultaneously within 21 days after the operation. ESR was (63.36 ± 11.89) mm/hon average preoperatively, gradually rose in a short time after the operation, reached (75.74 ± 13.58) mm/h 3 days after the operation, then gradually fell, and basically became normal with an average of (18.57 ± 12.14) mm/h about 21d after the operation. CRP level was (73.49 ± 21.25) mg/Lon average preoperatively, then gradually rose in a short time after the operation, reached (93.17 ± 17.62) mg/L, further gradually fell, and eventually basically became normal with an average of (8.16 ± 5.33) mg/Labout 21d after the operation. WBC count was (16,200 ± 4100) /mm^3 preoperatively, reached (15,800 ± 4500) /mm^3 3 days after the operation, then gradually fell and basically became normal with an average of (6200 ± 1700) /mm^3 about 21 days after the operation (see Table 3).

No esophageal perforation or laryngeal nerve injury occurred during the operation. After the operation, 2 patients had infection in the superficial layer of incision which healed after the dressing was changed. Twelve patients had a positive result of bacterial culture, including 7 staphylococcus aureus infections, 2 streptococcus infections, 1 escherichia coli infection and 1 staphylococcus epidermidis infection. The other 2 patients had a negative result of bacterial culture.

None of the patients reported recurrence of infection and all of them had good spinal canal volume and complete fusion of the grafted bone without loosening of the implant nor kyphosis of the cervical spine during the last follow-up.

3.1. Typical cases

The patient, male, 46 years old, preoperative: (A) T1-weighted image shows dural sac compression by the tissue with moderate signal intensity at the posterior edges of the C4 and C5 vertebrae (Fig. 1). (B) T2-weighted image shows an abscess at the posterior edges of the C4 and C5 vertebrae, compressing the spinal cord and dural sac. (C) T1-weighted transverse image shows the abscess passing through the posterior longitudinal ligament reaches the surface of the dural sac. (D) CT image indicates destruction of the C4 and C5 vertebrae.

Images retaken 36 months after the operation: (E) Lateral radiograph indicates the implant in place (Fig. 2). (F and G) T1-weighted and T2-weighted images show the condition of the

Table 2

JOA and VAS scores for comparison ($x \pm s$).

Score	Number of cases	Before the operation	1 week after the operation	3 months after the operation	6 months after the operation	12 months after the operation	The last follow-up	*F*	*P*
VAS	14	7.58 ± 1.77	3.85 ± 2.17	2.33 ± 1.21	1.74 ± 1.05	1.44 ± 1.25	1.53 ± 1.72	10.237	.028
JOA	14	8.81 ± 1.26	10.27 ± 2.47	13.36 ± 2.35	13.34 ± 2.52	12.83 ± 2.25	14.80 ± 1.84	9.879	.035

JOA = Japanese Orthopaedic Association, VAS = vsual analog scale.
$P < .05$ means that the difference is statistically significant.

Table 3

WBC, CRP, and ESR for comparison ($x \pm s$).

Score	Number of cases	Before the operation	3 days after the operation	7 days after the operation	14 days after the operation	21 days after the operation	*F*	*P*
CRP	14	73.49 ± 21.25	93.17 ± 17.62	31.46 ± 10.32	12.48 ± 7.71	8.16 ± 5.33	10.574	.022
ESR	14	63.36 ± 11.89	75.74 ± 13.58	57.21 ± 11.37	30.31 ± 15.62	18.57 ± 12.14	8.597	.031
WBC	14	1.62 ± 0.41	1.58 ± 0.45	1.24 ± 0.27	0.75 ± 0.22	0.62 ± 0.17	9.276	.035

CRP = C-reactive protein, ESR = Erythrocyte sedimentation rate, WBC = $1 \times 1000/mm^3$. WBC = white blood cell count.
$P < .05$ means that the difference is statistically significant.

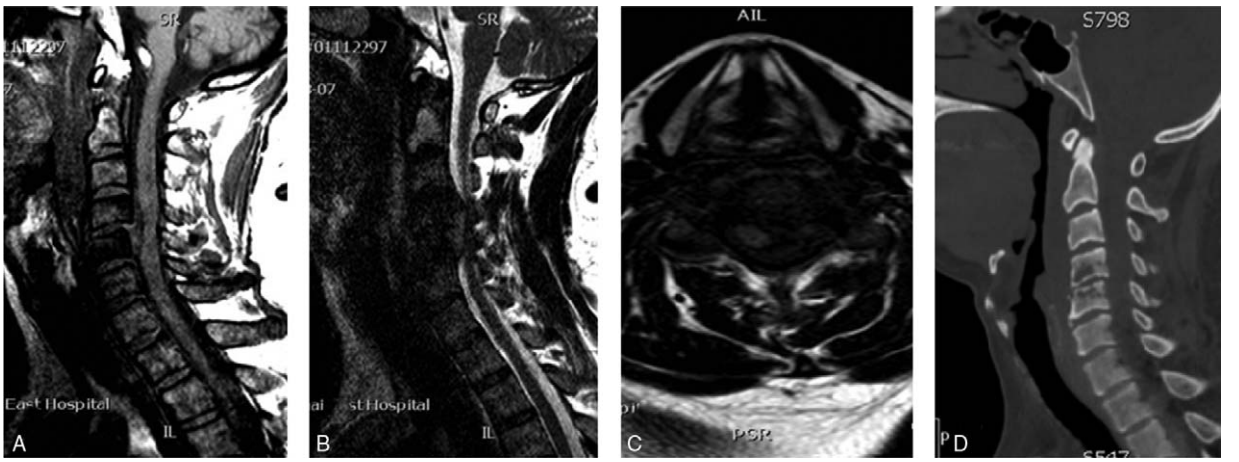

Figure 1. The patient, male, 46 years old, preoperative: (A) T1-weighted image shows dural sac compression by the tissue with moderate signal intensity at the posterior edges of the C4 and C5 vertebrae. (B) T2-weighted image shows an abscess at the posterior edges of the C4 and C5 vertebrae, compressing the spinal cord and dural sac. (C) T1-weighted transverse image shows the abscess passing through the posterior longitudinal ligament reaches the surface of the dural sac. (D) CT image indicates destruction of the C4 and C5 vertebrae.

spinal canal. (H) CT reconstruction image shows the fusion of the grafted bone.

(A) The membrane between the dural sac and the abscess can be noticed after intraoperative removal of the posterior longitudinal ligament (Fig. 3). (B) The section of the tissue infiltrated by neutrophils. (C) Sequestration. (D) Chronic bone tissue inflammation. (HE ×100)

4. Discussion

The incidence rate of purulent spine infection is low. In the early stage, it is difficult to diagnose and misdiagnosis is prone to happen due to a lack of distinct features of early-stage-infection. At present, definite diagnosis mainly relies on imaging combined with laboratory tests. Purulent spine infection could lead to intervertebral tissue collapse, which pushes the necrotic tissue into the spinal canal. In that case, an abscess gradually forms and compresses the spinal cord, resulting in a neurological deficit. If the abscess is large, paraplegia or even death could occur.[8]

The hematogenous spread of pathogenic bacteria is the main reason for purulent cervical spine infections [9] which account for 20% of spine infections. Meanwhile, it is difficult to find out the source of infection, thus the focus of infection cannot be identified in some patients.[10] A definite identification of the source of infection would greatly facilitate the perioperative antibiotics administration as well as reduces the incidence of double infection resulted from blind use of antibiotics. Nonspecific spine infection is mainly caused by staphylococcus aureus and escherichia coli, both of which can be definitely differentiated from fungi and mycobacterium tuberculosis.[4] This is identical with the result of bacterial culture in our study.

It is not difficult to make a definite diagnosis of cervical spine infection complicated by epidural abscess. The main problem is that the infection is complicated with progressive neurological function loss. Tuberculosis or tumor can be clearly identified through combination of MRI and blood culture. Furthermore, MRI is a very important measure for the diagnosis of purulent cervical spine infection. It is outstanding in identifying the focus

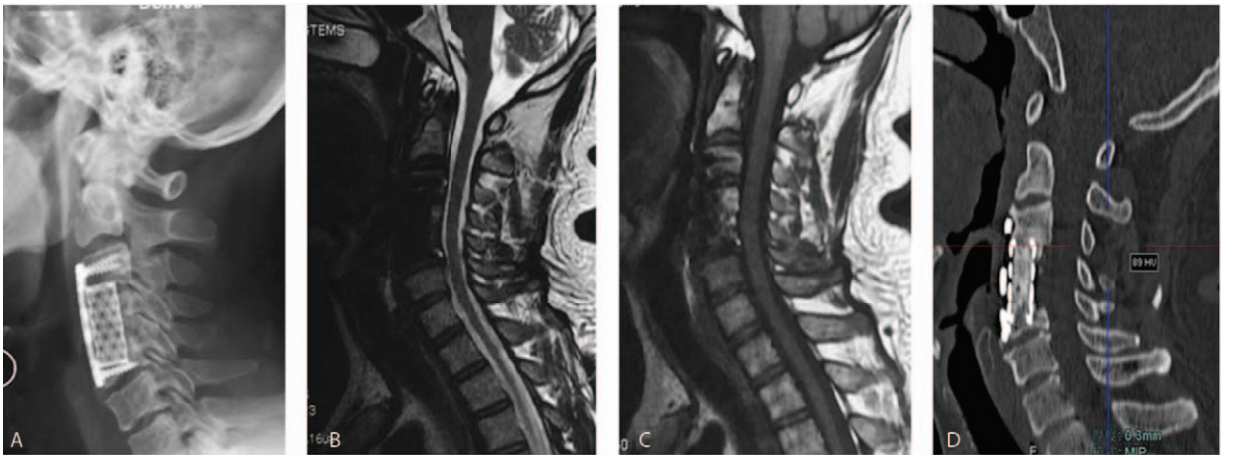

Figure 2. Images retaken 36 months after the operation: (A) lateral radiograph indicates the implant in place. (B and C) T1-weighted and T2-weighted images show the condition of the spinal canal. (D) CT reconstruction image shows the fusion of the grafted bone.

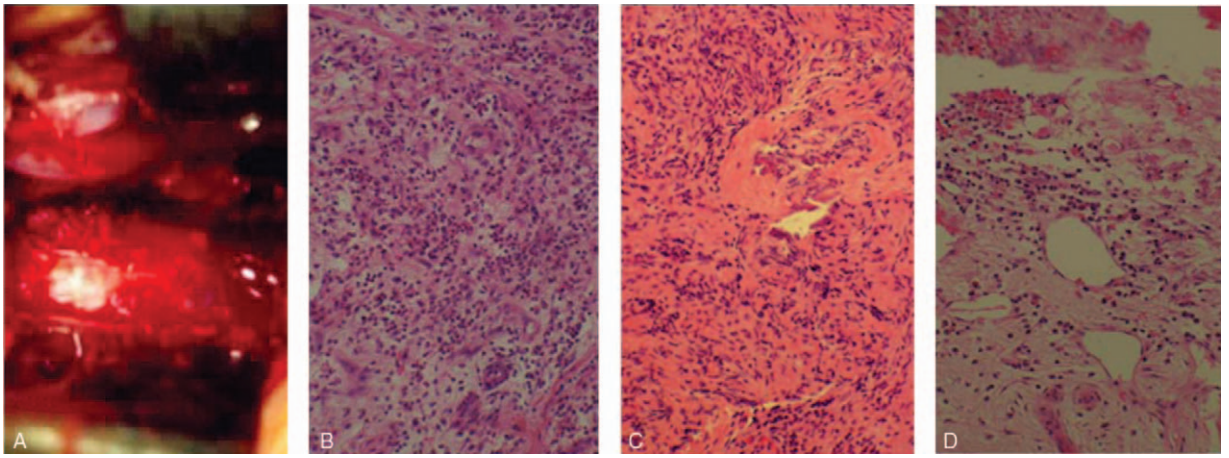

Figure 3. (A) The membrane between the dural sac and the abscess can be noticed after intraoperative removal of the posterior longitudinal ligament. (B) The section of the tissue infiltrated by neutrophils. (C) Sequestration. (D) Chronic bone tissue inflammation. (HE ×100). H&E = hematoxylin and eosin.

of infection in the early stage. Inflammatory edema and inflammatory reaction are remarkable for the obvious high signal intensity on (fat-saturated) T2-weighted images.[11] Therefore, patients with tendency of getting purulent cervical spine infection must complete MRI or even enhanced MRI in time. Since purulent cervical spine infection progresses rapidly, patients who have a fever and a neurological deficit on admission, just like those included in this study, should receive MRI test immediately. Once epidural abscess formation is suggestive, surgical therapy should be given as soon as possible. The images of 1 patient included in this study showed abnormal prevertebral and vertebral inflammatory signal and clear image of abscess in the spinal canal (Fig. 1).

The laboratory tests of WBC, CRP, ESR, and procalcitonin are indispensable. Procalcitonin has strong specificity but it is hyposensitive, thus the tests of WBC, CRP, and ESR are the main methods for verify the degrees of infection.[6,7] From the admission information of our patients we could find out that, after primary test, patients' average ESR was (63.36 ± 7.89) mm/h, average CRP was (73.49 ± 21.25) mg/L, whereas average WBC was (1.62 ± 0.41)/mm^3. Apart from reactive elevation of ESR and CRP value 3 days after operation, WBC was going down, moreover, 7 days after operation, CRP, ESR and WBC have respectively fallen to 31.46 ± 10.32 mg/L,57.21 ± 11.37 mm/h ,1.24 ± 0.2/mm^3. From these lab results, it is not hard to perceive that early surgery decompression combined with efficient antibiotic chemotherapy could well improve patients' blood test results, and further support to prove the feasibility of 1-stage approach surgery. Previous literatures recommended preoperative needle biopsy and bacterial culture of the lesion.[12] However, preoperative puncture may cause spread of infection or even death, and the positive rate of culture results is not high. Therefore, we think preoperative puncture is very dangerous.

We believe that surgical therapy should be actively considered in case of nerve compression.[13,14] Progressive compression by an abscess is different from an acute injury or a chronic injury like cervical spondylotic myelopathy. Gradually aggravating inflammatory stimulation and compression will cause irreversible change in the spinal cord. Meanwhile, the release of inflammatory substances and the increase of the local pressure may cause intracranial or medullispinal infection. Therefore, emergency operation could prevent many complications. In our opinion, the following key points should be followed in performing emergency 1-stage operation: (1) The width of areas undergo corpectomy should be at least 2 cm, if possible, the resection area border should be over 0.5 cm beyond both ends of the abscess. (2) It takes some time to form an abscess after the development of the infection. The dural sac is surrounded by pus, with a lot of pus substances and bacterial colonies on the surface. The pus substances and bacterial colonies, particularly those in the curvatures on both sides of the dural sac which are blind angles, must be removed as thorough as possible. (3) As a part crucial for the debridement result, the posterior longitudinal ligament, including the portion at the curvature of the dural sac, must be removed. (4) A thorough washing is also imperative when complete decompression can be ensured. The routine method is washing three consecutive times with a 50 ml injector which is consisted of normal saline, 1% hydrogen peroxide and diluted povidone iodine solution (povidone iodine: 0.9% sodium chloride solution = 1: 2) in turn, until the reticular structure of the cancellous bone can be clearly seen at the corpectomy boundaries. In the washing process, it is hard to maintain a constant stream velocity from the injector, plus the spine cord in the spinal canal cannot be washed directly, because high speed stream pressure to the dural sac could cause iatrogenic injury to the spine cord and pressure serves as an important factor of spine injury. Hence, we have to indirectly wash it with the liquid flowing down from adjacent vertebral body. While washing, the needle was pointed to the cancellous bone around decompression area to avoid direct impact to the spine cord.[13–15] In addition, during suction, neural surgical cotton chips should be placed to separate dural sac in case of rupture. (5) Fresh ilium with good blood supply should be selected as the grafted bone. Artificial bone and vertebral body bone should absolutely not be considered. Several bone graft materials are available in surgery,[16–19] for instance, autologous iliac bone, autologous cartilage dematrix bone, autologous bone harvested from decompression area,[20] inactive allogeneic bone etc. Since patients were admitted in the emergency room with enough time pressure, plus the operation area is normally contaminated, we cannot apply autologous bone from the decompression area. In addition, inactive autologous bone generally shows poor activity after grafting, further would case unsatisfying fusion state. Hence, we select autologous iliac bone as bone graft, it has

several advantages as following [18]: (1) Autologous tissue does not cause rejection reaction. (2) Iliac bone could provide sufficient supply for bone graft. (3) Iliac bone is cancellous bone, could present high activity in a shorter time.

Previous literature described that poor preoperative control of the focal of infection would increase the risk of recurrence, particularly for patients undergoing the reconstruction and internal fixation of the grafted bone. The bacterial infection causes a biological membrane to form around the implant, and it is difficult for antibiotics to pass through this membrane, which makes it harder to reach an effective bactericidal concentration, besides, insensitivity to antibiotic therapy and repeated recurrence could occur later.[21–23] However, preoperative long period medication can easily increase the risk of antimicrobial drug resistance. Meanwhile, persistent compression by the abscess could cause an irreversible spinal cord injury. Therefore, it is crucial to find an antibiotic to which the bacteria are sensitive to, as well as a timely decompression of the focal segmentin a short period. There were also some clinical cases in which the culture result was negative. Previous literature revealed that gram-positive staphylococcus aureus was the most common pathogenic bacterium causing osteomyelitis, and the cases of osteomyelitis accounted for about 80% of those of spine infection.[24] Therefore, we performed early debridement, decompression and fusion, using drugs according to experience and expanding the antibacterial spectrum, which have yielded a good result (Fig. 2).

For the problems mentioned above, we additionally gave rifampicin per os as routine. Although it was reported that cases of staphylococcus resisting to rifampicin are increasing,[25–26] some studies revealed that the curative effect of combination of quinolones and rifampicin against staphylococcus aureus was significant.[27–31] The study of Zimmer li et al.[32] showed that the effective rate of ciprofloxacin combined with rifampicin in the treatment of orthopedic implant infection was 100%, and that of ciprofloxacin alone was 58%. Rifampicin and fluoroquinolones demonstrate good intracellular permeability and bactericidal activity when they are applied together. This combination could pass through the biofilm on the material used for internal fixation and inhibit growth of intracellular staphylococcus.

In conclusion, whether to perform surgery in separated stages or the decision of operation time itself is not the key factor causing the recurrence of infection. Shad et al[33] reported 5 patients with cervical osteomyelitis undergoing staged anterior debridement, bone graft for fusion and internal fixation. Of the 5 patients, 4 had no recurrence of infection when the materials used for internal fixation were taken out 1 year after the operation, but bacterial colonies were found on the anterior fixation plates taken out. We consider that we could ascribe this result to whether a radical intraoperative debridement was done intraoperatively and whether a proper perioperative antibiotic chemotherapy was applied, and all these are closely related to the recovery of neurological function. Early decompression surgery and debridement can further protect neurological function. 1 patient included in this study had received treatment in another hospital for 10 days before admission to our hospital and had neurological function loss and neurological impairment 7 days before admission. However, the effect of the conservative treatment given by another hospital to the patient was not significant, and the patient missed the appropriate operation time. The neurological function of the patient had not recovered well after emergency decompression surgery performed by us, with ASIA B preoperatively and ASIA D during the last follow-up. But all other patients with neurological impairment who underwent decompression in our hospital as early as possible recovered quite well after the operation (see Table 1). Therefore, we should perform decompression as soon as possible for patients with neurological function loss, as well as bacterial culture, drug susceptibility testing and radical debridement. Postoperative recurrence rate in the patients undergoing emergency operation was not higher when compared with the patients receiving routine systemic antibiotic therapy. According to follow-up results, the biomechanics of the cervical spine and the fusion of the grafted bone in the patients undergoing emergency operation was very satisfactory (Fig. 2). Hence, we assume, if the diagnosis of purulent cervical spine infection is definite and the general condition of the patient is good, it could be much more beneficial for the patients when the following procedures are performed as soon as possible, which are debridement, decompression and bone graft fusion.

To sum, emergency 1-stage radical debridement and reconstruction using titanium mesh filled with autologous bone, combined with chemotherapy, is a safe and effective surgical therapy for cervical spine infection complicated by epidural abscess with incomplete quadriplegia.

Acknowledgments

The authors thank the patients consent with permission

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