One-stage anterior focus debridement, interbody graft using titanium mesh cages, and anterior instrumentation and fusion in the surgical treatment of short segment thoracic tuberculosis with paraplegia

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Abstract

Purpose The purpose of this study was to evaluate the clinical efficacy of primary anterior debridement, bone graft fusion and internal fixation in the treatment of short segmental thoracic tuberculosis with paraplegia.

Methods We performed a retrospective analysis of 16 adult patients with short segment thoracic spinal TB with paraplegia who underwent surgery between September 2013 to March 2017. All the 16 patients were treated using a single primary anterior debridement, bone graft fusion and internal fixation. Clinical manifestations, laboratory, neurological symptoms, bone fusion and imaging results were subjected to statistical analysis.

Results All patients underwent operation successfully. The preoperative ESR and CRP level of all patients were 72.6 ± 27.5 mm/h and 75.7 ± 25.9 mg/L, which decreased to 15.9 ± 4.6 mm/h and 4.7 ± 2.0 mg/L at the final follow-up, respectively. The preoperative thoracic kyphosis angle were $30.7 \pm 7.1^\circ$ respectively. The corresponding postoperative angles were ameliorated significantly to $9.1 \pm 1.9^\circ$. During the follow-up, spinal paraplegia was significantly improved in all patients. The symptoms of chest and back pain were alleviated and disappeared at 1–6 months postoperatively. Patients were followed up for 24–48 months (average, 35.6 ± 9.6 months). Among 16 patients, no recurrence, and bone fusion was achieved at the final follow-up.

Conclusion The clinical results of primary anterior debridement, bone graft fusion and internal fixation in the treatment of segmental thoracic tuberculosis with paraplegia were satisfactory.

Background

Tuberculosis (TB) is caused by *Mycobacterium tuberculosis*. Over the past decades, the incidence of spinal tuberculosis has continued to increase due to population growth, acceleration of mobility, and HIV infection and spread [1]. Spinal tuberculosis is one of the most common extrapulmonary tuberculosis, accounting for the top tuberculosis of total bones and joints [2]. Spinal tuberculosis with paraplegia accounts for about 10% ~ 46% of spinal tuberculosis cases [3]. Spinal tuberculosis can result in serious consequences without proper therapy in time. Spinal tuberculosis forms abscesses, sequestrum, and tuberculous granulation tissue, which enter the spinal canal to compress the spinal cord, causing nerve damage or even paraplegia. Although treatment with powerful anti-tuberculosis drugs has been used, surgical management is also critical. Based on combination chemotherapy, active surgical treatment has been accepted and can effectively shorten the treatment cycle, promote tuberculosis cure, reduce morbidity, and improve the quality of life [4].

The anterior segment, the weight-bearing area of the vertebral column, is preferred for spinal tuberculosis infection. Destruction of the anterior column alters the biomechanics and stability of the spine, which increases the risk of kyphosis and paraplegia progression in patients [5, 6]. Determining the optimal operative method is crucial, especially for Pott's paralysis of tuberculosis of short segment thoracic

vertebra. Anterior lesion removal bone-grafting fusion has always been a classic surgical procedure for the treatment of spinal tuberculosis[7],Because it not only can directly reach the lesion site with a larger operative horizon to completely remove lesions, but also anterior surgery can completely expose the lesions and such lesions can then be completely removed under direct vision to reduce the compression of the spinal cord. Bone grafting can be performed to correct kyphotic deformities and re-establish spinal stability[8], Moreover, full neural decompression, ample spinal stability reconstruction, and enough deformity correction can be achieved in one stage [9]. The anterior procedure leads to early resolution of the disease and faster fusion.Although the posterior approach, which is used routinely in spinal operation, may show some advantages, it damages the residual normal structure against spinal stability and disease healing [10]. Thus, anterior rather than posterior approach seems to be preferred. Anterior surgery is more suitable for spinal tuberculosis paraplegia, especially Pott's paralysis of tuberculosis of short segment thoracic vertebrae. Therefore, we investigated clinical outcomes of the anterior procedure for treating patients with tuberculosis paraplegia of short segment thoracic vertebrae.

Methods

Patients

From September 2013 to March 2017, 16 patients (age range 23–74 years, with an average age of 46.3 ± 14.5 years) with paraplegia of short segment thoracic vertebrae tuberculosis, including 7 men and 9 women, who underwent anterior debridement, bone grafting fusion and anterior fixation in our hospital enrolled the study. Spinal tuberculosis was diagnosed based on patients' symptoms (local pain and percussion pain accompanied with fever, night sweats, and neurological dysfunction), laboratory results (T-spot, tuberculosis antibody, erythrocyte sedimentation rate [ESR], and C-reactive protein [CRP]) and radiologic findings (radiography, computed tomography, and magnetic resonance imaging) and was confirmed by postoperative pathology examinations. Imaging studies showed vertebral body destruction, intervertebral space collapse, kyphosis, paravertebral abscess, and intraspinal invasion. Regarding thoracic vertebral damage, 1 patients had thoracic vertebrae 5 and 6 damage (T5-T6), 2 patients had thoracic vertebrae 6 and 7 damage (T6-T7), 2 patients had thoracic vertebrae 7 and 8 damage (T7-T8), 4 patients had thoracic vertebrae 8 and 9 damage (T8-T9), 5 patients had thoracic vertebrae 9 and 10 damage (T9-T10), 2 patients had thoracic vertebrae 10 and 11 damage (T10-T11) (Table 1). The same surgeons reviewed the surgical indications and performed the procedures. The patients were evaluated preoperatively and postoperatively in terms of Frankel Grade, kyphotic Cobb angle, and bony fusion. Table 1

Summary of the patients' data

Patient no.	Age(y)/sex	Level	Follow-up(months)	Kyphotic angle(°)			Frankle score		Fusion (months)
				PRE	POST	FFU	PRE	FFU	
1	23/M	T8-T9	24	32	11	11	A	D	4
2	47/F	T9-T10	36	42	8.4	10	A	E	5
3	48/F	T8-T9	48	36	10.6	11	C	E	5
4	56/M	T6-T7	48	28	10	10	B	D	6
5	57/M	T9-T10	42	25	9	9	B	E	5
6	37/M	T5-T6	24	29	10.2	12	A	D	4
7	42/F	T7-T8	24	26	7.2	8	A	E	5
8	29/M	T8-T9	30	20	7	6	B	E	4
9	32/F	T10-T11	36	36	8.8	10	C	E	4
10	48/F	T10-T11	24	30	10.3	12	C	E	5
11	45/F	T9-T10	36	33	9.6	11	A	D	6
12	55/M	T9-T10	48	28	9.8	11	B	E	6
13	24/M	T9-T10	24	24	5.6	7	A	E	3
14	62/M	T8-T9	48	36	13	11	B	E	6
15	74/F	T7-T8	42	45	8	10	C	D	8
16	61/F	T6-T7	36	21	6.4	6	C	E	6

Mean values: 46.3 ± 14.5(ages); 35.6 ± 9.6 (Follow-up);30.7 ± 7.1(PRE), 9.1 ± 1.9(POST), 9.7 ± 1.9 (FFU)(Kyphotic angle).

Written informed consent was obtained from all patients, and the study protocol was approved by the Institutional Ethics Review Board of Xi'an chest Hospital.

Treatment method

Preoperative preparation

All patients received at least 2–4 weeks of first-line anti-tuberculous treatment (rifampicin 0.45g, isoniazid 0.4g, pyrazinamide 1.5g,and ethambutol 0.75g) preoperatively, and supporting therapy and symptomatic treatment were conducted when the patient being hospitalized. Doses of anti-tb drugs were appropriately increased in patients with tuberculosis in other parts of the body, or in patients weighing more than 50kg. Operations were not performed until the symptoms improved, and the ESR or CRP decreased to normal or close to normal.

Surgical approach

Informed consent for surgery is signed by the patient. Patients were instructed to lay in lateral position. Transthoracic patients received tracheal intubation with a double lumen tube, and the side lobe was collapsed intraoperatively. A standard lateral anterior approach was used, and an right anterior posterolateral surgical incision was made. Skin and subcutaneous tissues were dissected layer by layer using only an incision of the oblique costal margin. The right latissimus dorsi muscle and pectoralis major muscle were dissected layer by layer. Ribs opposite to the diseased vertebra are exposed, stripped and cut, and the cutoff parts were reserved as autologous bone graft. The right thoracic cavity was opened with an thoracotomy device, and the right lung was collapsed and the right spinal column series was exposed. The right diseased vertebral body and anterior fascia were examined with obvious swelling and abnormal color and the paravertebral abscess was aspirated with a syringe as a culture specimen.

The anterior fascia of the diseased vertebral body was cut longitudinally and segmental vessels were ligated. Cheese-like substance, necrotic granulation tissue, dead bone particles and other lesions were completely removed, while normal vertebral bone tissue was retained. An abscess in the opposite direction was drawn and flushed repeatedly through the vertebral body defect. The compression of the spinal cord was completely relieved. The wound was washed repeatedly with saline, and 1–2g of streptomycin powder was administered. Autogenous bone and graft fusion with a titanium cage strut combined with an anterior vertebral screw-plate internal fixation system were used to recover the normal spinal curvature of patients with kyphosis(Fig. 1,2). The drainage tube was placed postoperatively, and culture specimens were sent for pathological examination.

Postoperative treatment

Conventional electrocardiographic monitoring and anti-infection and anti-tuberculosis treatment were provided. A drainage tube was placed for 1-3 days and removed until the 24-h drainage flow was < 50 mL. In addition, complete lung expansion was confirmed by radiography. The drainage time was extended in patients with penetrable pus cavities. Nutritional support was provided in patients with postoperative anemia, low serum albumin levels, or loss of appetite. The patients were required to get out of bed for 2 weeks after the operation. After hospital discharge, anti-tuberculosis therapy was maintained for 18–24 months.

Evaluation of clinical outcomes

The ESR and CRP were measured to evaluate the activity of short segment thoracic vertebrae tuberculosis with paraplegia. Roperatively and postoperatively in terms of Frankel Grade, kyphotic Cobb angle, and bony fusion were recorded to evaluate changes before and after surgery.

Statistical analysis

Data were analyzed using the independent sample t test and SPSS statistical software (IBM Corp.) p values < 0.05 were considered statistically significant.

Results

Clinical results

All patients underwent operation successfully. During the follow-up, spinal paraplegia was significantly improved in all patients. The symptoms of chest and back pain were alleviated and disappeared at 1–6 months postoperatively. Patients were followed up for 24–48 months (average, 35.6 ± 9.6 months). Among 16 patients, no recurrence, and bone fusion was achieved at the final follow-up.

Laboratory data

The preoperative ESR and CRP level of all patients were 72.6 ± 27.5 mm/h and 75.7 ± 25.9 mg/L, which decreased to 15.9 ± 4.6 mm/h and 4.7 ± 2.0 mg/L at the final follow-up, respectively (Table 2).

Table 2 Laboratory data of all patients

n	ESR (mm/h)			CRP(mg/L)		
	PRE	POST	FFU	PRE	POST	FFU
16	72.6 ± 27.5	46.6 ± 24.1	15.9 ± 4.6	75.7 ± 25.9	41.6 ± 15.0	4.7 ± 2.0

PRE preoperative, FFU final follow-up, POST postoperative, ESR erythrocyte sedimentation rate, CRP C-reactive protein

Neurologic function

Neurological symptoms of 16 patients were manifested as complete paraplegia, lower limb weakness, chest sensation or related numbness and paresthesia. Neurological function was evaluated by the Frankel classification and is listed in Table 1. All patients achieved function status improvement at different degrees. Preoperative and postoperative neurological status by the Frankel score system (n = 16)

Radiological data

The preoperative thoracic kyphosis angle were $30.7 \pm 7.1^\circ$ respectively. The corresponding postoperative angles were ameliorated significantly to $9.1 \pm 1.9^\circ$. At the final follow-up, only a small loss of correction was observed, as shown in Table 1.

Discussion

Spinal TB is one of the most common and severe forms of bone and joint TB. It mostly occurs in the thoracic spine region and always involves the anterior and middle spine. A lesion of the vertebral body caused by TB always lead to the development of kyphosis, paravertebral abscesses, or progressive neurological impairment[11]. Although conservative treatment for spinal TB can effectively alleviate pain, kyphotic deformity continues to progress, with 3% to 5% of patients showing severe progression and subsequent paraplegia[12]. Therefore, it is particularly important to perform necessary surgical interventions to relieve clinical symptoms and achieve good long-term outcomes[13].

It is a convenient way to completely remove tuberculous substances from the lesion vertebra and paravertebral abscesses, to safely decompress soft oppression of the spinal cord, and to fully perform spinal canal decompression. Anterior debridement and strut grafting enable surgeons to treat thoracic spinal tuberculosis with paraplegia directly and thoroughly, which is more favorable for biomechanical reconstruction. Anterior internal fixation can still maintain the spinal stability and correction of kyphosis when tuberculosis invades short thoracic vertebra segments. The anterior approach enables surgeons to

reach the lesion site directly, and a single incision can be used to perform multiple operations. Operators also have a more spacious and a direct field of vision, simplifying the operative procedures[14].Anterior debridement combined with strut grafting can provide a suitable host bed to simulate vertebral bone fusion, and instrumentation by titanium plate and mesh stabilizes biomechanical properties of the spine. This will reduce the risk of postoperative kyphosis and improve the surgical cure rate of short segmental thoracic vertebrae with paraplegia

Sixteen patients of short-segment thoracic tuberculosis with paraplegia in our study underwent the anterior approach debridement, strut grafting, and instrumentation and all of them had a sturdy implant and favorable curative state. A titanium cage supplemented by autologous bone or allograft bone graft achieved satisfying outcomes in our study. At the last follow-up, All patients recovered well without breakage or transposition of the implant or kyphosis recurrence. and all patients had achieved bone fusion, relief from pain, and neurological recovery.

Conclusions

In summary, we believe that the simple anterior approach for debridement, strut grafting, and instrumentation should be considered for tuberculosis of short segmental thoracic tuberculosis with paraplegia. The operative method should be determined based on the specific circumstances of each patient and the operator's proficiency level. Systemic anti-tuberculosis chemotherapy is essential to cure spinal tuberculosis. Lastly, comprehensive measures must be taken to improve the cure rate of short segmental thoracic tuberculosis with paraplegia.

Abbreviations

CRP:C-reactive protein

ESR:Erthrocyte sedimentation rate

FFU:Final follow-up

POST:Postoperative

PRE:Preoperative

Declarations

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Availability of data and materials

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

Huijun Zhang collected, analyzed, and interpreted the data and wrote the draft. Huijun Zhang and Zenghui Lu and Lin Wei performed the surgery. Lin Wei and Chao Ding assisted in the follow-up process and collection of data. Jun song Yang critically revised the manuscript. All the authors have read and approved the final manuscript.

Ethics approval and consent to participate

Written informed consent was obtained from all patients, and the study protocol was approved by the Institutional Ethics Review Board of XI'AN Chest Hospital.

Consent for publication

Written consent to publish patient identifiable information and data was obtained from the patients.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

Forty-seven-year-old female with short segment thoracic vertebra tuberculosis (T10-11 level). A,B Preoperative frontal and lateral x-rays showed bone destruction in the 10/11 vertebral body and narrowing of the vertebral space C Preoperative magnetic resonance imaging scan D Preoperative computed tomography scan demonstrate vertebral body destruction. E,F Radiographs postoperatively showing well-positioned internal fixation. G,H Radiographs showing satisfactory focal clearance and strut graft stability at the final follow-up

Figure 2

Twenty-six-year-old girl with short segment thoracic vertebra tuberculosis (T6-T7 level). A,B Preoperative frontal and lateral x-rays showed bone destruction in the 6/7 vertebral body and narrowing of the vertebral space C Preoperative magnetic resonance imaging scan shows vertebral body destruction and abscess. D Preoperative computed tomography scans demonstrate vertebral body destruction. E,F Radiographs postoperatively showing well-positioned internal fixation. G,H Radiographs showing satisfactory focal clearance and strut graft stability at the final follow-up