

Research Article

Clinical effect of posterior-only approach debridement, intervertebral fusion, and internal fixation for upper thoracic tuberculosis

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ABSTRACT

Objective: This study aimed to evaluate the effectiveness and feasibility of the posterior-only approach for debridement, interbody fusion, and internal fixation in treating upper thoracic tuberculosis.**Methods:** This study retrospectively analysed the clinical and radiographic data of 8 patients diagnosed with upper thoracic tuberculosis. All patients underwent posterior approach debridement, interbody fusion, and internal fixation. We conducted pre- and postoperative assessments of the visual analog scale (VAS), Oswestry disability index (ODI) scores, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), ASIA score, and kyphotic Cobb angle.**Results:** Back pain and lower limb weakness were the most common presenting symptoms. The mean duration of surgery, amount of blood loss, and volume of postoperative drainage were 262.5 ± 43.3 min, 625.0 ± 333.8 mL, and 285.0 ± 118.1 mL, respectively. Patients were followed up for 36 to 48 months. Three months after surgery, there was a significant improvement in VAS and ODI scores, which further improved until the final follow-up. A statistically significant difference was observed between the preoperative and postoperative periods ($P < .05$). At the final follow-up, lower extremity function had fully returned to normal in all 5 paralyzed patients. The ESR and CRP returned to normal, 18.1 ± 7.3 mm/h and 9.95 ± 5.41 mg/L, respectively, within 3 months postoperatively. There were statistical differences between the preoperative and postoperative periods ($P < .05$). The average kyphotic correction rate was $(71.5 \pm 7.3)\%$, and the average loss of correction angle was $(3.5 \pm 1.4)^\circ$. Intervertebral bone fusion was achieved by all patients within 15 months (mean 8.3 ± 3.2 months) postoperatively.**Conclusion:** The posterior-only approach seems an effective, safe, and reliable treatment method for upper thoracic tuberculosis, with favourable clinical and radiological outcomes.**Level of Evidence:** Level IV, Therapeutic study.

Introduction

Spinal tuberculosis accounts for 50% of all cases of osteoarticular tuberculosis.¹ The thoracic spine is the most common site of spinal tuberculosis, making it more vulnerable to severe physical damage, including vertebral collapse, kyphosis, and paralysis.^{2,4} Nonetheless, despite the severity of upper thoracic tuberculosis (T1-T4), responsible for only 5.9% of all spinal tuberculosis cases,² there are limited reports detailing its diagnosis and treatment.

Surgical intervention during concomitant pharmaceutical treatment for spinal tuberculosis is necessary when there are pronounced neurological deficits, marked deformities (kyphosis), and significant instability.^{5,6} The surgical approach for spinal tuberculosis is a long-standing issue of controversy.⁷⁻⁹ Since spinal tuberculosis primarily affects the anterior column of the vertebra, the anterior surgical approach offers a direct path to the diseased vertebral body lesions, allowing for a more extensive surgical field and providing convenience in debridement and reconstructing anterior column defects.^{10,11} Anterior approach debridement is a preferred technique among some scholars for treating

upper thoracic tuberculosis because of its numerous advantages.¹¹⁻¹³

The anterior approach to the upper thoracic spine is particularly challenging due to the sternum, clavicle, ribs, and mediastinal organs. Accessing the upper thoracic tuberculous area through the anterior approach poses an additional challenge as thoracotomy to reach the upper thoracic vertebrae is complicated by the complex anatomy that hinders the approach.¹⁴ Additionally, reconstruction of the surgical area and deformity correction through the anterior approach is challenging, especially when dealing with moderate or severe kyphosis.¹⁵ The posterior approach has a better corrective effect on kyphotic deformity than the anterior approach.⁸ Furthermore, according to some scholars, anterior debridement may be unnecessary in treating tuberculous spondylitis.¹⁶ Therefore, we prefer the posterior approach for upper thoracic tuberculosis, and we performed debridement, bone grafting, and internal fixation in 1 stage. This study summarizes our experience managing and following up on 8 patients with upper thoracic tuberculosis. It discusses the feasibility and effectiveness of posterior-only approach debridement, intervertebral fusion, and internal fixation for treating upper thoracic tuberculosis.

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Material and Methods

General materials

A retrospective analysis was conducted on the clinical and imaging data of 13 consecutive patients with upper thoracic tuberculosis admitted between January 2013 and November 2019. However, only 8 patients were followed up for over 2 years and had complete medical records. Approval for this study was granted by the The 940th Hospital of Joint Logistics Support Force of Chinese PLA of the authors' affiliated institutions (approval number: 2020KYL002). Informed consent was obtained from the patients who agreed to take part in the study. All patients underwent serological tests, which included erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and T-SPOT, as well as imaging examinations, such as plain radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) after admission. These tests are shown in Figure 1. The clinical diagnosis of upper thoracic tuberculosis was based on the clinical-radiographic-hematologic correlation commonly used for diagnosing tuberculosis, and the postoperative pathological examination confirmed the diagnosis.

Preoperative management

Among the 8 patients, 6 were administered a course of anti-tuberculous drugs (including isoniazid at 300 mg/day, rifampicin at 450 mg/day, pyrazinamide at 750 mg/day, and ethambutol at 750 mg/day) for 3 to 4 weeks before surgery. Two patients underwent emergency spinal cord decompression due to neurological damage and did not receive anti-tuberculosis drug treatment before the operation. ESR and CRP levels were monitored to evaluate the effectiveness of the anti-tuberculosis treatment. Additionally, preoperative nutritional support was provided to address any anemia or hypoproteinemia present.

Surgical procedure

After administering general anesthesia, the patient was positioned prone, and a posterior approach was used to access the upper thoracic vertebra. A midline incision was made, and posterior elements, including lamina, facet joints, and transverse processes, were exposed. Under C-arm fluoroscopic guidance, the damaged vertebra was identified, and pedicle screws were inserted. Generally, we preferred longer segmental fixation, at least 2 levels superior and inferior to the level of decompression. Partial removal of the ribs and costovertebral articulations was included for lateral exposure. Costovertebral resection at the severe lesion segment was performed to drain the prevertebral abscess and expose diseased vertebral bodies. The intercostal nerve on the focal side was sacrificed if necessary. Various spatulas removed the lesions, including sequestrum, abscess, caseous material, and necrotic disc tissue, until the normal bleeding bone was exposed. In general, a partial resection of the damaged is performed. If there was any space-occupying lesion in the spinal canal, adequate decompression of the spinal canal was performed. The abscess was drained, and necrotic tissue was curetted as thoroughly as possible. The surgical field was washed with a large volume of normal saline until the rinsing fluid was clear. The kyphosis was corrected by installing permanent rods and exerting decompression at the middle anchoring point. The interbody defect was measured,

and a suitable length of autologous iliac bone graft and rib bone graft or titanium mesh cages with autogenous bone grafts were taken to repair the interbody defect. The bone graft was immobilized with appropriate compression. After complete hemostasis, 500 mg of isoniazid and 1000 mg of streptomycin were injected into the operative area, and a drainage tube was inserted before suturing the incision. The material debrided was sent for histopathologic examination. A single surgeon performed the surgical procedure.

Postoperative management

The drainage tube remained in place for 48-96 hours and was removed when drainage volume decreased to <50 mL over 24 hours. Nutritional support was enhanced during the perioperative period, and physical therapy and rehabilitation training were implemented to prevent deep venous thrombosis and facilitate early recovery of nerve function. Postoperatively, conventional quadruple anti-tuberculosis therapy (isoniazid at 300 mg/day, rifampicin at 450 mg/day, pyrazinamide at 750 mg/day, and ethambutol at 750 mg/day) was continued for 3 months, followed by the continuation of triple anti-tuberculosis therapy (isoniazid 300 mg/day, rifampicin 450 mg/day, ethambutol 750 mg/day). The decision to discontinue pharmacotherapy was made according to the patient's progress assessed in the follow-up. However, the treatment cycle with the use of anti-tuberculous drugs was at least 12 months.

Follow-up assessment

After being discharged, patients underwent monthly assessments to monitor their clinical response and neurological function, which included visual analog scale (VAS), Oswestry disability index (ODI) scores, ESR, CRP, and ASIA classification, as well as the early detection of complications such as drug-related side effects and disease reactivation. X-rays and CT scans were performed every 3-6 months to evaluate kyphosis correction and bony fusion. The kyphotic angle is formed by the upper and lower endplate lines of the upper and lower vertebrae with a maximum inclination of the kyphosis.¹⁷ The determination of bone graft fusion was based on the presence of continuous bony trabeculae formed between the graft and host bone. The criteria for spinal tuberculosis cure required:^{18,19} 1) disappearance of all clinical symptoms and normal ESR levels following repeat laboratory testing, 2) CT evidence of bone graft fusion at the lesion site without paravertebral inflammation, and 3) no symptom recurrence for over 6 months after discontinuation of anti-tuberculosis drugs.

Statistical analysis

We conducted a paired-sample *t*-test to evaluate the differences in ESR, CRP, VAS, ODI scores, and Cobb's angle between preoperative and 3-month postoperative, and 3-month postoperative and final follow-up values. Statistical significance was considered when $P < .05$. All statistical calculations were performed using SPSS version 20 (IBM SPSS Corp.; Armonk, NY, USA) for Windows.

Results

The study involved 8 patients, 5 of whom were female and 3 were male, with a mean age of 56.9 ± 12.7 years (range: 32-71 years) at presentation. All were monitored for an average of 42.3 ± 4.3 months (range: 36-48 months). The most frequent presenting symptom was pain, comprising thoracodorsal pain and intercostal neuralgia, while other common symptoms included lower limb weakness and fever. Clinical findings revealed that spinal tenderness and paralysis were most notable. Table 1 provides a detailed record of clinical presentation, physical examination, and neurological assessment. No patients

HIGHLIGHTS

- Upper thoracic tuberculosis is a rare disease under-reported in the literature.
- The posterior approach is an effective method for completely decompressing the spinal cord, correcting kyphosis, and facilitating the recovery of spinal cord function.
- The posterior-only approach is a straightforward, safe, reliable, and efficient treatment option for upper thoracic tuberculosis.

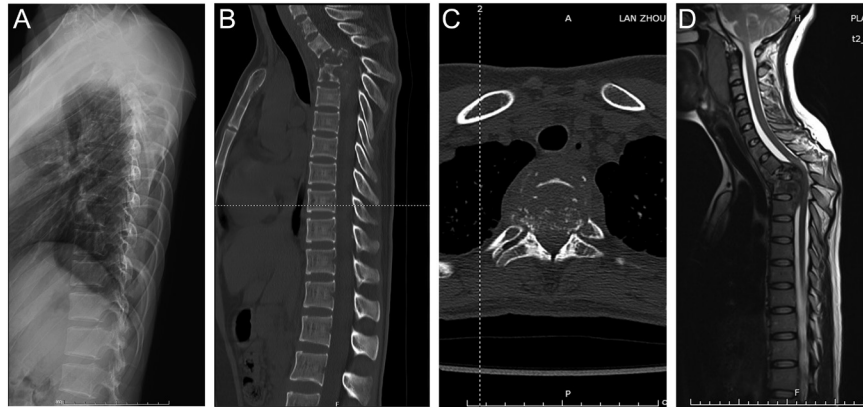


Figure 1. (A) Preoperative lateral X-ray showed no obvious abnormality. (B) In preoperative CT, destructive segments are located at T2-5. The local kyphotic Cobb angle was 47°. (C) Axial CT showed that the vertebra was full of star-like bone destruction with lesions protruding into the spinal canal. (D) Preoperative MRI, the spinal cord was severely compressed by the abscess and sequestrum.

exhibited pulmonary tuberculosis on chest radiographs, and histological examinations of sputum for acid-fast bacilli yielded negative results in all cases. Single-segment lesions were present in only 2 cases, whereas the remaining 6 had multi-vertebral lesions (Table 2).

Perioperative outcomes

On average, the operation time, blood loss, and postoperative drainage volume were 262.5±43.3 minutes (range: 200-330 minutes), 625.0 ± 333.8 mL (range: 300-1300 mL), and 285.0 ± 118.1 mL (range: 150-450 mL), respectively. A detailed summary of the patients' perioperative outcomes is provided in Table 2.

Pain and functional recovery

All cases experienced a significant reduction in preoperative VAS and ODI scores at 3 months post operation, and further improvement was observed up until the final follow-up period, with a significant difference noted between preoperative and 3-month postoperative, and 3-month postoperative and final follow-up values ($P < .05$) (Table 3). Out of 8 cases, 5 patients (5/8) showed remarkable neurological recovery as indicated by their postoperative ASIA classification score despite having had lower limb paralysis before surgery. At the final follow-up, symptoms of tuberculosis were fully resolved.

Laboratory outcomes

Preoperatively, the average ESR and CRP levels were 39.1 ± 13.5 mm/h (range: 21-66 mm/h) and 25.00 ± 14.34 mg/L (range: 13.2-58.2 mg/L), respectively, but both returned to normal within 3 months following the operation. Statistical significance was observed between preoperative, 3-month postoperative, and final follow-up values ($P < .05$) (Table 3).

Table 1. Clinical presentation of the patients in our series

Clinical symptoms and signs	No. of patients
Symptoms	
Thoracodorsal pain	6
Intercostal neuralgia	2
Subjective weakness of lower limbs	5
Subjective loss of sensations	3
Low-grade fever	5
Other constitutional symptoms (night sweats, weight loss, and malaise)	3
Clinical signs	
Spinal tenderness	6
Paralysis of lower limbs	5
Pyramidal-tract involvement	2
Discharging sinus	0
Spinal deformity or gibbus	3

Radiological outcomes

At 3 months post operation, the mean kyphotic Cobb angle was significantly reduced to (6.3 ± 3.2)° (range: 3°-12°) and was (9.8 ± 3.9)° (range: 5°-16°) at the final follow-up. Statistical significance was noted between the preoperative and 3-month postoperative measurements ($P < .05$). The kyphotic correction rate reached (71.5 ± 7.3)%, but there was a loss of correction angle at the final follow-up, measured at (3.5 ± 1.4)° with a loss rate of correction at (25.1 ± 10.7)% (Table 4). CT scans were conducted as part of a routine examination to assess bone fusion, achieved in all patients, on average, within 15 months (8.3 ± 3.2 months) (Figure 2).

Complications

No perioperative complications were associated with decompression; however, 1 patient experienced a loosening of the instrumentation due to unresolved spinal tuberculosis and required reoperation. No instances of wound infection, infectious meningitis, or tuberculosis recurrence occurred. Two patients experienced sinus tract formation, which healed following bone fusion. None of the patients experienced side effects related to anti-tuberculous drugs during follow-up.

Discussion

Spinal tuberculosis in the upper thoracic region is rare,³ and there is limited literature on its treatment.^{20,21} Early diagnosis of upper thoracic tuberculosis can be challenging due to the lack of obvious systemic and local symptoms and barriers presented by various tissues and organs, which can make it difficult to detect abnormalities with X-rays in the early stages of the disease. As the disease progresses, infection-related loss or collapse of the anterior column support in the upper thoracic region can cause further deformity, instability, and even spinal cord injury, leading to progressive kyphosis as the mobile cervical column topples over the fixed thoracic spine. Thus, early diagnosis and treatment of upper thoracic tuberculosis pose a significant challenge.

In spinal tuberculosis, mycobacteria are transported via end arterioles and deposited near the vertebral endplate's anterior aspect, with the vertebral body's anterior portion being most commonly affected.⁵ Consequently, many scholars view anterior radical debridement as the gold standard for the surgical treatment of spinal tuberculosis.²² Similarly, anterior approach debridement has been utilized by many scholars in the effective treatment of upper thoracic tuberculosis.^{13,23}

Table 2. Clinical data, perioperative outcomes, and complications

Case no.	Age (y)/ gender	Segments	Operation time (minutes)	Blood loss (ml)	Postoperative drainage volume (ml)	Hospitalization (days)	Duration of follow-up (months)	Fusion time (months)	Complications	Relapse
1	66/F	T3-T4	240	500	300	27	40	6	No	No
2	32/F	T2-T5	330	1300	450	42	48	15	Reoperation, Sinus	No
3	53/M	T3-T5	290	600	400	14	47	6	No	No
4	68/M	T2-T3	250	350	150	24	42	6	No	No
5	48/F	T3	220	400	200	12	36	6	No	No
6	60/M	T2-T4	300	900	400	15	46	9	Sinus	No
7	57/M	T3-T4	270	650	200	15	40	8	No	No
8	71/M	T4	200	300	180	20	39	10	No	No
Mean ± SD	56.9 ± 12.7	-	262.5 ± 43.3	625.0 ± 333.8	285.0 ± 118.1	21.1 ± 9.9	42.3 ± 4.3	8.3 ± 3.2	-	-

F, female; M, male.

Table 3. VAS, ODI, ESR, CRP, and ASIA classification score

Case no.	VAS			ODI			ESR (mm/h)			CRP (mg/L)			ASIA		
	Pre-op	3 m post-op	Final follow-up	Pre-op	3 m post-op	Final follow-up	Pre-op	3 m post-op	Final follow-up	Pre-op	3 m post-op	Final follow-up	Pre-op	3 m post-op	Final follow-up
1	4	2	0	46.7%	11.1%	11.1%	66	12	15	25.3	4.95	2.38	D	E	E
2	5	2	1	66%	28%	28%	37	18	3	18.9	4.48	1.87	C	E	E
3	4	1	0	40%	10%	10%	41	14	11	58.2	10.3	6.8	E	E	E
4	4	1	1	35.6%	11.1%	11.1%	38	29	10	20.8	17.1	5.9	D	E	E
5	5	1	0	28%	8%	8%	26	10	4	13.2	5.9	2.6	E	E	E
6	6	2	2	55.6%	31.1%	31.1%	45	28	19	29.1	18.5	9.2	C	D	E
7	6	2	1	52%	24%	24%	39	21	7	19.1	11.2	5.5	D	E	E
8	4	0	0	22.2%	8.9%	8.9%	21	13	9	15.4	7.2	3.5	E	E	E
Mean ± SD	4.8 ± 0.9	1.4 ± 0.7	0.6 ± 0.7	(43.3 ± 14.7)%	(16.5 ± 9.5)%	(16.5 ± 9.5)%	39.1 ± 13.5	18.1 ± 7.3	9.8 ± 5.4	25.00 ± 14.34	9.95 ± 5.41	4.72 ± 2.56	-	-	-
P	0.000*	0.000*	0.02**	0.000*	0.000*	0.000*	0.001**	0.005*	0.014**	0.014**	0.02*	0.003**	-	-	-

ASIA: American Spinal Injury Association; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; ODI: Oswestry disability index; VAS: visual analog scale.

*Compared with preoperative.

**Compared with 3 months postoperative.

Table 4. Kyphotic angle correction

Case no.	Kyphotic Cobb angle					
	Pre-op	3 m post-op	Correction rate (%)	Final follow-up	Angle lost	Lost rate (%)
1	15°	3°	80%	8°	5°	41.7%
2	47°	12°	74.5%	16°	4°	11.4%
3	36°	9°	75%	12°	3°	11.1%
4	14°	4°	71.4%	7°	3°	30%
5	9°	3°	66.7%	5°	2°	33.3%
6	39°	8°	79.5%	14°	6°	19.4%
7	18°	6°	66.7%	9°	3°	25%
8	12°	5°	58.3%	7°	2°	28.6%
Mean ± SD	23.8 ± 14.6	6.3 ± 3.2	(71.5 ± 7.3)%	9.8 ± 3.9	3.5 ± 1.4	(25.1 ± 10.7)%
<i>P</i>		0.004*		0.000**		

*Compared with preoperative.
**Compared with 3 months postoperative.

However, performing anterior approach thoracic spine surgery can be challenging, particularly in the upper thoracic region, requiring significant experience and expertise and may not be feasible in general practice.

Posterior extensive circumferential decompressive reconstructive techniques are often used in treating upper thoracic spine disease, and posterior-only approaches can achieve subtotal vertebrectomy.²⁴ This approach provides adequate operating space by removing the facet joint, diapophysis, and even thoracic nerve roots, resulting in direct visualization of the surfaces of the vertebral body and the outside of the dura mater,²⁵ which facilitates thorough removal of focal tuberculosis and complete spinal decompression without damaging the spinal cord. In our clinical study, the operation time, blood loss, and postoperative drainage volume were 262.5 ± 43.3 minutes, 625.0 ± 333.8 mL, and 285.0 ± 118.1 mL, respectively, which were more significant than the anterior approach or posterior approach reported in the literature,^{23,26} which may be related to the operative technique of the surgeon. All patients significantly relieved postoperative symptoms, with a marked reduction in VAS and ODI scores. During the follow-up period, ESR and CRP levels significantly decreased and returned to normal within 3 months postoperatively. No cases of spinal cord injury occurred during the operation, and patients with paralysis symptoms experienced the return of neurological function to normal following the operation. Therefore, satisfactory clinical results were achieved through posterior approach surgery.

Regarding complications and bone graft fusion, only 1 patient experienced complications related to instrumentation and required reoperation due to unresolved spinal tuberculosis. In contrast, all others

achieved excellent bone fusion during follow-up without relapse. Our clinical study's average bone graft fusion time was 8 months, consistent with the literature reports.^{27,28} A single posterior incision was used for posterior fixation, lesion removal, spinal cord decompression, and bone graft fusion, resulting in a clinical cure.

A posterior approach with pedicle screw fixation is known to have a better effect on kyphotic correction.⁹ In our study, the average postoperative kyphotic Cobb angle was $6.3^\circ \pm 3.2^\circ$, statistically and significantly better than before the operation and superior to the results reported in the literature for the anterior approach technique.^{20,27} Our kyphotic correction rate was similar to that of a previous study,⁹ and posterior approach long-segment pedicle screw fixation was particularly beneficial for correcting kyphosis. However, the loss of correction angle and rate were notably higher than those reported in the literature,⁹ possibly due to the older age of our patients and the presence of osteoporosis impacting the maintenance of the kyphotic correction rate. Additionally, some patients received an iliac bone block for anterior column bone grafting, which made them prone to kyphotic correction loss following the operation. This is consistent with literature reports that autogenous iliac bone graft is less effective than titanium mesh cages in maintaining kyphotic correction.²⁵ Moreover, although postoperative residual kyphosis was low in our study, the slight loss of correction angle at the final follow-up also contributed significantly to the loss rate of correction.

Surgical intervention accompanied by anti-tuberculosis treatment is indicated in patients with spinal tuberculosis who present with significant deformity and instability, neurological deficits, and spinal cord or neural root compression.⁵ Posterior approach surgery is



Figure 2. (A) Postoperative lateral X-ray film, local kyphosis had improved significantly. (B) Postoperative CT, solid bone fusion in diseased segments. The local kyphotic Cobb angle was 16°. (C) Axial CT showed that the intervertebral bone graft had achieved bone fusion. (D) Postoperative MRI, spinal cord compression wholly relieved.

minimally invasive, safe, reliable, and effective for treating upper thoracic tuberculosis, with favorable clinical and radiological outcomes.

Limitations

This is a retrospective study. The sample size is too small, the follow-up time is not long enough, and more indicators are needed to assess the effectiveness of the surgery, which may affect the credibility of this study. Further studies involving more extensive patient series, extended follow-up periods, and case-control comparisons are necessary to achieve a consensus on this issue.

Conclusion

The posterior-only approach is an effective, safe, and reliable treatment method for upper thoracic tuberculosis, with favorable clinical and radiological outcomes.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Ethics Committee Approval: This study was approved by the Ethics Committee of The 940th Hospital of Joint Logistics Support Force of Chinese PLA (approval number: 2020KYL002; date: 2020.04).

Informed Consent: Informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer reviewed.

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Declaration of Interests: The authors have no conflicts of interest to declare.

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