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Original Investigation

One-stage Posterior Approach in the Treatment of Consecutive Multi-segment Thoracic Tuberculosis with Kyphosis

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ABSTRACT

AIM: To evaluate the clinical efficacy of the one-stage posterior approach in treating consecutive multiple-segment thoracic tuberculosis with kyphosis.

MATERIAL and METHODS: A retrospective study was performed. The data of 22 patients with consecutive multi-level thoracic tuberculosis and kyphosis who underwent the one-stage posterior approach of debridement, bone grafting, drainage and pedicle screws fixation were collected. The kyphotic angle was 61.6°±3.1° pre-operatively. The neurologic status based on American Spinal Injury Association (ASIA) scoring was A in 5 cases, B in 4 cases, C in 9 cases, D in 3 cases and E in 1 case.

RESULTS: The average follow-up period was 43.4±5.0 months. The kyphotic angle was 19.8°±0.7° after operation ($p<0.01$), and 21.9°±1.2° at the last visit ($p<0.01$). No neurological deterioration was observed in any patients after surgery. A significant difference in ASIA score was detected when the state before the operation and at the last visit was compared ($p<0.01$). There was no recurrent paravertebral abscess of thoracic tuberculosis in any of these cases.

CONCLUSION: The one-stage posterior approach of debridement and drainage is a feasible surgical option for consecutive multi-segment thoracic tuberculosis with kyphosis. It can achieve debridement, decompression, and stabilization simultaneously.

KEYWORDS: Kyphosis, Multi-segment, Surgery, Thoracic tuberculosis

INTRODUCTION

Thoracic tuberculosis is probably secondary to pulmonary tuberculosis. The destruction of vertebrae may lead to instability, kyphosis, and neural deficiency of the spine (12). The characteristics of consecutive multi-level thoracic tuberculosis include indolent course and long-term invasion. Most patients have relapsed symptoms of tuberculosis due to irregular anti-tuberculosis treatment and appearance of drug-resistant strains of tuberculosis, and are characterized by marked neurological symptoms, back pain and spinal deformities (3). A few of the patients may have sensation and movement disorders, disturbance of urination and defecation, and even disability (6,9). Besides, concurrent pulmonary infection could cause high mortality among these patients (4).

As a matter of fact, the pendulum of surgical options for thoracic spinal tuberculosis periodically vacillates between the anterior approach, the posterior approach and the combined posterior–anterior approach (1,10,13,15). It has been suggested that the selection of the surgical approach often requires making trade-offs between the advantages and disadvantages of the above-mentioned choices, depending on their own indications (14). As for the cases with multi-segment spinal tuberculosis, a similar controversy also exists (4,7) and the operation procedure should be individualized with consideration of the location and extension of the lesion and also the neurological condition of the patient.

To our knowledge, there are few studies reporting the efficacy of a single-stage posterior procedure of debridement and

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reconstruction on consecutive multi-segment thoracic spinal tuberculosis with kyphosis. Therefore, we present the clinical data of 22 patients with consecutive multi-segment thoracic spinal tuberculosis and kyphosis who were treated with one-stage posterior procedure of debridement, bone grafting or iliac crest bone with titanium meshes combined with internal fixation. In addition, the outcome and effectiveness of this procedure were discussed.

MATERIAL and METHODS

Patient Cohort and Radiological Studies

From May 2008 to November 2014, the clinical data of 22 patients were reviewed. These patients were diagnosed as consecutive multi-segment thoracic spinal tuberculosis with kyphosis (average Cobb's angle=61.6±3.1°) at our institution (Table I). The ethical approval by our institutional review board was not required for this retrospective study.

Roentgenogram, computed tomography (CT) and magnetic resonance imaging (MRI) of the thoracic spine were performed on all the patients. This cohort was composed of 14 male and 8 female patients with a mean age of 45.5 years (range 19-76 years). All cases had featured symptoms of tuberculosis, including low fever and night-sweat. Besides, 17 cases had weight loss and 20 cases had back pain. It was noted that all had a history of tuberculosis (Table I). Physical examination showed tenderness and percussion pain in the thoracic vertebrae in 22 cases, rigidity of back muscle due to spasm in 15 cases, an ellipse mass on back on palpation in one case, sensory deprivation in the saddle area with loss of anal reflex in 9 cases, and knee jerk hyperreflexia in one case. The neurological status was graded according to the American Spinal Injury Association (ASIA) classification. There were 21 cases of paraplegia, including complete paralysis in 5 cases (5 with ASIA A), incomplete paralysis in 16 cases (4 with ASIA B, 9 with ASIA C, 3 with ASIA D) (Table II). The erythrocyte sedimentation rate (ESR) ranged from 46 to 97 mm/h (median: 68 mm/h), with 15 cases exceeding 60 mm/h. Pulmonary dysfunction was found in 11 cases, and hypoproteinemia in 16 cases (Table I). Active pulmonary tuberculosis was excluded in all cases.

Based on the evaluations (thoracic anteroposterior and lateral position X-rays, CT and MRI), destruction of the vertebra and intervertebral discs were found in all patients, and spinal cord compression was found in 17 cases. The number of involved segments was 2 in 3 cases, 3 in 13 cases, 4 in 3 cases, 5 in 2 cases, and 6 in 1 case. Nineteen cases had paravertebral abscess (8 cases on the left side; 7 cases on the right side; 4 cases on both sides). Five cases had destruction of costal bones, including three cases on the left side (T5, T8, and T9 separately) and 2 cases on the right (T6, T7 respectively). Four cases had lesions of the appendix of vertebra. The preoperative Cobb's angle of kyphotic deformity ranged from 40° to 105°, with an average of 61.6°±3.1° (Table I).

Treatment Strategies

Radiological examinations (X-rays, CT and MRI) were performed preoperatively to explore the extension of vertebral destruction and paravertebral abscess, the existence of sequestrums, soft tissue calcification, diseased appendix, and the integrity of the pedicles that would be implanted with pedicle screws. Before the procedure, all patients were prescribed isoniazid (INH)(5 mg/kg) and rifampicin (10 mg/kg), pyrazinamide (25 mg/kg) and ethambutol (15 mg/kg) for at least two weeks, until the ESR decreased below 40 mm/h and the temperature reached a level near normal. Exceptionally, for those patients who had neurological worsening to ASIA A or ASIA B level in a very short time, the surgery was performed as soon as possible to achieve early decompression. Instead, before operation, conservative therapy with a duration of no more than one week would be administered to stabilize the general condition and control the infection as much as possible.

Table I: Demographic Data of the Patients

Parameters	**n**
Gender (M/F)	14/8
Mean age in years (range)	45.5 (19-76)
History of pulmonary tuberculosis (%)	
Pulmonary tuberculosis	22 (100%)
Tuberculosis of pleura and pleural effusion	1 (4.5%)
Tuberculosis of lymph nodes	2 (9.1%)
Tuberculosis of femoral articulation and abscess in iliac fossa	1 (4.5%)
Renal tuberculosis	1 (4.5%)
Gastrointestinal tuberculosis	6 (27.3%)
Incidence of Co-morbidities (%)	
None	9 (40.9%)
Pulmonary dysfunction	11 (50.0%)
Hypoproteinemia	16 (72.7%)
Number of affected vertebrae (%)	
2 segments	3 (13.6%)
3 segments	13 (59.1%)
4 segments	3 (13.6%)
5 segments	2 (9.1%)
6 segments	1 (4.5%)
Preoperative Complications	
Paravertebral abscess (left/right/both)	19 (8/7/4)
Destruction of costal bones (left/right)	5 (3/2)
Destruction of the appendix of vertebrae	4
Mean preoperative kyphosis angle (range)	61.6±3.1°

***M:** Male, **F:** Female.*

Table II: Preoperative and Final Follow-Up Neurological Function (p<0.05)

ASIA score on admission	Number	ASIA score at final follow-up				
		A	B	C	D	E
A	5	1	0	1	2	1
B	4	0	0	2	1	1
C	9	0	0	1	3	5
D	3	0	0	0	0	3
E	1	0	0	0	0	1

ASIA: *American Spinal Injury Association.*

Surgical Technique

All patients were in the prone position after general anesthesia. The lamina, transverse processes, costotransverse and facet joints were exposed through a posterior midline incision. Then, screws were inserted respectively at pedicles of the healthy vertebra adjacent to the involved vertebra. After the placement of pedicle screws was confirmed by C-arm fluoroscopy, a contoured rod referring to the physiological kyphotic angle was placed to stablize the spine temporarily. Before laminectomy or hemilaminectomy and exposing the spinal roots, the degree of vertebral destruction was ascertained. If paraplegia was induced by spinal cord compression, the debridement of the foci would be carried out around the spinal canal for decompression and methylprednisolone was infused intravenously in all cases at 30 mg/kg in thirty minutes preceded the decompression. For the angular kyphosis deformity with high bone density, we used a drill instead of bone-chisel and dribbled ice saline constantly on the bone to avoid nerve root injury by overheated bone. Additionally, somatosensory-evoked potential monitoring was used to examine the activity of lower limbs at each step, especially during the decompression for detecting intraoperative neural damage. A posterior vertebral column resection (PVCR) technique was applied for spinal column resection to remove the posterior elements of the spinous processes, laminae, facet joints and transverse processes. This method could facilitate the correction of rigid deformities while reducing the risk of spinal cord over-stretch or kinking during osteotomy. Then, discectomy was performed and the abscess was completely evacuated. During this process, the pus was drained through negative pressure suction and the anterior longitudinal ligament, the thickened periosteum or abscess wall were bluntly dissected for the isolation of involved vertebrae. Following the preliminary debridement, the corpectomy was performed and the ring-like scar tissue was thoroughly resected so as to achieve complete decompression. In order to improve the debridement of the surrounding abscess, the granulation tissue on the abscess wall, the caseous tissue, the sequestrum and the granulation tissue were carefully removed. Furthermore, to evacuate the tubercular foci that had spread along the intercostal space, long and curved curettes of various arcs were used. After the decompression, the adjacent healthy vertebrae were distracted to insert bone graft or titanium mesh cages into the interbody. Among our cases, 15 patients received autogenic bone graft, and 7 patients received bone graft fusion with titanium mesh. During the posterior placement of grafts after osteotomy, it was necessary to sacrifice one or two adjacent nerve roots of one side to ensure better exposure, and provide enough space for the insertion of the titanium mesh or cage. However, this did not lead to obvious neurological problems. Subsequently, deformity correction and stabilization were ensured by installing permanent rods. 0.3 g isoniazid and/or 1-2 g streptomycin were placed into the intervertebral area during the operation.

Postoperative Procedure and Follow–up

Vital signs were monitored closely, and other symptomatic treatments were adopted. Postoperative chemotherapy with INH (0.3 g qd po), rifampicin (0.45 g qd im), ethambutol (0.75 g qd im), levofloxacin (0.75 g bid iv) and streptomycin (75 mg qd im) was given for six months, followed by rifampicin/INH/streptomycin/levofloxacin/pyrazinamide (75 mg qd im) for another 6 months. The whole course of the treatment would last for one and a half years at least. The drainage tube would be removed if the drainage flow was less than 50 mL/24 h and the lungs expanded well after one-day clipping of the tube. The spine was immobilized with an orthosis for six months until bony fusion was achieved. Hematological parameters, ESR, C-reactive protein (CRP), liver function tests were monitored and radiographic examinations (X-rays) were performed at the 3rd month after surgery, then every 6 months to monitor the side effects of drugs, and the bony fusion until two years after surgery.

Statistics Analysis

All statistical analysis was performed with the SPSS 18.0 analysis software. To compare the pre- and postoperative, clinical and radiological data, the Paired Sample t-test was used, and a p value <0.05 was considered statistically significant.

■ RESULTS

The average duration of surgery was 340.4±16.7 minutes, and the mean blood loss was 2238.6±102.3 ml during

surgery (Table III). Two cases had stretch injury of nerves and recovered after application of neurotrophic drugs and three-week hyperbaric oxygenation. One case had pleural membrane laceration, which was sutured during operation without any complication occurring after operation. Chyle leakage was detected in one case postoperatively, and resolved after mediastinum drainage for about two weeks. Two cases had dural sac rupture and were repaired with artificial dura. Postoperatively, two cases had numbness in the lower limbs, and were alleviated by rehabilitation training two weeks later. There were no injuries of large blood vessels or nerves, deep wound infection or sinus formation. All incisions were healed by first intention. In all cases, the symptoms of low fever and night-sweats disappeared in two weeks. The back pain in all cases was eased after the operation, with the longest duration for less than six months. No neurological deterioration or adverse events of drugs was observed in any patient after surgery. Most patients with spinal cord affection had recovered at the last follow-up (Table II), except for 1 case with ASIA A and 1 case with ASIA C who remained unchanged ($p< 0.01$). The follow-up period ranged from 24 to 108 months, with an average of 43.4±5.0 months. The ESR decreased from 67.7±3.1 mm/h to 27.5±1.4 mm/h post-operatively ($p<0.01$), and further decreased to 15.2±1.0 mm/h at the last follow-up ($p<0.01$). The kyphotic angle reduced from 61.6±3.1° pre-operatively to 19.8±0.7° after operation ($p<0.01$), and to 21.9±1.2° ($p<0.01$) at the final follow-up. The correction rate of kyphosis was 67.9%, and there was a mean correction loss of 2.0±0.9° at the last visit (Table IV). The radiological data of an illustrative case is presented in Figure 1A-E. Bone fusion was achieved in all patients at the last follow-up, with the fusion time ranging from 8 to 12 months. There was no recurrence of paravertebral abscess of tuberculosis in any case.

Table III: Clinical and Surgical Details of the Patient Group

No	Sex	Age (years)	Recurrent time (months)	Operation time (minutes)	Blood loss (ml)	Transfusion (ml)	Drainage (ml)	Extubation time (days)
1	M	44	71	355	2110	1700	240	13
2	M	22	35	369	3100	2500	150	11
3	M	26	17	297	2600	1900	80	10
4	M	22	23	357	2250	1800	270	15
5	M	20	11	360	3150	3000	290	12
6	F	67	19	265	2700	2500	160	10
7	F	54	13	357	2050	2000	190	11
8	F	66	27	275	2970	2400	210	16
9	M	64	18	316	2160	1900	90	9
10	M	65	46	375	2350	2500	85	7
11	F	62	32	269	2270	2000	65	8
12	M	73	29	361	2190	1900	70	8
13	F	76	18	395	2300	2100	50	7
14	F	34	16	215	1570	1600	170	11
15	F	52	19	416	2350	2100	160	12
16	M	74	14	503	1890	1900	250	16
17	M	23	23	295	2000	2300	80	9
18	M	41	52	431	2450	1800	170	9
19	M	23	36	258	1970	1500	155	12
20	M	29	34	267	1500	1700	190	14
21	F	46	58	251	1250	1000	60	11
22	M	19	15	501	2070	1800	230	16
Mean	-	45.5	28.4±3.4	340.4±16.7	2238.6±102.3	1995.5±93.3	155.2±15.8	11.2±0.6

***M:** Male, **F:** Female.*

DISCUSSION

Consecutive multi-segment thoracic tuberculosis is characterized by the formation of a large unabsorbable abscess and sequestrum or refractory sinus. The ideal strategy of thoracic spinal tuberculosis management should be to achieve debridement, deformity correction and stability reconstruction in one-stage. Nonetheless, a standardized surgical procedure is yet to be established. The controversial subject is whether the anterior or posterior approach should be adopted for debridement and instrumentation. Recently, several studies have investigated the optimal operative approach for the treatment of thoracic spinal tuberculosis. Liu et al.(8) suggested that the anterior-approach, posterior-approach and combined anterior and posterior approach could all effectively treat thoracic tuberculosis, with the anterior approach being more suited for serious vertebral collapse. Similar results were provided by Zeng et al.(17), indicating that the anterior approach should be limitedly applied for severe cervicothoracic tuberculosis. Nevertheless, other authors commented that the posterior approach was associated with more effective deformity correction, and less complications and mortality than the anterior approach (2,5,21). Taken together, anterior and posterior instrumentation have their own surgical indications respectively and thus the selection of the surgical approach should be based on the specific requirements of different kinds of patients.

The most obvious advantage of the single-stage posterior approach for treating multi-level thoracic tuberculosis is

Table IV: The Information of Follow-up (Cobb's Angle, ESR, Follow-up Time (Months))

No	Seg	Cobb's angle (°)			ESR (mm/h)			Follow-up Time (months)
		Pre	Post	Final	Pre	Post	Final	
1	**T7-9**	55	17	21	46	16	11	54
2	**T3-5**	69	25	31	50	18	9	43
3	**T2-4**	51	19	26	81	28	15	87
4	**T1-3**	59	18	22	47	29	11	34
5	**T11-L1**	60	13	15	73	38	21	69
6	**T8-12**	62	21	27	67	17	10	82
7	**T10-12**	50	23	20	97	29	9	24
8	**T5-7**	57	24	29	87	31	7	31
9	**T6-8**	66	19	21	61	32	12	27
10	**T4-6**	70	25	23	84	37	19	19
11	**T7-12**	60	20	22	65	27	21	34
12	**T7-8**	40	15	21	73	34	17	25
13	**T6-7**	59	21	23	56	32	19	31
14	**T6-10**	52	16	15	73	34	23	45
15	**T6-8**	98	25	35	69	32	15	34
16	**T1-4**	53	19	18	53	27	13	23
17	**T1-3**	59	23	20	65	21	16	108
18	**T9-12**	54	18	24	77	23	15	25
19	**T3-6**	58	21	19	51	24	20	49
20	**T2-4**	62	17	15	92	35	19	48
21	**T6-8**	57	18	12	69	26	15	36
22	**T9-10**	105	19	22	53	16	18	27
M	**-**	61.6±3.1	19.8±0.7	21.9±1.2	67.7±3.1	27.5±1.4	15.2±1.0	43.4±5.0
p			p<0.001			p<0.001		

Seg: *Segment,* ***Pre:*** *Pre-operative,* ***Post:*** *Post-operative,* ***Final:*** *Final follow-up,* ***M:*** *Mean,* ***ESR:*** *Erythrocyte sedimentation rate,* ***p:*** *p value.*

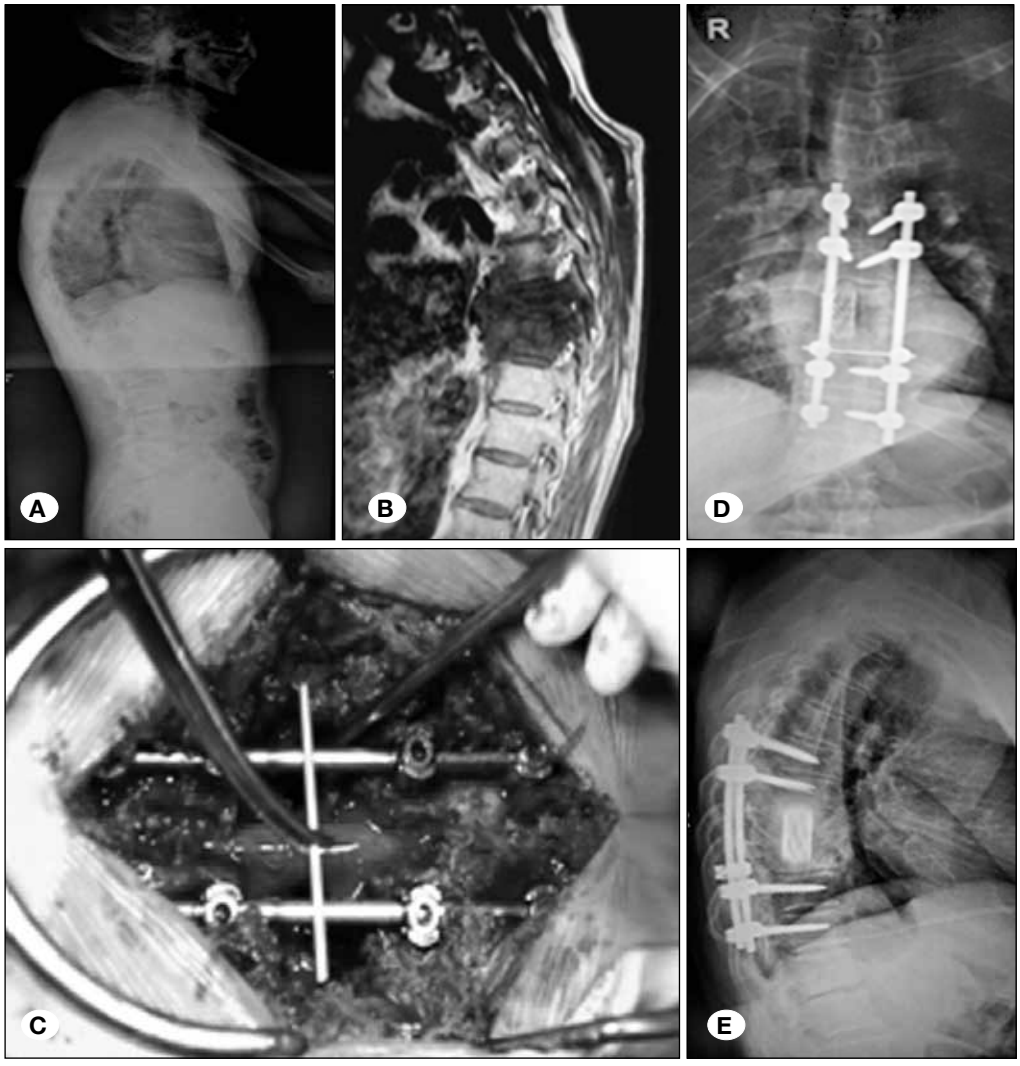

Figure 1: A 73-year-old male patient with T7–8 vertebral tuberculosis. He presented with back pain and paraplegia, with ASIA score C.
A, B) Preoperative lateral thoracic X-rays and sagittal MRI scan demonstrated the destruction of T7-8 vertebra, with a kyphosis angle of 40°, and the formation of bilateral abscesses. **C)** The patient underwent one-stage posterior approach of debridement, drainage and internal fixation. **D, E)** Cobb's angle was 15° on the X-rays after surgery. The final AISA score was D. No recurrence was observed.

that it assists not only the debridement, decompression and bone graft simultaneously, but also maintains the stability of the spine after the removal of consecutive vertebrae. It has been reported that the single-stage posterior approach was effective for those patients who had an upper thoracic lesion, obvious kyphosis, deformities with neurological deficits due to the persistent spinal cord compression, and/or where conservative treatment and/or anterior instrumentation had failed (18-20). It is believed by Cui et al. (2) that the posterior approach also plays a better role than the anterior approach in maintaining the stability of the spine. While in the meantime, through a posterior insertion of structural bone graft, the loss of height resulting from absence of the anterior part of the vertebra can be corrected. Nonetheless, it is doubted by Shi et al. (14) whether a single posterior approach is suitable for foci involving more than two adjacent segments due to the difficulties in manipulation and the placement of instrumentation on the adjacent normal vertebrae. In our practice, laminectomy, facetectomy and pediculectomy were performed to assist kyphosis correction, and meanwhile provide an adequate operative space. The subsequent placement of internal fixation on the adjacent healthy vertebrae can further ensure the maintenance of kyphosis correction. Additionally, it may be questioned that the motion and function of the fixed segment would be sacrificed in the posterior-approach, thus leading to degeneration of neighboring segments. However, the thoracic spine does not require such a large range of motion as that in the lumbar column (16).

According to the results of previous reports and our experience in treating multi-level thoracic tuberculosis, the advantages of our single-stage posterior procedure can be summarized as follows:

1) Debridement, decompression, correction, and bone fusion can be achieved simultaneously, and thus the damage is minimized (14). Furthermore, some serious injuries that have occurred with the anterior approach can be avoided, including sternotomy, cutting of the diaphragm or injury to the vital organs and large vessels/segmental vessels, and the following complications, especially massive intraoperative bleeding.

2) The placement of a tube can help the drainage of abscess and on the other hand, a pathway is provided for anti-tuberculosis drug perfusion in the intervertebral space. As a result, the recurrence rate can be significantly reduced.

3) For patients who have developed a disability due to the kyphosis, the quality of anterior instrumentation is difficult to control, which may result in the loosening of internal fixation or loss of correction. Inversely, a posterior approach can effectually prevent the complications of the anterior approach and achieve stabilization so as to obviate the progression of the kyphotic deformity. In the series of Ma et al., the correction loss following anterior instrumentation was more than that following the posterior approach (11).

4) By placing instrumentation on the adjacent healthy vertebrae, the foci can be thoroughly isolated and removed in our procedure. Therefore, the incidence of recurrence is decreased.

5) This procedure can offer surgeons appropriate operative exposures to achieve decompression and correction of deformity, and insert a bone graft or bone graft with titanium mesh. Hence, excessive stretching of the spinal cord and other intraoperative complications can be avoided.

Based on our experience, the following issues should be noted to ensure the success of the surgery. Firstly, to avoid deterioration of neurological symptoms and deformity induced by excessive correction, the rod should be curved appropriately. Secondly, as a challenging procedure, the surgery treating thoracic kyphosis with spinal cord deficits might be too difficult to insert screws in the posterior approach. To address this problem, it will be helpful to resect part of superior or inferior vertebral plates. If the pedicles are small, hook and rod fixation is suitable to avert spinal cord injury induced by manual implantation of screws. Last but not least, operating carefully is of great importance, as it can prevent the abscess from breaking into the thoracic cavity. However, if the leakage of abscess into the thoracic cavity is sometimes inevitable, debridement with repeated irrigation using saline and iodine complex during operation is feasible. Postoperatively, application of closed thoracic drainage bag, anti-infection treatments, and also anti-tuberculosis agents will further facilitate the recovery of patients.

CONCLUSION

The results of this study indicate that the one-stage posterior approach of debridement and drainage conform to the principles of the spinal tuberculosis treatment, and is viable for treating consecutive multi-level thoracic tuberculosis with kyphosis. It is feasible to prevent kyphosis through achieving debridement, decompression, stabilization, fusion, and correction simultaneously. However, our study has limited power due to its retrospective nature and small sample size. A prospective study with controlled variables may facilitate the comparison of the efficacy between different surgical modalities in the treatment of consecutive multi-segment thoracic tuberculosis with kyphosis.

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