



# Clinical Features and Outcomes of Spinal Tuberculosis in Central China

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**Purpose:** The appropriate management of spinal tuberculosis (TB) is challenging for clinicians and the key to treat spinal TB. Surgery and long course anti-TB chemotherapy may not be necessary to all situations. This study aimed to characterize the clinical features and factors affecting treatment outcomes.

**Patients and Methods:** A retrospective study of patients with spinal TB over a 5-year period at a teaching hospital in central China was conducted. Features of patients with spinal TB who received different treatment modalities and factors associated with patient outcomes at the end of chemotherapy were analyzed.

**Results:** Forty-five patients (21 men and 24 women) with spinal TB were available for analysis. The mean age was  $55.39 \pm 14.94$  years. The most common vertebral area involved was the lumbar (42.2%). The mean number of vertebrae involved was  $2.20 \pm 0.59$ . 27 patients (60.0%) received surgical treatment, of which 21 (77.8%) received radical surgical treatment. Thirty-five patients (77.8%) had achieved a favorable status. Statistically, there was no significant correlation between favorable status and surgery, but among 27 surgical patients with spinal tuberculosis, patients receiving radical surgery tended to achieve good prognosis ( $P = 0.010$ ; odds ratio = 0.053; 95% confidence interval 0.006–0.493). Moreover, there was no significant difference between long course and short course of anti-TB chemotherapy in prognosis in different treatment modalities.

**Conclusion:** Although the patients with spinal TB who needed surgical treatment often got a better prognosis when they had radical surgery, surgery was not actually a factor for the favorable outcomes of patients with spinal TB. In different treatment modalities, there was no additional benefit in longer anti-TB chemotherapy periods.

**Keywords:** surgical treatment, duration of anti-TB chemotherapy, retrospective study, outcome, spine, tuberculosis

## Introduction

Spinal tuberculosis (TB), also referred to as Pott's disease, was first modernly described by Percivall Pott in 1779.<sup>1,2</sup> Bone and joint TB may account for 15–35% of patients with extrapulmonary TB, and for 1–5% of all cases of TB. Spinal TB accounts for approximately half of patients with bone and joint TB.<sup>3</sup> The lower thoracic and the lumbar are the most commonly involved area. The most threatening complication of spinal tuberculosis is paraplegia, which can be onset early or late.<sup>4</sup> Therefore, early diagnosis and treatment is the key to the treatment of spinal TB. However, the optimal treatment of spinal TB remains controversial, particularly surgical treatment and the duration of chemotherapy.<sup>5</sup>

In the past, 12–18 months of anti-TB chemotherapy were advocated for bone and joint TB.<sup>6</sup> The prolonged anti-TB chemotherapy is likely to provoke the infection of drug-resistance *Mycobacterium tuberculosis* (MTB), interruption of treatment, or modification of the regimen during the chemotherapy. In addition, prolonged anti-TB chemotherapy may

lead to decreasing patient compliance and increasing the difficulty of case supervision.<sup>7</sup> More recently, some studies have shown that shorter anti-TB regimens than the standard are as effective as standard anti-TB regimens.<sup>8–10</sup> Consequently, extensive attention has been given to shortening anti-TB chemotherapy to eliminate adverse consequences during tuberculosis management.<sup>11</sup>

Surgical treatment for spinal TB was proven to be effective,<sup>12–14</sup> and some studies have shown that surgical treatment was a favorable factor for the prognosis of patients with spinal TB.<sup>15,16</sup> And some studies advocated aggressive surgery for spinal TB.<sup>17</sup> However, some studies reported that spinal TB patients with surgery or not had equally favorable outcome,<sup>18</sup> This may imply that surgery may not be necessary to all situations.<sup>11,16,19</sup>

Due to these controversies regarding the surgical treatment and duration of anti-TB chemotherapy of spinal TB, we conducted a retrospective study at a teaching hospital over a 5-year period. This study aimed to determine the factors for favorable outcomes in patients with spinal TB, in terms of surgical treatment and duration of anti-TB chemotherapy in central China.

## Materials and Methods

### Study Design and Population

From January 1, 2016 to December 31, 2021, patients with a diagnosis of spinal TB were reviewed at a teaching hospital in Central China. Only patients older than 10 years with clinical evidence of spinal TB were included in the study.

A diagnosis of spinal TB was made in patients had one of the following criteria: (1) Patients had microbiologic or histopathological evidence (caseating granuloma or granulomatous inflammation with or without positive AFB smear) of TB infection; (2) Patients had typical radiographic or clinical features; (3) Patients had symptoms and signs compatible with spinal TB and a good reaction to anti-TB therapy. Exclusion criteria: (1) Irregular use of anti-TB drugs; (2) death from non-spinal TB; (3) still on treatment at the time of data analysis.

We collected the patient's demographics, clinical features at presentation, laboratory results and radiographic findings, histological findings, microbiological results, treatment modality and anti-TB drugs used, duration of treatment, and patient outcome at the end of treatment. Then, we analyzed features of patients with spinal TB who received different treatment modalities and factors associated with patient outcomes at the end of chemotherapy.

### Definitions

Based on the duration of anti-TB chemotherapy as triple therapy (isoniazid, rifampin, and ethambutol) or quadruple therapy (isoniazid, rifampin, pyrazinamide and ethambutol), the treatment duration was classified into two groups: (1) a short course defined of less than 12 months or equal to 12 months; (2) a long course defined of more than 12 months.

Patient outcome at the end of chemotherapy was classified into two groups: (1) favorable status: full physical activity at work, no evidence of central nervous system involvement, no remaining sinus or abscess that was clinically or radiologically detectable, and radiological evidence of healing of the spinal lesion; (2) unfavorable status: not radiographically quiescent, limited physical activity, clinically evident abscess or sinus present, myelopathy with functional impairment, a need for additional chemotherapy for spinal disease, or death associated with spinal disease.

Based on anti-TB chemotherapy, treatment was classified as non-surgery and surgery. (1) Surgery was defined as diagnostic operations, abscess drainage or curettage, debridement, anterior decompression, anterior or posterior stabilization with bone graft or instrumentation, vertebral curettage, laminectomy, and discectomy. (2) Non-surgery was defined as patient did not have surgery we defined above.

The type of surgical procedure was classified as radical or non-radical.<sup>16</sup> (1) A radical surgery was defined as patient had vertebral curettage with or without decompression or bone fusion with instrumentation. (2) Nonradical surgery was defined as diagnostic operations, abscess drainage or curettage, debridement, anterior decompression, laminectomy, or discectomy et al.

### Statistical Analysis

All statistical calculations were done using the SPSS version 15.0 (SPSS Inc., Chicago, IL, USA). *P* values were calculated using the  $\chi^2$  or Fisher exact test for categorical variables and by the Student *t* test for continuous variables.

Odds ratio (OR) and 95% confidence intervals (CIs) were calculated for each variable by logistic regression analysis. Values of  $P < 0.05$  were considered statistically significant.

## Results

### Baseline Characteristics

From January 1, 2016 to December 31, 2021, a 5-year period, 131 patients with bone and joint tuberculosis were admitted to our hospital and 51 patients with spinal TB were selected to follow-up, of which 6 were lost to irregular medication and non-tuberculosis causes of death in total and 45 were included in the analysis.

All 45 patients were available for assessment of end-of-treatment outcomes. All patients received antituberculosis chemotherapy, including 3 or 4 drugs containing isoniazid, rifampicin, pyrazinamide, and ethambutol. Demographic characteristics and clinical features of the 45 patients with spinal tuberculosis are shown in Table 1. There were 21 (46.7%) males and 24 (53.3%) females, with the mean age ( $\pm$  standard deviation [SD]) of 55.39 years ( $\pm$  14.94). The most common vertebra involved was the lumbar (42.2%), followed by the thoracic (28.9%) and the lumbosacral (13.3%). The mean number of vertebra ( $\pm$  SD) involved was 2.20 ( $\pm$  0.59). 84.4% of patients had one or two vertebrae involved. The other 15.6% of patients had 3 vertebrae involved or more. No patients had sinus. 24 patients (53.3%) had abscesses visible by Computed Tomography (CT) or Magnetic Resonance Imaging (MRI). 26 patients (57.8%) had symptoms of neurological compression. The mean duration of anti-TB chemotherapy ( $\pm$  SD) was 21.24 months ( $\pm$  15.26) in 45 patients.

**Table 1** Demographic Characteristics and Clinical Features of Patients with Spinal TB

Patient Characteristics	Include patients (n=45)
Mean age $\pm$ SD (years)	55.39 $\pm$ 14.94 y
Gender	
Female, %(n/)	53.3% (24/45)
Male, %(n/)	46.7% (21/45)
Residence environment	
Village	60.0% (27/45)
Downtown	40.0% (18/45)
Ethnicity	
The Han	84.4% (38/45)
The Tujia	15.6% (7/45)
Mean hospital days (days)	32.38 $\pm$ 21.81 d
Positive TB culture	17.8% (8/45)
Involved vertebra	
Cervical	4.4% (2/45)
Cervicothoracic	2.2% (1/45)
Thoracic	28.9% (13/45)
Thoracolumbar	8.9% (4/45)
Lumbar	42.2% (19/45)
Lumbosacral	13.3% (6/45)
Mean number of involved vertebrae	2.20 $\pm$ 0.59
No. vertebrae involved	
1 or 2	84.4% (38/45)
3 or more	15.6% (7/45)
Sinus formation	0
Abscess	53.3% (24/45)
Neural compression	57.8% (26/45)
Mean duration of chemotherapy (months)	21.24 $\pm$ 15.26 m

**Note:** Data presented as % (n) or mean  $\pm$  standard deviation (SD).

## Clinical Features in Different Treatment Modalities

Of the 45 patients with spinal tuberculosis, 27 (60.0%) underwent surgical treatment. The other 18 patients underwent non-surgical treatment. The clinical characteristics of surgical *versus* non-surgical patients with spinal TB are shown in Table 2. Surgical patients had more involvement of the lumbar (40.7% vs. 44.4%;  $P = 0.038$ ; OR = 0.215; 95% CI 0.050–0.919), abscess (66.7% vs. 33.3%;  $P = 0.032$ ; OR = 4.000; 95% CI 1.129–14.175) and neural compression (74.1% vs. 33.3%;  $P = 0.009$ ; OR = 5.714; 95% CI 1.551–21.058).

Of the 27 surgical patients, 21 underwent radical surgical treatment. The other 6 patients underwent non-radical surgical treatment. The clinical characteristics of patients with spinal TB treated with non-radical surgery *versus* those treated with radical surgery are shown in Table 3. According to univariate logistic analysis, there was no statistical difference between radical surgical patients and non-radical surgical patients in terms of age ( $P = 0.062$ ), radiologic site of lesion ( $P = 0.093$ ), number of involved vertebrae ( $P = 0.303$ ), duration of chemotherapy ( $P = 0.677$ ), or symptoms of neural compression ( $P = 0.143$ ).

At the end of chemotherapy, 16 patients were on the short course regimen. 29 patients were treated on the long course regimen. The clinical characteristics of patients on the short course regimen *versus* the long course regimen are shown in Table 4. There were no statistically significant differences in age ( $P = 0.603$ ), surgery or not ( $P = 0.376$ ), or surgical type ( $P = 0.677$ ) in spinal TB patients with the long course regimen compared to the short one.

## Analysis of Outcome

The prognosis of the patients at the end of chemotherapy was compared, as shown in Table 5. 35 patients had a favorable outcome and 10 patients had an unfavorable outcome. Among patients with spinal TB had surgery, those with radical surgery had a significantly better outcome than those with non-radical surgery ( $P = 0.010$ ; OR = 0.053; 95% CI 0.006–0.493). However, for all patients with spinal tuberculosis, there was no statistically significant difference in favorable outcome between surgical and non-surgical treatment ( $P = 1.000$ ), nor in radiologic site of lesion ( $P = 0.378$ ), number of vertebrae involved ( $P = 0.168$ ), and duration of chemotherapy ( $P = 0.740$ ).

Multiple logistic regression analysis of 45 patients with spinal TB (Table 6) did not reveal any factor of favorable outcome in terms of age, sex, duration of chemotherapy, or whether surgery was performed. However, multivariate

**Table 2** Clinical Characteristics of Patients with Spinal TB with Surgery *versus* Non-Surgery

	Non-Surgical Patients	Surgical Patients	OR (95% CI)	P
Mean age $\pm$ SD (n=45)	59.75 $\pm$ 15.59 y	52.48 $\pm$ 14.02 y	0.963 (0.918–1.010)	0.120
No. males/females (n = 45)	8/10	13/14	0.862 (0.260–2.854)	0.807
Concurrent TB (n = 45)	4/18 (22.2)	4/27 (14.8)	0.609 (0.131–2.831)	0.527
Radiologic site of lesion (n = 45)			0.567 (0.327–0.983)	0.043
Cervical	0/18	2/27 (7.4)		
Cervicothoracic	0/18	1/27 (3.7)		
Thoracic	3/18 (16.7)	10/27 (37.0)	1.600 (0.463–5.527)	0.457
Thoracolumbar	3/18 (16.7)	1/27 (3.7)		
Lumbar	8/18 (44.4)	11/27 (40.7)	0.215 (0.050–0.919)	0.038
Lumbosacral	4/18 (22.2)	2/27 (7.4)		
No. vertebrae involved (n = 45)			1.818 (0.312–10.586)	0.506
1 or 2	16/18 (88.9)	22/27 (81.5)		
3 or more	2/18 (11.1)	5/27 (18.5)		
Sinus formation (n = 45)	0/18	0/27		
Abscess (n = 45)	6/18 (33.3)	18/27 (66.7)	4.000 (1.129–14.175)	0.032
Neural compression (n = 45)	6/18 (33.3)	20/27 (74.1)	5.714 (1.551–21.058)	0.009
Duration of chemotherapy (n = 45)			0.559 (0.155–2.024)	0.376
Short course	5/18 (27.8)	11/27 (40.7)		
Long course	13/18 (72.2)	16/27 (59.3)		

**Notes:** Unless noted, values are expressed as No./total No. (%). Logistic regression analysis was used to calculate the OR and P value.

**Table 3** Clinical Characteristics of Patients with Spinal TB Treated with Radical versus Nonradical Surgery

	Non-Radical Surgical Patients	Radical Surgical Patients	OR (95% CI)	P
Mean age $\pm$ SD (n=27)	42.50 $\pm$ 17.42y	55.33 $\pm$ 11.88y	1.068 (0.997–1.145)	0.062
No. males/females (n = 27)	4/2	9/12	2.667 (0.397–17.914)	0.313
Concurrent TB (n = 27)	1/6 (16.7)	3/21 (14.3)	0.833 (0.070–9.858)	0.885
Radiologic site of lesion (n = 27)			1.886 (0.899–3.960)	0.093
Cervical	1/6 (16.7)	1/21 (4.8)		
Cervicothoracic	1/6 (16.7)	0/21		
Thoracic	2/6 (33.3)	8/21 (38.1)		
Thoracolumbar	1/6 (16.7)	0/21		
Lumbar	1/6 (16.7)	10/21 (47.6)		
Lumbosacral	0/6	2/21 (9.5)		
No. vertebrae involved (n = 27)			0.333 (0.041–2.699)	0.303
1 or 2	4/6 (66.7)	18/21 (85.7)		
3 or more	2/6 (33.3)	3/21 (14.3)		
Sinus formation (n = 27)	0/6	0/21		
Abscess (n = 27)	4/6 (66.7)	14/21 (66.7)	1.000 (0.146–6.853)	1.000
Neural compression (n = 27)	3/6 (50.0)	17/21 (81.0)	4.250 (0.613–29.451)	0.143
Duration of chemotherapy (n = 27)			0.667 (0.099–4.478)	0.677
Short course	2/6 (33.3)	9/21 (42.9)		
Long course	4/6 (66.7)	12/21 (57.1)		

**Notes:** Unless noted, values are expressed as No./total No. (%). Logistic regression analysis was used to calculate the OR and P value.

**Table 4** Clinical Characteristics of Patients with Short versus Long Course of Spinal TB

	Short-Course Patients	Long-Course Patients	OR (95% CI)	P
Mean age $\pm$ SD (n=45)	56.94 $\pm$ 10.68y	54.54 $\pm$ 16.95y	0.989 (0.947–1.032)	0.603
No. males/females (n = 45)	7/9	14/15	0.833 (0.244–2.843)	0.771
Concurrent TB (n = 45)	2/16 (12.5)	6/29 (20.7)	1.826 (0.323–10.329)	0.496
Radiologic site of lesion (n = 45)			1.378 (0.853–2.226)	0.191
Cervical	1/16 (6.3)	1/29 (3.4)		
Cervicothoracic	0/16	1/29 (3.4)		
Thoracic	8/16 (50.0)	5/29 (17.2)		
Thoracolumbar	0/16	4/29 (13.8)		
Lumbar	5/16 (31.3)	14/29 (48.3)		
Lumbosacral	2/16 (12.5)	4/29 (13.8)		
No. vertebrae involved (n = 45)			1.458 (0.249–8.539)	0.676
1 or 2	14/16 (87.5)	24/29 (82.8)		
3 or more	2/16 (12.5)	5/29 (17.2)		
Sinus formation (n = 45)	0/16	0/29		
Abscess (n = 45)	11/16 (68.8)	13/29 (44.8)	0.396 (0.102–1.336)	0.129
Neural compression (n = 45)	11/16 (68.8)	15/29 (51.7)	0.487 (0.135–1.758)	0.272
Surgery or not (n=45)			0.559 (0.155–2.024)	0.376
Non-surgical	5/16 (31.3)	13/29 (44.8)		
Surgical	11/16 (68.8)	16/29 (55.2)		
Surgical type (n = 27)			0.677 (0.099–4.478)	0.677
Non-radical surgical	2/11 (33.3)	4/16 (25.0)		
Radical surgical	9/11 (81.8)	12/16 (75.0)		

**Notes:** Unless noted, values are expressed as No./total No. (%). Logistic regression analysis was used to calculate the OR and P value.

logistic regression analysis of 27 patients with spinal TB had surgical treatment (Table 7) suggested that the type of surgery was significantly associated with a favorable outcome ( $P = 0.033$ ; OR= 0.052; 95% CI 0.003–0.786). In the surgical patients with spinal TB, the patients had radical surgery were used to have a favorable outcome, but surgery was not a factor of favorable outcome for all patients with spinal TB.

**Table 5** Comparison of Prognosis of Patients with Spinal TB at the End of Antituberculosis Chemotherapy

	Favorable Patients	Unfavorable Patients	OR (95% CI)	P
Mean age $\pm$ SD (n=45)	55.99 $\pm$ 14.91 y	53.30 $\pm$ 15.63 y	0.988 (0.944–1.035)	0.613
No. males/females (n = 45)	15/20	6/4	0.500 (0.119–2.092)	0.343
Concurrent TB (n = 45)	7/35 (20.0)	1/10 (10.0)	0.444 (0.048–4.116)	0.475
Radiologic site of lesion (n = 45)			0.788 (0.464–1.339)	0.378
Cervical	1/35 (2.9)	1/10 (10.0)		
Cervicothoracic	0/35	1/10 (10.0)		
Thoracic	12/35 (34.3)	1/10 (10.0)		
Thoracolumbar	2/35 (5.7)	2/10 (20.0)		
Lumbar	14/35 (40.0)	5/10 (50.0)		
Lumbosacral	6/35 (17.1)	0/10		
No. vertebrae involved (n = 45)			3.321 (0.603–18.307)	0.168
1 or 2	31/35 (88.6)	7/10 (70.0)		
3 or more	4/35 (11.4)	3/10 (30.0)		
Sinus formation (n = 45)	0/35	0/10		
Abscess (n = 45)	21/35 (60.0)	3/10 (30.0)	0.286 (0.063–1.296)	0.104
Neural compression (n = 45)	21/35 (60.0)	5/10 (50.0)	0.667 (0.162–2.736)	0.574
Surgery or not (n=45)			1.000 (0.238–4.198)	1.000
Non-surgical	14/35 (40.0)	4/10 (40.0)		
Surgical	21/35 (60.0)	6/10 (60.0)		
Surgical type (n = 27)			0.053 (0.006–0.493)	0.010
Non-radical surgical	2/21 (9.5)	4/6 (66.7)		
Radical surgical	19/21 (90.5)	2/6 (33.3)		
Duration of chemotherapy (n = 45)			0.783 (0.185–3.319)	0.740
Short course	12/35 (34.3)	4/10 (40.0)		
Long course	23/35 (65.7)	6/10 (60.0)		

**Notes:** Unless noted, values are expressed as No./total No. (%). Logistic regression analysis was used to calculate the OR and P value.

**Table 6** Logistic Regression Analysis of Variable Factors on Outcome of 45 Patients with Spinal TB

Variables	Coefficient	Standard Error	OR	95% CI	P
Age (y)	−0.021	0.025	0.979	0.932–1.029	0.411
Males	−0.861	0.767	0.423	0.094–1.900	0.262
Long-course chemotherapy	−0.385	0.779	0.680	0.148–3.131	0.621
Surgical treatment	−0.272	0.799	0.762	0.159–3.644	0.733
Constant	1.961	2.750	7.105		0.476

**Table 7** Logistic Regression Analysis of Variable Factors on Outcome of 27 Surgical Patients with Spinal TB

Variables	Coefficient	Standard Error	OR	95% CI	P
Age (y)	−0.016	0.045	0.984	0.901–1.074	0.717
Males	−0.567	1.192	0.567	0.055–5.870	0.634
Long-course chemotherapy	−1.145	1.278	0.318	0.026–3.900	0.371
radical surgical treatment	−2.957	1.386	0.052	0.003–0.786	0.033
Constant	7.083	3.997	1192.111		0.076

The analysis of the outcome in relation to the duration of chemotherapy and treatment modality is shown in Table 8. In the radical surgical treatment group, 9 patients received short-term chemotherapy and eight of them (88.9%) had a favorable outcome. 11 patients (91.7%) who received a long-term chemotherapy regimen also had a favorable outcome.

**Table 8** Analysis of Patient Prognosis with Duration of Chemotherapy and Treatment Modality

Treatment Modality	Regimen	Favorable Patients	Unfavorable Patients	P
Non-surgical treatment	Short-course	4/5 (80.0)	1/5 (20.0)	0.701
	Long-course	10/13 (76.9)	3/13 (23.1)	
Non-radical surgical treatment	Short-course	0/2	2/2 (100.00)	0.400
	Long-course	2/4 (50.0)	2/4 (50.0)	
Radical surgical treatment	Short-course	8/9 (88.9)	1/9 (11.1)	0.686
	Long-course	11/12 (91.7)	1/12 (8.3)	

**Note:** Values are expressed as No./total No. (%).

However, there was no statistically significant difference between long and short courses under radical surgical treatment ( $P = 0.686$ ). Similarly, there was no statistically significant difference between long and short courses under non-surgical ( $P = 0.701$ ) and non-radical surgical treatment ( $P = 0.400$ ). It indicates that there is no advantage in the long course of anti-tuberculosis treatment for patients with spinal TB in different treatment modalities.

## Discussion

In the present study, we characterized the clinical features of patients with spinal TB in different treatment modalities and analyzed the factors influencing the prognosis of patients with spinal TB. Surgical patients with spinal TB had more involvement of the lumbar, abscesses and neural compression, compared to non-surgical patients with spinal TB. But there was no statistical difference between radical and non-radical surgical patients with spinal TB, or short- and long-course regimen. As for outcome, the patients with spinal TB who needed surgical treatment often got a better prognosis when they had radical surgery. However, surgery is not actually a factor for the favorable outcomes of patients with spinal TB. And in different treatment modalities, there is no additional benefit in longer treatment periods.

In contrast to the approach of our study, which emphasized surgical type grouping (radical and non-radical surgery groups) in the retrospective study by Park et al<sup>16</sup> and whether surgical treatment (drug-only and surgery-combined drug groups) in the retrospective study by Su et al,<sup>15</sup> our study approach combined both grouping concepts and compared the groups separately in the spinal TB patients we studied. Besides, we expanded definition of radical surgery based on the study of Park et al. Because we believe that vertebral curettage is the key to radical surgery, not decompression or bone fusion. In the Korean findings, radical surgical patients with spinal TB were characterized by neurological compression symptoms and thoracic involved,<sup>16</sup> Similarly, in our study, we also found surgical patients with spinal TB had symptoms of neural compression, but often accompanied by abscesses and more often involved in the lumbar, not thoracic. Furthermore, there were no significant differences in the clinical characteristics of patients with spinal TB in the duration of anti-TB chemotherapy and surgical type.

Surgery is an important adjunct to the treatment of spinal tuberculosis,<sup>20,21</sup> but the necessity of surgical treatment for patients with spinal tuberculosis is controversial.<sup>22,23</sup> Park et al<sup>16</sup> retrospectively analyzed 137 patients with spinal TB and concluded that radical surgery combined with antituberculosis chemotherapy was a significant favorable prognostic factor. However, in a Cochrane review of randomized controlled trials, it believed there was no significant benefit to apply surgery in the treatment of spinal TB.<sup>18</sup> And according to Zhang et al<sup>20</sup> in their meta-analysis similarly concluded that surgery or not had no significant effect on the prognosis of patients with spinal TB. In the present study, we also believed surgery was not a favorable prognostic factor for patients with spinal TB, but we unexpectedly found the patients with spinal TB who needed surgical treatment often got a better prognosis when they had radical surgery. We speculate it may be an explanation for the controversy about whether surgery is a favorable prognostic factor for patients with spinal TB. By reason of surgical treatment of spinal TB exists to address complications, such as abscesses, nerve injuries, and spinal deformities.<sup>24,25</sup> If patients do not have these complications or these complications can be managed by the organism, standardized anti-tuberculosis chemotherapy is the key to the treatment of spinal TB.<sup>26,27</sup> On the other hand, if the organism is not able to manage these complications, the patient who choose radical surgery are more likely to have a favorable outcome.<sup>11</sup> In clinical practice, it has a certain guiding role in the application of surgical treatment in spinal TB.

Antituberculosis chemotherapy remains the mainstay of treatment for spinal tuberculosis,<sup>28</sup> but the duration of antituberculosis chemotherapy for patients with spinal tuberculosis has been heated one of the controversies.<sup>22,29</sup> The definitions of long and short courses of anti-TB chemotherapy are not entirely consistent in different studies, which may result from the application of different anti-TB guidelines for different countries or regions. The American Thoracic Society recommends 6 months of anti-TB chemotherapy for adults and 12 months for children.<sup>30</sup> The British Thoracic Society recommends daily use of rifampicin and isoniazid for 6 months.<sup>31</sup> However, Chinese and Indian guidelines recommend a total course of anti-TB chemotherapy between 12 and 18 months.<sup>32,33</sup> Recent studies also recommend at least 12 months of treatment for patients with spinal TB.<sup>33</sup> Therefore, in our study, instead of setting the short course of anti-TB chemotherapy at 6 or 9 months,<sup>29,32,34</sup> or even an ultra-short course of 3 months,<sup>35</sup> as in other studies, the short course of treatment was set at less than or equal to 12 months. We believe this is more in line with the characteristics of the course of anti-TB treatment for Chinese patients under Chinese guidelines.

Efficacy of anti-TB chemotherapy has been validated, but long-term anti-TB chemotherapy leads to an increase in drug-resistant MTB and frequency of anti-TB drug side effects.<sup>19,33</sup> Many studies have validated and explored the possibility of shortening the course of anti-TB chemotherapy,<sup>32,34,36</sup> and the MRC study showed that the prognosis of patients treated with 6 or 9 months of antituberculosis chemotherapy was favorable and did not differ significantly from one of 18 months of antituberculosis treatment.<sup>11,37</sup> However, it has also been suggested that 6 months of treatment may not be sufficient for the treatment of bone and joint TB, including spinal TB.<sup>33</sup> In our results (Table 8), it was further suggested that short course ( $\leq 12$  months) *versus* long course ( $>12$  months) in patients with spinal TB was also not significantly associated in different treatment modalities.

However, we acknowledge the present study has several obvious limitations. First, it was a single-center retrospective study and the sample size was small. Some confounders, such as the change in the length of anti-TB chemotherapy, and practices of follow-up as mentioned above, could not be evaluated. Although there were significant differences in comparisons of several variables associated with outcome, the statistical power is adequate for drawing certain conclusions. Second, we enrolled cases not diagnosed by microbiology and histopathology, because of difficulty in diagnosis of TB, especially extrapulmonary TB. However, such cases were also enrolled in other studies.<sup>15,16</sup> Third, we did not analyze the causes of unfavorable outcome such as the infection of drug-resistant MTB. In the present study, the patients involved in our study did not have the infection of drug-resistant MTB before the follow-up. We only evaluated the outcomes in the follow-up, and did not detect drug-resistant MTB in patients with unfavorable outcome. Hence, it needs more multi-center and well-designed studies to substantiate the present findings.

## Conclusion

The present study demonstrated surgical treatment of spinal tuberculosis did not improve the clinical outcome of patients with spinal TB, but radical surgery improved the clinical outcome of patients who need surgery. And in different treatment modalities, there is no additional benefit in longer treatment periods. These findings suggested the directions to application of operation in patients with spinal TB and feasibility of shortening the course of anti-TB chemotherapy in different treatment modalities, which need to be verified by more studies.

## Abbreviations

TB, Tuberculosis; MTB, *Mycobacterium tuberculosis*; CT, Computed Tomography; MRI, Magnetic Resonance Imaging; SD, standard deviation; OR, Odds ratio; CIs or CI, confidence intervals.

## Patient Consent and Ethics Statement

This project was approved by the Ethics Committee of Yichang Central People's Hospital (202112401). The need to obtain individual informed consent was waived for this study utilized existing data collected from the hospital information system and did not pose any additional risks to the patients. The study was conducted in accordance with the Declaration of Helsinki.



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## Disclosure

The authors report no conflicts of interest in this work.

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