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Review

Functional Prognosis of Spinal Cord Injury Due to Spinal Tuberculosis

Farida Arisanti [1,*], Tertianto Prabowo [1], Putri Endyana [1], Apichana Kovindha [2]

1. Department of Physical Medicine and Rehabilitation, Faculty of Medicine Padjajaran University/Hasan Sadikin General Hospital, Bandung, Indonesia; E-Mails: farida.arisanti@unpad.ac.id; prabowo2003@gmail.com; putriendyana@yahoo.com
2. Department of Rehabilitation Medicine, Faculty of Medicine Chiang Mai University/Maharaj Nakorn Chiang Mai Hospital, Thailand; E-Mail: apichana.k@cmu.ac.th

* **Correspondence:** Farida Arisanti; E-Mail: farida.arisanti@unpad.ac.id

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Abstract

Spinal tuberculosis (TB), an extrapulmonary manifestation of TB, primarily involves one or multiple vertebrae, with a high prevalence at the thoracolumbar region, which can compromise spinal cord integrity and result in severe sequelae such as paraplegia, bladder and bowel dysfunction, and mobility limitation. This study aimed to review medical, surgical, and rehabilitation management, clinical outcomes, and prognostic factors of spinal TB with spinal cord injury (SCI). Research was conducted utilizing databases such as PubMed, Google Scholar, and the Cochrane Library to identify original research articles published between 2019 and 2024, along with systematic and narrative reviews, that were relevant to spinal TB and clinical outcomes. Antituberculosis drug therapy, incomplete motor deficits, early onset paraplegia, young age, and good nutritional status provide a better prognosis for neurological and functional recovery. On the other hand, poor prognosis factors are normochromic normocytic anemia, initial lymphocytosis, and fever; in addition, a long duration of disease, poor patient compliance to medications, multidrug-resistant TB, poor nutritional status, and the presence of comorbid systemic diseases are negative predictors for recovery. Insufficient research necessitates further investigation into spinal cord-specific outcomes for spinal TB to improve rehabilitation prognostics. Early intervention and antituberculosis therapy enhance

better prognoses for neurological and functional recovery, especially in those with incomplete motor function, young age, good nutritional status, and compliance with treatment.

Keywords
Spinal cord injury; spinal tuberculosis; prognosis; rehabilitation; recovery of function

1. Introduction

Spinal tuberculosis (TB), also referred to as TB spondylitis or Pott's disease of the spine, is the most prevalent form of extrapulmonary TB caused by secondary infection of Mycobacterium tuberculosis in the spine and its adnexal tissues. Worldwide, the annual incidence of spinal TB exceeds 100,000 [1]. This condition has been increasing in both developing and developed countries, primarily due to factors such as increasing Human Immunodeficiency Virus (HIV) coinfection, multidrug resistance of the organism, and global migration.

Spinal TB accounts for 50% of all musculoskeletal tuberculosis and most often affects the lower thoracic and thoracolumbar area [1, 2]. Untreated spinal TB can lead to severe and long-lasting consequences of significant morbidity, persistent neurological deficit, and pronounced spinal deformities [2, 3]. These complications can result in a substantial decline in functioning, particularly in mobility, self-care, and bladder-bowel function [4]. Having a combination of deformity, instability, and neurologic deficit may require surgical intervention to prevent further deterioration [1-3].

The management goals are eradication of disease, prevention of neurological deficits, correction of deformity, early mobilization, and resuming normal daily activities. Early diagnosis and treatment with antituberculosis drugs or a combination of medical and surgical interventions generally give good results. Comprehensive rehabilitation is crucial for facilitating and optimizing neurological and functional outcomes [5].

Rehabilitation professionals are interested in prognostic factors, but previous research in spinal TB with or without SCI was limited. Therefore, we reviewed more recent literature on spinal TB published in medical journals and databases such as PubMed, Google Scholar, and the Cochrane Library between 2019 and 2024. The results are presented as a narrative review containing as follows: prevalence and clinical manifestation, diagnosis, non-traumatic SCI, management including medical, surgical, and rehabilitation, and prognostic factors and outcomes including clinical outcomes, neurological recovery and functional outcomes, and conclusions.

2. Prevalence and Clinical Manifestation

Spinal TB is prevalent, with 95% of TB cases reported from developing countries, and Indonesia is the country with the second largest TB prevalence in the world after India [6]. Of all TB cases, 10%-20% have musculoskeletal involvement, with 50% of them being spinal TB, most prevalent in the thoracic vertebrae (40%-50%), followed by lumbar and cervical vertebrae [5, 6]. Dissemination of TB results from reactivation of latent pulmonary foci [7]. During the mycobacteremia phase, bacteria can spread to the spine via hematogenous and lymphatic systems. The hematogenous spread of infection involves the paradisiacal region arteries and the paravertebral venous plexus.

Based on the spread region, spinal TB infection can be classified into paradiscal, central, anterior, and posterior [1, 7]. The paradiscal type is the most prevalent form; the infection typically begins in the vertebral body and then progresses to the adjacent disc, leading to its destruction and collapse. The central type is less common, where the central portion of the vertebral body is affected by the bacteria spreading through the valveless Batson's paravertebral venous plexus [8, 9]. The anterior type is characterized by the subligamentous spread of infection beneath the anterior longitudinal ligament from the anterior vertebral body to the anterior end plate via the end arteries in the vertebral end plates, causing progressive destruction, vertebral collapse, and kyphotic deformity [7, 10]. The posterior type is rare, and the infection spreads through the posterior external vertebral venous plexus or directly from an adjacent infected area. The destruction of the posterior column can cause lateral translation with or without rotation and increases the risk of neurologic deficits because of delay in diagnosis, leading to spinal instability and deformity. Examples of lesions based on location of involvement seen in magnetic resonance imaging (MRI) are depicted in Figure 1.

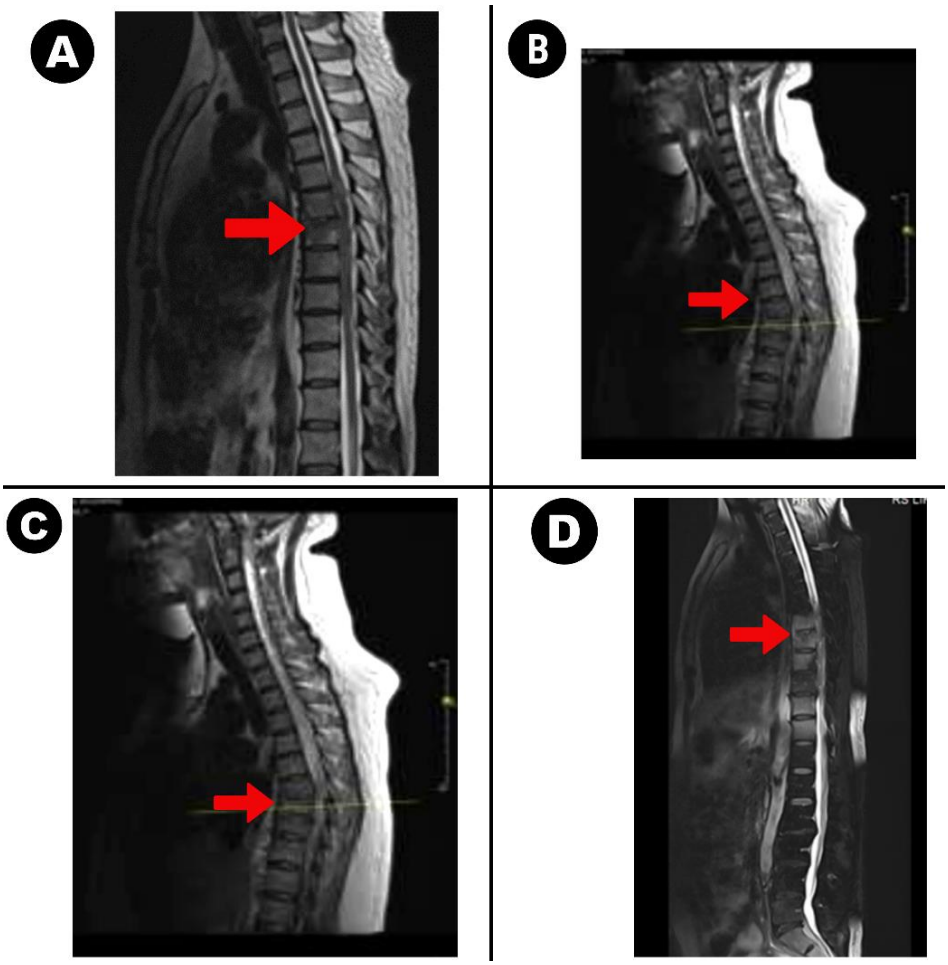

Figure 1 MRI of Spinal TB based on different locations of column involvements with red arrows pointing at the following lesions: a) Paradiscal, b) Central, c) Anterior, d) Posterior.

Due to the slow progress of the disease, clinical manifestations are influenced by severity, duration, location, and complications [11]. The most common complaint is back pain, with the degree of pain depending on the degree of spinal destruction and instability [4]. Constitutional

symptoms such as fever, night sweats, malaise, loss of weight, and appetite are less common [11]. Three typical clinical features of spinal TB are cold abscess, vertebrae deformity (Figure 2), and neurological deficits [1]. Cold abscess, a collection of exudates originating from the vertebrae that infects the surrounding soft tissues and ligaments, is usually painless and without an inflammatory response around it [12, 13].

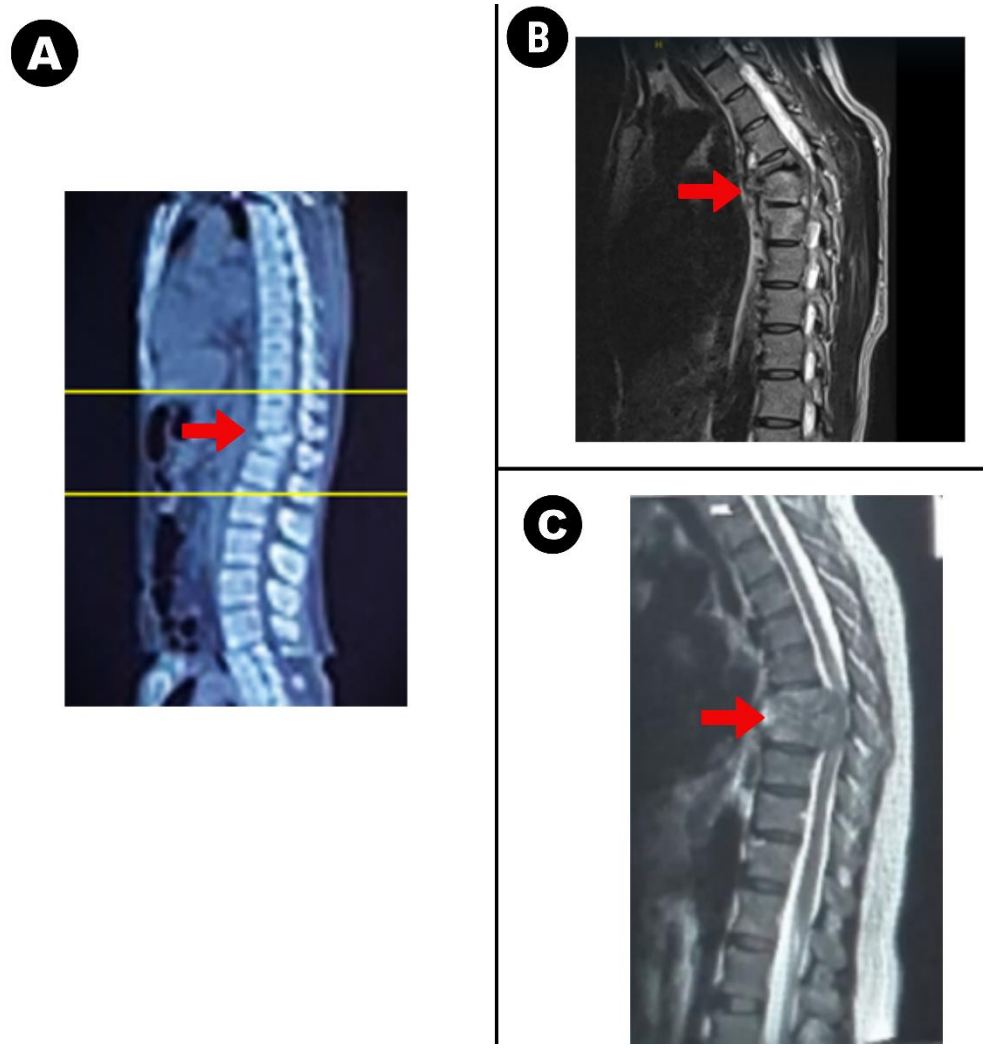

Figure 2 Various spinal deformities pointed with red arrows ranging from a) knuckle with collapse on one vertebra, b) gibbus with collapse of 2-3 vertebrae, c) short kyphosis (collapse more than three vertebrae with minimal angular deformity).

In the thoracic region, the cold abscess is often presented as a fusiform paravertebral swelling caused by the spread of infection through the intercostal vessels. It can appear as a mass in the chest wall, a sign of underlying spinal TB [1]. Kyphosis, a pronounced vertebral deformity, is common in thoracic vertebrae in children and in lumbar vertebrae in adults [4]. Single-segment involvement is more prevalent than multifocal segments; however, based on comprehensive incidence rates, multifocal contiguous involvement is the most prevalent [2]. Moreover, an acute onset of paralysis in individuals with thoracic spinal TB is attributed to the narrow spinal canal of the thoracic spine and inadequate blood supply to the thoracic spinal cord [14].

3. Diagnosis

Diagnosing spinal TB should always be supported by clinical findings, laboratory tests, and imaging. Imaging of the entire spine is recommended to detect the extension of the infection and to exclude any adjacent or skipped lesions [11]. MRI is the most reliable investigation, but plain spinal radiography is an essential diagnostic tool, particularly in low-resource countries [15]. The plain x-ray findings of spinal TB (Figure 3), typically including destruction of vertebral end plates, vertebral body destruction, and disc space narrowing, may not be apparent as these changes may not be visible on plain radiographs for up to 8 weeks, making late diagnosis in its early stages [16].

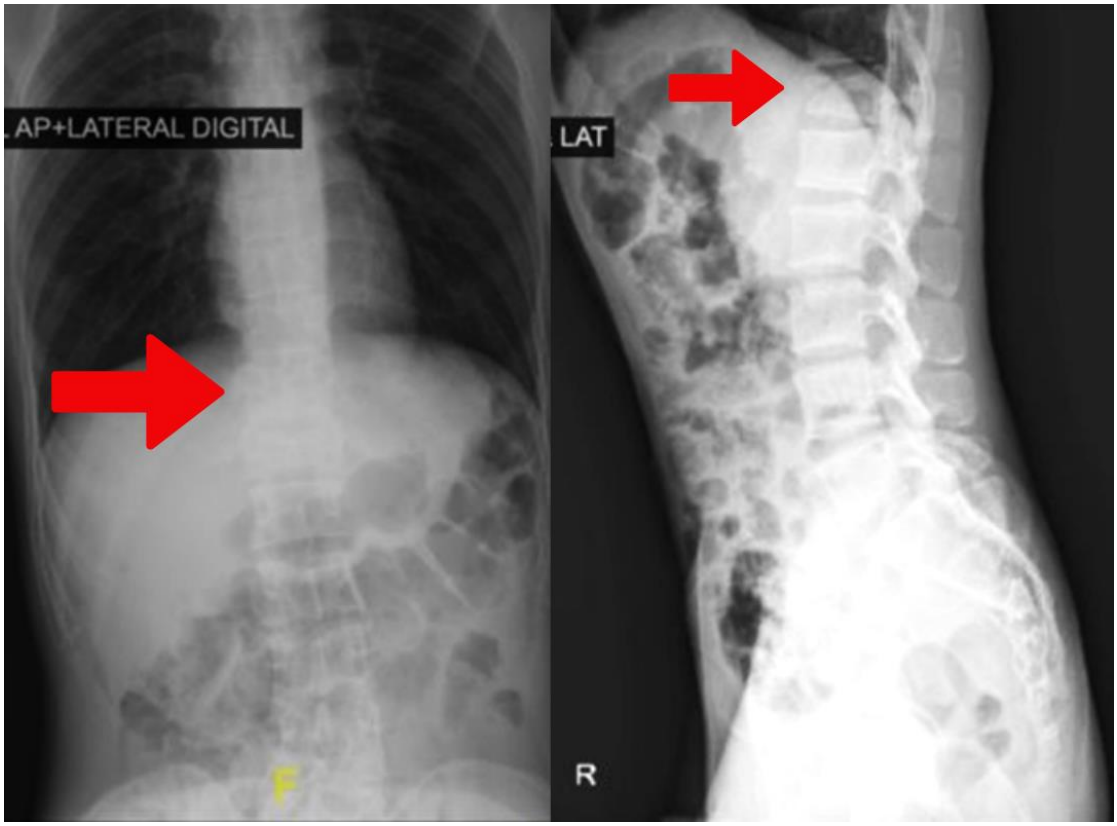

Figure 3 illustrates plain X-rays of the spine revealing deformities at thoracic vertebra 12. a) The anterior-posterior view demonstrates the vertebral body destruction and disc space narrowing. b) The lateral view highlights end plate destruction and wedging of the vertebrae, indicated by red arrows.

Computed Tomography scans can better visualize various forms of bone destruction, including fragmentary destruction, osteolytic destruction, subperiosteal destruction, and localized destructive lesions with sclerotic margins [7, 10]. In addition, the development of significant late kyphosis can be expected if three or more of the following criteria are present: (1) separation of the facet joints, (2) retropulsion of the vertebral body, (3) lateral translation, and (4) toppling vertebrae (Figure 4) [7].

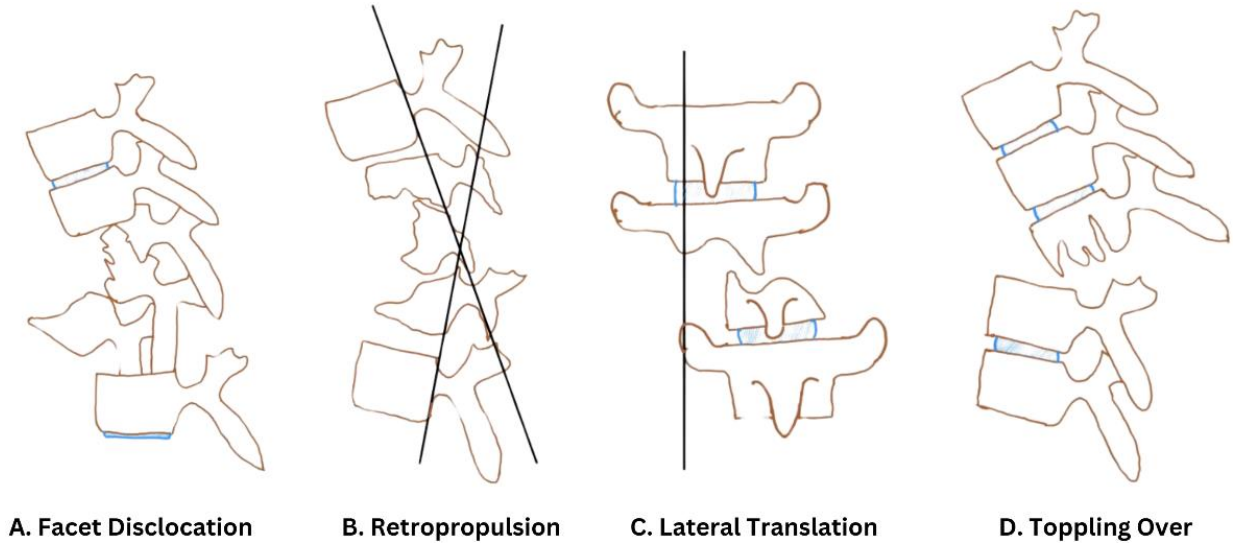

Figure 4 Deformities of the spine following different types of destruction.

MRI can demonstrate soft tissue involvement, spreading abscess, spondylodiscitis, and neural compression (Figure 5) and shows high sensitivity and specificity in differentiating spinal TB from non-TB lesions [7, 17].

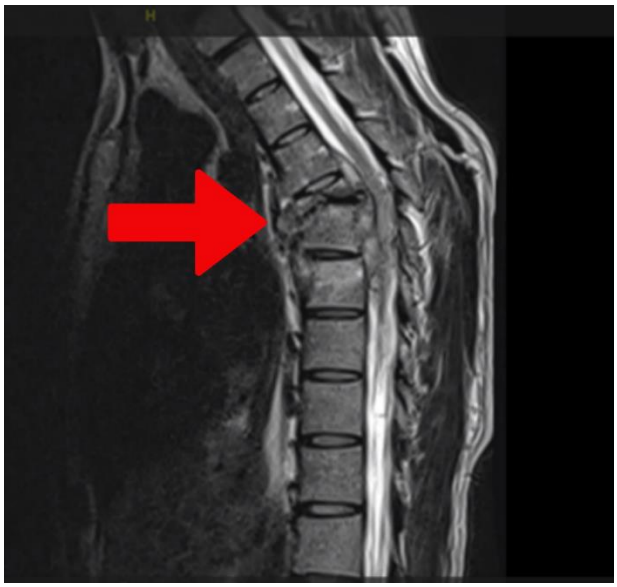

Figure 5 MRI of the thoracic spine with involvement of two vertebrae causing gibbus and spinal cord compression.

Confirming definite diagnosis relies on histopathological investigations of tissue specimens showing acid-fast bacilli (AFB), caseous necrosis, epithelioid cell granulomas, and Langhans' giant cells [10]. Molecular diagnostic investigations, e.g., Polymerase Chain Reactions and line probe assay, are increasingly used due to their efficiency and reliability [1].

4. Non-Traumatic SCI

About 10% to 30% of individuals with spinal TB developed a significant non-traumatic etiology of SCI, resulting in impairments of neuromusculoskeletal and bladder functions and, consequently, limitation of mobility [18]. In patients with early onset of SCI, neurological deficits occur during the active phase of infection, i.e., in the first 2 years and in cases that have not received treatment [11]. The common mechanisms of SCI in early onset are compression of the spinal cord anteriorly by extradural abscess destruction of the vertebral column and spinal cord edema. The risk of neurological deficits increases 7.3 times when having more than 50% narrowing of the spinal canal and 12 times when having spinal cord edema [18]. Empirical research reveals a notable enhancement in neurological recovery following surgical intervention [19].

Neurological deficits may be caused by myelopathy, radiculopathy, or myeloradiculopathy, depending on the location and size of the lesion. Myelopathy is a dysfunction of the spinal cord with upper motor signs and symptoms such as muscle weakness, loss or impaired sensation, impaired urination, and defecation functions. Radiculopathy is a dysfunction of the spinal nerves, nerve roots, or both with lower motor neuron signs and symptoms such as radicular pain, impaired sensation, and muscle functions. According to two retrospective studies from India, more than half of spinal TB patients had incomplete SCI with partial motor sparing, and about 1/3 had no neurological deficits [7, 12].

5. Management

The aim of comprehensive management of spinal TB with or without SCI is to cure the disease and enhance clinical outcomes and neurological and functional recovery, e.g., restoring mobility and independence in daily activities.

5.1 Medical Management

The World Health Organization recommends initial anti-TB pharmacotherapy treatment with isoniazid, rifampicin, pyrazinamide, and ethambutol for 2 months, followed by an additional 4 months of therapy with isoniazid and rifampicin [20].

5.2 Surgical Management

The need for surgical intervention in spinal TB is still a topic of debate. Some suggest that neurological deficits can recover well after receiving antituberculosis drugs and that spinal lesions can be healed without surgery [3, 21]. Others argue that surgical intervention is necessary for spinal TB patients complicated by spinal instability, spinal cord compression with neurological deficits, sequestration, paravertebral abscess, and sinus formation [14, 16, 21]. In addition, surgical intervention is considered necessary for individuals with no neurological improvement after 3 to 4 weeks of anti-TB drug therapy or having deterioration during treatment, recurrent neurological issues following initial improvement, respiratory and swallowing difficulties from cervical abscess, and severe neurological impairments persisting beyond a duration of 6 months [16]. In cases with rapid and profound neurological deterioration, an emergency surgical intervention is mandatory to correct the worsening neurological state promptly. Thus, the duration of preoperative anti-TB drug therapy is frequently less than 2 weeks, insufficient preoperative medical management [14].

5.3 Rehabilitation Management

Rehabilitation is vitally important throughout all stages of management [22]. It was reported that 5 out of 6 individuals diagnosed with spinal TB attained full functional recovery within 2 years, emphasizing the efficacy of the rehabilitation program when implemented in conjunction with suitable surgical and medical interventions [3]. Attention must be directed towards spinal instability when administering rehabilitation interventions to facilitate neurological and functional recovery [4]. Muscle retraining and mobilization are essential as prolonged immobilization precipitates complications such as muscle wasting or atrophy, contractures, and pressure ulcers. Inpatient rehabilitation has been shown to significantly enhance functional outcomes by providing comprehensive, personalized training and supervised physical and occupational therapy designed for individual needs [12].

In the acute phase, the implementation of isometric exercises aims to strengthen the paraspinal and gluteal musculature, which is crucial for subsequent standing, balance, and ambulation in later stages [22]. In addition, appropriate bed positioning to prevent complications, breathing exercises to improve or maintain pulmonary functions, and effective coughing are necessary during the pre-operative phase. In the subacute phase, the rehabilitation program emphasizes active and active-assisted exercises, accompanied by retraining sitting and standing balance, with or without assistance or assistive devices [22]. In the chronic phase, ambulation is predominantly emphasized by a progressive increment in the intensity of gait retraining and core abdominal muscle exercises [4, 22].

In patients with urination difficulty and/or urinary incontinence, proper assessment and management of neurogenic lower urinary tract dysfunction are crucial [1, 9, 22]. Initially, they may need temporary use of an indwelling catheter for continuous bladder drainage and later change to intermittent catheterization to prevent urinary tract infections. In those with incomplete SCI, voluntary voiding may be possible after implementing bladder training with an intermittent catheterization program. They may have impaired bowel control as well. To facilitate bowel movement and bowel evacuation, a high-fiber diet with adequate fluid intake and provision of proper assist bowel emptying technique can be beneficial [4]. Endurance exercises are also necessary to maintain or improve cardiopulmonary functions and physical exercise tolerance [22].

In addition, SCI from spinal TB frequently manifests symptoms including spasticity and neuropathic pain, which can be treated with pharmacotherapy, e.g., baclofen and botulinum toxin for spasticity and gabapentin for neuropathic pain [22]. In addition, physical modalities for pain control and stretching exercises for alleviating spasticity can effectively control pain and spasticity and thus optimize the patients' functional ability and quality of life [18, 22]. Nevertheless, the impact of types and intensity of exercises and rehabilitation interventions on the functional outcomes of individuals with spinal TB remains unknown, highlighting a need for further investigation in this area [4].

6. Prognostic Factors and Outcomes

6.1 Clinical Outcomes

The patient's chronological age, the location and quantity of the spinal segments involved, the extent of kyphotic deformity, the presence of concurrent medical conditions, as well as the

surgeon's level of proficiency are considered factors for evaluating the prognosis of spinal TB [1]. Younger populations and optimal nutritional status are associated with better medical outcomes; in contrast, older age has a less favorable prognosis due to having comorbidities and osteoporosis, and elderly with positive acid-fast bacilli smear have unfavorable outcomes [16, 23]. Poor patient compliance with oral anti-TB drug therapy leads to multi-drug-resistant TB [24].

According to a retrospective study of patients with spinal TB one month after receiving anti-TB drug therapy, favorable outcomes were defined as weight gain, no fever, improvement of the general state, relief of pain, improvement in the classic inflammatory markers, and absence of vertebral deformities, neurological impairment, or sepsis; the study found that poor prognosis factors were normochromic normocytic anemia, initial lymphocytosis, and fever; interestingly whereas vertebral fracture seen in plain spinal X-ray was associated with favorable outcomes, which may be due to the presence of the peri-fracture hematoma allowing better vascularization of the bone and better antibiotic penetration into the infectious focus [25].

6.2 Neurological Recovery

Conservative management, anti-TB drug therapy, and the use of orthotic devices have shown high success rates in both disease eradication and spinal stabilization [26]. It is explained that the anti-TB drugs diminish caseous necrotic tissue and epidural abscess formations and facilitate neurological improvement in those with tubercular epidural abscesses [27]. Early therapeutic interventions, particularly within six weeks of the initial onset of neurological deficits, show a positive correlation with neurological recovery by increasing muscle power and decreasing spasticity [27]. On the other hand, delaying the therapy can make the disease severity and neurological status worse [25], indicating the necessity of timely management [18]. Moreover, rapid disease progression is related to a less favorable prognosis for neurological recovery.

In uncomplicated cases, there was no significant difference in the outcomes between those receiving conservation treatment and those undergoing surgery [7]. However, spinal decompression and stabilization have been effective treatments for those with spinal cord compression [3]. Studies demonstrated that the posterior approach resulted in significant neurological improvements among patients with initially incomplete SCI but less improvement in those with initially complete lesions [3, 4, 28]. Nevertheless, one study showed that a posterior extensive circumferential decompressive reconstructive technique could improve neurological outcomes in those with initially complete SCI [4, 29]. In patients with thoracic-level spinal TB, comparative studies between anterior and posterior approaches found no significant differences in neurological recovery [3, 23]. At the same time, the anterior approach has been shown to improve disability levels in patients with cervical TB [3, 23].

In patients with SCI from spinal TB, the rate of improvement is significantly higher in patients with incomplete motor function than those with complete lesions or sensory sparing, indicating the importance of initial neurological status [28]. Additionally, having normal bowel and bladder control is a decisive prognostic factor of complete recovery [4]. Of patients with cervical spinal TB and myelopathy, a retrospective follow-up study of 115 cases in China demonstrated that less involved vertebrae, surgery, and high Japanese Orthopedic Association (JOA) score before treatment were predictors for neurological recovery; in addition, the cumulative complete neurologic recovery rates

at 6 months and 12 months were higher in the surgery group than in the non-surgery group, but no difference between groups at 28 months [25].

6.3 Functional Outcomes

Pain and neurological deficits commonly disturb or limit individual functioning. After receiving medical, surgical, and rehabilitation interventions, both patients and rehabilitation professionals expect optimal functional recovery, i.e., being able to perform activities of daily living and mobility independently [22]. Three assessment tools, including the modified Barthel Index (MBI), total score of 20 or 100, Oswestry Disability Index (ODI), and JOA score, are frequently used for evaluating functional outcomes in patients with spinal TB [4].

One prospective study recruited 70 medically treated patients of spinal TB and determined prognostic factors; disability was assessed with MBI (total score of 20) and good functional outcome was classified if MBI was more than 12; based on multivariate analysis, duration of illness more than 6 months, cord compression and spinal extension of abscess were associated with poor outcomes [4].

Another prospective study of 47 patients with spinal TB, after receiving anti-TB drugs, reported all except 4 patients underwent surgical interventions and rehabilitation [22]; the patients' activities of daily living (feeding, bathing, grooming, dressing, bladder care, bowel care, and toileting) and mobility (wheelchair to bed transfer, walking, and stair climbing) were assessed using MBI on admission and at discharge from inpatient rehabilitation; the MBI scores for Activities of Daily Living (ADL) and mobility at discharge increased significantly and the percentage of independent patients also increased from 10% to 70%, indicating the benefits of medical treatment, surgical decompression, and inpatient rehabilitation from pre- to 6 months post-operative periods [22].

Like traumatic SCI, the ability to walk is expected by patients with spinal TB and SCI. To date, there has been no evidence to support predictors of walking in the latter group. According to previous and recent studies in traumatic SCI, the muscle power function of hip flexors and knee extensors is a primary predictor for ambulation [12]. A recent study of patients with traumatic paraplegic SCI confirmed that motor function of L2 and L3 myotomes of the more impaired leg assessed ≤15 days after injury yielded prognostic value for walking at 6 months after injury whereas motor function of L4-S1 myotomes can predict outdoor walking at 6 months after injury [30]. Moreover, researchers from Europe and the United States of America determined a clinical predictive rule to predict walking function after traumatic SCI. The European group suggested using a combination of age and 4 neurological tests (motor function of L3 and S1 myotomes and sensory function of L3 and S1 dermatomes) to predict indoor ambulation at one year post SCI [18]. The American group proposed a simple surrogate test of S1 pinprick sensation at the lateral side of both heels within the first month, preferably within 1 week after injury, to predict independent walking at 1 year [30]. Of note, these predictive factors were assessed within 1 month after injury, unlikely to be applied to patients with SCI from spinal TB who are usually diagnosed later. Therefore, there is a need for further research to establish spinal cord-specific outcome measures and determine predictors for spinal TB cases.

7. Conclusions

Non-traumatic SCI due to spinal TB is prevalent in low-resource countries. Neurological impairments are often from anterior spinal cord compression caused by an extradural abscess. Based on some retrospective and few prospective studies, anti-TB drug therapy for 6-12 months, surgery, and rehabilitation interventions provide good clinical outcomes neurological and functional recovery. Younger age and good nutrition enhance clinical improvement. Normochromic normocytic anemia, initial lymphocytosis, and fever are early predictive factors of poor clinical outcomes. Duration of illness of more than 6 months, spinal cord compression, and spinal extension of abscess are prognostic factors of poor outcomes. In addition, prolonged illness, poor patient compliance, multidrug-resistant tuberculosis, inadequate nutrition, and comorbid conditions adversely affect recovery. Those with initially incomplete motor SCI demonstrate significantly more significant neurological improvements than those with complete lesions or having sensory sparing only. Preservation of bowel and bladder function is another predictor of overall recovery. Research on prognostic and predictive factors for outcomes in patients with spinal TB is limited and needs further investigation.

Author Contributions

Farida Arisanti and Putri Endyana conceived of the presented idea, developed the theory and performed the computations. Farida Arisanti, Putri Endyana and Apichana Kovindha verified the analytical methods. Tertianto Prabowo and Apichana Kovindha, encouraged Farida Arisanti and Putri Endyana to investigate [specific aspect of functional outcome in spinal tuberculosis] and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Shanmuganathan R, Ramachandran K, Shetty AP, Kanna RM. Active tuberculosis of spine: Current updates. N Am Spine Soc J. 2023; 16: 100267.
2. Ifthekar S, Ahuja K, Yadav G, Mittal S, Trivedi V, Kandwal P. Sociodemographic patterns of spinal tuberculosis patients from a tertiary care teaching hospital: A 5-year cross-sectional study. J West Afr Coll Surg. 2024; 14: 339-344.
3. Ahmed AU, Chowdhury SN, Quader M, Sarker T, Ohi SM, Zahid MM. Outcome of surgical intervention of spinal tuberculosis patients. Banglad J Neurosurg. 2022; 12: 94-101.
4. Yong LN, Ahmedy F, Yin KN, Engkasan JP. Functional outcomes in spinal tuberculosis: A review of the literature. Asian Spine J. 2020; 15: 381-391.
5. Onuminya J, Morgan E, Shobode M. Spinal tuberculosis-current management approach. Niger J Orthop Trauma. 2019; 18: 35.

6. World Health Organization. Tuberculosis Report. Vol. XLIX [Internet]. Geneva, Switzerland: World Health Organization; 2020. Available from: https://iris.who.int/bitstream/handle/10665/336069/9789240013131-eng.pdf.
7. Khanna K, Sabharwal S. Spinal tuberculosis: A comprehensive review for the modern spine surgeon. Spine J. 2019; 19: 1858-1870.
8. Vaishnav B, Suthar N, Shaikh S, Tambile R. Clinical study of spinal tuberculosis presenting with neuro-deficits in Western India. Indian J Tuberc. 2019; 66: 81-86.
9. Leowattana W, Leowattana P, Leowattana T. Tuberculosis of the spine. World J Orthop. 2023; 14: 275-293.
10. Kubihal V, Sharma R, Kumar RK, Chandrashekhara SH, Garg R. Imaging update in spinal tuberculosis. J Clin Orthop Trauma. 2022; 25: 101742.
11. Ali A, Musbahi O, White VL, Montgomery AS. Spinal tuberculosis: A literature review. JBJS Rev. 2019; 7: e9.
12. Wichmann TO, Jensen MH, Kasch H, Rasmussen MM. Early clinical predictors of functional recovery following traumatic spinal cord injury: A population-based study of 143 patients. Acta Neurochir. 2021; 163: 2289-2296.
13. Bhattacharjee S, Chakraborty S, Baby S, Jain V, Khan H. A Rare Presentation-Case Report on Tubercular Cold Abscess. J Drug Deliv Ther. 2024; 14: 7-9.
14. Li W, Liu Z, Xiao X, Xu Z, Sun Z, Zhang Z, et al. Early surgical intervention for active thoracic spinal tuberculosis patients with paraparesis and paraplegia. BMC Musculoskelet Disord. 2021; 22: 213.
15. Sonawane DV, Kolur SS, Pawar HK, Chandanwale A, Pawar E, Jawale SA, et al. Comprehensive spinal tuberculosis score: A clinical guide for the management of thoracolumbar spinal tuberculosis. Asian Spine J. 2024; 18: 42-49.
16. Sae-Jung S, Wongba N, Leurmprasert K. Predictive factors for neurological deficit in patients with spinal tuberculosis. J Orthop Surg. 2019; 27. doi: 10.1177/2309499019868813.
17. Spernovasilis N, Apostolos K, Markaki I, Konsoula A, Ntontis Z, Koutserimpas C, et al. Brucella spondylitis: Current knowledge and recent advances. In: Spinal infections: Pathogenesis, diagnosis, management and outcomes. Basel, Switzerland: MDPI; 2024. pp. 1-18.
18. Mittal S, Yadav G, Ahuja K, Ifthekar S, Sarkar B, Kandwal P. Predicting neurological deficit in patients with spinal tuberculosis-A single-center retrospective case-control study. SICOT J. 2021; 7: 7.
19. Chughtai WN, Razzaque MA, Shafiq M, Ahmed N, Fatima T. Postoperative neurological outcome in spinal tuberculosis patients presenting with severe neurological deficits. Pak J Neurol Surg. 2023; 27: 205-216.
20. Abid SK, Kumar R, Yadav PK, Kumar R. Determining the optimal duration of drug therapy in spinal tuberculosis: A cohort study. Int J Med Biomed Stud. 2024; 8: 192-199.
21. Kilinc F, Setzer M, Behmanesh B, Jussen D, Geßler F, Prinz V, et al. Surgical management and clinical outcome of cervical, thoracic and thoracolumbar spinal tuberculosis in a middle-European adult population. Sci Rep. 2023; 13: 7000.
22. Dhouibi J, Kalai A, Chaabeni A, Aissa A, Ben Salah Frih Z, Jellad A. Rehabilitation management of patients with spinal tuberculosis (Review). Med Int. 2024; 4: 28.

23. Zhang T, Li S, Ma L, Liu H, Yang C, Zhang L. Clinical effect of posterior-only approach debridement, intervertebral fusion, and internal fixation for upper thoracic tuberculosis. Acta Orthop Traumatol Turc. 2024; 58: 203-208.
24. Jang JG, Chung JH. Diagnosis and treatment of multidrug-resistant tuberculosis. Yeungnam Univ J Med. 2020; 37: 277-285.
25. Boussaid S, M'rabet M, Rekik S, Jammali S, Rahmouni S, Zouaoui K, et al. Spinal tuberculosis: Features and early predictive factors of poor outcomes. Mediterr J Rheumatol. 2023; 34: 220-228.
26. Rava A, Mercurio M, Gargiulo G, Fusini F, Boasso G, Galasso O, et al. Conservative treatment of spinal tuberculosis in a retrospective cohort study over 20-year period: High eradication rate and successful health status can be expected. Ann Jt. 2023; 8: 34.
27. Prabhu RM, Rathod TN, Kolur SS, Hadole BS, Chavan S, Marathe NA, et al. Evaluation of functional outcome and neurological recovery pattern in patients with retro-thecal tubercular epidural abscess managed at a tertiary center. J Orthop. 2022; 30: 25-29.
28. Ye S, Sun J, Jing J. Isolated posterior instrumentation for selected cases of thoracic and lumbar spinal tuberculosis without radical debridement. Z Orthop Unfall. 2022; 160: 679-685.
29. Omran K, Abdel-Fattah AS. Posterior extensive circumferential decompressive reconstructive technique in surgical treatment of upper thoracic spine compressive lesions. World Neurosurg. 2019; 123: e501-e508.
30. Cathomen A, Maier D, Kriz J, Abel R, Röhrich F, Baumberger M, et al. Walking outcome after traumatic paraplegic spinal cord injury: The function of which myotomes makes a difference? Neurorehabil Neural Repair. 2023; 37: 316-327.