PEDIATRIC TUBERCULOUS SPONDYLITIS: CURRENT CONCEPTS IN DIAGNOSIS AND MANAGEMENT

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Abstract. Tuberculous spondylitis in children represents a severe form of extrapulmonary tuberculosis characterized by progressive vertebral destruction, spinal deformity, and potential neurological complications. Pediatric cases differ significantly from adult forms due to growth-related factors, high regenerative capacity, and distinct clinical presentation. This review summarizes current concepts in the pathogenesis, diagnosis, and management of pediatric spinal tuberculosis, with particular emphasis on the role of anti-tuberculosis chemotherapy and modern surgical strategies. Early diagnosis and a multidisciplinary approach are essential to prevent severe kyphotic deformities and long-term disability.

Keywords: Tuberculous spondylitis; Spinal tuberculosis; Children; Pediatric tuberculosis; Kyphotic deformity; Anti-tuberculosis therapy; Spinal surgery; Extrapulmonary tuberculosis.

Аннотация. Туберкулёзный спондилит у детей представляет собой тяжёлую форму внелёгочного туберкулёза, характеризующуюся прогрессирующим разрушением позвонков, деформацией позвоночника и возможными неврологическими осложнениями. Педиатрические случаи существенно отличаются от взрослых форм вследствие факторов, связанных с ростом, высокой регенераторной способности и особенностями клинического течения. В настоящем обзоре обобщены современные представления о патогенезе, диагностике и лечении туберкулёза позвоночника у детей с особым акцентом на роли противотуберкулёзной

химиотерапии и современных хирургических стратегий. Ранняя диагностика и мультидисциплинарный подход являются ключевыми факторами профилактики тяжёлых кифотических деформаций и долговременной инвалидизации.

Ключевые слова: туберкулёзный спондилит; туберкулёз позвоночника; дети; педиатрический туберкулёз; кифотическая деформация; противотуберкулёзная терапия; хирургия позвоночника; внелёгочный туберкулёз.

Introduction. Tuberculous spondylitis is a specific infectious lesion of the spine caused by mycobacteria belonging to the Mycobacterium tuberculosis complex. In most cases, the disease develops as a result of hematogenous dissemination from a primary focus in the lungs or lymph nodes. Rarely, it may occur as a complication of Bacillus Calmette–Guérin (BCG) vaccination.

Morphologically, tuberculous spondylitis is characterized by granulomatous necrotizing inflammation and is classified as a primary chronic osteomyelitis of the spine. In children, the disease exhibits distinct clinical and biological features that significantly influence both its course and management.

Clinical features of tuberculous spondylitis in children. Pediatric tuberculous spondylitis is characterized by several key features: a tendency toward multilevel vertebral involvement with subtotal or total destruction of vertebral bodies; early development and progression of kyphotic deformity, driven by continued growth of the posterior spinal column; spinal deformity as the initial clinical manifestation, often preceding pain; less pronounced pain syndrome compared to adults; rare occurrence of severe irreversible neurological deficits despite spinal canal compromise; high neurological recovery potential due to compensatory mechanisms; occurrence in both immunocompetent and immunocompromised children. In immunodeficient patients, including those with HIV infection or primary immunodeficiencies, the morphological pattern may

differ from classical granulomatous inflammation due to incomplete phagocytosis and absence of typical necrotic granulomas.

Diagnosis. According to WHO guidelines (2021), two levels of diagnostic certainty for extrapulmonary tuberculosis are distinguished: clinically established (unconfirmed) diagnosis based on clinical, radiological, and laboratory findings without bacteriological confirmation, and confirmed diagnosis established by detection of *M. tuberculosis* in specimens obtained directly from the lesion using culture methods and molecular genetic techniques (PCR). In settings with limited diagnostic resources, diagnosis may rely on clinical and imaging findings alone. Importantly, immunological and serological tests (e.g., skin tests, IGRA) are not sufficient to confirm or exclude spinal tuberculosis or assess disease activity.

Principles of treatment. Anti-Tuberculosis Chemotherapy is the cornerstone of modern management of tuberculous spondylitis in children is prolonged combination anti-tuberculosis chemotherapy, individualized according to drug susceptibility testing. Early initiation of appropriate therapy is critical, as delayed or inadequate treatment significantly increases the risk of progressive vertebral destruction, severe deformity, and neurological complications.

A fundamental principle of treatment is the earliest possible microbiological verification of the pathogen. This is achieved through invasive diagnostic procedures such as percutaneous abscess puncture or vertebral biopsy from the zone of destruction. The obtained material is subjected to a comprehensive microbiological evaluation, including direct microscopy, culture on both solid and liquid media, and molecular genetic testing. The use of polymerase chain reaction (PCR) allows rapid detection of Mycobacterium tuberculosis DNA, while molecular assays targeting resistance-associated mutations enable early identification of drug-resistant strains. Collectively, these methods significantly reduce the time required for etiological confirmation from several weeks, as seen with conventional culture techniques, to a few days or even hours.

The choice of chemotherapy regimen, including drug combination and duration, is determined by the susceptibility profile of the pathogen and the clinical severity of the disease. In pediatric patients, careful consideration must be given to drug tolerability, pharmacokinetics, and potential adverse effects, particularly in long-term treatment courses.

The effectiveness of conservative therapy is assessed using a combination of clinical and radiological criteria. Clinically, improvement is reflected by the resolution of systemic inflammatory signs and stabilization of the patient's general condition. Radiologically, the key indicators of treatment success include regression or complete resolution of paravertebral abscesses and the appearance of reparative changes in the affected vertebrae, such as sclerosis and bone remodeling.

Surgical treatment of active disease. Despite advances in chemotherapy, surgical treatment remains an essential component in the management of pediatric tuberculous spondylitis, particularly in complicated or advanced cases. The decision to perform surgery is based on a combination of neurological, orthopedic, and infectious criteria.

Absolute indications for surgical intervention include neurological complications resulting from spinal cord compression, such as partial or complete paralysis and pelvic organ dysfunction. Orthopedic indications encompass progressive spinal deformity, instability of the spinal column, and persistent pain that is not responsive to conservative measures, including external immobilization. Furthermore, surgical treatment is indicated in cases of ineffective anti-tuberculosis chemotherapy, especially when multidrug-resistant (MDR) or extensively drug-resistant (XDR) tuberculosis is suspected or confirmed.

The overarching goals of surgical management are comprehensive and multifaceted. They include radical debridement of infected and necrotic tissues, adequate decompression of neural structures, restoration of spinal stability, correction of existing deformity, and, importantly in children, the creation of

biomechanical conditions that allow for balanced longitudinal growth of both anterior and posterior spinal columns.

Modern surgical techniques. Contemporary surgical strategies for tuberculous spondylitis in children are based on the principles of radicality, stability, and deformity correction, often achieved within a single-stage procedure.

Radical debridement constitutes the initial and critical step of surgical intervention. The choice of surgical approach depends on the anatomical localization of the lesion and may include extrapleural transthoracic, thoracodiaphragmatic, retroperitoneal, or combined approaches. The procedure involves thorough evacuation of abscesses, excision of necrotic and infected vertebral tissues, and decompression of the dural sac with meticulous removal of epidural pathological components.

Following debridement, anterior spinal reconstruction is performed to restore the load-bearing capacity of the spinal column. This is achieved using structural bone grafts, including autografts (rib or iliac crest) and allografts, often supplemented with titanium cages to provide immediate mechanical support. This combined approach of radical debridement and anterior reconstruction is historically referred to as “Hong Kong surgery” and remains a fundamental concept in the surgical management of spinal tuberculosis.

Posterior instrumentation has become an indispensable component of modern surgical treatment, particularly in pediatric patients with extensive vertebral involvement. It provides immediate spinal stability, facilitates deformity correction, and prevents further progression of kyphosis. To ensure adequate stabilization, instrumentation should extend one to two vertebral segments beyond the reconstructed area in both cranial and caudal directions.

In cases of severe kyphotic deformity exceeding 50°, isolated anterior or posterior approaches are insufficient. Adequate correction requires combined anterior and posterior reconstruction, often including resection of posterior spinal elements. Attempting correction through a posterior-only approach is associated

with a substantial risk of neurological complications due to potential dural sac buckling and spinal cord compromise.

Management of cervicothoracic deformities presents additional technical challenges due to the complex biomechanics of this transitional zone. Surgical correction in these cases requires the use of combined fixation systems and intraoperative stabilization techniques, such as halo ring fixation or Mayfield head clamps, to ensure controlled alignment and minimize neurological risk.

Postoperative Considerations. Postoperative management is a critical component of overall treatment success and requires careful long-term follow-up. Removal of spinal implants may be considered after 1–1.5 years, provided that solid anterior fusion has been confirmed by imaging modalities such as computed tomography.

Radiological evidence of graft resorption is a concerning finding and may indicate recurrence or progression of the infectious process, necessitating further evaluation and possible re-intervention. The development of pseudarthrosis at the reconstruction site or the formation of seromas around instrumentation components typically reflects mechanical instability and requires revision surgery with reinforcement of spinal fixation.

Discussion. Management of pediatric tuberculous spondylitis requires a multidisciplinary approach integrating infectious disease specialists, orthopedic surgeons, and radiologists. Early diagnosis and individualized treatment strategies are critical to preventing severe deformities and disability.

Children demonstrate unique advantages, including higher regenerative capacity and better neurological recovery; however, they are also at increased risk of progressive deformity due to ongoing growth.

Conclusion. Tuberculous spondylitis in children remains a complex clinical condition requiring timely diagnosis and combined therapeutic strategies. Advances in molecular diagnostics and surgical techniques have significantly

improved outcomes, yet challenges persist in managing severe deformities and drug-resistant forms.

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