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Radiological Evaluation of Extrathoracic Tuberculosis in Pediatric Patients

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ABSTRACT

Objective: Tuberculosis (TB) is still a global health concern. Although thoracic TB is the most common manifestation, TB can also affect extrathoracic sites, including the central nervous system, musculoskeletal system, and abdomen. The incidence of extrathoracic TB in children is higher compared to adults. This study aimed to examine the radiological findings of pediatric extrathoracic TB involvement in the central nervous system, musculoskeletal system, and abdomen.

Materials and Methods: The radiological features of 19 patients diagnosed with extrathoracic TB in childhood at Erciyes University Medical School between 2011 and 2024 were examined retrospectively. Patient gender, age, medical history, and laboratory data were reviewed from the hospital archiving systems.

Results: Nineteen patients diagnosed with extrathoracic TB were evaluated. Ten patients (52.9%) were female, and nine (47.1%) were male. The mean age was 97.5±20.8 months (ranging from 2 to 300 months). Three patients (15.8%) were immunocompromised, and nine patients (47.1%) had coexisting pulmonary TB. Central nervous system involvement was observed in six patients (31.6%), musculoskeletal system involvement in ten patients (52.6%), and abdominal involvement in three patients (15.8%).

Conclusion: Recognizing the classic radiological findings of pediatric extrathoracic pulmonary TB is crucial for prompt diagnosis, initiation of appropriate treatment, and prevention of long-term morbidity.

Keywords: Children, imaging, pediatrics, radiology, tuberculosis.

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INTRODUCTION

Tuberculosis (TB) remains one of the global health concerns.[1] In 2020, 10 million people were infected with TB, including 1.1 million children.[2] Immunocompromised children and adolescents, in particular, have a predisposition for developing extrathoracic TB.[3] Tuberculosis presents various clinical and radiological features depending on the organ involved. Thoracic TB, including lung disease and lymphadenopathy, is the most common manifestation. However, TB can also infect extrathoracic sites, including the central nervous system, musculoskeletal system, and abdomen. Extrathoracic TB is more common in children than in adults.[4]

Imaging is essential in identifying and monitoring both thoracic and extrathoracic TB lesions. This study aimed to examine the radiological findings of pediatric extrathoracic TB involvement in the central nervous system, musculoskeletal system, and abdomen.

MATERIALS AND METHODS

This retrospective study evaluated the imaging findings of children and adolescents diagnosed with extrathoracic TB at Erciyes University Medical School between 2011 and 2024. The study was approved by the Clinical Research Ethics Committee of Erciyes University (decision number: 2024/111). Extrathoracic TB was defined based on the presence of acid-resistant bacteria (ARB) in samples or histological findings. Patient gender, age, medical history, laboratory, and radiological data were retrieved from the hospital archiving systems.

Extrathoracic TB was classified as TB of the central nervous system, TB of the musculoskeletal system, and TB of the abdomen. In central nervous system TB, the presence of meningeal involvement, hydrocephalus, infarction, and spinal involvement was recorded. In musculoskeletal TB, the presence of osteomyelitis, along with the location of infection in the bone, arthritis, and soft tissue involvement, was documented. In abdominal TB, nodal, peritoneal, gastrointestinal, and solid organ involvement were recorded. Patients with coexisting pulmonary TB were also documented. The patients included in the study were between 0 and 18 years old.

Patients with unclear laboratory results for ARB or histological findings were excluded from the study.

Statistical Analysis

Statistical analysis was conducted using SPSS IBM Statistics Version 22.0. Descriptive statistics were provided as appropriate, with the mean (±standard deviation) and percentiles used to describe the data.

RESULTS

Nineteen patients diagnosed with extrathoracic TB were examined. Ten patients (52.9%) were female, and nine (47.1%) were male. The mean age was 97.5±20.8 months (ranging from 2 to 300 months). Three of the patients (15.8%) were immunocompromised. Nine patients (47.1%) had coexisting pulmonary TB.

The central nervous system was involved in six patients (31.6%). Musculoskeletal system involvement was observed in ten patients (52.6%), and abdominal involvement was noted in three patients (15.8%).

KEY MESSAGES

- Tuberculosis (TB) can infect extrathoracic sites, including the central nervous system, musculoskeletal system, and abdomen.
- Basal meningeal enhancement, hydrocephalus, and infarcts form the triad of neuroradiological findings in central nervous system TB and tuberculoma represents parenchymal involvement in central nervous system TB.
- The most common skeletal manifestations are spondylitis, arthritis, and osteomyelitis and characteristic features of TB spondylitis include vertebral intraosseous abscesses with relatively preserved disc spaces, severe bony destruction, and well-defined enhancing paraspinal soft tissue.

Among the six patients with central nervous system TB, meningitis and parenchymal tuberculomas were observed in four and two patients, respectively. Meningitis presented radiologically with basal meningeal enhancement filling the basal cisterns (Fig. 1) and, in one patient, with a spinal epidural abscess (Fig. 2a). Hydrocephalus was a concurrent finding in meningitis for three patients; one demonstrated communicating hydrocephalus, and two had non-communicating hydrocephalus. Infarcts were visualized in two patients with meningitis. In one patient, the infarcts were localized in the basal ganglia, while in the other, they were widespread, affecting the basal ganglia, corpus callosum, brainstem, and cerebellum. In one patient with meningitis, TB osteomyelitis developed after 11 years of follow-up, affecting the distal metaphysis of the tibia. Tuberculomas were commonly located at the corticomedullary junction; however, other areas of the brain and cerebellum were also affected. The noncaseating form was observed in one patient, while both caseating and noncaseating forms were seen in another patient.

Among the ten patients with musculoskeletal involvement, three presented with spondylitis, one with a psoas abscess, one with arthritis, four with osteomyelitis, and one with a subcutaneous and muscular abscess. Spondylitis lesions were located at the mid-thoracic level in two patients and at the lower thoracic level in one patient. Gibbus deformity was observed in two patients (Fig. 2b). In the patient with TB arthritis, the knee joint was involved. Early stages of arthritis showed rice bodies in the joint space with effusion, accompanied by infection foci in the bone marrow. Over time, the joint space gradually narrowed, and periarticular osteoporosis and peripheral bony erosions appeared on

Figure 1. Magnetic resonance imaging (MRI) of a 3-year old boy with tuberculosis (TB) meningitis. Contrast-enhanced T1-weighted axial brain MRI shows diffuse meningeal enhancement around basal cisterns (white arrow) and right middle cerebral artery (black arrow) indicative of central nervous system TB.

X-ray imaging (Fig. 3). Tuberculosis osteomyelitis was located at the proximal metaphysis of long bones, affecting the femur (two patients), tibia (one patient), and humerus (one patient). In three cases, infection spread to the epiphysis through the physis (Fig. 4a). The patients with transphyseal spread were approximately 18 months old. In all patients with TB osteomyelitis, the infection extended into the surrounding soft tissue by eroding bone cortices, resulting in soft tissue abscess formation in three patients. During the follow-up of one patient with osteomyelitis, an additional osteomyelitis focus in the same bone appeared after a few weeks.

All three patients with abdominal TB showed classic radiological findings of peritonitis, including ascites, peritoneal contrast enhancement, and peritoneal implants. Intra-abdominal TB-infected lymph nodes were observed in two patients as a concurrent finding (Fig. 4b). In one patient with peritonitis, intestinal involvement with inflammation of the terminal ileum was also present.

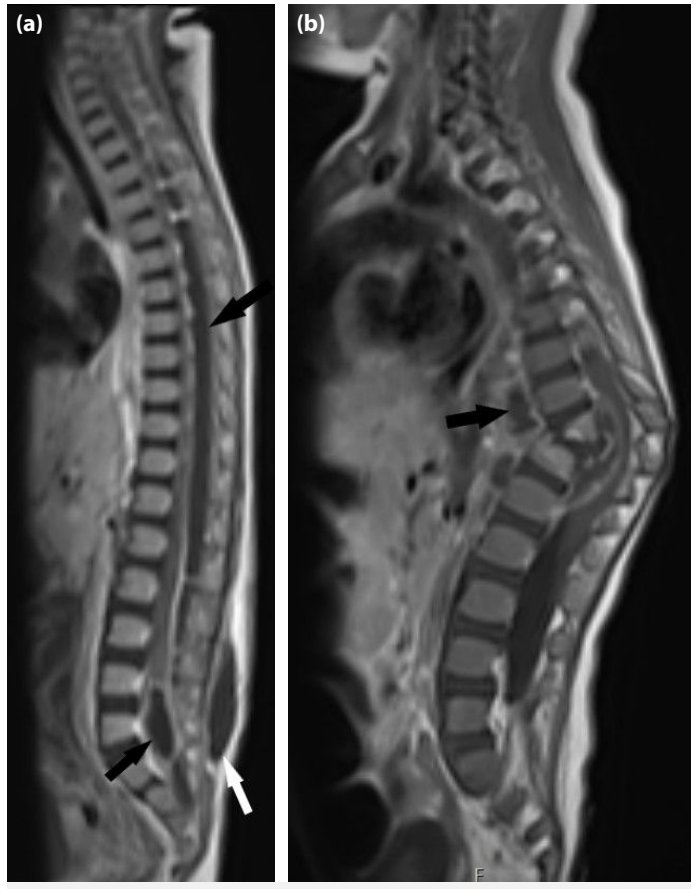

Figure 2. (a) MRI of an 18-year-old girl with spinal arachnoiditis. Contrast-enhanced T1-weighted sagittal spinal MRI reveals an epidural abscess surrounding the spinal cord and thecal sac (black arrows), with a soft tissue abscess in the lumbar subcutaneous area (white arrow). **(b)** MRI of a 3-year-old girl with TB spondylitis. Contrast-enhanced T1-weighted sagittal spinal MRI shows low thoracic involvement, with vertebral destruction and relatively preserved disc spaces. A paravertebral abscess is also visible (arrow).

DISCUSSION

This study documents the sites and radiological findings of extrathoracic TB in pediatric patients, based on a single-center experience. The systems affected by extrathoracic TB were the central nervous system, musculoskeletal system, and abdomen. The central nervous system was involved in 31.6% of patients, the musculoskeletal system in 52.6%, and the abdomen in 15.8%. Central nervous system TB presented with meningitis, tuberculomas, hydrocephalus, infarcts, and epidural abscesses. Musculoskeletal involvement included spondylitis, psoas abscess, arthritis, osteomyelitis, and subcutaneous and muscular abscesses. Abdominal

Figure 3. A 10-year-old girl with TB arthritis. Anteroposterior radiograph of the left knee shows juxta-articular osteoporosis, peripheral bony erosions, and joint space narrowing (Phemister's triad). Dense, rounded areas in the distal femoral and proximal tibial regions result from orthopedic interventions performed to treat osteomyelitis.

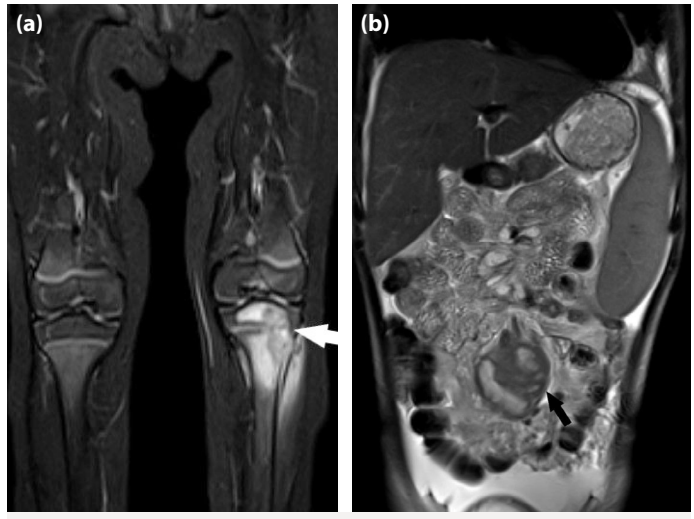

Figure 4. (a) 18-month-old girl with TB osteomyelitis. T2-weighted, fat-suppressed coronal extremity MRI shows high signal intensity in the proximal metaphysis and epiphysis of the tibia, indicating transphyseal spread (arrow). **(b)** 17-year-old boy with abdominal TB. T2-weighted coronal abdomen MRI displays enlarged, clustered lymph nodes with central necrosis (arrow), as well as ascites, indicative of peritoneal involvement.

involvement presented with peritonitis, infected lymph nodes, and terminal ileitis. No cases of genitourinary involvement were encountered.

Central nervous system involvement in TB is uncommon, affecting about 2% of all cases. Tuberculosis bacteria disseminate hematogenously from primary sites, reaching the meninges, parenchyma, and spinal canal. They may remain dormant before accessing the cerebrospinal fluid (CSF).[5] Basal meningeal enhancement, hydrocephalus, and infarcts constitute the triad of neuroradiological findings in central nervous system TB. Basal meningeal enhancement, indicative of meningeal inflammation, has an incidence of 75% to 92% and is one of the most important features in diagnosing TB meningitis. This enhancement is visible on post-contrast computed tomography (CT) or magnetic resonance imaging (MRI) scans, primarily in the basal cisterns but also around the optic chiasm, cranial nerves, ependyma, choroid plexus, and tentorium.[6,7] In this study, the main finding of central nervous system involvement was meningitis. Of the six patients with central nervous system TB, four demonstrated meningitis, and two exhibited tuberculomas. Basal meningeal enhancement was observed in three of the four patients with meningitis, and one patient with meningitis presented with a spinal epidural abscess.

Hydrocephalus is a common finding, affecting approximately 80% of pediatric patients with TB meningitis.[7] It occurs in two forms: communicating hydrocephalus and non-communicating hydrocephalus. Obstruction within the subarachnoid space is called "communicating hydrocephalus," whereas obstruction at the aqueduct or the outlet of the fourth ventricle is referred to as "non-communicating hydrocephalus."[8] Hydrocephalus appears early in children and can manifest within a few days of onset.[9] In this study, hydrocephalus was a concurrent finding of meningitis in three patients. Of these, one exhibited communicating hydrocephalus, while two showed non-communicating hydrocephalus. Hydrocephalus was an early finding in all three cases, visible on the initial imaging performed to diagnose meningitis.

The main cause of infarcts in central nervous system TB is vasculitis, particularly affecting small and medium-sized

vessels. Infarcts usually involve the internal capsule and basal ganglia, though larger vascular territories can also be affected. Diffusion-weighted imaging (DWI) can detect these infarcts in the early phase.[10] In this study, infarcts were identified in two patients. In one case, the infarcts were localized to the basal ganglia, whereas in the other case, they were widespread, involving the corpus callosum, brainstem, cerebellum, and basal ganglia.

Tuberculoma represents the parenchymal involvement of central nervous system TB. It may present as solitary or multiple round lesions, commonly located at the corticomedullary junctions or periventricular regions. The imaging characteristics of tuberculoma on MRI are classified as either non-caseating or caseating, depending on the pathological state of its center. The non-caseating form appears hypointense on T1 and hyperintense on T2, with homogeneous enhancement and no diffusion restriction. In contrast, the caseating form is isointense to the cortex on T1, showing a characteristic low signal on T2, with either peripheral or homogenous enhancement and no diffusion restriction. When a caseating tuberculoma undergoes liquefaction, central T2 hyperintensity and diffusion restriction may appear, which may lead to misdiagnosis as an abscess.[8–12] Among the six cases of central nervous system TB in the study, two presented with tuberculomas. Lesions were commonly located at the corticomedullary junction, with additional occurrences in the cerebellum and brainstem. The lesions were predominantly caseating in one patient, while a combination of caseating and non-caseating forms was observed in the other. No diffusion restriction was noted in tuberculomas, reducing the likelihood of misdiagnosing a TB abscess.

Spinal arachnoiditis accounts for up to 70% of pediatric TB meningitis cases. MRI findings include enhancing subarachnoid nodules, clustering of nerve roots, abnormal signals with cord enhancement, and CSF loculations. Although spinal arachnoiditis is often asymptomatic, severe cases can progress to motor or sensory deficits. Spinal cord abscesses or tuberculomas are rare, while epidural TB abscesses represent a spinal manifestation of meningitis.[7,11,13,14] Of the four cases with TB meningitis, only one exhibited spinal involvement, presenting as an epidural abscess.

Musculoskeletal tuberculosis accounts for approximately 20% of pediatric extrathoracic TB cases. Less than half of these patients also present with concurrent pulmonary TB. The most common skeletal manifestations include spondylitis (50%), arthritis (20%), and osteomyelitis (11%). In spondylitis, the lower thoracic and upper lumbar spine are frequently involved. MRI helps differentiate TB spondylodiscitis from pyogenic spondylodiscitis.

Tuberculosis spondylodiscitis typically involves multiple vertebral levels. Its characteristic features include vertebral intraosseous abscesses with relatively preserved disc spaces, severe bony destruction, and well-defined, enhancing paraspinal soft tissue. In later stages, collapse of the vertebral bodies and gibbus deformity may develop.[15,16] In this study, three patients presented with spondylitis: two with middle thoracic involvement and one with lower thoracic involvement. Radiologically, these lesions were typical of TB spondylitis, showing multiple vertebral involvements, vertebral intraosseous abscesses, relatively preserved disc spaces, and enhancing paravertebral soft tissue. Gibbus deformity was observed in two of these patients. All patients with spondylitis also had coexisting pulmonary tuberculosis.

Tuberculous arthritis typically presents as a monoarthritic condition, most commonly affecting the hip and knee joints. Tuberculous arthritis usually originates from metaphyseal osteomyelitis and spreads transphyseally. Classic radiographic features, known as Phemister's triad, consists of juxta-articular osteoporosis, peripheral bony erosions, and gradual joint space narrowing.[9,16] In this study, one patient exhibited TB arthritis in the knee, with follow-up X-rays showing typical Phemister's triad features.

Tuberculous osteomyelitis commonly affects the long tubular bones, particularly in the lower limbs.[17] It is usually located at the metaphysis or epiphysis and may extend transphyseally from the metaphysis.[18] Compared to pyogenic osteomyelitis, tuberculous osteomyelitis shows less sclerosis, sequestra, and periosteal reaction. It can mimic tumors, such as Langerhans cell histiocytosis and Ewing sarcoma, or other infections like fungal and pyogenic types. Multifocal involvement occurs in approximately 5–10% of skeletal tuberculosis cases and is often associated with concurrent pulmonary infections.[9] In this study, all four cases of osteomyelitis were located in the metaphysis of long tubular bones. In three cases involving children around 18 months old, transphyseal spread led to epiphyseal extension. The infection reached the epiphysis because vascular canals remain open in young children until about 18 months of age.[19] All patients exhibited soft tissue involvement, with three demonstrating soft tissue abscesses. None of the patients with TB osteomyelitis showed coexisting pulmonary infection.

Abdominal TB is rare in children, accounting for only 1% to 3% of all extrathoracic TB cases.[10] Abdominal TB can spread through hematogenous and lymphatic routes, ingestion of infected lung secretions, or through infected lymph nodes. It presents in four types: nodal, peritoneal, gastrointestinal, and solid organ involvement, with the nodal form being the most common. The mesenteric, paraaortic, periportal, and peripancreatic nodes are commonly involved.[20] TB lymph nodes

typically appear on CT and MRI as peripherally enhancing, enlarged clusters with central necrosis.[21] In children, peritoneal involvement often arises from the contiguous spread of pulmonary disease, intestinal disease, or lymphadenopathy.[16] The wet form, characterized by free or loculated ascites, is the most common presentation of peritoneal involvement in abdominal TB.[22] Gastrointestinal TB frequently affects the terminal ileum, with common imaging features including annular wall thickening in the cecum and terminal ileum, often accompanied by lymphadenopathy.[23] In this study, three patients had abdominal TB. The most common finding was peritonitis, presenting as ascites in all three cases. Mesenteric TB-infected lymph nodes were identified in two patients with TB peritonitis, and terminal ileal involvement was present in one patient with TB peritonitis. No solid organ involvement was noted in patients with extrathoracic TB, in this study.

Tuberculosis of the urogenital system is rare in children.[16] Pelvicaliectasis, parenchymal scarring, calcification, and retroperitoneal lymphadenopathy are the most common presentations[9] of urogenital TB. In this study, no patients showed urogenital involvement.

CONCLUSION

Tuberculosis can affect extrathoracic sites. Recognizing the classic radiological findings of pediatric extrathoracic TB is crucial for making a definitive diagnosis, initiating appropriate treatment, and preventing long-term morbidity.

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