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PEDIATRIC CENTRAL NERVOUS SYSTEM TUBERCULOSIS: A CROSS-SECTIONAL HOSPITAL-BASED STUDY

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Abstract

Background Central nervous system (CNS) tuberculosis is the most severe form of extrapulmonary tuberculosis in children, commonly presenting as tuberculous meningitis and associated with high mortality and long-term neurological sequelae. Early diagnosis remains challenging due to nonspecific clinical features and varied presentation. ***Methodology*** This cross-sectional study was conducted in the Department of Paediatrics, Sree Mookambika Institute of Medical Sciences, Kulasekharam, from May 2025 to January 2026. Children with suspected CNS tuberculosis fulfilling predefined clinical, radiological, and laboratory criteria were included. Detailed history, clinical examination, hematological investigations, tuberculin skin testing, cerebrospinal fluid analysis, and neuroimaging (CT/MRI brain) were performed. Data were recorded in a structured pro forma and analyzed using appropriate statistical methods, with $p<0.05$ considered significant. ***Results*** A total of 65 children were studied. Male predominance was observed. Most cases belonged to lower socioeconomic groups (72.3%). History of contact with tuberculosis was present in 60% of cases. Tuberculous meningitis was the most common presentation (67.7%), followed by tuberculous encephalopathy (18.4%), CNS tuberculoma (4.6%), and TB vasculopathy (6.3%). Pott's spine with paraplegia and brain abscess were rare manifestations (1.5% each). ***Conclusion*** CNS tuberculosis in children predominantly affects lower socioeconomic groups with significant history of TB exposure. Tuberculous meningitis is the most common presentation. Early suspicion and prompt diagnosis are essential to reduce morbidity and mortality.

Keywords: CNS tuberculosis, tuberculous meningitis, children, neurotuberculosis, neuroimaging, CSF analysis.

INTRODUCTION

Central nervous system (CNS) tuberculosis (TB), particularly tuberculous meningitis (TBM), represents the most severe and life-threatening form of infection caused by Mycobacterium tuberculosis. It is associated with high rates of mortality and long-term neurological disability, despite advances in anti-tubercular therapy and intensive care management. TBM contributes disproportionately to tuberculosis-related deaths and remains one of the most devastating manifestations of extrapulmonary TB [1].

The burden of CNS tuberculosis is especially significant because of its aggressive clinical course and delayed diagnosis. Even with appropriate treatment, mortality rates may exceed 50%, and a substantial proportion of survivors are left with permanent neurological sequelae. These include cognitive impairment, developmental delay in children, seizures, hydrocephalus, motor deficits, and cranial nerve palsies, which significantly affect quality of life and long-term functional outcomes [2]. A large number of cases remain undiagnosed or are diagnosed late, particularly in resource-limited settings, leading to poor outcomes due to delayed initiation of therapy [3].

In children, CNS tuberculosis often arises following recent primary infection, typically acquired through close household contact with an infectious adult case. Young children, especially those under five years of age, represent a highly vulnerable group due to their immature immune system and higher risk of progression from primary TB infection to disseminated disease, including CNS involvement. The epidemiology of pediatric CNS TB is not well defined in many regions, particularly in developing countries, where underreporting, limited diagnostic facilities, and lack of systematic surveillance contribute to gaps in knowledge [4].

The pathogenesis of TBM involves hematogenous dissemination of Mycobacterium tuberculosis from a primary pulmonary focus to the meninges and brain parenchyma, leading to the formation of Rich foci. Rupture of these foci into the subarachnoid space results

in intense inflammatory response, causing basal meningitis, vasculitis, infarctions, and hydrocephalus. These pathological processes explain the wide spectrum of clinical manifestations and severe neurological complications associated with CNS TB [5].

Early diagnosis of CNS tuberculosis remains challenging due to its non-specific clinical presentation in the early stages, which often mimics other forms of meningitis. Delay in recognition and treatment initiation is strongly associated with poor neurological outcomes. Therefore, early identification of clinical patterns, radiological findings, and cerebrospinal fluid characteristics plays a crucial role in improving prognosis.

Given the high morbidity, mortality, and diagnostic challenges associated with pediatric CNS tuberculosis, there is a need for detailed clinical and epidemiological studies. Understanding the spectrum of disease presentation in children can aid in early diagnosis, timely management, and reduction of long-term neurological sequelae. In this context, the present study aims to analyze CNS tuberculosis among children in a cross-sectional setting.

Aim and Objectives

Aim

To study the clinical, radiological, and laboratory profile of central nervous system (CNS) tuberculosis among children in a tertiary care setting.

Objectives

1. To describe the clinical spectrum of CNS tuberculosis in pediatric patients.
2. To analyze the common presenting symptoms and neurological signs in children with CNS tuberculosis.
3. To evaluate cerebrospinal fluid (CSF) and neuroimaging findings associated with CNS tuberculosis.

MATERIALS AND METHODS

The present study was conducted in the Department of Paediatrics, Sree Mookambika Institute of Medical Sciences, Kulasekharam, during the study period from May 2025 to January 2026. The study included children of either sex with suspected central nervous system (CNS) tuberculosis who fulfilled the predefined clinical, laboratory, and radiological criteria. Inclusion criteria comprised children presenting with a history of vague ill health lasting 2–8 weeks prior to meningeal signs, including nonspecific symptoms such as malaise, anorexia, fatigue, fever, myalgia, and headache. Clinical features such as neck stiffness, focal neurological deficits, behavioral changes, and altered consciousness were also considered. Additional supporting criteria included fever with weight loss or failure to gain weight, history of contact with tuberculosis in the last two years, positive tuberculin skin test, presence of precipitating illness, abdominal ultrasound suggestive of tuberculosis, cerebrospinal fluid (CSF) findings consistent with tuberculous meningitis, cranial CT findings suggestive of tuberculoma, and relevant clinical history including antiretroviral therapy. Patients who had not received prior anti-tubercular therapy were included in the study, while those already on anti-tubercular treatment were excluded.

All selected patients underwent detailed history taking, thorough general and systemic examination, and relevant hematological investigations including hemoglobin level, total leukocyte count, differential leukocyte count, and erythrocyte sedimentation rate. Radiological investigations included chest X-ray, cranial ultrasound, computed tomography (CT) of the brain, and magnetic resonance imaging (MRI) wherever indicated. Tuberculin skin testing was performed using intradermal injection of 0.1 ml purified protein derivative (PPD-5) into the volar aspect of the forearm. CSF analysis, including culture and sensitivity testing (considered the gold standard), was performed in all cases. Additional investigations were carried out as required to support diagnosis, and all findings were recorded in a predesigned and pretested pro forma.

Statistical analysis was performed using Microsoft Excel and analyzed using SPSS version 24 (IBM SPSS Statistics Inc., Chicago, Illinois, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Appropriate statistical tests such as Chi-square test and Fisher's exact test were applied to assess associations between categorical variables, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1 – Demographic and contact profile: The majority of cases occurred in the youngest age group, 0–5 years (56.9%), indicating that young children are particularly vulnerable to severe, disseminated forms of TB affecting the central nervous system — likely related to their immature cell-mediated immunity, which predisposes to hematogenous spread of mycobacteria beyond the lungs. A mild male predominance was observed (55.4% vs 44.6%). Socioeconomic distribution showed that the large majority of children belonged to the lower middle, upper lower, and lower strata combined (80%), reflecting the well-established link between poverty, overcrowding, undernutrition, and increased risk of TB exposure and progression to severe disease. A history of contact with a known TB case was present in 60% of children, highlighting the important role of household or close-contact transmission in pediatric CNS TB; the substantial 40% without an identifiable

contact history may reflect under-detection of source cases in the community or limitations in contact tracing, and emphasizes the need for more thorough screening of household and close contacts.

Table 1:Age,gender,socioeconomicstatusandhistoryofcontactdistributionamongthestudysubjects

AgeGroup	**N**	**%**
0-5Years	37	56.9
5-10Years	13	20
10-12Years	15	23.1
Gender		
Male	36	55.4
Female	29	44.6
SocioeconomicStatus		
Upper	2	3.1
UpperMiddle	11	16.9
LowerMiddle	25	38.5
UpperLower	22	33.8
Lower	5	7.7
Total	65	100
Historyof Contact		
Yes	39	60
No	26	40

Table2:DistributionofcasesaccordingtotypeofCNStuberculosis

Type	**N**	**%**
TubercularMeningitis	44	67.7
TBVasculopathy	04	6.3
CNSTuberculoma	03	4.6
TuberculousEncephalopathy	12	18.4
TuberculousBrainAbscess	01	1.5
Pott'sspine&pott'sparaplegia	01	1.5
NonOsseousspinaltubrculoma	00	00
SpinalMeningitis	00	00
Total	65	100

Table 2 – Type of CNS tuberculosis: Tubercular meningitis (TBM) was overwhelmingly the most common presentation, accounting for more than two-thirds of cases (67.7%), consistent with TBM being recognized as the most frequent and most severe neurological manifestation of tuberculosis in children. Tuberculous encephalopathy was the second most common form (18.4%), a presentation often attributed to a hypersensitivity reaction to tuberculoprotein and typically seen in younger infants, which aligns with the predominance of the 0–5 year age group in this cohort. The remaining forms — TB vasculopathy (6.3%), CNS tuberculoma (4.6%), tuberculous brain abscess (1.5%), and Pott's spine with paraplegia (1.5%) — were relatively uncommon, together making up less than 15% of cases, but represent clinically important variants that should be considered in children presenting with focal neurological deficits, spinal symptoms, or atypical features.

DISCUSSION

In the present study of pediatric CNS tuberculosis, a slight male predominance was observed, with males constituting a higher proportion of cases compared to females. Similar gender distribution has been reported in previous pediatric tuberculosis studies, where male preponderance is often attributed to increased exposure, sociocultural factors, and healthcare-seeking behavior differences [6]. However, gender differences in CNS tuberculosis are generally not strongly significant and may vary across populations.

Socioeconomic status showed a clear association with disease burden, with the majority of cases belonging to the lower middle (38.5%) and upper lower (33.8%) socioeconomic groups, while only a small proportion (3.1%) belonged to the upper class. This finding highlights the strong relationship between tuberculosis and poverty. Overcrowding, malnutrition, poor ventilation, and limited access to healthcare are well-established risk factors for tuberculosis transmission and progression to severe forms such as CNS involvement [7]. Similar observations have been reported in global TB burden studies, where low socioeconomic conditions

significantly increase the risk of both primary infection and disseminated disease [8].

A history of contact with tuberculosis was present in 60% of cases, emphasizing the importance of close household exposure as a major risk factor in pediatric CNS tuberculosis. Children, particularly those under 10 years of age, are highly susceptible to progression from primary infection to severe disease due to immature cell-mediated immunity. This finding is consistent with previous studies that identified recent household contact as one of the strongest predictors of pediatric TBM [9].

Clinically, tuberculous meningitis (TBM) was the most common presentation, accounting for 67.7% of cases, followed by tuberculous encephalopathy (18.4%). Less common manifestations included TB vasculopathy (6.3%), CNS tuberculoma (4.6%), and tuberculous brain abscess (1.5%). The presence of Pott's spine with paraplegia in 1.5% of cases reflects disseminated tuberculosis involving multiple systems. These findings are consistent with the known spectrum of CNS tuberculosis, where TBM remains the most frequent and severe form due to hematogenous spread of Mycobacterium tuberculosis to the meninges and subarachnoid space [10].

The varied clinical spectrum observed in the present study highlights the diagnostic challenges associated with CNS tuberculosis in children. Early symptoms are often nonspecific, leading to delayed diagnosis and progression to advanced neurological disease. The predominance of TBM in our study aligns with literature indicating that it is the most common CNS manifestation and carries the highest risk of mortality and long-term neurological sequelae [11].

Overall, the findings emphasize that pediatric CNS tuberculosis predominantly affects children from lower socioeconomic backgrounds with a history of close contact exposure. The high proportion of TBM underscores the need for early clinical suspicion, prompt neuroimaging, and CSF evaluation for timely diagnosis and management.

CONCLUSION

The present study highlights that central nervous system (CNS) tuberculosis in children predominantly affects those from lower socioeconomic backgrounds and those with a positive history of tuberculosis contact. Tuberculous meningitis remains the most common clinical presentation, followed by other severe manifestations such as tuberculous encephalopathy, vasculopathy, and tuberculoma.

The study emphasizes the wide clinical spectrum of CNS tuberculosis and the diagnostic challenges due to its nonspecific early presentation. The findings underline the importance of maintaining a high index of suspicion in children presenting with prolonged fever, neurological symptoms, and a history of TB exposure.

Early recognition through clinical evaluation, neuroimaging, and cerebrospinal fluid analysis is crucial for timely initiation of treatment. Prompt diagnosis and management are essential to reduce morbidity, prevent neurological sequelae, and improve overall outcomes in pediatric CNS tuberculosis.

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