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Original Article

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Comparison of CT findings between pyogenic meningitis and tuberculosis meningitis at a tertiary care Hospital

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ABSTRACT

BACKGROUND & OBJECTIVES: Early detection and management of tuberculous meningitis (TBM) can improve prognosis. TBM and pyogenic meningitis (PM) present with similar symptoms. This study aimed to determine the frequency of TBM and PM in children with meningitis and compare their CT findings.
METHODOLOGY: This study was conducted in the Department of Paediatrics, The Children's Hospital, Lahore, from 1st January to 31st June 2025. A total of 94 children aged 4 months to 14 years who fulfilled the diagnostic criteria for TBM or PM were included. After informed consent, contrast-enhanced CT scans were performed and assessed for basal enhancement, hydrocephalus, infarction, and intracranial tuberculoma. Data were analyzed using SPSS version 20. Chi-square test was applied, with $p < 0.05$ considered significant.
RESULTS: Of the study population, 49 children (52.1%) had PM and 45 (47.9%) had TBM. Basal enhancement was more frequent in TBM (77.8% vs 51.0%, $p = 0.020$) than in PM. Hydrocephalus (55.6% vs 32.7%, $p = 0.012$), infarction (42.2% vs 22.4%, $p = 0.018$), and intracranial tuberculomas (35.6% vs 10.2%, $p = 0.001$) were also significantly higher in TBM.
CONCLUSION: CT (computed tomography) helps differentiate TBM from PM in children. Key findings basal cisternal enhancement, hydrocephalus, infarction, and tuberculomas support the diagnosis of TBM. These features aid early recognition and treatment in resource-limited settings.
KEYWORDS: Tuberculous Meningitis, Meningitis, Tomography, X-Ray Computed, Child, Hydrocephalus.

INTRODUCTION

Tuberculous meningitis (TBM) is an extra-pulmonary form of tuberculosis (TB) characterized by sub-acute or chronic inflammation of the meninges as a result of invasion of the subarachnoid space by Mycobacterium tuberculosis bacilli [1]. Meningitis has been one of the major causes of morbidity and mortality among children, especially in low- and middle-income countries, where the outcomes were worse due to delayed diagnostic processes and limited access to sophisticated imaging. New data in South Asia underscores the importance of both bacterial meningitis and tuberculous meningitis (TBM) to still have a significant disease burden, coupled with long-term neurological adverse effects in a significant proportion of children, many of whom have contracted the disease [2]. A systematic review of meningitis in India also pointed out that the incidence of central nervous system infections has been at a high level all over the years, which indicates the differences in the regional epidemiology, vaccination rates, and healthcare access [3].

TBM is known to be the most difficult type of extrapulmonary tuberculosis. Early diagnosis plays a very important role in preventing severe consequences. Recent imaging-based research in Bangladesh and southern India shows that computed tomography (CT) often reveals basal cisternal enhancement (swelling of spaces at the base of the brain), hydrocephalus (abnormal buildup of fluid in the brain), infarctions (areas of tissue death), and intracranial tuberculomas (tuberculous masses within the brain). These features strongly imply that TBM can be identified by imaging soon after onset. These radiological results highlight the importance of imaging in distinguishing TBM from other causes of meningitis. This is especially crucial where advanced imaging methods such as MRI are not readily available.

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On the other hand, pyogenic meningitis (PM) can be characterized by such acute symptoms as fever, vomiting, irritability, and seizures. A report on the pediatric cohort of Nepal stated that acute bacterial meningitis is still linked with high rates of seizures, altered consciousness, and elevated intracranial pressure and that it should be regarded as the necessity to identify it early and provide aggressive treatment in children [5]. In PM, CT can be normal at the onset of the disease to cerebral edoema or ventricular effusion, and it can be hard to tell PM and TBM apart by using clinical features alone.

Neuroimaging plays a crucial role in the assessment of children with suspected central nervous system infections. Despite the high sensitivity of MRI in the detection of early infarctions and small parenchymal lesions, CT is the most universal and convenient imaging modality in low-resource and emergency practice. Mondal (2022) demonstrated that CT and MRI often show clinically significant abnormalities of children with treatment-related seizures, further justifying the use of CT as a first-line diagnostic test in numerous conditions related to paediatric neurology [6].

The results of cerebrospinal fluid (CSF) analysis remain part of meningitis evaluation, but interpretation may be complicated in cases where meningitis is partially treated or in its early stages. Recent recommendations state that CSF values can be used in conjunction with neuroimaging and clinical manifestations to enhance the process of diagnosis in suspected children with meningitis [7]. An important role of CT in the initial assessment of meningitis is that, in most clinical circumstances, CT is the pretest before lumbar puncture to rule out hydrocephalus, mass effect, or contraindication to the procedure.

Because of the clinical overlap between TBM and PM, the high prevalence of neurological complications, and the role of CT in the daily clinical practice of the pediatric population, it is important to develop reliable CT imaging patterns to aid in the timely differentiation. Thus, the current research is expected to establish the rates of TBM and PM amongst the children presenting with meningitis at a tertiary care hospital and to compare their CT results, considering the current evidence in the area.

The infection of tuberculosis is possible when the aerosols with M. tuberculosis bacilli are inhaled. The organism infiltrates lung epithelium and triggers the actions of lung cells (i.e., alveolar macrophages, neutrophils, and dendritic cells), which release cytokine and chemokine molecules that become a part of immune protection [8].

Another study shows that the CT findings (basal enhancement 40.90% vs. 12.5%), hydrocephalus (65.90% vs. 16.66%), tuberculoma (20.45% vs. 0.0%), and infarction (18.18% vs. 8.13%) were found to be more common in the TBM than in PM. TBM was found in 46/79 (88.2%) and pyogenic meningitis in 33/79 (41.8%) [8]. CT scan has become a highly accessible investigation with less marginal cost in the hospitals among the public sectors. It is the opinion that the diagnostic complication we experienced with meningitis in our patients will be eliminated of most cases after these patients undergo a CT scan. Such access of such data in a high-burden developing country such as Pakistan could be useful in foreseeing the prognosis of such patients and taking early preventive measures to mitigate the outcome. The hardware- and operator-sensitive method of CT implies the necessity to reconsider known results of CT in the local context and subsequently make it a part of practice. Thus, additional studies are essential to determine the best way to integrate CT in the diagnostic route of the pediatric spectrum to enhance clinical care. The outcomes of the current research will provide a glimpse into the scale of the issue and define local background statistical data in this respect, to support further studies in the field.

The research aims at identifying the frequency of tuberculous meningitis (TBM) and pyogenic meningitis in cases of meningitis and comparing the frequencies of CT results in cases of pyogenic meningitis and tuberculous meningitis at a tertiary care hospital.

METHODOLOGY

After approval from the ethical review committee of the CPSP (Ref No: CPSP/REU/PED-2022-075-7123), 94 cases presenting to the Department of Paediatrics, CHL, meeting the inclusion criteria were enrolled in the study. The study was an observational cross-sectional study conducted from 1st January to 31st June 2025. Written informed consent and detailed history were obtained from the parents/guardians of each patient. A sample size of 94 cases was calculated using a 95% confidence interval and a 10% margin of error, with a pyogenic meningitis frequency of 41.8%.8 The sampling technique was non-probability, consecutive sampling.

The inclusion criteria were children of both genders aged 4 months to 14 years with a diagnosis of either tuberculous meningitis (TBM) or pyogenic meningitis (PM) as per the operational definition, and whose parents or guardians had provided informed consent. The exclusion criteria were diagnosed cases of brain tumor or cyst of any type or size, as well as recurrent and operated cases; history of head trauma in the last year; children with absolute contraindications for CT such as implants, pacemakers, or a history of metallic foreign bodies inside the body; children with contraindications to lumbar puncture such as bleeding disorders, platelet count <50,000, and patients with severely deranged renal function or failure to obtain an adequate volume of CSF (>5 ml).

Patients with presumed TBM or pyogenic meningitis were assessed according to operational definitions. Every patient who met the criteria for pyogenic or tuberculous meningitis underwent a CT scan of the brain (with IV contrast) at the Department of Radiology of the same institute. The scans were performed using a Toshiba Xpress machine, with the slice direction parallel to the orbito-meatal plane and slice thicknesses of 5-8 mm. Conray 420 was used as the contrast medium at a dose of 1 mL/kg, administered intravenously.

The CT scans were reported by a single consultant radiologist (with 8 years of teaching experience) to ensure consistency and minimize inter-observer variation. The CT scan reports of both groups were analysed for the presence of basal enhancement, hydrocephalus, infarction, and intracranial tuberculoma. Tuberculous meningitis (TBM) was defined as the presence of any two or more specified clinical features fever >99°F for over two weeks, persistent dull headache for ≥7 days, vomiting ≥3 times/day for ≥3 days, or TB contact within the past 2 years together with at least one positive laboratory finding, including AFB smear or culture positive for Mycobacterium tuberculosis, or CSF showing lymphocytic pleocytosis (20–500/mm³), protein >100 mg/dl, and glucose <60% of plasma level.

Pyogenic meningitis (PM) was diagnosed based on a positive CSF Gram stain or culture for pyogenic organisms, with clinical and CSF improvement on antibiotics. CT findings were defined as follows: basal enhancement contrast filling cisterns or related patterns; hydrocephalus ventricular dilatation >25% of normal; infarction hypodensity in ≥1 arterial territory; intracranial tuberculoma diffuse white matter hypodensity in specific brain regions with surrounding edema suggestive of mass lesion.

All collected data were entered and analyzed using SPSS version 20. Numerical variables, such as age and weight, are presented as mean ± SD. Categorical variables, including gender, type of meningitis, and outcomes such as basal enhancement, hydrocephalus, infarction, and intracranial tuberculoma (yes/no), are given as frequencies and percentages. CT findings in both groups were compared using the Chi-square test. Data were stratified by age, gender, and weight to control for effect modifiers. After stratification, the Chi-square test was applied, with a p-value of <0.05 considered statistically significant.

RESULTS

The mean age of participants was 6.8 ± 3.9 years, with the majority (41.5%) in the 2 months -4 years age group. Males comprised 58.5% of the participants, while females constituted 41.5%. The mean weight was 20.4 ± 8.6 kg, with most participants (60.6%) weighing ≤ 20 kg (Table-I).

Table- I: Baseline Characteristics of the Study Population (n = 94).

Variable	Categories	n (%)
Age (years)	2 months-4	39 (41.5)
	5-9	34 (36.2)
	10-14	21 (22.3)
Gender	Male	55 (58.5)
	Female	39 (41.5)
Weight(kg)	≤ 20	57 (60.6)
	>20	37 (39.4)

Basal enhancement was significantly more frequent in tuberculous meningitis (77.8%) compared to bacterial meningitis (51.0%, p = 0.020). Hydrocephalus was also more common in tuberculous cases (55.6% vs. 32.7%, p = 0.012). Similarly, infarction (42.2% vs. 22.4%, p = 0.018) and intracranial tuberculoma (35.6% vs. 10.2%, p = 0.001) were significantly higher in the tuberculous meningitis group (Table-II).

Table II: Comparison of CT findings between bacterial and tuberculous meningitis.

CT Finding	Category	PM n(%)	TBM n(%)	P-value
Basal Enhancement	Yes	25 (51.0)	35 (77.8)	0.020
	No	24 (49.0)	10 (22.2)	
Hydrocephalus	Yes	16 (32.7)	25 (55.6)	0.012
	No	33 (67.3)	20 (44.4)	
Infarction	Yes	11 (22.4)	19 (42.2)	0.018
	No	38 (77.6)	26 (57.8)	
Tuberculoma	Yes	5 (10.2)	16 (35.6)	0.001
	No	44 (89.8)	29 (64.4)	
Total		49(100)	45(100)	

DISCUSSION

Brain imaging can play a significant role in identifying the presence of tuberculous meningitis (TBM) or pyogenic meningitis (PM) when there are limited possibilities of using molecular diagnostic tests in low-resource settings. Computed tomography (CT) has been popular because of its availability and potential to provide meaningful information, facilitating early diagnosis and proper management among the available modalities [9]. The aim of the current study was to determine the prevalence of TBM and PM among children presenting with meningitis and to compare CT findings in a tertiary care hospital.

The age distribution in our study, with the majority of the cases being in the younger children (2 months to 4 years old), is associated with current research in the area and the region. A Pakistan-based study of 2024 has documented an average age of only 3 months when children had bacterial meningitis but a mean age of 2.81+-2.29 years when the tuberculosis patients were studied in Abbotabad [10,11].

In our research on efficiency, the prevalence of the basal meningeal enhancement was very high in children with tuberculous meningitis (77.8%). It was lower in children with bacterial meningitis (51.0, p = 0.020). These results are in line with the recent literature on paediatric imaging, which reports basal meningeal enhancement in 75-92 per cent of cases of tuberculous meningitis [12]. In our research, Hydrocephalus was seen in 55.6 per cent of children with tuberculous meningitis and 32.7 per cent of those with pyogenic meningitis (p =0.012). MRI was also used in a study conducted in Peshawar that showed an increased prevalence of hydrocephalus in tuberculous meningitis, though the frequency was lower (22.6%) [13]. Such a difference can be explained by differences in imaging methods, the timing of presentation, or the diagnostic criteria used. In contrast, in both publications, hydrocephalus was more common in TBM (our data: 55.6% vs. 32.7, p =0.012; Ahmad et al14 (28.0% vs. 19.8, p =0.032) and this supports the value of hydrocephalus as a helpful radiological sign of TBM. Relating to the tuberculomas, we found the prevalence of 35.6 in TBM,.102 in bacterial meningitis (p = 0.001), which is consistent with [13].

A noticeable difference is associated with infarctions; in our case, infarction was more common in TBM (42.2% vs 22.4, p = 0.018), and in the study by Ahmad et al., infarction was more common in the case of bacterial meningitis (38.4% vs 18.3, p = 0.001). This variation could be due to a difference in the population of the studies, imaging modalities (CT and MRI) or within the timing of imaging compared to the disease progression. Generally, although both articles lead to the same conclusion regarding the diagnosis of tuberculomas and hydrocephalus, interpreting the neuroimaging as evidence of either TBM or bacterial meningitis, the discordant patterns in infarction can illuminate the significance of context dependent interpretation of the neuroimaging.

Consistent with our findings, recent clinical recommendations and evidence-based reviews also note that basal cisternal hyperplasia, hydrocephalus, infarction, and intracranial tuberculomas are the typical radiological features that can be used to differentiate between tuberculous and pyogenic meningitis. Another point that is emphasized in these sources is the fact that MRI is superior in its sensitivity over CT, especially in the detection of small tuberculomas and early ischemic changes [13].

LIMITATION: There are a number of limitations of this study. First, it was a one-centre study that was carried out in a tertiary care hospital, thereby not making the generalization of the results to other healthcare conditions practical, especially where limited dynamic diagnostic tools are available. Second, only CT scans were performed; even though a commonly available technique, CT performs worse than MRI in terms of implicating early ischemic changes, as well as small tuberculomas, which could have provided underreported findings. Third, TBM and pyogenic meningitis were diagnosed based on interactionally determined and rational definitions and on available microbiological evidence; not all cases could have been culture-confirmed, which could have led to misclassification bias. Last but not least, the sample size is relatively small, which may reduce the statistical power to detect subtle differences among groups.

CONCLUSION

In this research, we have shown that certain CT appearances are more common in children with tuberculous meningitis than in those with pyogenic meningitis, specifically basal enhancement, hydrocephalus, infarction, and intracranial tuberculomas. When these radiological characteristics are interpreted alongside clinical and laboratory data, they can help distinguish early TBM from pyogenic meningitis in children.

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Asim Khan: Substantial contributions to the conception and design of data for the work.
Wajiha Rizwan : Interpretation of data and reviewing it critically for important intellectual content.
Ayesha Akram: Analysis of data for the work.
Bilal Zafar : Drafting the work.
Khaver Ali: Final approval of the version to be published.