European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Original Research Article

Frequency of Tuberculomas in Diagnosed Cases of Tuberculous Meningitis on Magnetic Resonance Imaging (MRI)

Article History:

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Received: 17-11-2025
Revised: 19-12-2025
Accepted: 23-12-2025
Published: 30-12-2025

Abstract: **Objective:** To determine the frequency of tuberculomas in diagnosed cases of tuberculous meningitis on magnetic resonance imaging in pediatric patients. **Study Design:** Descriptive cross-sectional study. **Place and Duration of Study**: Conducted from 10 August 2025 to 10 November 2025. at Department of Diagnostic Radiology, Liaquat University Hospital Jamshoro .**Methodology:** A total of 110 children aged 6 months to 14 years with magnetic resonance imaging diagnosis of tuberculous meningitis were included. Tuberculomas were identified on basis of signal characteristics. Data were analyzed by Statistical Package for Social Sciences version 26. Mean ± standard deviation was calculated for age, weight and height. Frequency and percentage were calculated for gender, residence, tuberculomas, type of tuberculomas, number of lesions, location of lesion and size of lesion. Chi square test and Fisher exact test were applied, and p value <0.05 was taken as significant. **Results:** Mean age was 7.44 ± 4.17 years. Males were 67 (60.9%) and rural residents were 69 (62.7%). Tuberculomas were detected in 6 (5.50%) patients. Caseating type was found in 5 (83.30%) and non-caseating in 1 (16.70%). Supratentorial location was seen in 5 (83.30%) cases. No significant association was observed with age (p=0.679), gender (p=1.000), residence (p=0.193) and clinical features (p=0.259). **Conclusion:** Tuberculomas were infrequent in pediatric tuberculous meningitis and mostly caseating and supratentorial in location.

Keywords: Child; Magnetic Resonance Imaging; Meningitis, Tuberculous; Tuberculoma; Tuberculosis

INTRODUCTION

Tuberculous meningitis is the most severe form of extrapulmonary tuberculosis, resulting from the dissemination of Mycobacterium tuberculosis to the meninges.[1] It tends to be more common in children and immunocompromised patients, with a high mortality rate and potential for neurological sequelae.[2]

Patients with tuberculous meningitis present with symptoms such as fever, headache, vomiting, stiff neck, altered level of consciousness, and sometimes seizures and neurological deficits.[3] The progression of the disease is usually subacute, occurring over weeks, and if not treated, complications such as hydrocephalus, stroke, and cranial nerve palsies can occur.[4]

Magnetic resonance imaging (MRI) is an essential tool for the diagnosis of tuberculous meningitis, along with its complications. MRI is more sensitive than computed tomography (CT) in the detection of basal meningeal enhancement, hydrocephalus, infarcts, and parenchymal lesions.[5] On the other hand, basal exudates and meningeal thickening are seen during the enhanced MRI scan. Moreover, diffusion-weighted imaging helps in the early detection and differentiation of infarcts.[6] MRI is also used for assessing the severity and managing the disease, especially in the presence of complications.

Tuberculomas are granulomatous mass lesions that are visible on MRI in cases of tuberculous meningitis.[7] They are either solitary or multiple in number, located in the supratentorial or infratentorial compartment, or in any combination thereof. [8] Non-caseating types of tuberculomas are hypointense on

T1-weighted images, hyperintense on T2-weighted images, and show homogeneous enhancement on MRI, while caseating types are isointense or hypointense on T1- and T2-weighted images, with ring enhancement.[9] The occurrence of tuberculomas in cases of tuberculous meningitis varies, depending on the age group and severity of the disease, and their demonstration on MRI scans is significant because these lesions could be mistaken for other mass lesions.[10]

Tuberculosis is endemic in the region, and tuberculous meningitis is a significant cause of morbidity in the pediatric population attending the tertiary care hospital in Jamshoro. Data regarding the incidence of tuberculomas on MRI scans in this region are limited. The rationale for this study is to assess the local incidence and MRI findings of tuberculomas, which will enable the early diagnosis and management of the disease and lay the groundwork for further research in the region of Jamshoro.

METHODOLOGY

This descriptive cross-sectional study was carried out at Department of Diagnostic Radiology, Liaquat University Hospital Jamshoro, from 10 August 2025 to 10 November 2025. Approval was taken from hospital ethical review committee of Liaquat University Hospital Jamshoro before starting data collection The approval reference number was No. LUMHS/REC/-805 dated 03-06-2025. Study was started only after permission was granted from concerned authorities. Sample size was calculated by using WHO sample size calculator on basis of previous study by Prakash N et al 2024 which reported 4.8% frequency of tuberculoma in patients with tuberculosis meningitis.11 By taking 95% confidence interval and 4% margin of error, total 110 patients of TBM were required.

Children with age 6 months to 14 years, either gender and having diagnosis of tuberculosis meningitis on MRI were included in study. Patients having non-specific tuberculoma MRI findings were excluded. Children with known noninfectious causes of acute CNS presentation including trauma, toxic exposure, malignancy, epilepsy, suspected metabolic disorder, cerebrovascular accidents and febrile seizures were not included. Patients suffering from other CNS infections like pyogenic meningitis, viral encephalitis and rickettsial infection were also excluded. Tuberculosis meningitis was considered when MRI brain showed basal meningeal enhancement, hydrocephalus or infarcts suggestive of TB infection in appropriate clinical setting. Written informed consent was taken from parents of all enrolled children. They were informed about confidentiality, anonymity and purpose of research before participation.

A thorough clinical history was taken, and all patients underwent brain imaging with a 1.5 T MRI scanner. Routine T1-weighted and T2-weighted images, along with contrast T1-weighted images and diffusion-weighted images, were obtained. The details of the number of lesions (single or multiple), their locations (supratentorial or infratentorial), size of lesion, and signal characteristics (caseating or non-caseating) were carefully noted. After obtaining the images, the images were reviewed to check for the presence or absence of tuberculomas and other abnormalities including basal meningeal enhancement, hydrocephalus and infarcts. Tuberculomas were detected based on their signal characteristics. A non-caseating granuloma is a lesion that is hypointense on T1, hyperintense on T2, shows no diffusion restriction, and shows homogeneous contrast enhancement. A caseating granuloma is a lesion that is isointense to cortex on T1, shows low signal intensity on T2, shows homogeneous or peripheral enhancement, and shows no diffusion restriction.

Data were entered and analyzed by using SPSS version 26.

Quantitative variables including age, weight and height were presented as mean ± standard deviation. Categorical variables like gender, residence, tuberculomas, type of tuberculomas, number of lesions, locations of lesion and size of lesion were expressed as frequency and percentage. Stratification was done with respect to age, gender, residence and symptoms to see their effect on frequency of tuberculomas. Fisher exact test was applied for comparison. P value <0.05 was taken as statistically significant.

RESULTS

The study was conducted on a total of 110 diagnosed cases of tuberculous meningitis. The mean age of the patients was 7.44 ± 4.17 years, with mean weight of 24.87 ± 11.86 kg and mean height of 120.12 ± 26.80 cm. Among the study participants, majority was males 67 (60.9%) while females were 43 (39.1%). Regarding residence, most of the patients belongs to rural areas 69 (62.7%) as compare to urban 41 (37.3%). The most common presenting sign and symptom was fever which was found in 42 (38.2%) patients, followed by headache in 26 (23.6%), impaired consciousness in 15 (13.6%), vomiting in 14 (12.7%), focal neurological signs in 7 (6.4%), and seizures in 6 (5.5%) of the patients (Table 1).

Table 1. Patient Demographics

Demographics	Mean ± SD
Age (Years)	7.44 ± 4.17
Weight (kg)	24.87 ± 11.86
Height (cm)	120.12 ± 26.80
Gender	
Male n (%)	67 (60.9%)
Female n (%)	43 (39.1%)
Residence	
Rural n (%)	69 (62.7%)
Urban n (%)	41 (37.3%)
Signs & Symptoms	
Fever n (%)	42 (38.2%)
Headache n (%)	26 (23.6%)
Vomiting n (%)	14 (12.7%)
Impaired Consciousness n (%)	15 (13.6%)
Focal Neurological Signs n (%)	7 (6.4%)
Seizures n (%)	6 (5.5%)

Out of 110 patients, tuberculomas was detected in only 6 (5.50%) cases on magnetic resonance imaging. Among those six cases who had tuberculomas, caseating type was more common and found in 5 (83.30%) cases whereas non-caseating type was seen only in 1 (16.70%) case. The distribution of lesions was equally divided between single and multiple, with 3 (50.00%) cases each. Regarding location, supratentorial lesions were more predominant and noted in 5 (83.30%) cases while infratentorial location was observed in only 1 (16.70%) case (Table 2).

Table 2. Frequency of Tuberculomas in Diagnosed Cases of Tuberculous Meningitis on MRI n=110

Variable	Frequency	%age
Tuberculomas		
Yes	6	5.50%
No	104	94.50%
Total	110	100%
Type of Tuberculomas		
Caseating	5	83.30%
Non-caseating	1	16.70%
Total	6	100%
Number of Lesions		
Single	3	50.00%
Multiple	3	50.00%
Total	6	100%
Location of Lesion		
Supratentorial	5	83.30%
Infratentorial	1	16.70%
Total	6	100%

In age group of ≤7 years, tuberculomas was present in 4 (7.3%) patients, while in age group >7 years it was found in 2 (3.6%) patients, with no statistically significant difference (p=0.679). When gender was analyzed, tuberculomas was detected in 4 (6.0%) males and in 2 (4.7%) females, and again the difference was not significant (p=1.000). On the basis of residence, tuberculomas was identified in 2 (2.9%) patients from rural areas and in 4 (9.8%) patients from urban areas, though this association also did not reach statistical significance (p=0.193). Among the signs and symptoms subgroups, tuberculomas was present in 2 (4.8%) patients with fever, 1 (7.1%) with vomiting, 2 (13.3%) with impaired consciousness, and 1 (14.3%) with focal neurological signs, while no tuberculomas was detected among patients who had headache or seizures, however overall association with signs and symptoms was not statistically significant (p=0.259) (Table 3).

Table 3. Association of Tuberculomas with Demographic Factors.

Demographic Factors	Subgroups	Tuberculomas		p-value
		Yes n(%)	No n(%)	
Age Group (years)	≤7	4 (7.3%)	51 (92.7%)	0.679*
	>7	2 (3.6%)	53 (96.4%)	
Gender	Male	4 (6.0%)	63 (94.0%)	1.000*
	Female	2 (4.7%)	41 (95.3%)	
Residence	Rural	2 (2.9%)	67 (97.1%)	0.193*
	Urban	4 (9.8%)	37 (90.2%)	
Signs & Symptoms	Fever	2 (4.8%)	40 (95.2%)	0.259*
	Headache	0 (0.0%)	26 (100.0%)	
	Vomiting	1 (7.1%)	13 (92.9%)	
	Impaired Consciousness	2 (13.3%)	13 (86.7%)	
	Focal Neurological Signs	1 (14.3%)	6 (85.7%)	
	Seizures	0 (0.0%)	6 (100%)	

Fischer Exact Test

DISCUSSION

In this study, the mean age was found to be 7.44 ± 4.17 years, with males dominating the group with 67 (60.9%). This finding is in keeping with the established fact that tuberculosis infection is more prevalent in children in developing countries where malnutrition and poor hygiene are rife, and where males are more exposed to the outdoors and thus more likely to contract the infection. The frequency of tuberculomas was found to be 6 (5.50%), which is relatively low. This could be because it is a late complication of tuberculous meningitis and the fact that the patients present early in the disease before the tuberculomas have had the opportunity to develop and present with MRI findings. In the group of patients with tuberculomas, the caseating type was more prevalent 5(83.30%) than the non-caseating type 1(16.70%). This is because caseating necrosis is the hallmark of tuberculous infection, resulting from the delayed hypersensitivity response to the Mycobacterium tuberculosis antigens, which causes central caseation with the formation of a cheese-like material in the granuloma. Supratentorial localization was more prevalent 5(83.30%) than the infratentorial localization 1(16.70%), and this is because the supratentorial area is more vascular and larger, and thus more likely to have the hematogenous spread Mycobacterium tuberculosis infection result in lesions in this area.

The frequency of tuberculomas was found to be 6 (5.50%) in the present study. This is comparatively lower than what was reported by Nabi et al. 13 where tuberculomas was detected in 33 (53%) of 62 patients who underwent MRI, and also lower than Abdelmalek et al. 12 who found tuberculomas in 19 of 29 (65.5%) patients on MRI. This difference in frequency may be because the present study was conducted on pediatric population only and patients was presented in relatively early stage of disease before tuberculomas had fully developed, also sample size of present study was larger and more representative of general tuberculous meningitis population. Regarding type of tuberculomas, caseating type was more predominant and found in 5 (83.30%) cases while non-caseating was seen in only 1 (16.70%) case in present study. This finding is supported by Shahzad et al. 14 who noted that hypo-intense core with hyper-intense rim on T2 weighted images which is a feature of caseating tuberculoma was seen in 6 (30%) of their patients, and they also highlighted that early non-caseating nature of tuberculoma is indicated by hyper-intensity on T2 with meningeal enhancement. The predominance of caseating type in present study suggest that most patients was presented at a relatively advanced stage of granuloma formation where central necrosis had already occurred via delayed type hypersensitivity mechanism. In the present study, both single and multiple lesions was equally distributed with 3 (50%) cases each. This is somewhat different from Shah et al. [15] who reported multiple tuberculomas in 18 (64%) and single in 10 (36%) patients, and Nabi et al. 13 who found multiple tuberculomas in 82.4% cases. Similarly, Shahzad et al. [14] also found multiple lesions in 18 (90%) patients and Azam et al. 16 reported more than one lesion in 6 of 9 tuberculoma patients. The higher frequency of multiple lesions in these studies as compared to present study may be explained by the fact that those studies included adult patients or had more advanced disease at presentation, and hematogenous dissemination of mycobacterium tuberculosis tend to produce multiple foci more commonly in immunocompromised or advanced cases. Supratentorial location was more common and observed in 5 (83.30%) cases while infratentorial was seen in only 1 (16.70%) case in present study. This finding is in agreement with Nabi et al. [13] who reported supratentorial only involvement in 20.5% of cases, however they also found combined

supratentorial and infratentorial involvement in 64.7% which suggest more widespread disease in their cohort. The predominance of supratentorial location in present study is consistent with known pathophysiology that supratentorial compartment has greater cerebral blood flow and larger parenchymal volume, which make it more susceptible to hematogenous seeding of mycobacterium tuberculosis.

No statistically significant association was found between tuberculomas and age (p=0.679), gender (p=1.000), residence (p=0.193), and signs and symptoms (p=0.259) in present study. This non-significant finding is likely attributable to very small number of tuberculomas cases which was only 6 (5.50%), making it statistically difficult to establish any meaningful association. Mandour et al. [17] also highlighted that tuberculomas can develop paradoxically during treatment regardless of patient demographic characteristics, which further support the idea that tuberculomas development may not be strongly linked to basic demographic variables.18 The overall low frequency of tuberculomas in present study as compared to other studies [12,13] suggest that MRI was able to detect early and fewer lesions in this pediatric cohort, and this also highlight the importance of MRI as a sensitive imaging modality for detection of tuberculomas in tuberculous meningitis patients as was also emphasized by Nabi et al. [13] and Abdelmalek et al.[12]

There are limitations to the present study, which are acknowledged here. The present study was conducted in a single center, and this might have affected the wider applicability of the present study to the general population. The sample size was small, and this might have affected the statistical power, especially for tuberculomas, which were present in only six patients. Patients were not followed up, and this would have helped assess the progression of tuberculomas. Moreover, the present study was cross-sectional, and the cause-and-effect relationship between demographic factors and tuberculoma formation could not be assessed.

CONCLUSION

The present study concludes that tuberculomas are an uncommon yet clinically significant complication of tuberculous meningitis in pediatric patients. Among the detected tuberculoma cases, the caseating type and supratentorial location were the most predominant findings. No significant associations were found between tuberculomas and demographic variables, such as age, gender, and residence, and clinical signs and symptoms.

Disclaimer:

There is no disclaimer for this study

Patients' Consent:

Written informed consent was taken from every participant before including in the study. All patient were informed that their personal data will remain confidential and they have right to withdraw from study at any time.

Conflict of Interest:

The author declare that they have no competing interest related to this research work.

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