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Diagnostic accuracy of contrast-enhanced magnetic resonance imaging in diagnosing tuberculous meningitis keeping lumbar puncture as the gold standard

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ABSTRACT

Background: Tuberculous meningitis (TM), caused by Mycobacterium tuberculosis, is the most common kind of CNS tuberculosis (TB). If not treated effectively, TB meningitis can result in a higher rate of neurologic sequelae and death.

Objective: To evaluate the diagnostic accuracy of contrast-enhanced magnetic resonance imaging in diagnosing tuberculous meningitis keeping cerebrospinal fluid analysis as a gold standard.

Methods: Our study comprised 109 individuals with clinical indications of tuberculous meningitis. Patients with cerebral haemorrhage, claustrophobia, or metallic implants in their bodies were not eligible. A 1.5 Tesla MRI machine was used to scan the brain starting from the vertex to the base of the skull. The MRI sequences collected and reviewed by radiologists for tuberculous meningitis were axial T2 turbo spin echo, axial T2 fluid attenuation inversion recovery (FLAIR), axial diffusion-weighted imaging (DWI)—apparent diffusion coefficient (ADC), and axial T2 gradient echo (GRE). CSF analysis was performed on the patient following a lumbar puncture.

Results: Out of 109 patients included in this study, 55(50.5%) were male and 54(49.5%) were females. On Contrast Enhanced FLAIR imaging patients showed abnormal features like meningeal enhancement (65.1%), tuberculomas (48.6%), hydrocephalus (47.7%) and in-

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farcts (26.6%). MRI showed a sensitivity of 76%, a specificity of 81%, a positive predictive value of 91.89% and a negative predictive value of 54.2%. The accuracy of contrast enhanced magnetic resonance imaging in diagnosing TBM was 77.1%.

Conclusion: Contrast Enhanced Magnetic Resonance Imaging has good sensitivity, specificity and diagnostic accuracy in diagnosing TB Meningitis.

Key words
Tuberculous Meningitis; Magnetic Resonance Imaging; Diagnostic Accuracy; CSF analysis

Introduction

Tuberculous meningitis (TM), caused by Mycobacterium tuberculosis (M. Tuberculosis), is the most common kind of CNS tuberculosis (TB). If not treated effectively, TB meningitis can result in a higher rate of neurologic sequelae and death [1]. When an intracranial tuberculoma (Rich focus) ruptures, it typically results in basal meningitis, leading to TB meningitis. Due to tuberculous vasculitis, hydrocephalus, cranial nerve palsies, and ischemic brain damage takes place. Lungs are typically the main site of TB infection [2].

Patients with tuberculous meningitis (TBM) frequently experience seizures, which are associated with a substantially greater risk of death and neurological impairment, particularly in young patients [3]. Patients with advanced clinical stages of tuberculous meningitis may exhibit Glasgow Coma Scale values of 10 or less [4].

The clinical characteristics of TBM are comparable to those of other meningitis causes. TBM typically manifests as a subacute meningitic condition. Headache (50–80%) and anorexia (60–80%) are frequent initial symptoms, followed by vomiting (30–60%), photophobia (5–10%), and fever (60–95%). The most indicative sign of TBM in adults is a longer-than-five-day sickness duration. A sputum smear-positive case of pulmonary TB has been exposed to almost half of patients with TBM. Patients may present with neck stiffness, disorientation, coma, any type of cranial nerve palsy, hemiparesis, paraparesis and seizures (more common in children than in adults). About half of the patients have chest X-rays suggesting current or previous TB infections, although these results are not specific to areas where TB is prevalent. A miliary pattern on CXR, on the other hand, can indicate extra-pulmonary TB [5].

The diagnosis of brain abnormalities linked to TB meningitis heavily relies on imaging. Hydrocephalus, meningeal enhancement, infarction, enhancing lesion, tuberculoma, abscess, cerebral oedema, and calcification are among the neuroimaging characteristics of tuberculous meningitis [6]. Magnetic resonance imaging is a non-invasive imaging method that gives great spatial resolution without the use of ionizing radiation. When compared to CT, MRI offers a substantially higher discriminatory value, especially for identifying the majority of pathologic meningeal disorders [6].

It has been demonstrated that brainstem disease can be best visualized using T2-weighted magnetic resonance imaging. Meningeal enhancement, hydrocephalus, basal exudates, infarcts, and tuberculomas are the most frequent findings, in descending order. Figures 1, 2a & 2b show meningeal enhancements in different cases in different MRI sequences, to better understand the effect of different MRI sequences in diagnosing it. Infarcts are caused by vasculitis that affects the vessels of the Willis circle, the middle cerebral artery, and the vertebrobasilar circulation [7].

In order to forecast the course of this illness and assess its implications, magnetic resonance imaging is essential. A prevalent form of tuberculosis, tuberculoma typically results in convulsions and focal symptoms and manifests as one or more lesions that take up space [8]. In Figures 4a & 4b, tuberculomas in DWI and ADC MRI sequences are shown. In CT & MRI, tuberculomas typically appear as rings or nodules and can occasionally be confused with underlying vascular impairment and ischemic damage. When this happens, tuberculomas could disappear and so go unnoticed, especially in those with weakened immune systems who have a poor reac-

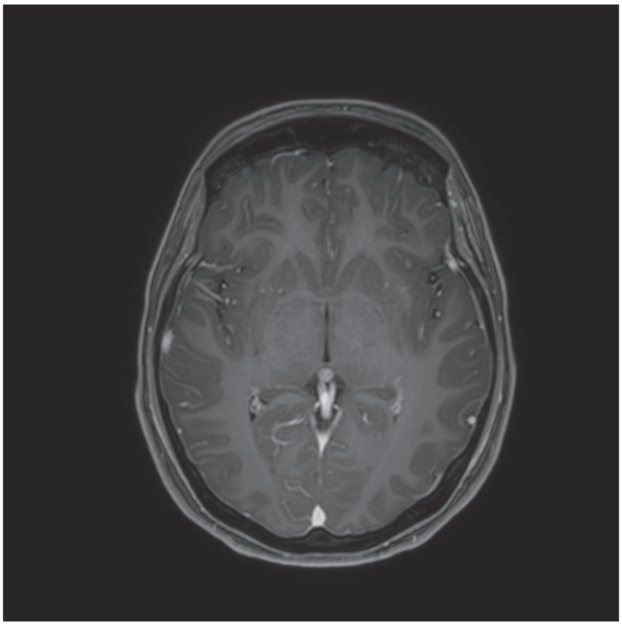
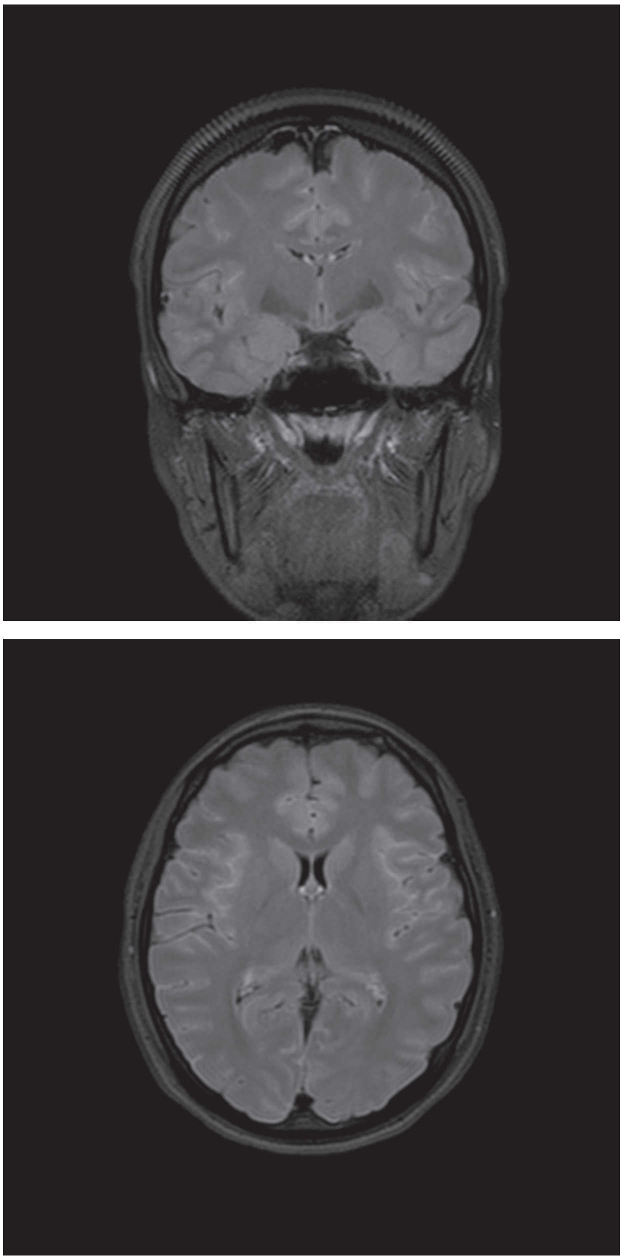


Figure 1: *Diffused Leptomeningeal Enhancement seen on post-contrast T1 weighted image*

tive response, such as HIV patients [9]. Figures 3a and 3b show the tuberculomas on different MRI sequences, included in our study.

Patients with tuberculous meningitis experience focal impairments far more frequently than those with other types of meningoencephalitis. Compared to other types of inflammation of the central nervous system, tuberculous meningitis causes endarteritis and more infarcts. Extrapyramidal stiffness and motor abnormalities, decerebrate spinal alignment, and blurred vision are also more common in tuberculous meningitis patients. This might be because the disease causes increased basal exudates, which damage basal tissues such as the basal ganglia, brain stem, and cranial nerves [10].

Mycobacteria in the cerebrospinal fluid (CSF), as well as through direct staining and culture, can be used to confirm a tuberculous meningitis diagnosis. These tests, meanwhile, take a lot of time and are rarely accurate [11]. Regular investigations on CSF must be performed (cell counts and differentials, protein level, glucose level), as well as microbiologic testing for bacteria, fungi, and Mycobacterium tuberculosis, if the clinical presentation is suggestive of TBM. While sampling CSF for probable TB meningitis, a least 1 ml of the fluid preferably up to 10 ml, should be collected. On a CSF smear, acid-fast bacilli can occasionally be observed, however, M. tuberculosis is more frequently produced in culture. Although unusual, a spiderweb clotting in collected CSF is an indication of tuberculous meningitis. Although ELISPOT testing is typically false negative and useless in identifying acute tuberculous meningitis, it can, paradoxically, turn positive once treatment has begun, confirming the diagnosis [12].



Figures 2a & 2b *show CE-FLAIR images with diffused Leptomeningeal enhancements*

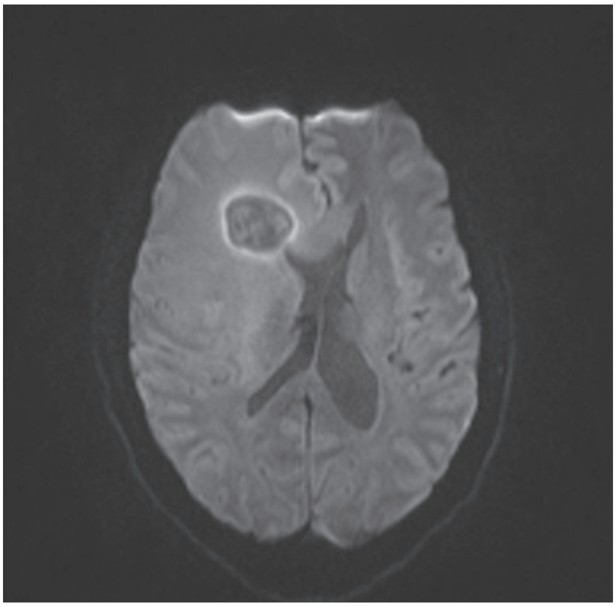


Figure 3a: *On DWI Sequence, the lesion shows a high diffusion-weighted signal at the periphery while heterogenous values at the centre.*

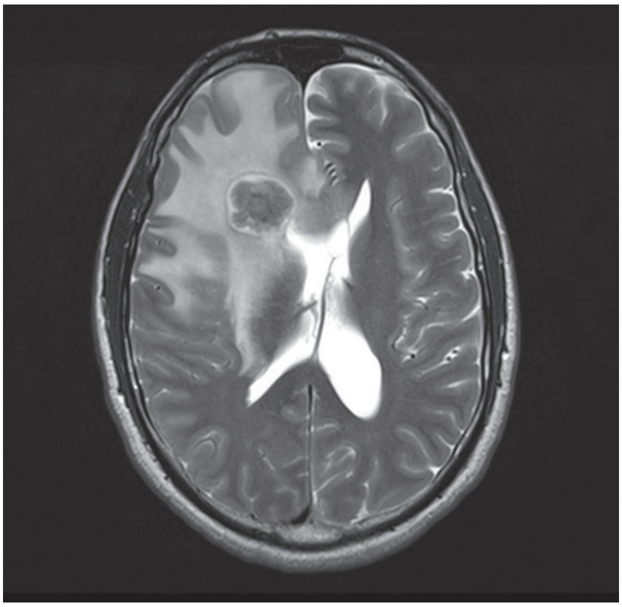


Figure 3b: *A rounded-shaped lesion is present in the right frontal lobe showing a dual rim sign on T2 weighted images. The lesion has a low T2 signal at the centre*

TBM can be challenging to diagnose, and without definitive microbiologic confirmation, the diagnosis may rely mainly on clinical and preliminary CSF results. Patients with focal deficits, substantial CSF pleocytosis, and symptoms for longer than six days are more likely to have TBM. Even though culture takes quite a while and has a low level of specificity (40-80%), it must be performed to identify an individual's receptivity to treatment [13].

Our study will discuss the detailed role of contrast-enhanced magnetic resonance imaging along with its accuracy to provide a diagnostic criterion for tuberculous meningitis to the medical community to initiate the baseline treatment of tuberculous meningitis to slow down the progression of the disease and for better clinical outcome of the patient.

Table 1: Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value and Diagnostic Accuracy of MRI in diagnosing Tuberculous Meningitis keeping Lumbar Puncture as gold standard.

Values	Results
Sensitivity	80.95%
Specificity	76%
Positive Predictive Value	91.89%
Negative Predictive Value	54.2%
Diagnostic Accuracy	77.1%

Material/Subjects/Patients and Methods

The analytical cross-sectional study approach was adopted at Sir Ganga Ram Hospital. Our study comprised 109 individuals with clinical indications of tuberculous meningitis. Patients with cerebral haemorrhage, claustrophobia, or metallic implants in their bodies were not eligible. Data was collected by using Questionnaire/Performa. MRI procedures were used to evaluate the common baseline findings of tuberculous meningitis. A non-probability convenient sampling technique was used in this study. Data was evaluated and analyzed with statistical package for social sciences (SPSS) v-24 and Microsoft excel.

Results:

Out of 109 patients included in this study, 55(50.5%)

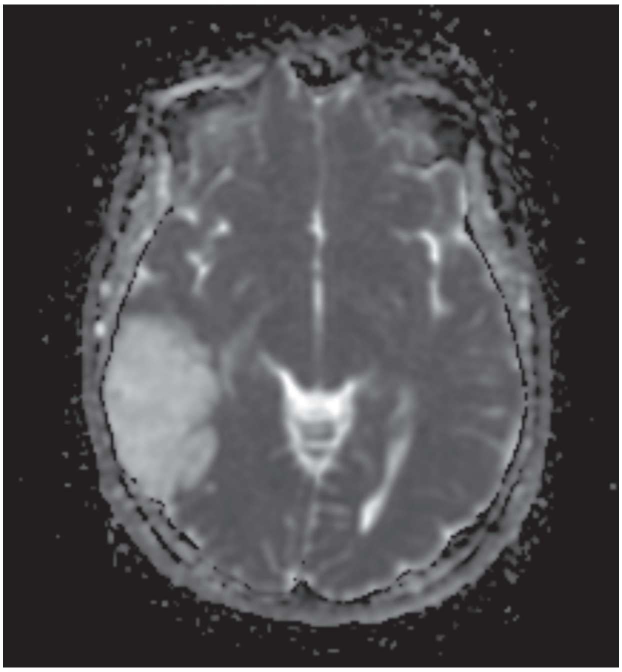


Figure 4a: ADC Mapping of DWI sequence showing a temporal region lesion showing heterogeneous diffused signals.

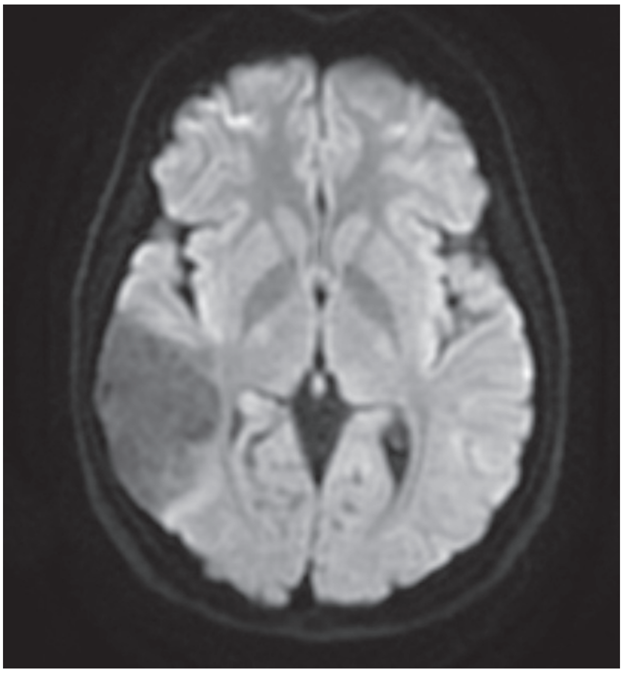


Figure 4b: DWI Sequence of temporal region lesion showing heterogeneous diffused signals.

were male and 54(49.5%) were females. Fifty-Seven (52.3%) patients had impaired cognitive abilities, while Fifty-Two (47.7%) patients had average cognitive abilities. 78(71.6%) patients presented with headache, 86(78.9%) had fever, 22(20.2%) patients had Neck Stiffness, 26(24.2%) patients were presented with hemiparesis, 10(9.2%) patients had paraparesis while 47(43. 1%) patients were having episodes of seizures. On Contrast Enhanced FLAIR imaging patients showed abnormal features like meningeal enhancement (65.1%), tuberculomas (48.6%), hydrocephalus (47.7%) and infarcts (26.6%). MRI showed a sensitivity of 76%, a specificity of 81%, a positive predictive value of 91.89% and a negative predictive value of 54.2%. As given in Table 1 below, the Diagnostic accuracy of contrast-enhanced magnetic resonance imaging in diagnosing TBM was found to be 77.1%.

Discussion:

Tuberculous meningitis (TM), caused by Mycobacterium tuberculosis (M. Tuberculosis), is the most common kind of CNS tuberculosis (TB). If not treated effectively, TB meningitis can result in a higher rate of neurologic sequelae and death. The cerebrospinal fluid (CSF) analysis performed through lumbar puncture is nowadays the gold standard for diagnosing TBM. Lumbar puncture, however, is an invasive treatment with some dangers. Although lumbar puncture is still the gold standard for diagnosing TBM, magnetic resonance imaging (MRI) has shown potential in this area.

Tuberculous meningitis is diagnosed using the patient's history, physical checkup, and laboratory evaluation, although the capacity to identify and discriminate cerebral infections has greatly increased with the development of MRI. This dominance is due to the absence of bone artefacts and the multi-planar capabilities of MRI.

On contrast-enhanced imaging, patients showed abnormal features like meningeal enhancement (65.1%), tuberculomas (48.6%), hydrocephalus (47.7%) and infarcts (26.6%). MRI showed a sensitivity of 76%, a specificity of 81%, a positive predictive value of 91.89% and a negative predictive value of 54.2%. The diagnostic accuracy of contrast-enhanced magnetic resonance imaging in diagnosing TBM was found to be 77.1%.

Similar to our work, Vaswani conducted a prospective study in Karachi, Pakistan. There were 57 patients in total. Clinical signs and symptoms included photophobia, fever, stiff neck, vomiting and headache in the patients. 90% of the patients in the study had a history of vomiting, according to the clinical characteristics and symptoms. T1 weighted post-contrast image diagnostic accuracy was also calculated. Post-contrast FLAIR sequence of MRI showed a sensitivity of 96% and a specificity of 85.71% [14]. 27 patients were examined using routine sequences, in a prospective research. Only six individuals were diagnosed using T1WI, whereas twelve patients tested positive using FLAIR imaging. Twelve individuals had CSF-positive results after all patients underwent spinal taps following MRI. As a result, the contrast boosted FLAIR's sensitivity and remained at 100% [15].

In Karachi, Pakistan, 50 patients were enrolled in a retrospective analysis utilising their medical data. This study was different from ours in that it was conducted retrospectively and employed ordinary FLAIR sequence pictures instead of contrast-enhanced images. There were ten genuine negatives and 36 true positives. There were two false positive cases detected; one was caused by motion blur, and the other had meningeal carcinomatosis. They were 84.3% specific and 94.7% sensitive [16].

Galassia et al [17], investigated retrospectively 24 patients. Since there were two groups and a total of 35 experiments involving 24 patients, this research was more complicated. T1 weighted Fat suppression images were taken before Contrast Enhanced FLAIR images in 21 of the 33 analyses in the first group. In the second group, 12 of the 33 studies employed CE FLAIR imaging before Contrast-enhanced T1 weighted Fat Suppression images. There was a 2 to 5-minute break between each sort of group. The findings demonstrated that CE T1 weighted Fat Suppression imaging is more sensitive than CE FLAIR imaging. The study's finding was completely different from ours because they discovered that in 25 out of 33 investigations, contrast-enhanced T1-weighted pictures were preferred over CE-FLAIR [17].

In a different study [18], MR signal intensity differences between T1WI FS and FLAIR pictures were assessed, with the results favouring FLAIR images in meningitis patients. Additionally, it demonstrates that meningeal enhancement can be more clearly seen and distinguished when vascular enhancement is suppressed on FLAIR images. In comparison to traditional post-contrast T1WI, the CE FLAIR sequence had an overall accuracy of 90.3% as opposed to 54.8%.47[18].

Conclusion:

Contrast-Enhanced Magnetic Resonance Imaging has high sensitivity, specificity and diagnostic accuracy in diagnosing Tuberculous Meningitis. **R**

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