Spectrum of Magnetic Resonance Imaging findings of CNS tuberculosis with varied manifestations and complications

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Learning objectives

1. To identify and describe the various typical and atypical imaging findings of CNS (Central nervous system) tuberculosis (TB) on MRI (Magnetic resonance imaging).
2. To differentiate these findings of CNS Tuberculosis from most common differentials with similar imaging findings on the basis of MRI in a tabulated format.
Background

- Tuberculosis (TB) is one of the most common, endemic infection seen in developing countries with high incidence and prevalence.
- Tuberculosis (TB) is caused by *Mycobacterium tuberculosis* and accounts for many deaths worldwide annually.
- Involvement of CNS is a serious type of extra-pulmonary manifestation with greater prevalence in immunocompromised patients. Also there is an increasing incidence due to infection by MDR (multi-drug resistant) strains of mycobacteria.
- CNS TB usually results from haematogenous spread and can also result from direct rupture or extension of a subpial or subependymal focus (Rich focus).
- CNS TB may involve the meninges, brain, spinal cord, and the skull bones and can show varied manifestations like parenchymal and leptomeningeal tuberculomas, abscesses, cerebritis, vasculitis, infarction, meningitis, and osteomyelitis.
- **Spectrum of lesions in CNS TB include:**
  1. TB meningitis
  2. Tuberculous granuloma (tuberculoma)
  3. Miliary and leptomeningeal granuloma
  4. Tuberculous abscess
  5. Tuberculous encephalopathy
  6. Tuberculous cerebritis
  7. Vasculitis and infarction
  8. Cranial neuropathy
  9. Non-osseous spinal cord tuberculosis
  10. Calvarial tuberculosis, subdural and epidural abscess
- MRI features of TB commonly mimic those of other non-neoplastic and neoplastic diseases and hence needs to be differentiated.
Findings and procedure details

Findings and procedure details:

MRI of 30 patients suspected of CNS tuberculosis in the age group 20-70 years were performed between December 2015 to March 2016 and were reviewed retrospectively.

**Imaging Protocol:**

*Pre contrast:*

Axial, Saggital and Coronal spin echo T1 and T2 weighted images.

Axial T2 thin sections.

FLAIR (fluid attenuated inversion recovery images) in axial and coronal planes.

DW and ADC images.

*Post contrast:*

T1 weighted axial, Saggital and coronal images.

FLAIR axial images.

Single -voxel MR spectroscopy was done in affording patients only.

In our study 25 patients showed varied manifestations of CNS TB and its complications and were corroborated with CSF and clinical findings. However 5 cases presented with differentials with features almost similar to CNS TB.

Here we present a tabulated format to educate the viewer by including these non TB cases thus describing findings that may help differentiate between TB from other conditions with similar imaging features.

**Imaging features of CNS TB on MRI:**

**TB meningitis:**

Post-contrast T1 images show diffuse meningeal enhancement around basal cisterns and Sylvian fissures with the most complication being communicating hydrocephalus which is caused by blockage of the basal cisterns by inflammatory exudates (fig 4).
Tuberculomas:

Tuberculoma is the most common parenchymal lesion in CNS TB which can be solitary, multiple, or miliary, and may be seen anywhere within the brain parenchyma, although it most commonly occurs within the frontal and parietal lobes and usually involve the cortico-medullary junction and periventricular region.

Non-caseating granuloma:

Iso to hypointense on T1 and hyperintense on T2-weighted images showing homogenous post contrast enhancement.

Caseating solid granuloma:

Hypointense on T1 and strikingly hypointense on T2-weighted images (WI) due to granulation tissue and compressed glial tissue in the central core resulting in greater cellular density than the brain parenchyma (fig 3).

Caseating granuloma with central liquefaction:

It appears centrally hypointense on T1, and hyperintense on T2 images with a peripheral hypointense rim on T2W images. Post contrast T1W images show rim enhancement in caseating granulomas (fig 2). The oedema surrounding the granuloma is relatively less than pyogenic abscess.

Lipid-lactate peak is typically seen on MR spectroscopy (MRS) with distinct lipid peak. (fig 3).

Miliary and leptomeningeal granulomas:

Diffuse infiltration of brain by multiple small granulomas (< 2 mm) which have high or low signal on T2 with post-contrast numerous round areas of intense enhancement. Leptomeningeal granulomas (fig 4) show similar appearance however, they are seen located in the sulcal spaces and basal cisterns.

Tuberculous abscess:

Abscesses in CNS TB are more common in the elderly and immunocompromised patients and are often solitary or multiple and are frequently multiloculated.

On imaging, a TB abscess is usually indistinguishable from a caseating tuberculoma or a pyogenic abscess. However, TB abscess has thinner enhancing walls, is larger (> 3 cm in diameter), and it has peripheral oedema and mass effect (fig 2).


**Tuberculous encephalopathy:**

Severe unilateral or bilateral cerebral oedema. On T2-weighted images, hyperintensity is seen in white matter suggesting myelin loss.

**Tuberculous cerebritis:**

Focal cerebritis appears hypo on T1, hyperintense on T2 and small areas of patchy enhancement on post-contrast scan.

**Vasculitis and infarction:**

MR imaging shows areas of hyperintensities on T2 Images with restricted diffusion on DW (diffusion weighted) and ADC (apparent diffusion coefficient) images.

**Cranial neuropathies:**

Commonly affected are II, III, IV, and VII cranial nerves. On MRI the affected nerves appear thickened and show hyperintensity on T2 weighted images. On contrast, the proximal portion of the nerve may show enhancement.

**Non osseous spinal Tuberculosis:**

MRI features consist of CSF loculation, and obliteration of the spinal subarachnoid space with a loss of outline of the spinal cord in the cervico-thoracic spine, and matting of the nerve roots in the lumbar region.

Nodular, thick, linear, intradural enhancement, often completely filling the subarachnoid space on postcontrast images can be seen.

Spinal cord involvement in the form of infarction and syringomyelia may occur as a complication of arachnoiditis. Parenchymal TB myelitis and tuberculoma formation may also occur.

**Calvarial Tuberculosis, subdural and epidural abscess:**

*Dural and subdural pathology:* It appears hyperintense on T2W and iso to hypointense on T1W images. The dural granulomas appear hypo to isointense on T2W, and isointense on T1W images. Rim enhancement can be seen on post-contrast images.

*Epidural TB:* Lesions appear to be isointense on T1W images, and have mixed intensity on T2W images. On post-contrast images, uniform enhancement can be seen if the TB
inflammatory process is phlegmonous in nature whereas peripheral enhancement is seen if true epidural abscess formation or caseation has developed.

**Fig. 1:** Axial T2 images showing multiple hypointense granulomas with mild perilesional edema with few showing restricted diffusion on DW images with post contrast axial T1 images showing peripheral rim like enhancement.

**References:** Radiology, Nair Medical college, BYL Nair Hospital - Mumbai/IN
**Fig. 2:** Axial T2 and axial FLAIR images showing caseating centrally liquefied granulomas which are hyperintense in the centre showing hypointense rim in left frontal region. These lesions show peripheral enhancement on Post contrast axial T1 images.

**References:** Radiology, Nair Medical college, BYL Nair Hospital - Mumbai/IN
**Fig. 3:** Axial T2 and post contrast T1 images showing T2 hypointense granuloma with perilesional edema in right temporo-parietal region showing rim like peripheral enhancement. Single-voxel MRS image showing lipid-lactate peak.

**References:** Radiology, Nair Medical college, BYL Nair Hospital - Mumbai/IN
Fig. 4: Axial T2 image showing communicating hydrocephalus with gliosis of right fronto-parietal region due to recurrent vasculitic infarcts. T1 Sagittal post contrast and axial FLAIR post contrast images showing meningeal enhancement with enhancing basal exudates and granulomas in basal cisterns.

References: Radiology, Nair Medical college, BYL Nair Hospital - Mumbai/IN

Differentials encountered on basis of MRI features:

Case I: (Fig 5)

17 year old female with predominant complaints of focal seizures with no history of fever or weight loss and normal CSF examination.

On MRI evaluation the lesion was diagnosed as Neurocysticercosis (NCC) with differentiating features with CNS TB as follows:
<table>
<thead>
<tr>
<th>FEATURES ON MRI</th>
<th>CNS TB</th>
<th>NCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE</td>
<td>&gt;2 cms</td>
<td>&lt;2 cms</td>
</tr>
<tr>
<td>LOCATION</td>
<td>Parenchymal</td>
<td>Cortical and sub-cortical</td>
</tr>
<tr>
<td>SHAPE</td>
<td>Irregular</td>
<td>Regular</td>
</tr>
<tr>
<td>WALL</td>
<td>Thick walled</td>
<td>Thin walled</td>
</tr>
<tr>
<td>NUMBER</td>
<td>Conglomerated</td>
<td>Usually single</td>
</tr>
<tr>
<td>SCOLEX</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>EDEMA</td>
<td>Mild</td>
<td>Severe</td>
</tr>
<tr>
<td>T1 WI</td>
<td>Core iso to hypointense</td>
<td>Core iso to hypointense</td>
</tr>
<tr>
<td>T2 WI</td>
<td>Core hypo / hyperintense with hypointense rim</td>
<td>Core hyperintense with hypointense rim</td>
</tr>
<tr>
<td>DWI</td>
<td>Restriction</td>
<td>Variable restriction in core</td>
</tr>
<tr>
<td>ADC</td>
<td>Low values</td>
<td>High values</td>
</tr>
<tr>
<td>T1 POST CONTRAST</td>
<td>Ring / homogenous / irregular enhancement</td>
<td>Rim enhancement</td>
</tr>
<tr>
<td>MRS SPECTROSCOPY</td>
<td>Specific, grossly diminished NAA, Lipid lactate peak with distinct lipid peak</td>
<td>Nonspecific, moderately diminished NAA, Presence of lactate peak with absent lipid peak</td>
</tr>
</tbody>
</table>
Fig. 5: Axial T2 W images showing differentiating features between neurocysticercosis (NCC) on the right and Tuberculoma on the left with post contrast axial T1 images showing the enhancement pattern.

References: Radiology, Nair Medical college, BYL Nair Hospital - Mumbai/IN

Case II: (Fig 6)

34 year old male presented with focal seizures, on and off fever and weight loss. On blood investigations the patient was found to be HIV positive.

On MRI evaluation the lesion was diagnosed as Toxoplasmosis as opposed to CNS TB due to its characteristic location and MRS findings. The differentiating MRI features are as follows:

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>CNS TB</th>
<th>TOXOPLASMOsis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurocysticercosis</td>
<td>CNS Tuberculomas</td>
<td></td>
</tr>
<tr>
<td>LOCATION</td>
<td>Frontal and parietal cortico-medullary junction</td>
<td>Periventricular, basal ganglia, thalamus and corpus callosum</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>T1 WI</td>
<td>Core iso to hypointense</td>
<td>Core iso to hypointense</td>
</tr>
<tr>
<td>T2 WI</td>
<td>Core iso to hyperintense with hypointense rim</td>
<td>Variable intensity</td>
</tr>
<tr>
<td>ENHANCEMENT</td>
<td>Irregular outline with rim enhancement</td>
<td>Rim enhancement</td>
</tr>
<tr>
<td>DWI</td>
<td>May or may not show restriction</td>
<td>Restriction</td>
</tr>
<tr>
<td>ADC</td>
<td>Low values</td>
<td>High values</td>
</tr>
<tr>
<td>MRS</td>
<td>Lipid peak</td>
<td>Lipid-lactate peak suppressed</td>
</tr>
</tbody>
</table>

**Fig. 6:** Axial FLAIR and axial Post contrast T1 images showing differentiation between Toxoplasma on the right and Tuberculomas on the left.
Case III: (Fig 7)

67 year old female with neurological symptoms and unilateral hemiparesis with on and off history of fever.

On MRI solitary relatively large lesion was found in the right parietal region which was characteristically showing choline-creatine peak on single voxel MRS as opposed to CNS TB and hence was diagnosed as a Glioma. The differentiating MRI features are as follows:

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>CNS TB</th>
<th>GLIOMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 WI</td>
<td>Core iso to hypointense</td>
<td>Hypointense</td>
</tr>
<tr>
<td>T2 WI</td>
<td>Core iso to hyperintense or hypointense with hypointense rim</td>
<td>Hyperintense and can involve the corpus callosum</td>
</tr>
<tr>
<td>POST CONTRAST T1</td>
<td>Irregular or rim enhancement</td>
<td>Thick rim or nodular enhancement</td>
</tr>
<tr>
<td>DWI</td>
<td>Variable restriction</td>
<td>Variable restriction</td>
</tr>
<tr>
<td>ADC</td>
<td>Low values</td>
<td>High values</td>
</tr>
<tr>
<td>MRS</td>
<td>Lipid peak</td>
<td>Suppressed NAA with elevated creatine choline peak</td>
</tr>
<tr>
<td>MR PERFUSION</td>
<td>Low rCBV(cerebral blood volume) values</td>
<td>High rCBV values</td>
</tr>
</tbody>
</table>
Fig. 7: Axial DW and Axial post contrast T1 images showing differentiating features of glioma on the right and Tuberculoma on the left with glioma showing restricted diffusion peripherally. Single-voxel MRS images with Glioma showing a Choline-creatine peak and a tuberculoma showing lipid-lactate peak.

References: Radiology, Nair Medical college, BYL Nair Hospital - Mumbai/IN

Case IV: (fig 8)

47 year old male with various neurological symptoms.

On MRI examination multiple lesions showing rim enhancement were noted in the parenchyma. However on additional evaluation, lung mass was diagnosed on CECT chest; hence proving the diagnosis of metastases as opposed to CNS TB. The differentiating MRI features are as follows:

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>CNS TB</th>
<th>METASTASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 WI Core</td>
<td>iso to hypointense</td>
<td>Hypointense</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>CNS TB</th>
<th>METASTASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLIOMA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TUBERCULOMAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRI Sequence</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>T2 WI</strong></td>
<td>Core iso to hyperintense or hypointense with hypointense rim</td>
<td></td>
</tr>
<tr>
<td><strong>POST CONTRAST T1</strong></td>
<td>Rim enhancement with irregular outline Thick rim and nodular enhancement</td>
<td></td>
</tr>
<tr>
<td><strong>DWI</strong></td>
<td>Variable restriction Dark</td>
<td></td>
</tr>
<tr>
<td><strong>ADC</strong></td>
<td>Low values High values</td>
<td></td>
</tr>
<tr>
<td><strong>MRS</strong></td>
<td>Lipid peak Suppressed NAA with elevated creatine choline peak</td>
<td></td>
</tr>
<tr>
<td><strong>MR PERFUSION</strong></td>
<td>Low rCBV(cerebral blood volume) values High rCBV values</td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 8:** Axial T2 and post contrast T1 images showing differentiating features of metastases (on the right) with Tuberculomas (on the left).

**References:** Radiology, Nair Medical college, BYL Nair Hospital - Mumbai/IN
Case V: (Fig 9)

37 year old female with complaints of progressive muscle weakness, paraesthesias and fatigue with on and off history of fever and weight loss.

On MRI multiple T2 and FLAIR hyperintense lesions were seen showing open ring enhancement towards cortex on post contrast images favouring a diagnosis of demyelinating lesions (Multiple sclerosis) as opposed to CNS TB. The differentiating MRI features are as follows:

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>CNS TB</th>
<th>DEMYELINATING LESIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TI WI</td>
<td>Core iso to hypointense</td>
<td>Hypointense</td>
</tr>
<tr>
<td>T2 WI</td>
<td>Core iso to hyperintense or hypointense with hypointense rim</td>
<td>Hypointense</td>
</tr>
<tr>
<td>POST CONTRAST T1</td>
<td>Rim enhancement with irregular outline</td>
<td>Open rim enhancement thinner at cortical side</td>
</tr>
<tr>
<td>DWI</td>
<td>Variable restriction</td>
<td>Variable according to stage of disease</td>
</tr>
<tr>
<td>ADC</td>
<td>Low values</td>
<td>Variable values</td>
</tr>
<tr>
<td>MRS</td>
<td>Lipid peak</td>
<td>Variable, NAA (N-acetyl aspartate)/ Creatine ratio in the core is higher than in malignant lesions, Glutamate peak</td>
</tr>
</tbody>
</table>
Fig. 9: Axial FLAIR images showing demyelinating lesions (Multiple sclerosis) on the right and Tuberculomas with perilesional edema on the left. Post contrast T1 images showing demyelinating lesions showing open / partial ring enhancement towards cortex (arrow) as opposed to complete ring enhancement of tuberculomas.

References: Radiology, Nair Medical college, BYL Nair Hospital - Mumbai/IN
Conclusion

- Tuberculosis is the most common cause of CNS lesions in endemic areas with high incidence and prevalence.
- Most commonly observed cases were of CNS tuberculomas with varied typical and a few atypical manifestations on MR imaging.
- Common differential diagnoses were identified and MR was used as a tool to narrow down specific diagnosis.
- Tabulation of differentiating features of CNS TB and variety of differentials helps in easy access to specific imaging features.
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