CNS Tuberculosis imaging and surgery

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Presented By
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Tuberculosis

- As old as recorded history
- Symptoms described in the Rig Veda (1500 BC)
- Unequivocal lesions in Egyptian mummies
- Odier, Ford described meningeal TB 1790
- Surgical excision Wernicke and Hahn 1882,
Tuberculosis

- CNS tuberculosis complicates 10% of all TB
- Never the first manifestation
- Occurs within 6-12 months
- Circle of Willis more frequently involved than the basilar system
Mycobacterium tuberculosis

- Acid fast bacillus
- Does not stain on gram stain
- Obligate aerobes
- Difficult to grow
- High lipid in cell wall
- Hominis/ Bovine/ Avium
Pathogenesis

- May develop during initial infection/ reactivation

- Haematogenous dissemination
  - Commonest
  - Focus in brain (Rich focus)
  - Rupture of focus into subarachnoid/ ventricular space

- Contiguous spread
CNS tuberculosis

- Intracranial
  - Parenchymal
  - Meningeal
  - Osseous

- Spinal
  - Parenchymal
  - Meningeal
  - Arachnoiditis
  - Osseous
Epidemiology

- Incidence varies blacks > whites

- Predominantly in the young (50% <10)

- Abscess in 4-8% (20% with HIV)
Pathology

- Immature lesions – multiple tubercles in oedematous brain
- Mature: avascular mass, nodular extensions, yellowish gritty caseous areas
- 60% attached to dura
Pathology (parrenchymal)

- Can be present anywhere
- Cerebellum in children
- Cerebral hemisphere and basal ganglia commoner in adults
Pathology (tuberculoma)

- Tuberculoma (classical lesion)
- Tuberculoma en plaque
- Tuberculous abscess
- Cystic tuberculoma
- Multiple grape like tuberculoma
- Microtuberculoma
- Calcified tuberculoma
- Tuberculous encephalopathy
Pathology (tuberculoma)

- Dastur described six main types
  - Parenchymal changes.

  - (1) Ventriculitis
  - (2) Border-zone encephalitis
  - (3) Infarction
  - (4) Internal hydrocephalus
  - (5) Diffuse oedema
  - (6) Tuberculoma
Pathology (meningeal)

- Classically Commonest in 6m – 3 years
- Now adults 50%
- Thick exudate encasing nerves, vessels
- HCP, tuberculoma, arachnoiditis
- Diffuse perivasculitis
- Infarcts
- Pachymeningitis
Diagnosis

- Montoux test
- Hb/ ESR
- CXR
- ELISA
- CSF
- PCR
- Imaging
- Biopsy
Imaging

• X ray
• Angiography
• CT
• MRI

of historical significance
Imaging

- Tuberculoma
  - Typically cortical and subcortical
  - Multiple in 10-35%
  - Milliary rare (children)

- Meningitis (commonest form of CNS TB)
  - Isolated meningitis is rare (5% in children)
  - Basal cisterns
Imaging (CT tuberculoma)

- Cerebritis: hypodense areas
- Perilesional oedema out of proportion
- Early tuberculoma: iso to slightly hyper dense, ring enhancement
- Evolved: well delineated ring enhancing mass, target sign (central enhancement or calcification)
- Healed: often calcify
- Manifestations
  - Small disc/ rings
  - Large rings with central lucency
  - Large nodular mass with irregular outline
  - Multiple lesions in 15-20%
Caseating tuberculosis granuloma involving the left temporal lobe. CECT shows a rim-enhancing lesion in the left temporal lobe consistent with a caseating tuberculosis granuloma.
Imaging (MRI tuberculoma)

- T₁: isointence
- T₂: central hyper with hypo ring
- Marked thin rim enhancement
- Hypo on T₂: fibrosis, gliosis, macrophage infiltration
Par enchymal tuberculosis. contrast-enhanced T1-weighted MR image demonstrates multiple enhancing caseating and non-caseating tuberculomas, predominantly within the left frontal and parietal lobes.
Milliary CNS tuberculosis. Axial contrast-enhanced T1-weighted MR image shows multiple small high-signal-intensity foci within both cerebral hemispheres.
(a) Sagittal T2- hyperintensity in the cervical spinal cord extending from C2 to C7. A hypointense nodule representing the granuloma is noted at the C4 level. (b) Sagittal T1 & (c) axial T1- with fat suppression after contrast reveal an area of solid nodular enhancement representing non-caseating tuberculosis granuloma of the spinal cord. A smaller enhancing granuloma is also noted at the C2 level on the sagittal image.
• decrease in NAA/Cr
• slight decrease in NAA/Cho
• lipid-lactate peaks are usually elevated (86%)
<table>
<thead>
<tr>
<th>CT</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Noncaseating granuloma</strong></td>
<td>T1WI: low SI</td>
</tr>
<tr>
<td>NECT: hypo-/isodense</td>
<td>T2WI: <strong>high SI</strong></td>
</tr>
<tr>
<td>CECT: homogenous enhancement</td>
<td>T1WI Gd: <strong>homogenous enhancement</strong></td>
</tr>
<tr>
<td>Caseating granuloma with a solid center</td>
<td>T1WI: low/intermediate SI</td>
</tr>
<tr>
<td>CECT: heterogenous enhancement centrally</td>
<td>T2WI: <strong>intermediate/low SI</strong></td>
</tr>
<tr>
<td>Ring enhancement of the capsule</td>
<td>T1WI Gd: rim enhancement</td>
</tr>
<tr>
<td>Caseating granuloma with a liquid center</td>
<td>T1WI: hypointense SI</td>
</tr>
<tr>
<td>NECT: hypodense</td>
<td>T2WI: <strong>hyperintense SI</strong> + rim hypo</td>
</tr>
<tr>
<td>CECT: rim enhancement</td>
<td>T1WI Gd: rim enhancement</td>
</tr>
</tbody>
</table>

Imaging (meningitis)

- Active
- Sequelae
  - Hydrocephalus
  - Ischemia and infarction
    - Medial lenticulostriate 75%
    - Thalamoperforating
    - Cortex 25%
    - Bilateral 70%
  - Atrophy
  - Calcification
Imaging (CT meningitis)

**NCCT:**
- scans may be normal
- Obliteration of basal cisterns by hypo/iso dense exudate
- en plaque dural thickening
- Popcorn calcification
- Hydrocephalus
- Sequelae of chronic meningitis
  - Infarcts

**CECT:**
- Abnormal meningeal enhancement (may persist)
- Leptomeningeal enhancement sylvian fissures, tentorium
- Granulomas in the basal meninges
- Ependymitis
Imaging (MRI meningitis)

- Unenhanced scan: does not show active meningitis
  - Spine
    - CSF loculations
    - Obliteration of arachnoid space
    - Loss of cord outline in cervicodorsal cord
    - Thickening and clumping of roots in the lumbar cord
- Contrast T1: basal meningeal enhancement
  - spine
    - Linear enhancement of cord/roots
Tuberculous meningitis. Axial contrast-enhanced T1-weighted magnetic resonance (MR) image shows florid meningeal enhancement that is most pronounced within the basal cisterns.
Tubercular meningitis. Axial FLAIR–MR] showing marked hyperintensity of the basal cisterns and prominent temporal horns in a patient with mild communicating hydrocephalus
Caseating dural /epidural tuberculosis granuloma or abscess

a) Axial T2– nodular hyperintensity posterior to the clivus and anterior to the medulla (arrow).

b) Axial T1 contrast– dural/epidural rim enhancement suggestive of caseating tuberculosis granuloma or abscess.

c) Sagittal enhanced T1– the caseating dural/epidural tuberculosis granuloma or abscess posterior to the clivus. Abnormal meningeal enhancement is present.
Spinal tuberculous meningitis. Sagittal gadolinium-enhanced T1-weighted MR image of the thoracic spine demonstrates irregular, linear, nodular meningeal enhancement.
Enhanced T1–weighted magnetic resonance imaging with fat suppression show intense enhancement of the subarachnoid space indicating arachnoiditis
Tuberculous pachymeningitis

- Rare
- Common sites of involvement are cavernous sinus, floor of middle cranial fossa and tentorium.
- **Radiographic features**
  - **CT**
    - Hyperattenuating solid plaque like densities (calcification may be seen)
  - **MRI**
    - $T_1$: hypo intense thickened duramater.
    - $T_2$: hypo intense thickened meninges.
    - $T_1$ C+ (GAD): intense homogenous enhancement of thickened meninges.
Management

- Medical therapy

- Surgery
  - indications
    - Vision or life threatened by mass effect
    - Failure of response to medical therapy
    - Paradoxical increase in lesion size with therapy
    - Diagnosis in doubt
## Medical therapy

### Recommended dose

<table>
<thead>
<tr>
<th>Drug</th>
<th>Daily</th>
<th>3 times per week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dose and range (mg/kg body weight)</td>
<td>Maximum (mg)</td>
</tr>
<tr>
<td>Isoniazid</td>
<td>5 (4–6)</td>
<td>300</td>
</tr>
<tr>
<td>Rifampicin</td>
<td>10 (8–12)</td>
<td>600</td>
</tr>
<tr>
<td>Pyrazinamide</td>
<td>25 (20–30)</td>
<td>–</td>
</tr>
<tr>
<td>Ethambutol</td>
<td>15 (15–20)</td>
<td>–</td>
</tr>
<tr>
<td>Streptomycin*</td>
<td>15 (12–18)</td>
<td>–</td>
</tr>
</tbody>
</table>

* Patients aged over 60 years may not be able to tolerate more than 500–750 mg daily, so some guidelines recommend reduction of the dose to 10 mg/kg per day in patients in this age group (2). Patients weighing less than 50 kg may not tolerate doses above 500–750 mg daily (WHO Model Formulary 2008, www.who.int/selection_medicines/list/en/).

### Intensive phase treatment

<table>
<thead>
<tr>
<th></th>
<th>2 months of HRZE*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Continuation phase</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 months of HR</td>
</tr>
</tbody>
</table>

* WHO no longer recommends omission of ethambutol during the intensive phase of treatment for patients with non-cavitary, smear-negative PTB or EPTB who are known to be HIV-negative. In tuberculous meningitis, ethambutol should be replaced by streptomycin.

H = isoniazid, R = rifampicin, Z = pyrazinamide, E = ethambutol, S = streptomycin
WHO recommendations

Pulmonary and extrapulmonary disease should be treated with the same regimens (see Chapter 3).¹ Note that some experts recommend 9–12 months of treatment for TB meningitis (2, 3) given the serious risk of disability and mortality, and 9 months of treatment for TB of bones or joints because of the difficulties of assessing treatment response (3). Unless drug resistance is suspected, adjuvant corticosteroid treatment is recommended for TB meningitis and pericarditis (1–4). In tuberculous meningitis, ethambutol should be replaced by streptomycin.


Duration of treatment

6 months


12 months


18 months or Longer

## Treatment

**Rate of radiological resolution of intracranial tuberculoma**

<table>
<thead>
<tr>
<th>Series</th>
<th>duration of ATT</th>
<th>residual lesions %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang 1996 (16)</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Rajeshwari 1995 (6)</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Awada 1998 (2)</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Poonnoose 2003 (28)</td>
<td>18</td>
<td>69.2</td>
</tr>
</tbody>
</table>

Medical management

- 4 drugs x 3-4 months
- 2 drugs x 14-16 months occasionally longer
- Regression of size from 4-6 weeks
- Most resolve in 12-14 months

  R Patir, R Bhatia, Tandon PN. Surgical management of tuberculous infections of the nervous system. Schmidek and Sweet operative neurosurgical techniques 5th edition; 1617-1631

- AED to continue
- INH blocks phenytoin metabolism
- Steroids in all irrespective of age and stage

Resistant tuberculosis

- MDR: resistant to INH and Rifampicin
- EDR/ XDR: MDR + resistance to Quinolones and injectable second line drugs
Second line drugs

<table>
<thead>
<tr>
<th>Group</th>
<th>Drugs (abbreviations)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1:</strong> First-line oral agents</td>
<td>• pyrazinamide (Z) • ethambutol (E) • rifabutin (Rfb)</td>
<td>Use any of the first-line oral agents (Group 1) that are likely to be effective.</td>
</tr>
<tr>
<td><strong>Group 2:</strong> Injectable agents</td>
<td>• kanamycin (Km) • amikacin (Am) • capreomycin (Cm) • streptomycin (S)</td>
<td>Use an effective aminoglycoside or polypeptide by injection (Group 2).³</td>
</tr>
<tr>
<td><strong>Group 3:</strong> Fluoroquinolones</td>
<td>• levofloxacin (Lfx) • moxifloxacin (Mfx) • ofloxacin (Olx)</td>
<td>Use a fluoroquinolone (Group 3).</td>
</tr>
<tr>
<td><strong>Group 4:</strong> Oral bacteriostatic second-line agents</td>
<td>• para-aminosalicylic acid (PAS) • cycloserine (Cs) • terizidone (Tzd) • ethionamide (Eto) • protonamide (Pto)</td>
<td>Use the remaining Group 4 drugs to complete a regimen of at least four effective drugs.</td>
</tr>
<tr>
<td><strong>Group 5:</strong> Agents with unclear role in treatment of drug resistant-TB</td>
<td>• clofazimine (Czf) • linezolid (Lzd) • amoxicillin/clavulanate (Amx/Ctv) • thioacetazone (Thz) • imipenem/cilastatin (Imp/Cln) • high-dose isoniazid (high-dose H)⁵ • clarithromycin (Cir)</td>
<td>For regimens with fewer than four effective drugs, consider adding two Group 5 drugs. The total number of drugs will depend on the degree of uncertainty, and regimens often contain five to seven.</td>
</tr>
</tbody>
</table>

Use at least 4 drugs

3/11/2010 CNS tuberculosis imaging and surgery
Surgery

- Severe elevation of ICP
- Threatening life or vision
- Do not respond to drugs clinically/radiologically
- Diagnosis in doubt
- Obstructive hydrocephalus

  R Patir, R Bhatia, Tandon PN. Surgical management of tuberculous infections of the nervous system. Schmidek and Sweet operative neurosurgical techniques 5th edition; 1617-1631

- Aim diagnosis/relieve pressure
Surgical management

- Biopsy of the mass lesion
- Hydrocephalus
  - Communicating (commoner)
  - Non communicating
Surgery principles

- Non eloquent areas total excision (small lesion)
- Subtotal/ partial excision (large lesion/ eloquent cortex)
- Conservative excision around vital structures
- Evacuation of central liquifactive portion in deep seated lesions
- Residual lesions may respond to medical therapy
  - R Patir, R Bhatia, Tandon PN. Surgical management of tuberculous infections of the nervous system. Schmidek and Sweet operative neurosurgical techniques 5th edition; 1617-1631
- Hydrocephalus
MRC Grading for hydrocephalus

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fully conscious, no paresis</td>
</tr>
<tr>
<td>2</td>
<td>Decreased level of consciousness, localizing pain</td>
</tr>
<tr>
<td>3</td>
<td>Deeply comatose ± gross paresis</td>
</tr>
</tbody>
</table>
Grading for hydrocephalus

<table>
<thead>
<tr>
<th>Grade</th>
<th>Vellore grading</th>
<th>Modified Vellore grading</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Headache, vomiting, fever ± neck stiffness</td>
<td>GCS 15</td>
</tr>
<tr>
<td></td>
<td>No neurological deficit</td>
<td>Headache, vomiting, fever ± neck stiffness</td>
</tr>
<tr>
<td></td>
<td>Normal sensorium</td>
<td>No neurological deficit</td>
</tr>
<tr>
<td>II</td>
<td>Neurological deficit present</td>
<td>GCS 15</td>
</tr>
<tr>
<td></td>
<td>Altered sensorium but easily arousable</td>
<td>Neurological deficit present</td>
</tr>
<tr>
<td>III</td>
<td>Dense neurological deficit may or may not be present</td>
<td>GCS 9-14</td>
</tr>
<tr>
<td></td>
<td>Deeply comatose</td>
<td>Neurological deficit may or may not be present</td>
</tr>
<tr>
<td>IV</td>
<td>Decerebrate or decorticate posturing</td>
<td>GCS 3-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neurological deficit may or may not be present</td>
</tr>
</tbody>
</table>

From Palur et al.

Vellore grading


Modified Vellore grading

Rajshekar V. Management of hydrocephalus in patients with tuberculous meningitis. Neurol India 2009;57:368-74
Hydrocephalus

- Inevitable in those who survive 4-6 weeks
- Mortality 20-100%
- Grade at admission significant
- Early shunt for grade I,II
• ETV
  • 73.1% success rate for ETV in TBM with hydrocephalus
    • A chugh, M hussain et al. Surgical outcome of tuberculous meningitis hydrocephalus treated by endoscopic third ventriculostomy: prognostic factors and postoperative neuroimaging for functional assessment of ventriculostomy: J Neurosurg Pediatrics 3:000–000, 2009

• Endovascular revascularization for ischemia

• STA MCA bypass
  • The left superficial temporal artery–MCA bypass was found to be capable of preventing new ischemic events in the 21-month follow-up period
# AIIMS DATA (1975-1992)

<table>
<thead>
<tr>
<th>Location</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPRATENTORIAL</td>
<td>78</td>
</tr>
<tr>
<td>PARIETAL</td>
<td>28</td>
</tr>
<tr>
<td>FRONTAL</td>
<td>26</td>
</tr>
<tr>
<td>TEMPORAL</td>
<td>15</td>
</tr>
<tr>
<td>BG / THALAMUS</td>
<td>4</td>
</tr>
<tr>
<td>SELAR/SUPRASELLAR</td>
<td>4</td>
</tr>
<tr>
<td>ORBITAL FISSURE</td>
<td>1</td>
</tr>
<tr>
<td>INFRATENTORIAL</td>
<td>50</td>
</tr>
<tr>
<td>CEREBELLUM</td>
<td>44</td>
</tr>
<tr>
<td>CP ANGLE</td>
<td>3</td>
</tr>
<tr>
<td>TENTORIUM</td>
<td>1</td>
</tr>
<tr>
<td>BRAINSTEM</td>
<td>2</td>
</tr>
</tbody>
</table>
Thank you