CHILDHOOD TUBERCULOSIS

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OBJECTIVES

- Give an overview of the demographics, pathogenesis and diagnosis of Tuberculosis (TB)
- Discuss current imaging utilization and updates in the evaluation of childhood TB
- Describe the spectrum of imaging findings seen in children with TB
Prehistoric humans 8000 BC and Egyptian mummies from 2500 - 1000 BC revealed evidence of TB disease.

DNA studies of an Inca mummy around 700 AD showed evidence of Pott's disease.

1827–1892: Jean Antoine Villemin proved the infectious nature of TB.

In 1882: Robert Koch identified the tubercle bacillus.

Early 20th century: The TB vaccine, BCG was developed by Calmette and Guérin.

1943: Streptomycin was discovered by Waksman.
TB is a global health problem (1/3 infected with TB)

- 8.6 million incident cases of TB worldwide in 2012
- 122 per 100,000 population

TB burden: Asia (58%), Africa region (27%), Eastern Mediterranean (8 %), Europe (4 %), and America (3%)

- Common cause of death from any infectious agent worldwide
- 1.3 million died from TB in 2012

TB and HIV co-infection has increased

- 1.1 million (13 %) of new TB cases have HIV

Drug resistant TB

WHO Global Tuberculosis Report 2013
2012 TB burden in children (<15 years)

- 530,000 cases (6% of 8.6 million new cases in 2012)
- 64,000 deaths/year

Tuberculosis in children can be hard to diagnose

- Most children have nonspecific symptoms
- Culture is not routinely attempted in children
- Tuberculin skin test, IGRA has false + / -
- Xpert MTB/RIF molecular test is unable to detect culture positive TB in 20-25%

Medical Imaging plays a very important role in diagnosis and follow up of TB in children
Radiograph (x-ray) most commonly used imaging test

- Sensitivity of 38.8%, specificity of 74.4% for TB diagnosis
- Normal CXR does not rule out TB

Computed tomography (CT)
- More accurate than x-ray for lymphadenopathy
- Assessment of disease extent and activity
- Helpful for suspected TB with unequivocal CXR or without microbiologic proof

Ultrasound and MRI now plays an increasing role
Primary infection is mostly seen in younger children.

Mycobacteria are inhaled, settle in the lung, and cause an inflammatory reaction (Ghon focus).

Bacilli multiply and spread via lymphatics causing lymphadenopathy.

Ghon complex: lung lesion, lymphadenopathy, and lymphangitis.

Bacilli are dormant until re-activation (Latent TB infection) or progress into active TB disease in some children.

Radiographs usually show lymphadenopathy.

Subtle lung changes (Ghon focus) may or may not be seen.
LEFT UPPER LOBE GHON FOCUS WITH LEFT HILAR LYMPHADENOPATHY

PRIMARY TB INFECTION
PRIMARY TB INFECTION

RIGHT HILAR LYMPHADENOPATHY
A pre-clinical state:

- Absence of clinical symptoms
- Usually positive tuberculin skin test or Quantiferon test
- Chest x-ray are usually normal
- Chest x-ray may also show residual changes of infection in the lungs (granulomas) and/or lymph nodes

The original focus of infection is eradicated within weeks or months but bacilli remain viable within dormant granulomas.

Most children are identified during contact investigations or skin test screenings.
Asymptomatic 9-year-old boy with positive Tuberculin skin test

CHEST X-RAY SHOWS NO APPARENT ABNORMALITY

LATENT TB INFECTION (LTBI)
LATENT TB INFECTION (LTBI)

CALCIFIED GHON FOCUS

CALCIFIED RIGHT HILAR LYMPH NODES
Failure of cell mediated immunity to contain or eradicate the infection leads to disease progression.

At risk: immunocompromised, infants and children < 4 yrs, persons with untreated or inadequately treated TB disease.

Symptoms depend on age and degree of dissemination.

Some have few symptoms.

Spectrum of disease progression:

- Progression of primary pulmonary disease
- Progression of lymphadenopathy
- Progression of lung and lymph node disease with complications
- Disseminated disease / hematogenous spread (virtually any organ)
PRIMARY TB DISEASE

RML INFILTRATE WITH RIGHT HILAR LYMPHADENOPATHY
PRIMARY PROGRESSIVE TB
PULMONARY DISEASE WITH CAVITATION
PRIMARY PROGRESSIVE TB
PULMONARY DISEASE WITH CAVITATION

LEFT UPPER LOBE
NECROTIC CONSOLIDATION

RIGHT LUNG NECROSIS WITH CAVITATION
Common in primary TB

Usually unilateral but could be bilateral

Predilection to the right side

The younger the child, the higher incidence

Can compress the airway causing hyperaeration or atelectasis
PRIMARY PROGRESSIVE TB
LYMPHADENOPATHY PROGRESSION

PARATRACHEAL LYMPHADENOPATHY
WITH TRACHEAL NARROWING

CARINAL LYMPHADENOPATHY
WITH BRONCHIAL NARROWING
PRIMARY PROGRESSIVE TB
PULMONARY AND LYMPHADENOPATHY PROGRESSION
PRIMARY PROGRESSIVE TB: PARENCHYMAL DISEASE WITH CAVITATION AND POTT’S DISEASE
Presents with barking cough, sputum production, hemoptysis and dyspnea

Result of an enlarged lymph node compression or erosion

Radiographic findings:

- Hyperaeration
- Segmental or subsegmental atelectasis
- Collapse / consolidation

CT with 3D and MPR

Highly accurate

Shows lymphadenopathy compressing the large airway

Shows associated small airways, lung, pleura, and bone disease
TRACHEOBRONCHIAL TB:
ACTIVELY CASEATING TYPE
TRACHEOBRONCHIAL TB
TRACHEOBRONCHIAL TB:
SPECTRUM OF CT FINDINGS
Well recognized manifestation of TB in children.

Pleural effusions, thickening and calcification.

Pleural effusions are usually unilateral and may vary in size.

Maybe serous, proteinaceous, bloody or purulent.
PLEURAL AND PERICARDIAL TB

CONSTRUCTIVE PERICARDITIS:
IRRREGULARAR, THICK, ENHANCING PERICARDIUM
A consequence of primary or post primary disease

Younger children are more prone

Hematogenous dissemination, initially involving lung interstitium and ultimately the airspaces

Nodules measuring 2-3 mm in diameter are seen best on CT

More in lower lung zones because of greater blood flow

Clearing is usually from 7 to 22 months after treatment

TB involvement of other organs is common

Evaluation of other sites especially the brain is important

MILIARY PATTERN
Etiology
- TB spread across placenta
- Fetal ingestion or aspiration of infected amniotic fluid

Symptoms are nonspecific
Importance of clinical suspicion and imaging

Imaging manifestation
- Disseminated / miliary pattern
Also referred to as Adult-type or Reactivation TB
After dormancy, organism are able to reactivate and proliferate leading to post primary
Most common form of TB in adults and older children

Imaging Features:
- Consolidation involving the upper lobes due to decreased lymph flow
- Cavitation is common
- Often associated with significant fibrosis
- Lack of lymphadenopathy
POST PRIMARY OR ADULT TYPE TB
POST PRIMARY OR ADULT TYPE TB
SEQUELAE OF CHRONIC TB: SPECTRUM OF ABNORMALITIES
TB INFECTION

PRIMARY INFECTION

LATENT TB INFECTION

REACTIVATION
a. LUNG APICES
b. EXTRAPULMONARY
c. DISSEMINATED

PRIMARY PROGRESSIVE TB DISEASE

1. PULMONARY
2. EXTRAPULMONARY
3. DISSEMINATED
Latent TB infection

X-ray shows lymphadenopathy with or without lung disease

Radiographs could be normal

Primary Progressive TB Disease

Progressive lymph node and lung disease

Can affect intrathoracic & extrathoracic structures

Post primary TB

Apical cavitary consolidation, fibrosis and atelectasis

There is overlap of radiographic manifestations between primary and post-primary TB
Tuberculosis can affect virtually any organ.
Genitourinary TB is commonly encountered. Intestinal involvement in 55-90% of fatal cases. Hepatobiliary, lymphadenopathy and peritonitis. A minority of patients (<50%) with abdominal TB have abnormal chest radiographic findings. Clinical symptoms are diverse and non-specific. Clinical presentation does not correlate with the severity and extent of imaging findings.
HEPATOSPLENIC TUBERCULOSIS

- Hematogenous dissemination
- Imaging appearance
  - Micronodular
  - Macronodular
  - Mass-like
    - May contain calcifications
- DDX: neoplasm, abscess, fungal infections
GASTROINTESTINAL TB

- Ingestion of the tubercle bacilli
- Direct extension from an adjacent infected organ
- Hematogenous spread

Presentation: abdominal pain, weight loss, anemia, and fever with night sweats, obstruction, palpable mass RLQ

- Hemorrhage, perforation, and malabsorption

Ileocecal involvement in 80 – 90%

Imaging: Inflammation causing mucosal thickening and irregularity, luminal narrowing, and obstruction

DDx: amebiasis, crohn's disease, ileocecal malignancy!
Most common abdominal manifestation: Mesenteric, omental, and peripancreatic locations.

Large, multiple, peripheral enhancement with central areas of low attenuation.

Common among children, supraclavicular and cervical lymph nodes also seen.

Ddx: metastases, Whipple disease, lymphoma, MAI.
Diffuse or focal inflammatory reaction
Associated with widespread abdominal TB

Types
- Wet type: large viscous ascitis
- Dry or plastic: caseous nodules, fibrous reaction and dense adhesions
- Fibrotic fixed: omental masses, matted bowel
SIGNIFICANT ASCITES

ASCITES WITH THICKENED CECAL WALL

WET TB PERITONITIS
DRY TB PERITONITIS
Skeletal involvement in TB occurs in 1-3% - Spondylitis, arthritis, osteomyelitis

Hematogenous spread, direct invasion

Children are more prone than adults

Concurrent intrathoracic TB is present in < 50%

Associated soft tissue abscess

Arthritis: 25% of cases, usually monoarticular - Phemister triad, usually affects hips and knees

Osteomyelitis: unifocal or multifocal - Cystic, infiltrative, erosive, spina ventosa
TUBERCULOUS ARTHRITIS

PHEMISTER TRIAD:
OSTEOPENIA, EROSION, JOINT SPACE NARROWING

PATIENT HAS DESTROYED LUNG FROM TB
CYSTIC TB OSTEOMYELITIS

EROSIVE TB OSTEOMYELITIS
Spine is most common site of bone involvement

Usually upper lumbar (L1) and lower thoracic

More than one vertebral body are typically affected

Begins in the anterior part of the vertebral body adjacent to endplates, spreads to into the disk space

Leads to vertebral collapse - Gibbus deformity

Paraspinal involvement usually the psoas

DDX: pyogenic vertebral osteomyelitis, metastasis, primary neoplasm (lymphoma, myeloma)
TUBERCULOUS SPONDYLITIS
TUBERCULOUS SPONDYLITIS
Hematogenous dissemination to brain and meninges becomes clinically apparent 6 months after infection.

Gelatinous exudate fills the meninges along the basal cisterns and along the walls of the meningeal vessels - Vasculitis causing infarcts (50%) - Communicating hydrocephalus (50-77%).

Abnormal meningeal enhancement typically more pronounced in the basal cisterns.

Other manifestations: tuberculoma, cerebritis, abscess, miliary pattern, subdural epyema and atrophy.
TUBERCULOUS MENINGITIS

DENSE BASAL CISTERN SIGN ON NON-CONTRAST CT
CNS TUBERCULOSIS:
SPECTRUM OF IMAGING FINDINGS
Tuberculosis is a global health concern. TB affects virtually every organ in the body. Childhood TB diagnosis and management could be challenging. Medical imaging plays a very important role. Imaging manifestations are quite diverse. Familiarization with the spectrum of imaging abnormalities is very important. A clinico-radiologic approach is needed for more accurate interpretation of imaging findings.