

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 the evaluation of childhood TB
- Describe the spectrum of imaging findings seen in children with TB

HISTORICAL FACTS

- 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 EPIDEMIOLOGY

- 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 (3.6% of new cases, 20% of previously treated)

TUBERCULOSIS IN CHILDREN

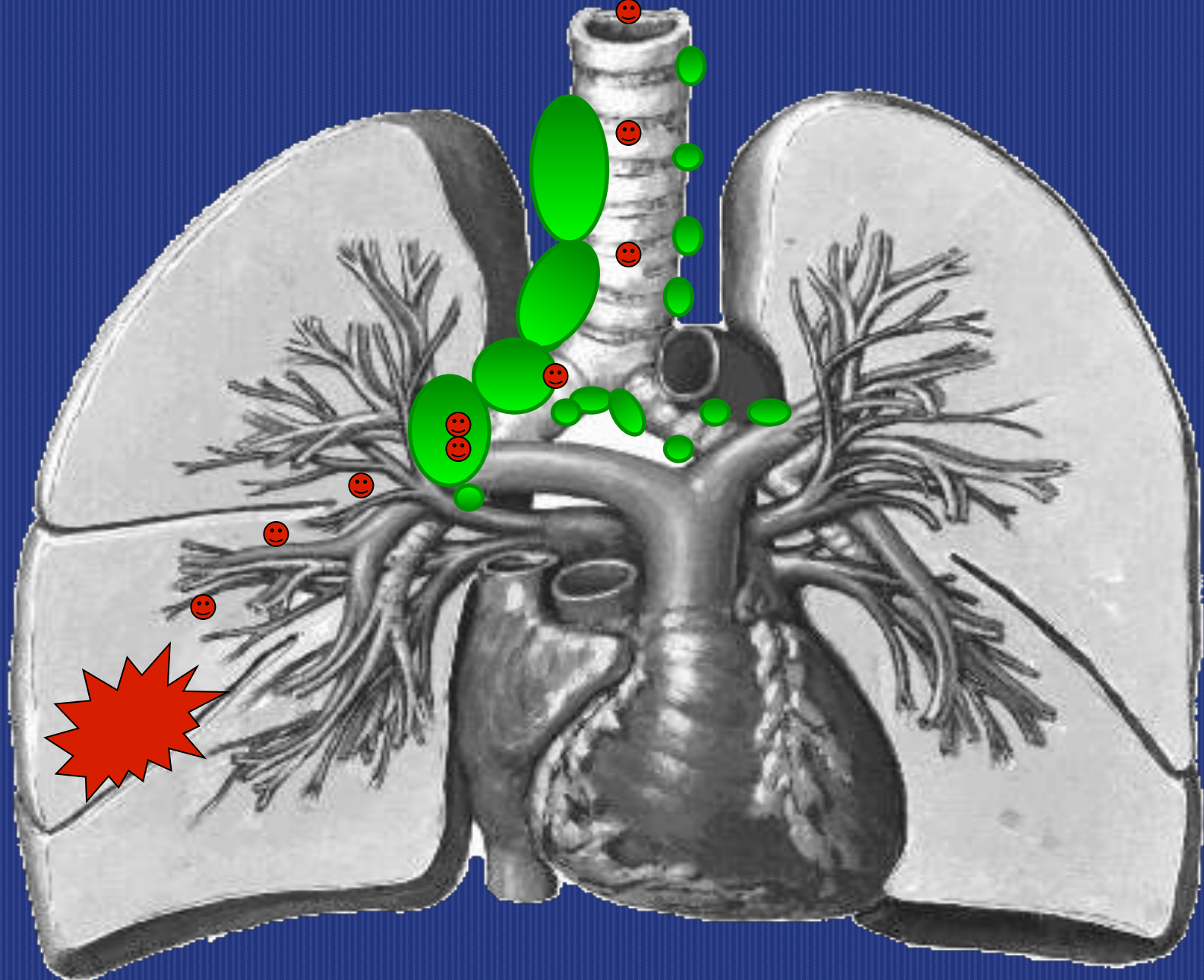
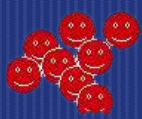
- 2012 TB burden in children (<15 years)
 - 530,000 cases (6% of 8.6 million new cases in 2012)
 - 64,000 deaths/year
- Tuberculosis in children can be hard to diagnose
 - Most children have nonspecific symptoms
 - Culture is not routinely attempted in children
 - Tuberculin skin test, IGRA has false + / -
 - 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**

IMAGING TESTS

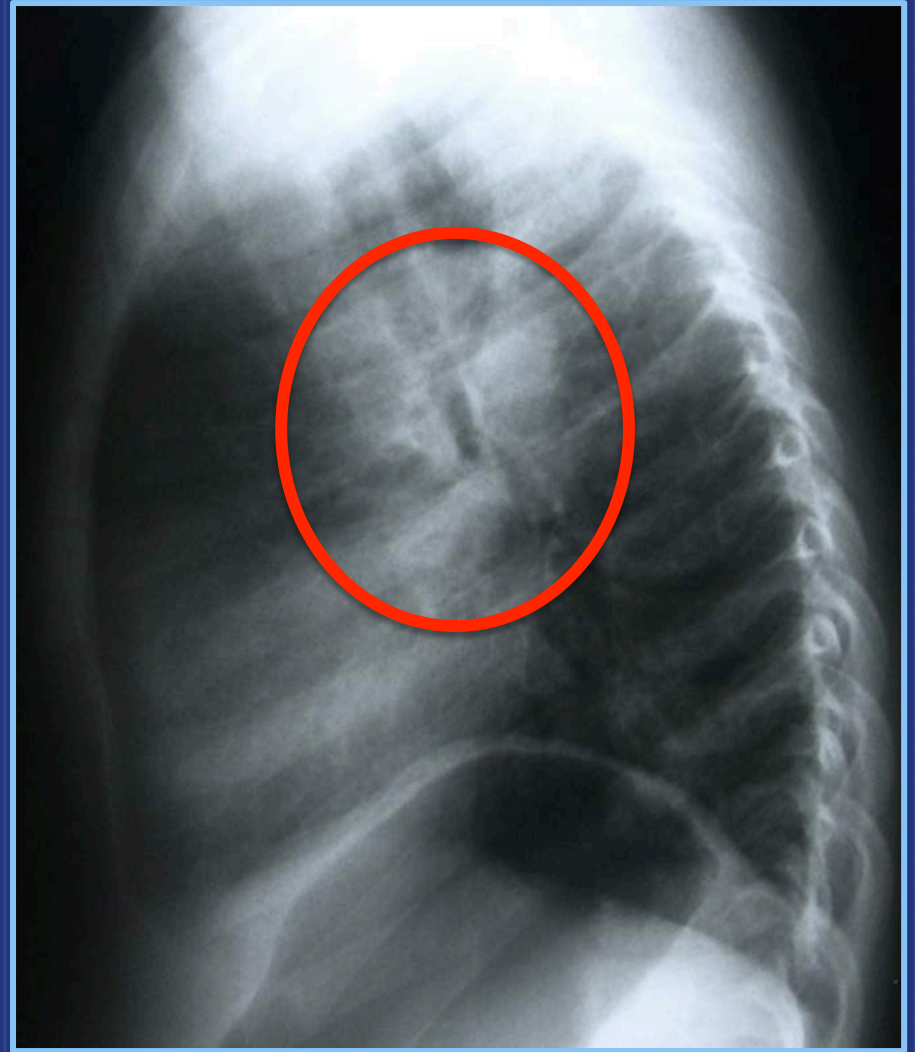
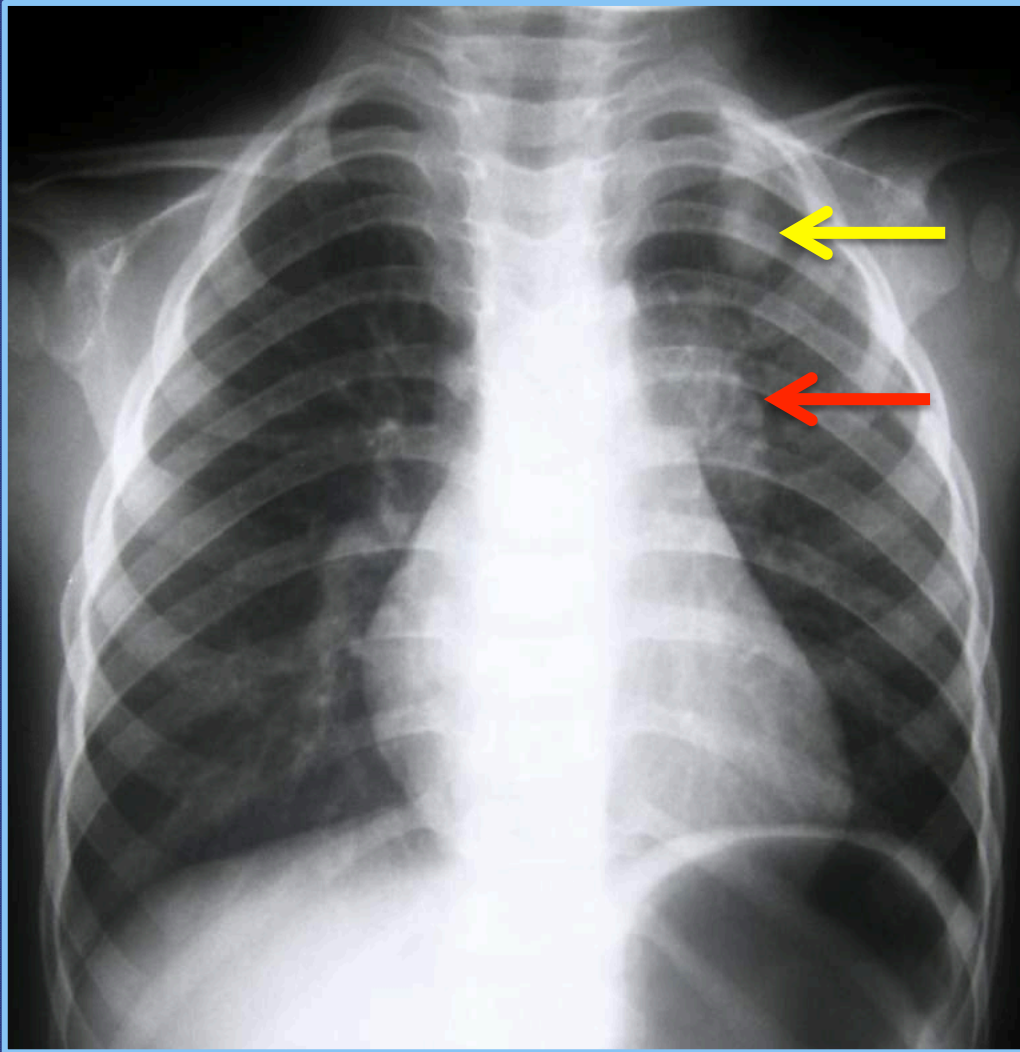
- Radiograph (x-ray) most commonly used imaging test
 - Sensitivity of 38.8%, specificity of 74.4% for TB diagnosis
 - Normal CXR does not rule out TB
 - For lymphadenopathy, 67% sensitive; 59% specific
- Computed tomography (CT)
 - More accurate than x-ray for lymphadenopathy
 - Assessment of disease extent and activity
 - Helpful for suspected TB with unequivocal CXR or without microbiologic proof
- Ultrasound and MRI now plays an increasing role

PRIMARY INFECTION

- Primary infection is mostly seen in younger children
- Mycobacteria are inhaled, settles in the lung, and causes inflammatory reaction (Ghon focus)
- Bacilli multiplies and spread via lymphatics causing lymphadenopathy
- Ghon complex: lung lesion, lymphadenopathy, and lymphangitis
- Bacilli are dormant until re-activation (Latent TB infection) or progresses into active TB disease in some children
- Radiographs usually show lymphadenopathy
 - Subtle lung changes (Ghon focus) may or may not be seen

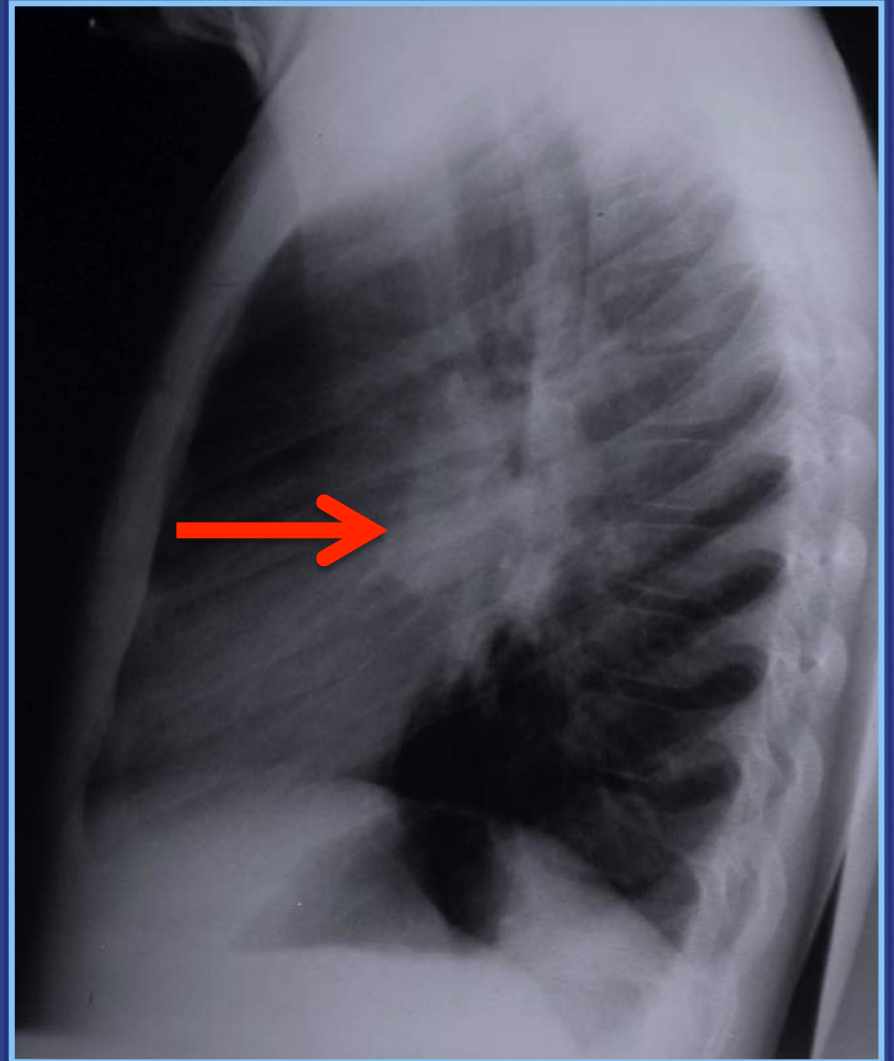
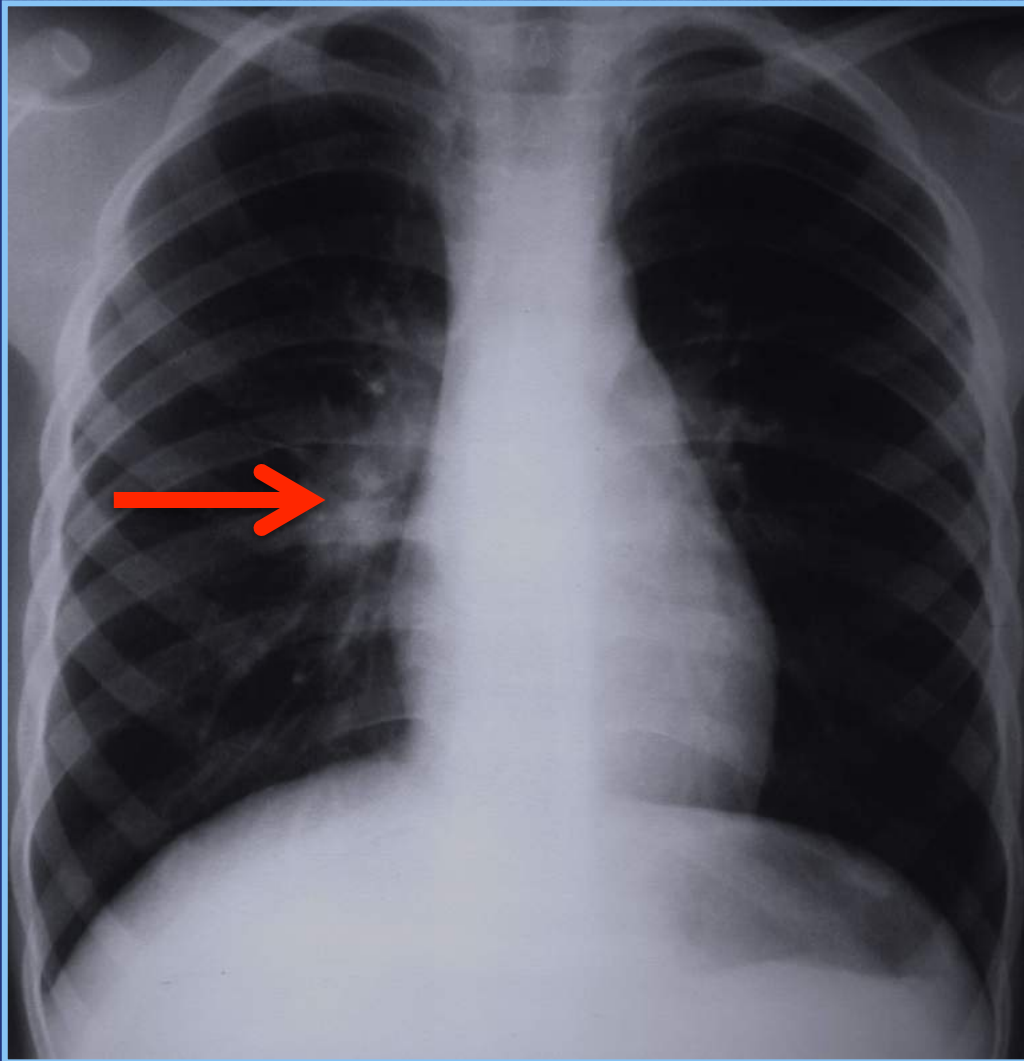


PRIMARY TB INFECTION



LEFT UPPER LOBE GHON FOCUS WITH LEFT HILAR LYMPHADENOPATHY

PRIMARY TB INFECTION

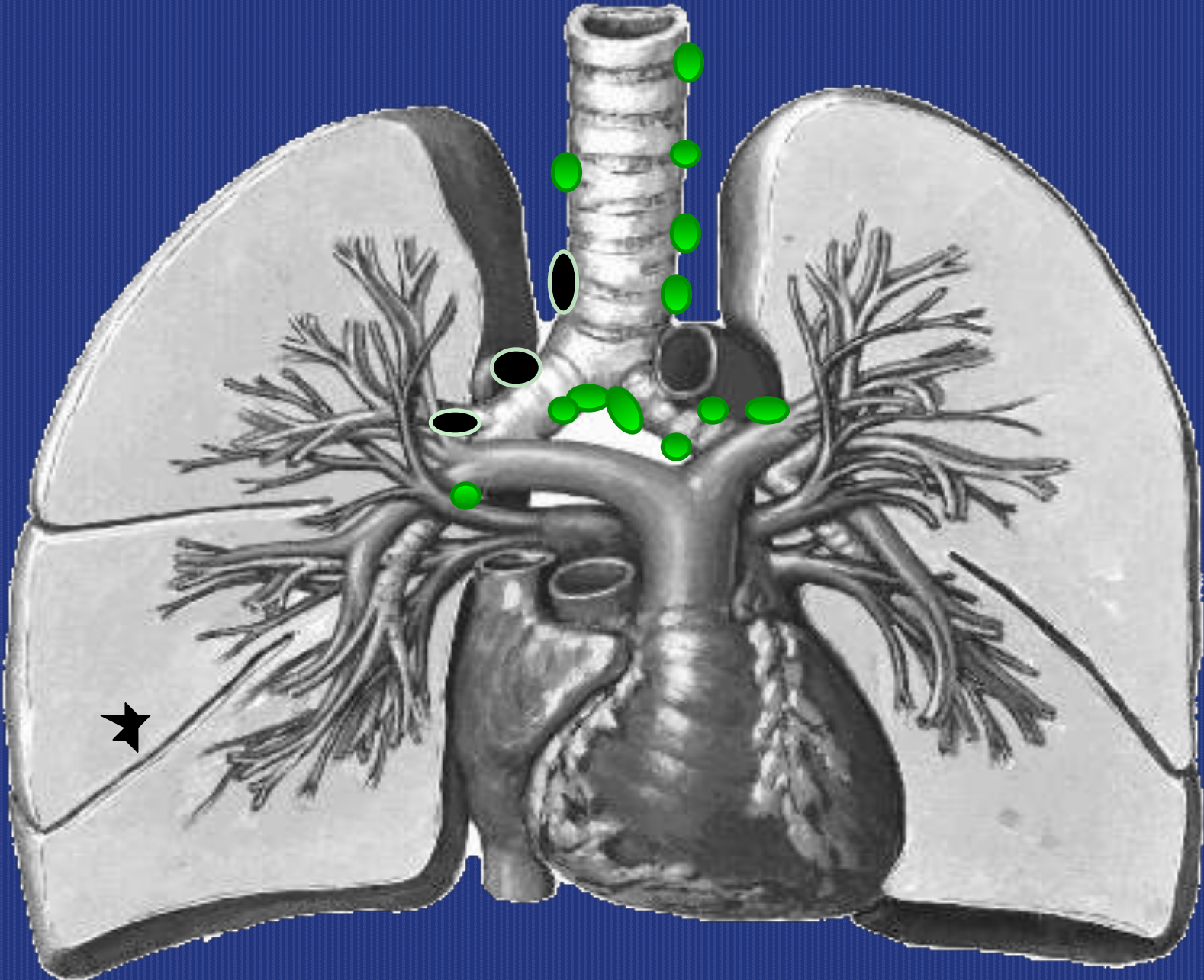


RIGHT HILAR LYMPHADENOPATHY

LATENT TB INFECTION (LTBI)

- 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

LATENT TB INFECTION

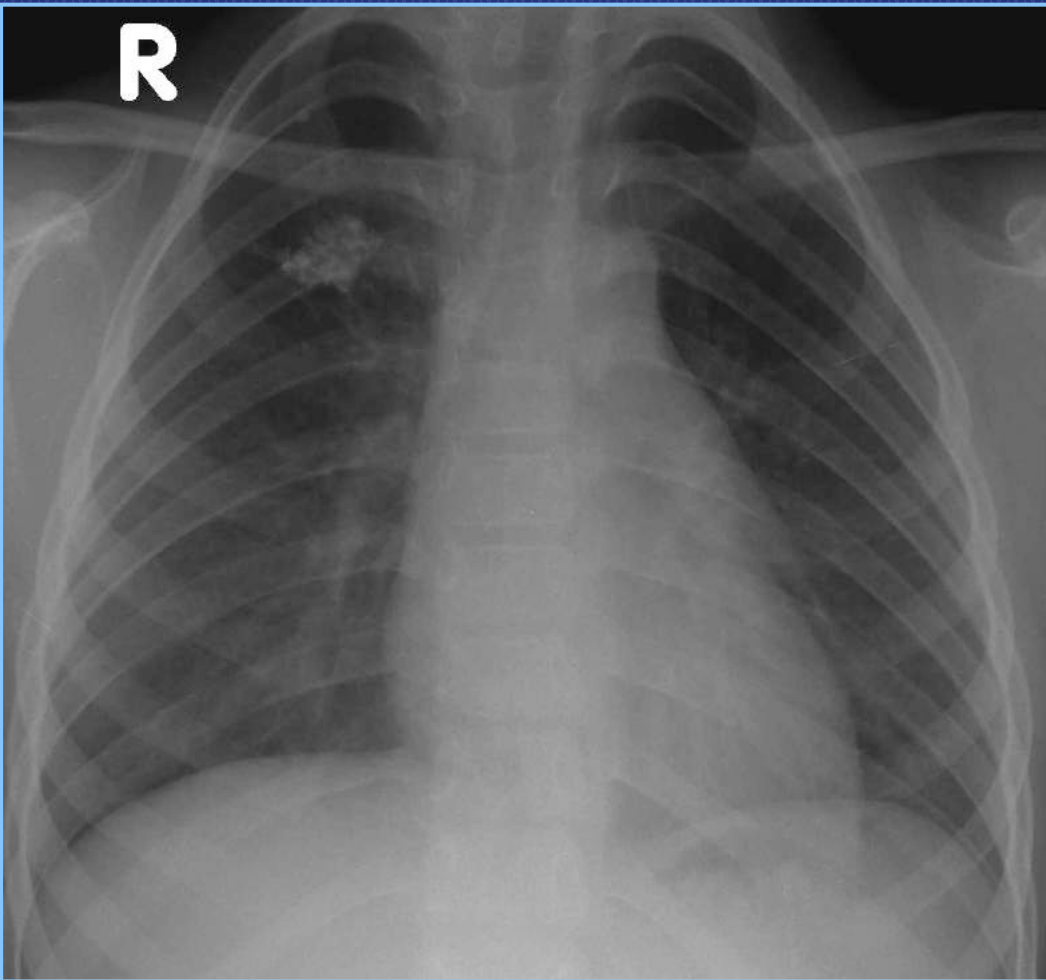


LATENT TB INFECTION (LTBI)

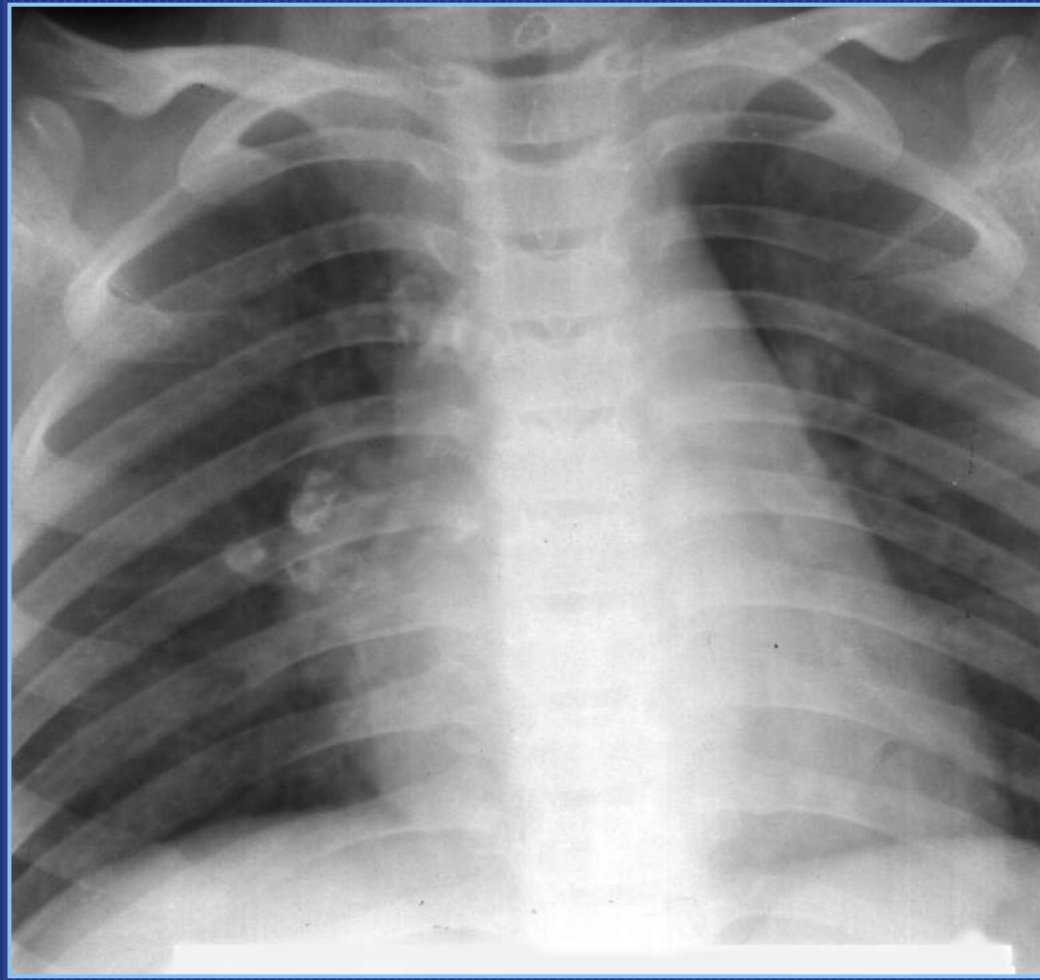


Asymptomatic 9-year-old boy with positive Tuberculin skin test
CHEST X-RAY SHOWS NO APPARENT ABNORMALITY

LATENT TB INFECTION (LTBI)



CALCIFIED GHON FOCUS

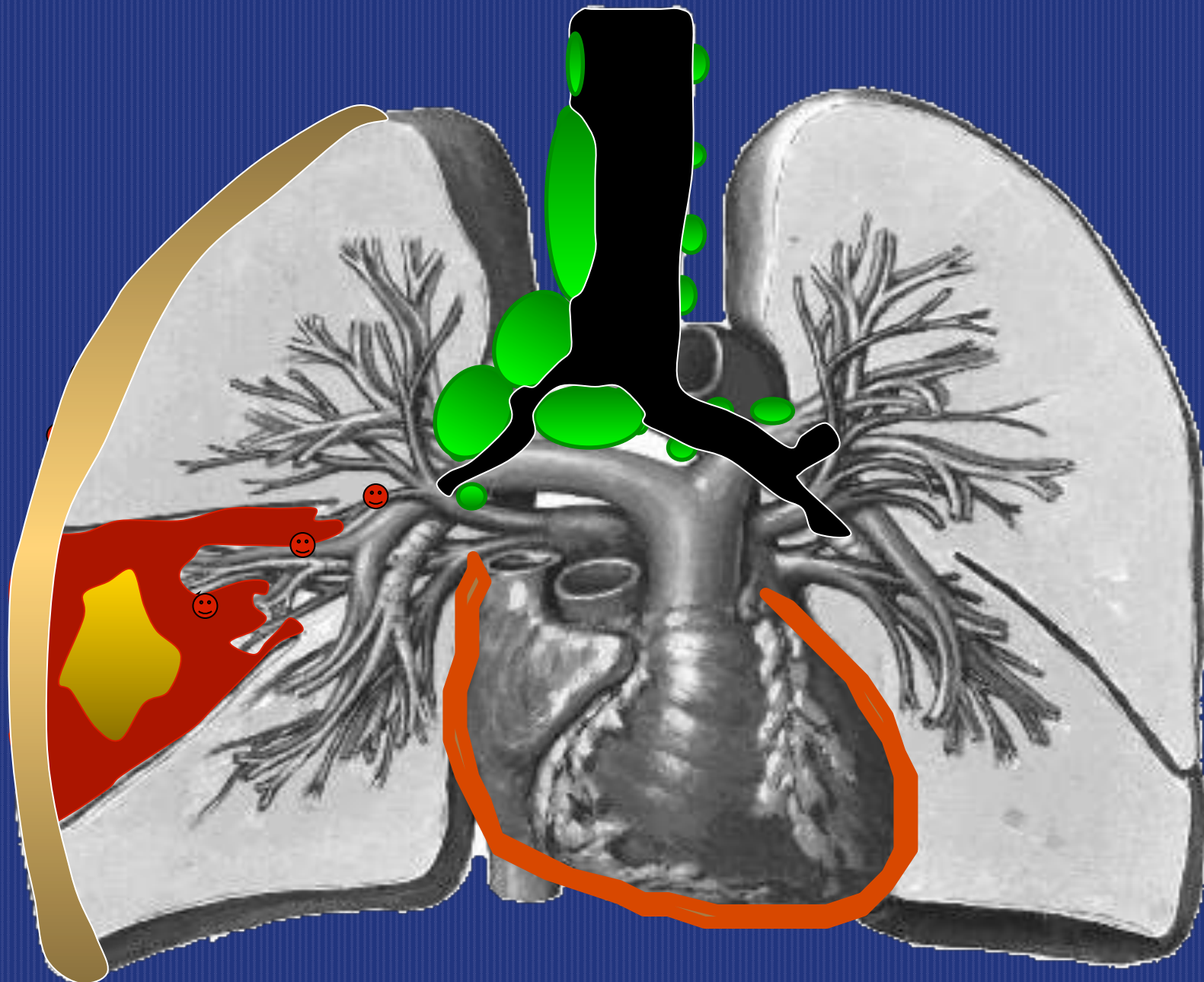


**CALCIFIED RIGHT
HILAR LYMPH NODES**

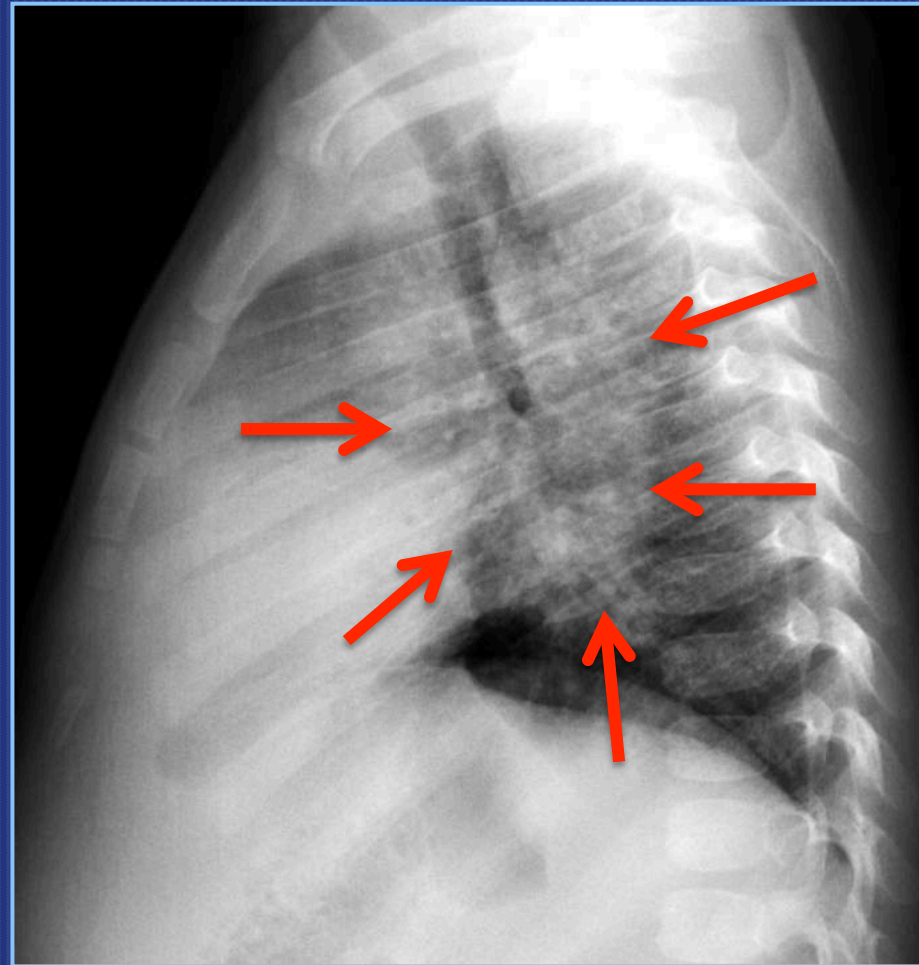
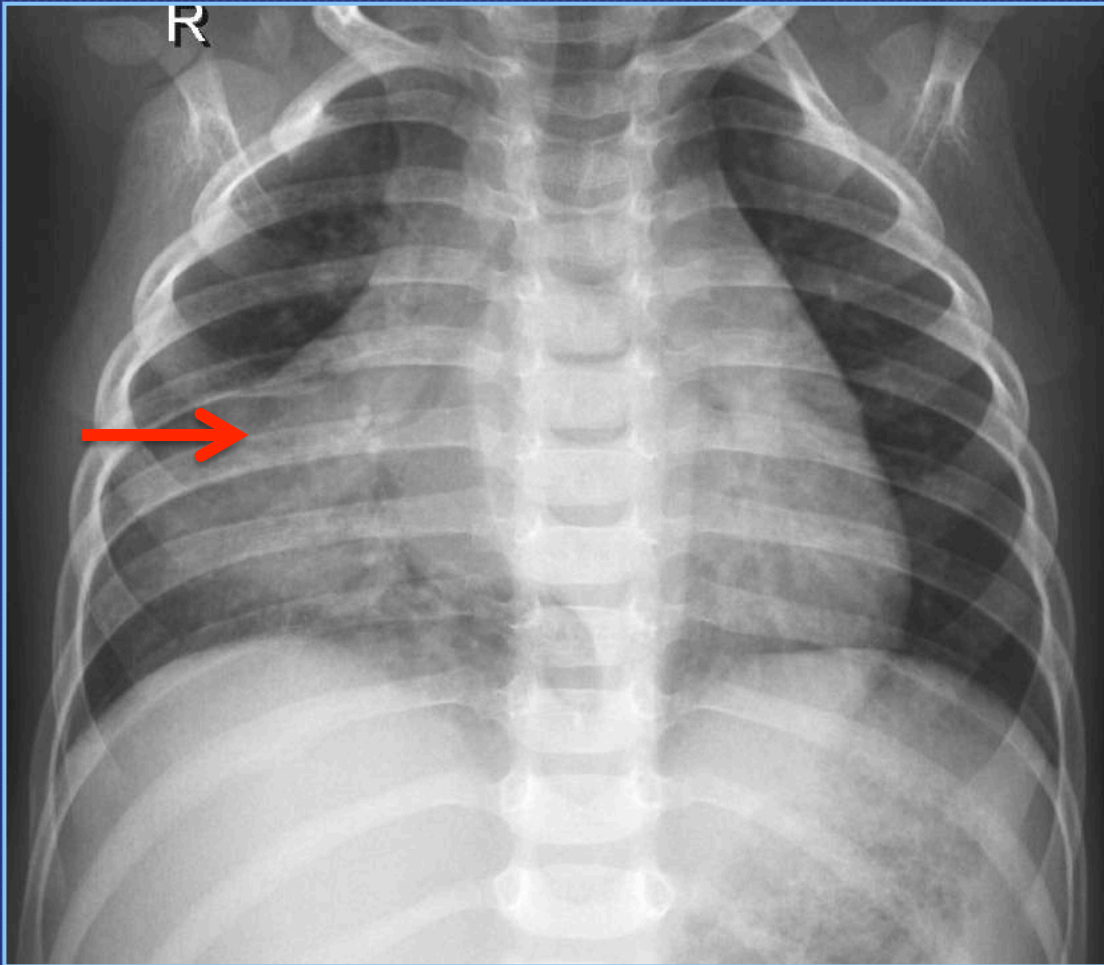
PRIMARY PROGRESSIVE TB DISEASE

- 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 PROGRESSIVE TB DISEASE



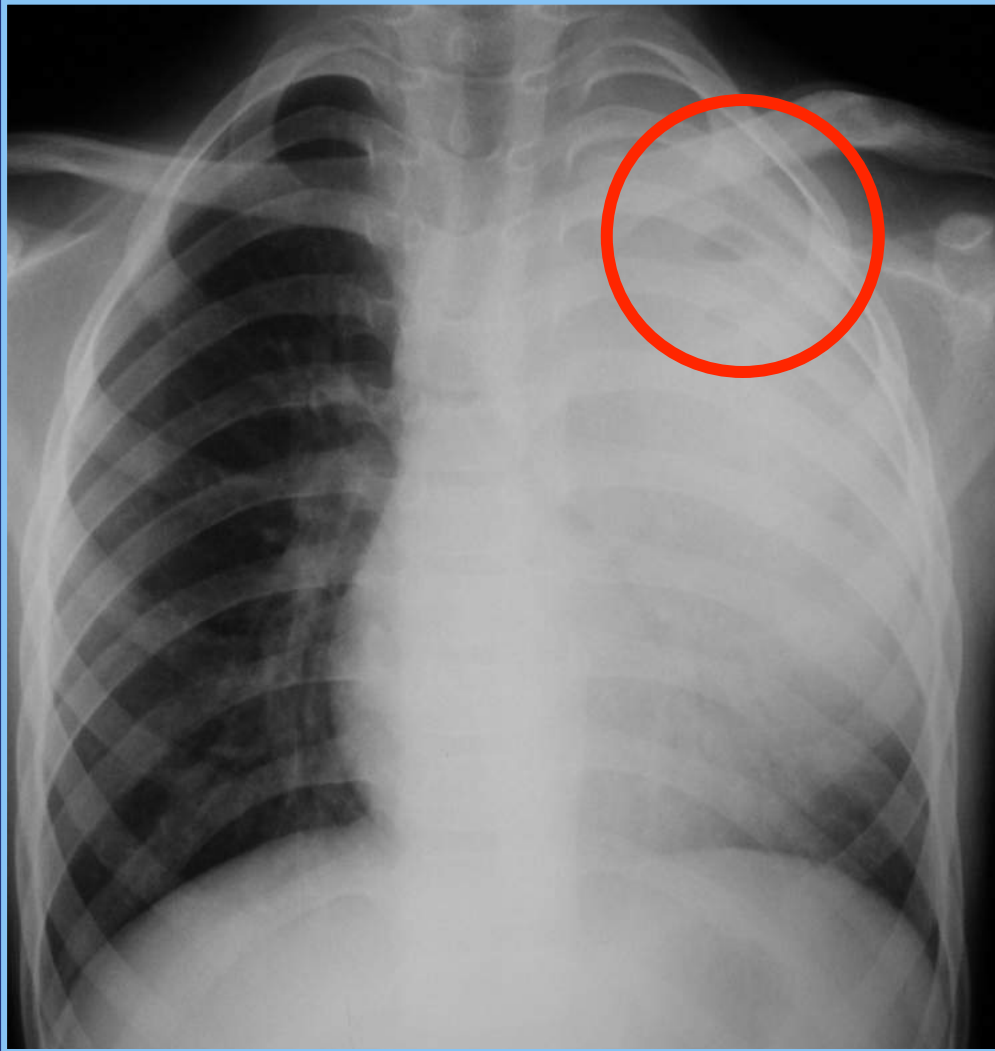
PRIMARY TB DISEASE



RML INFILTRATE WITH RIGHT HILAR LYMPHADENOPATHY

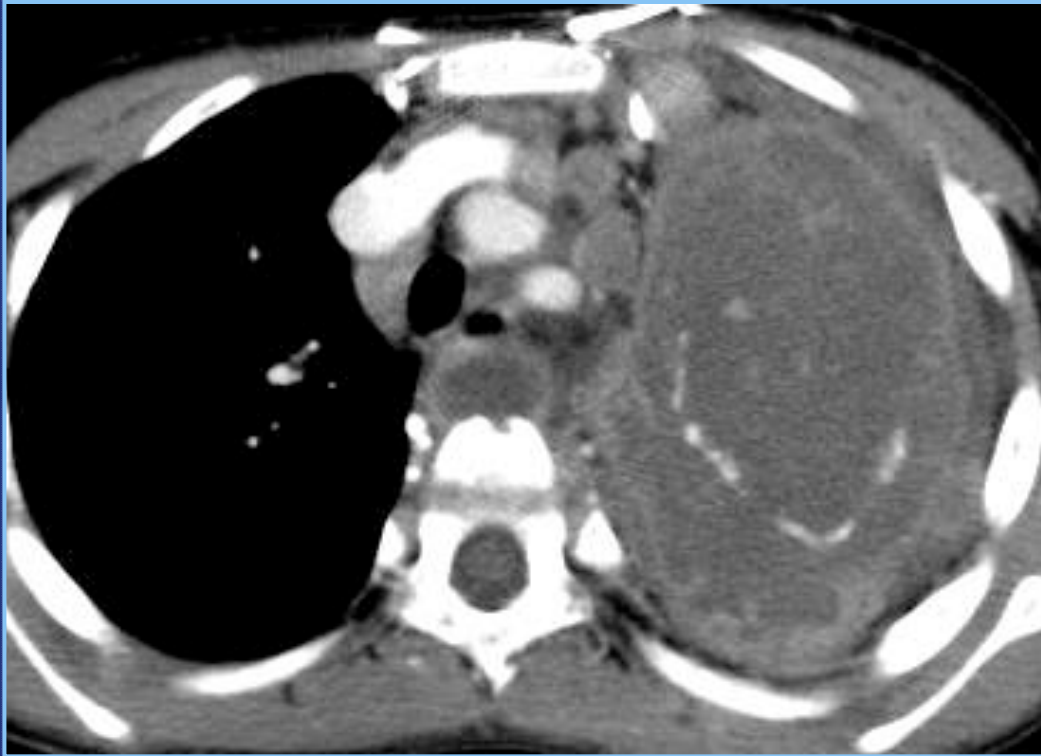
PRIMARY PROGRESSIVE TB

PULMONARY DISEASE WITH CAVITATION

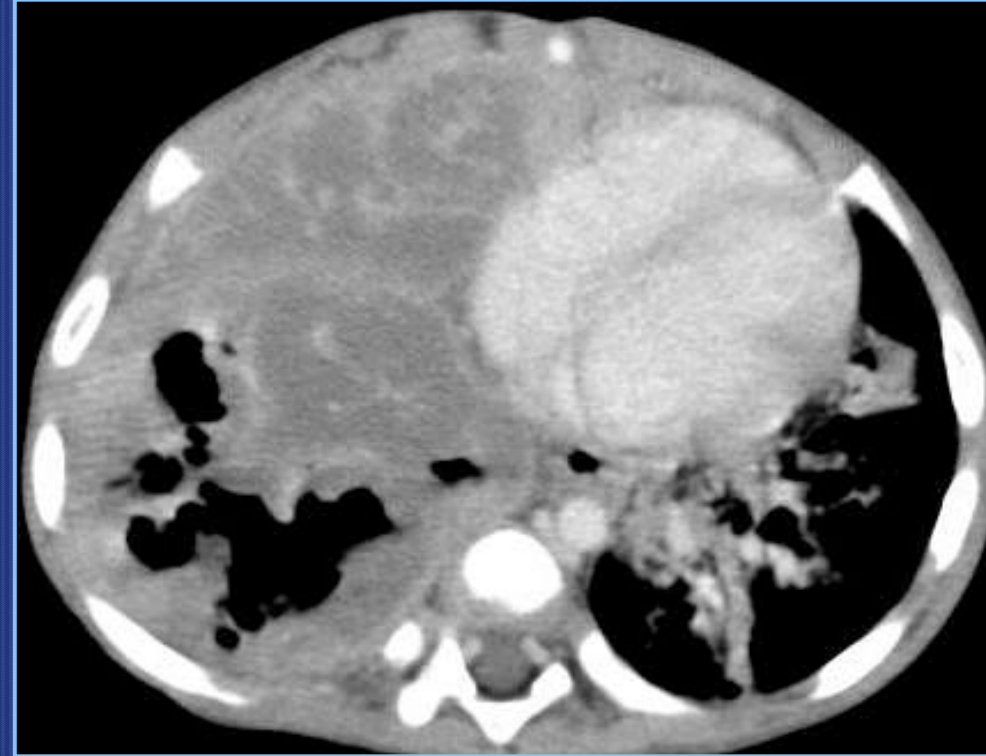


PRIMARY PROGRESSIVE TB

PULMONARY DISEASE WITH CAVITATION



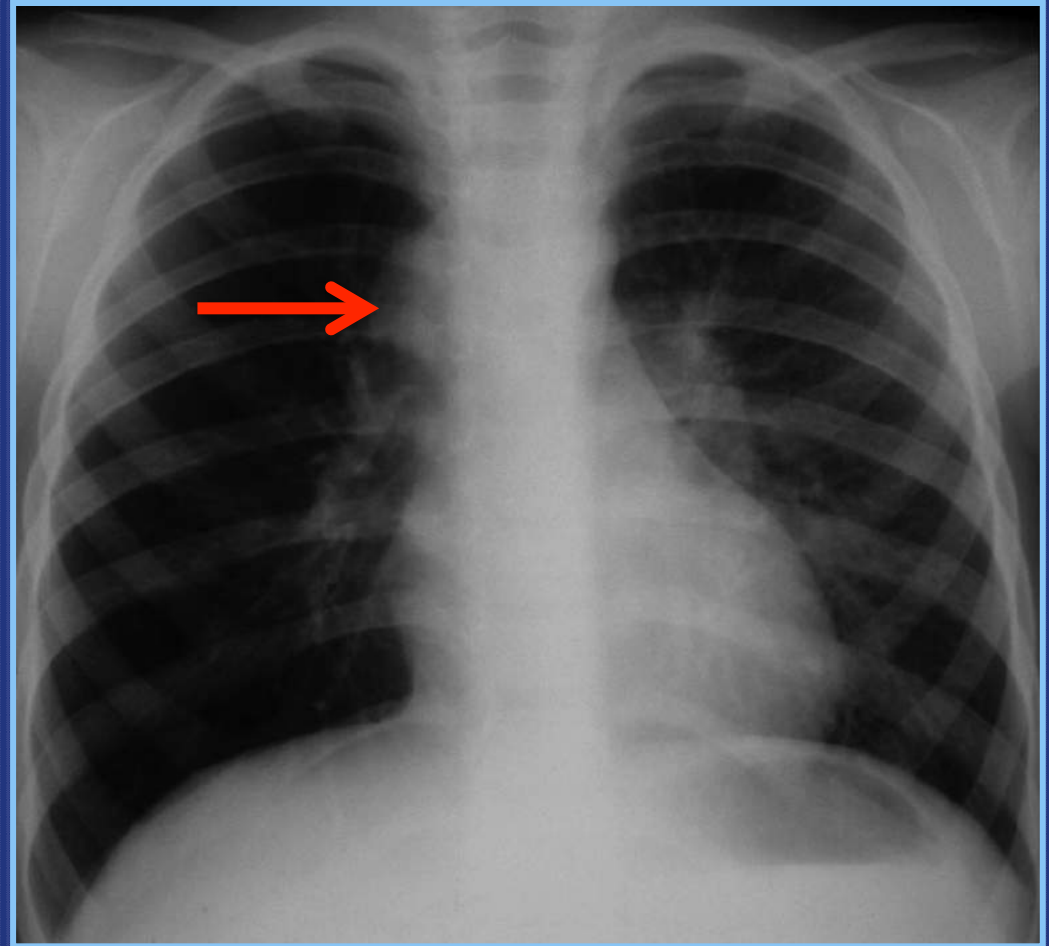
**LEFT UPPER LOBE
NECROTIC CONSOLIDATION**



**RIGHT LUNG NECROSIS WITH
CAVITATION**

LYMPHADENOPATHY

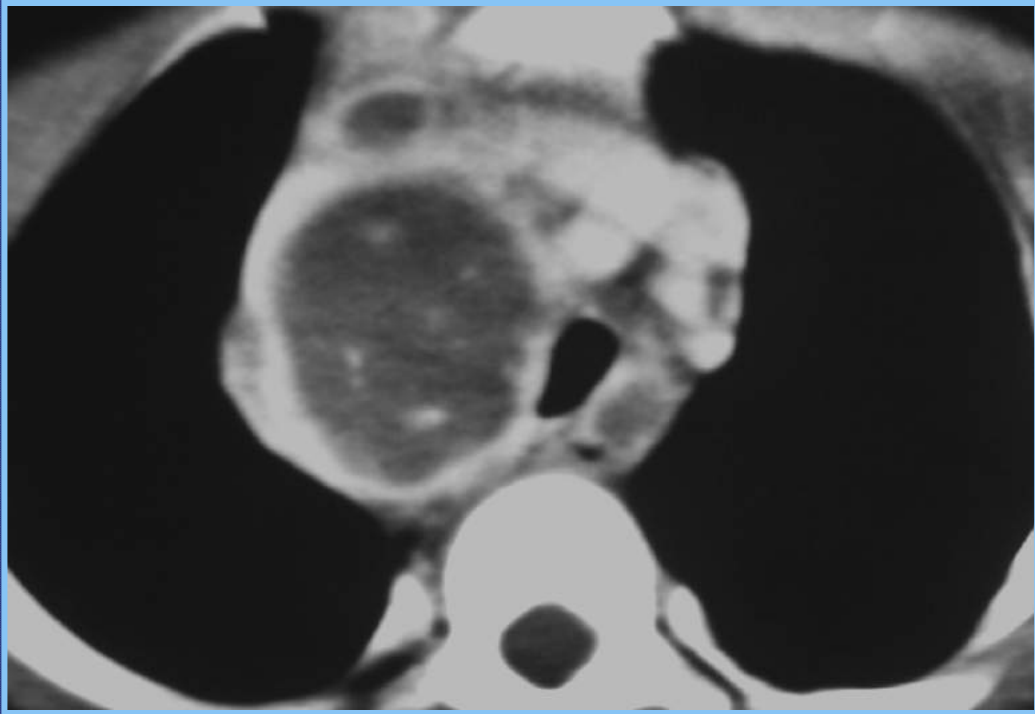
- Common in primary TB
- Usually unilateral but could be bilateral
- Predilection to the right side
- The younger the child, the higher incidence
- Can compress the airway causing hyperaeration or atelectasis



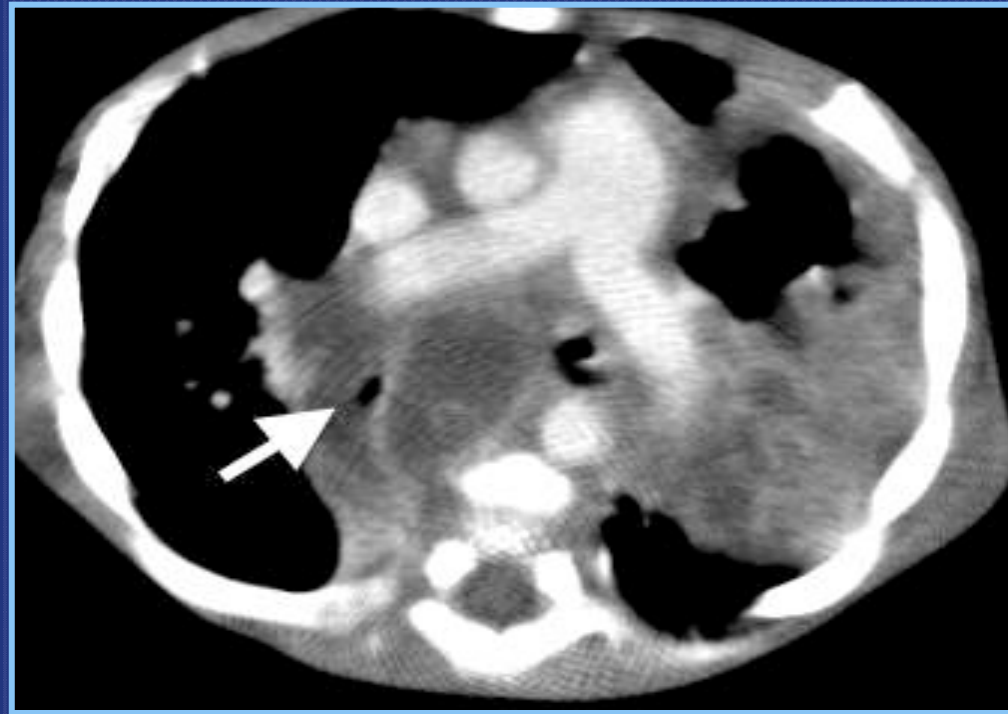
**RIGHT HILAR ADENOPATHY
AND RIGHT LUNG HYPERAERATION**

PRIMARY PROGRESSIVE TB

LYMPHADENOPATHY PROGRESSION



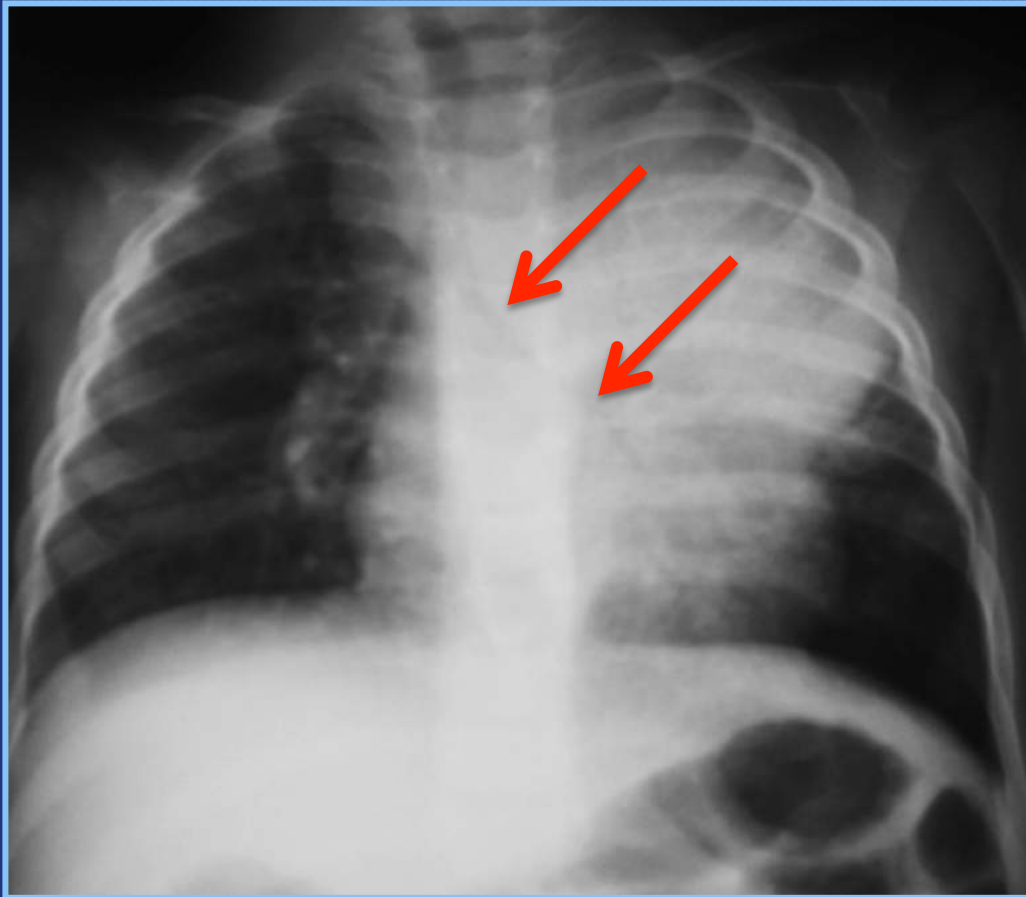
**PARATRACHEAL LYMPHADENOPATHY
WITH TRACHEAL NARROWING**



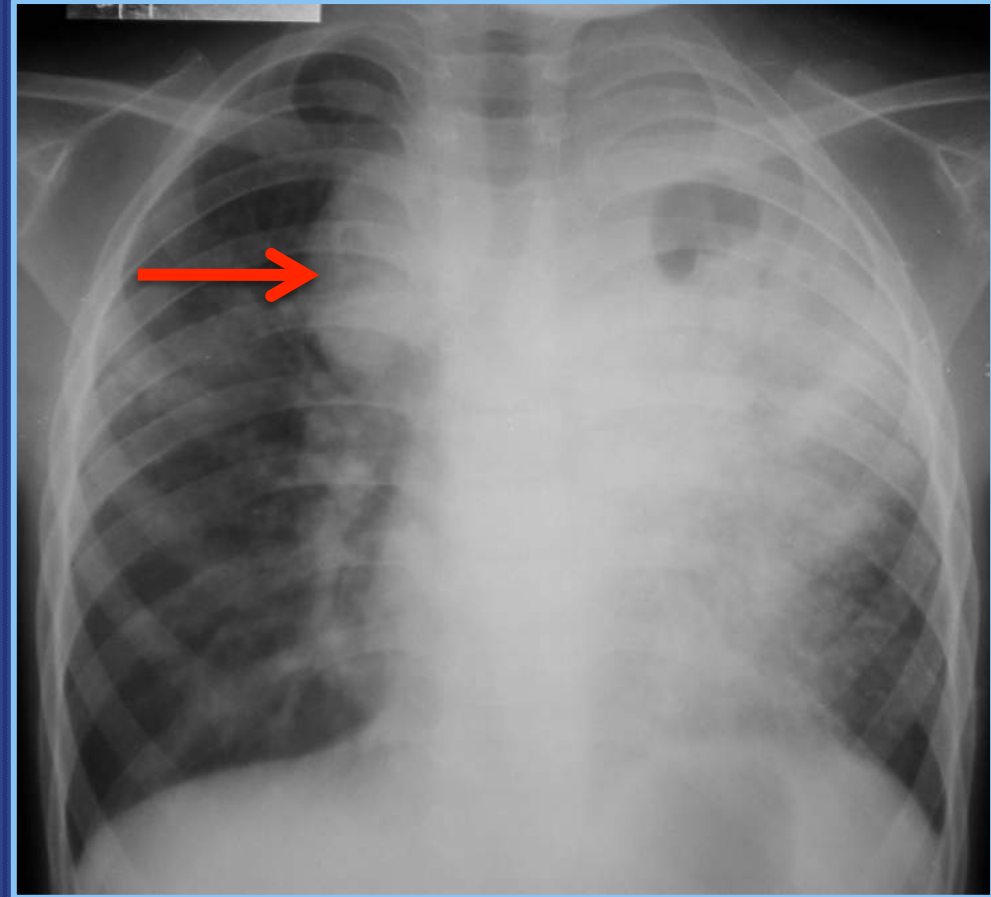
**CARINAL LYMPHADENOPATHY
WITH BRONCHIAL NARROWING**

PRIMARY PROGRESSIVE TB

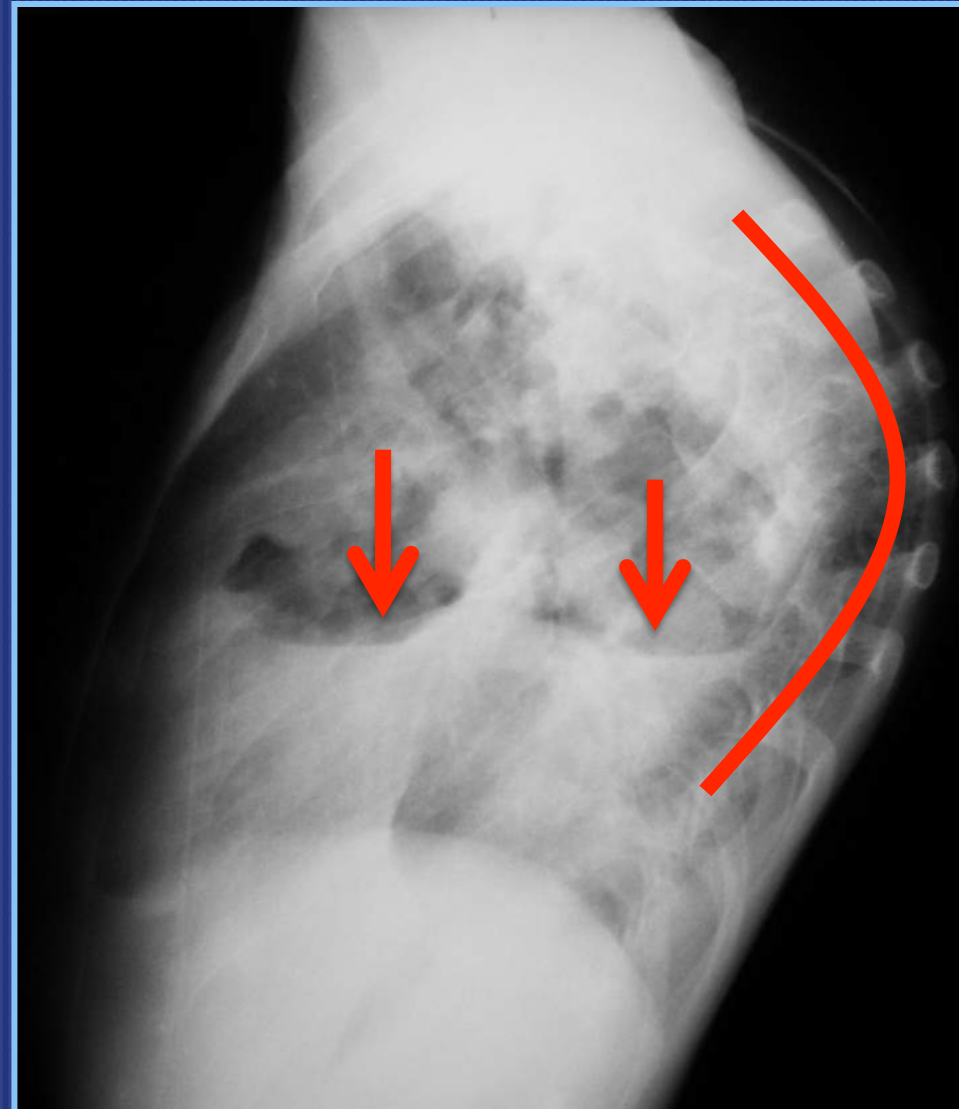
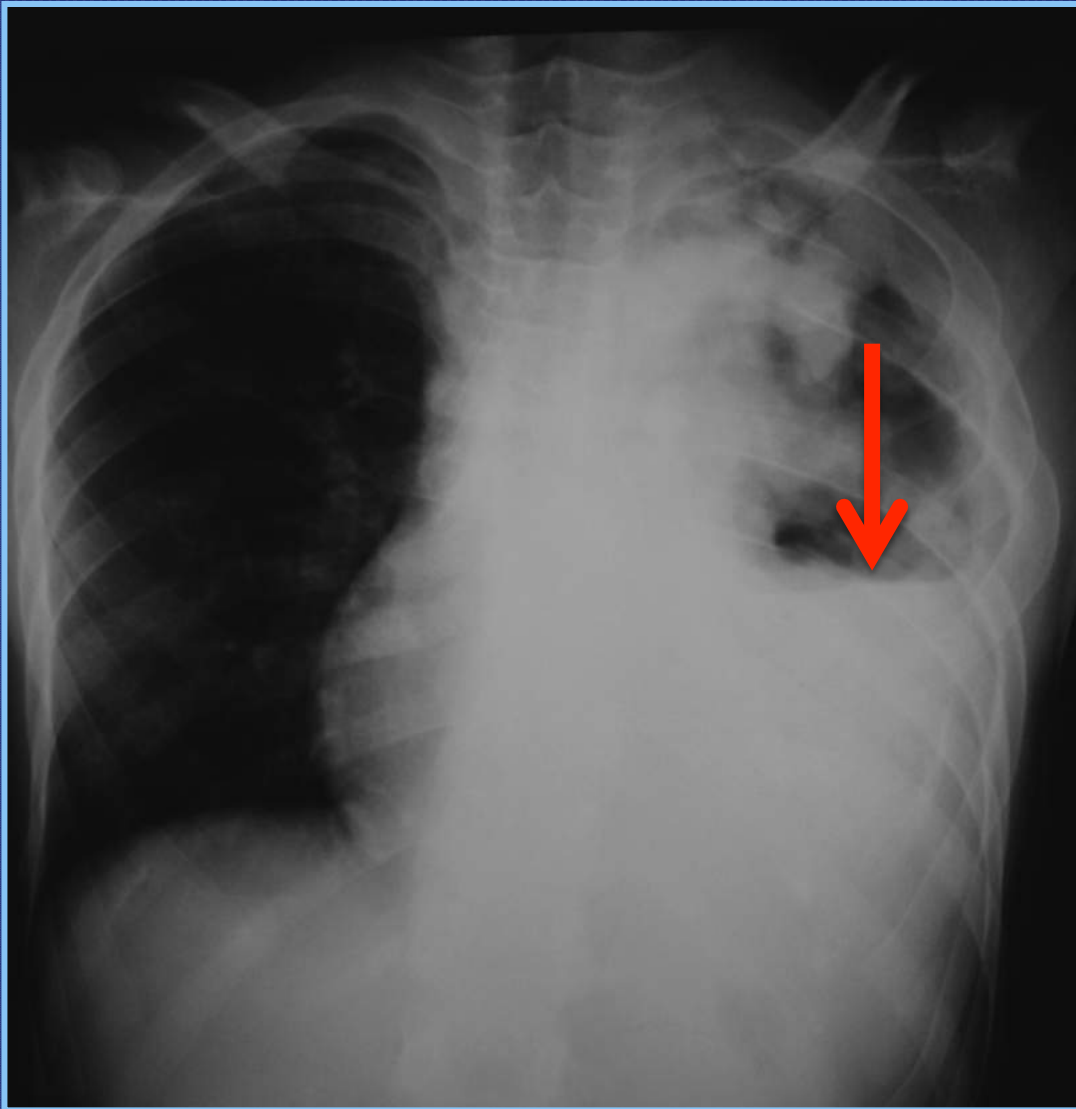
PULMONARY AND LYMPHADENOPATHY PROGRESSION



**LYMPHADENOPATHY AND LUNG DISEASE
DISPLACING THE LEFT MAIN BRONCHUS**



**RIGHT PARATRACHEAL LYMPHADENOPATHY
AND CAVITARY LEFT LUNG DISEASE**

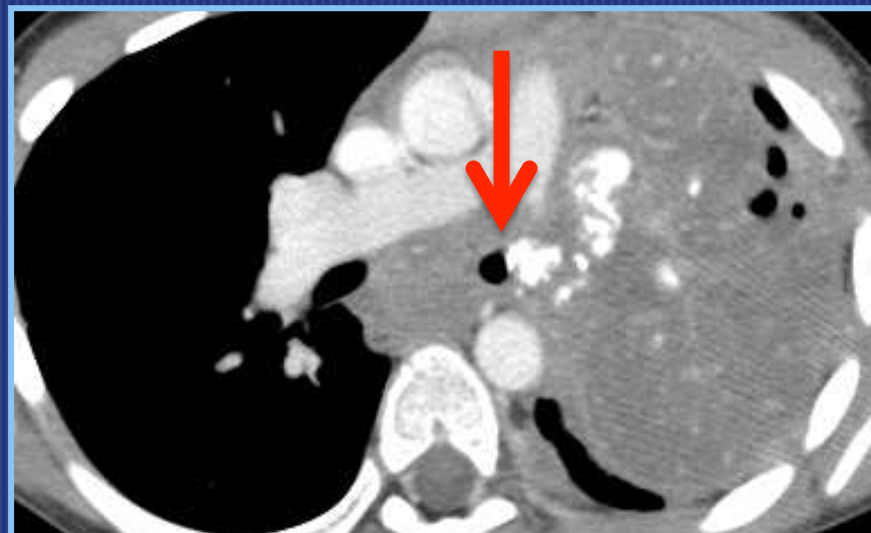
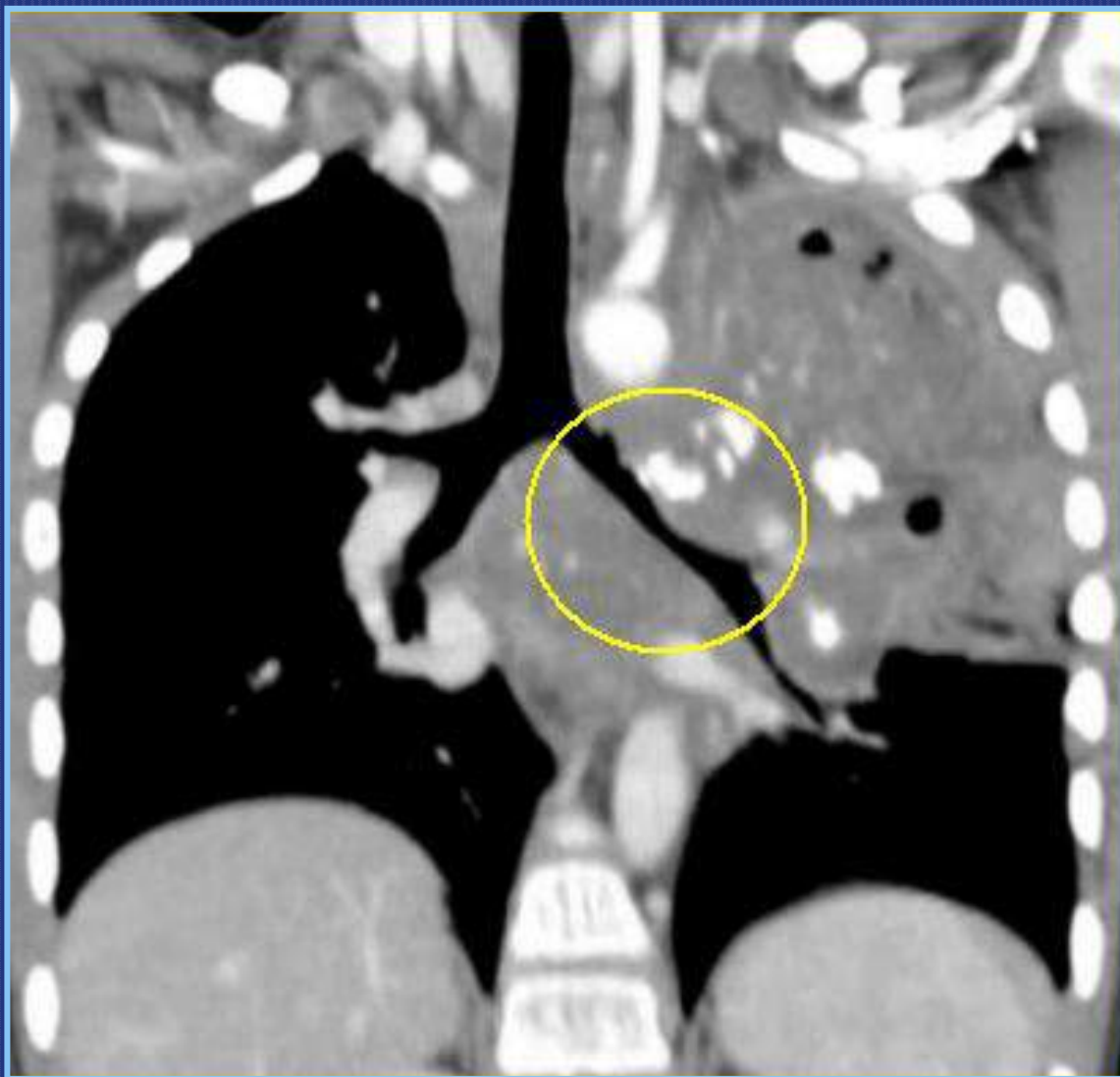


**PRIMARY PROGRESSIVE TB : PARENCHYMAL DISEASE WITH CAVITATION
AND POTT'S DISEASE**

TRACHEOBRONCHIAL TUBERCULOSIS IN CHILDREN

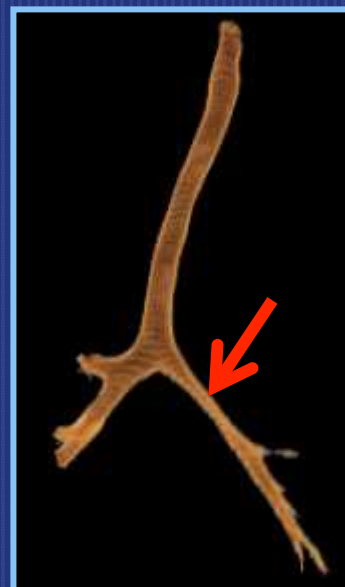
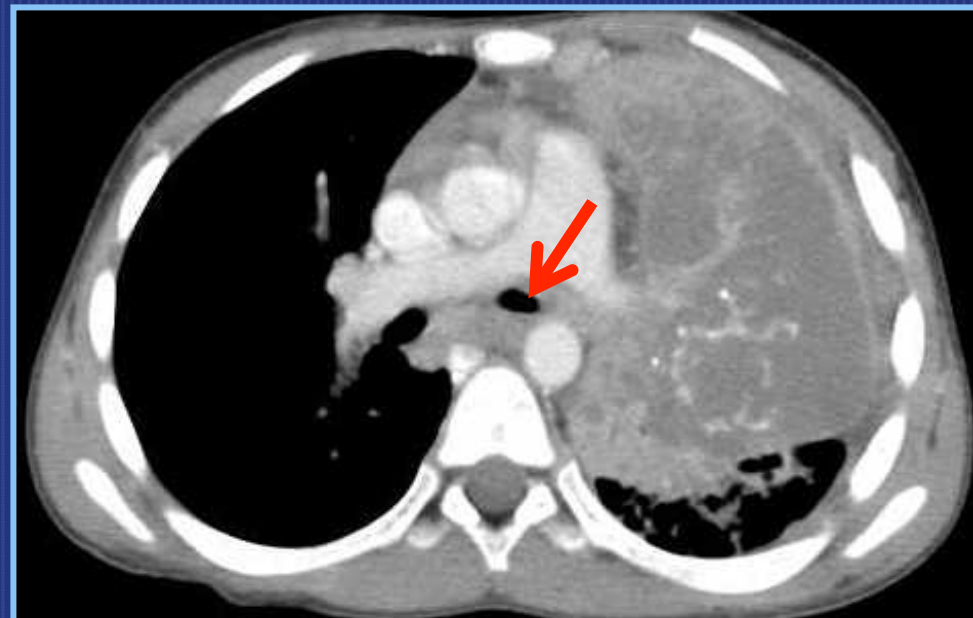
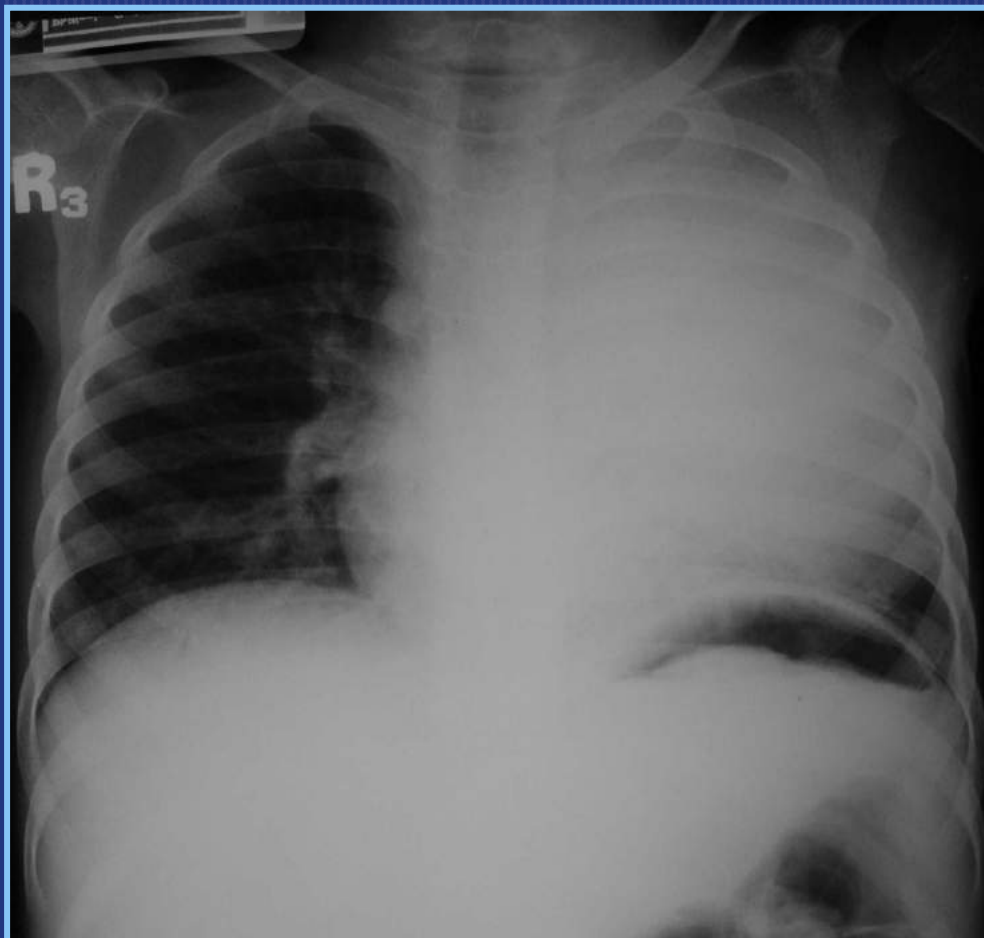
- Presents with barking cough, sputum production, hemoptysis and dyspnea
- Result of an enlarged lymph node compression or erosion
- Radiographic findings:
 - Hyperaeration
 - Segmental or subsegmental atelectasis
 - Collapse / consolidation
- CT with 3D and MPR
 - Highly accurate
 - Shows lymphadenopathy compressing the large airway
 - Shows associated small airways, lung, pleura, and bone disease

TRACHEOBRONCHIAL TB: ACTIVELY CASEATING TYPE

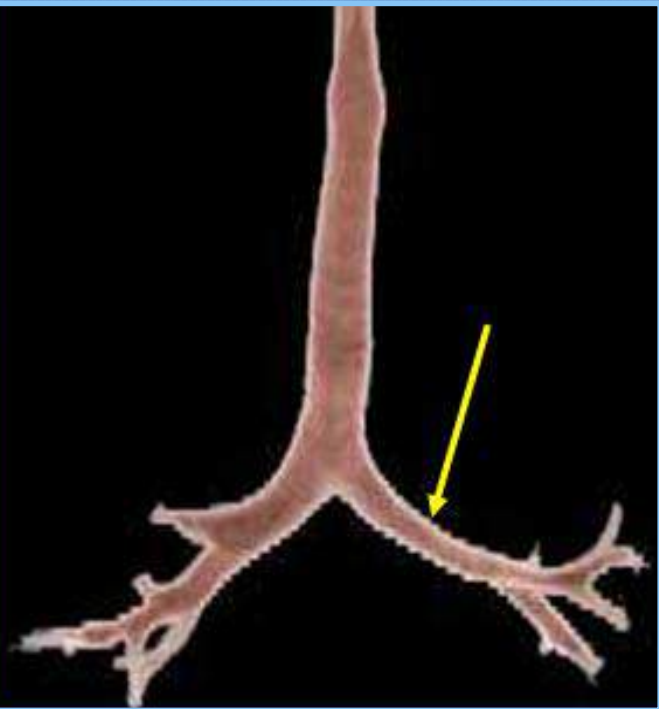


FIBEROPTIC BRONCHOSCOPY

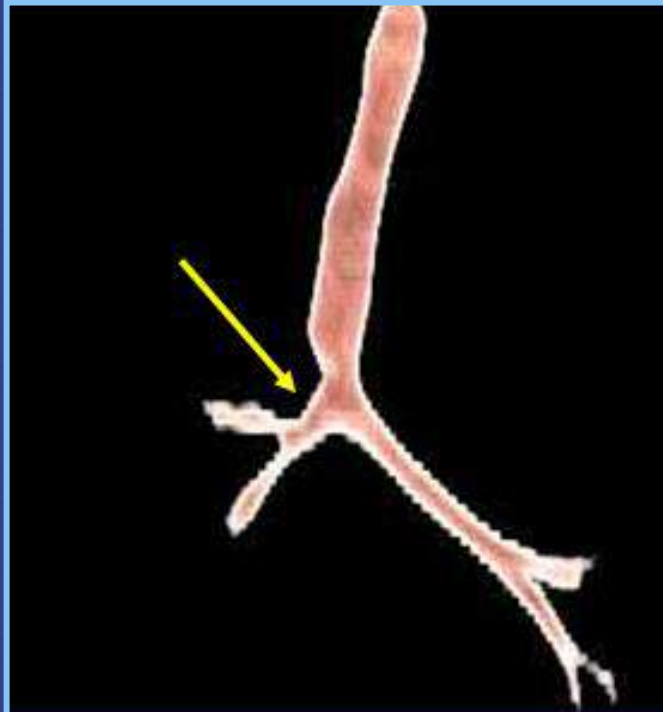
TRACHEOBRONCHIAL TB



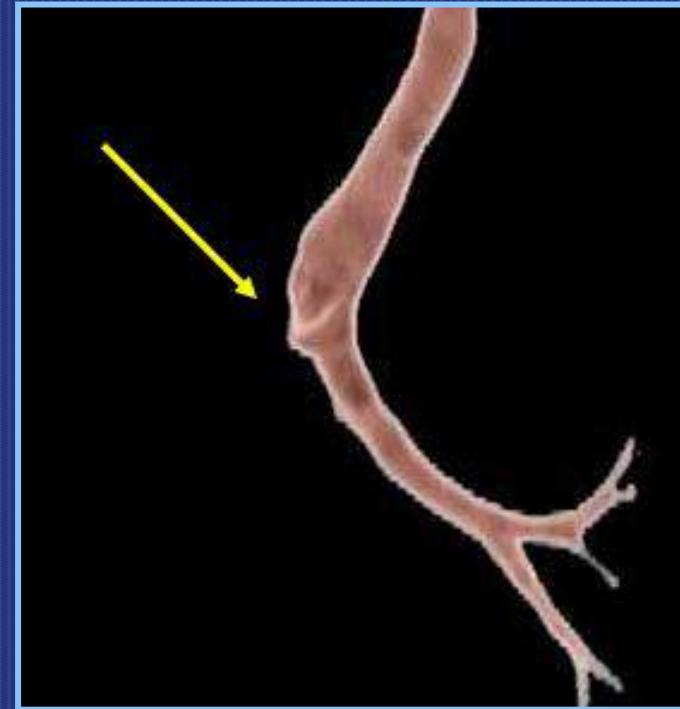
TRACHEOBRONCHIAL TB: SPECTRUM OF CT FINDINGS



SMOOTH NARROWING

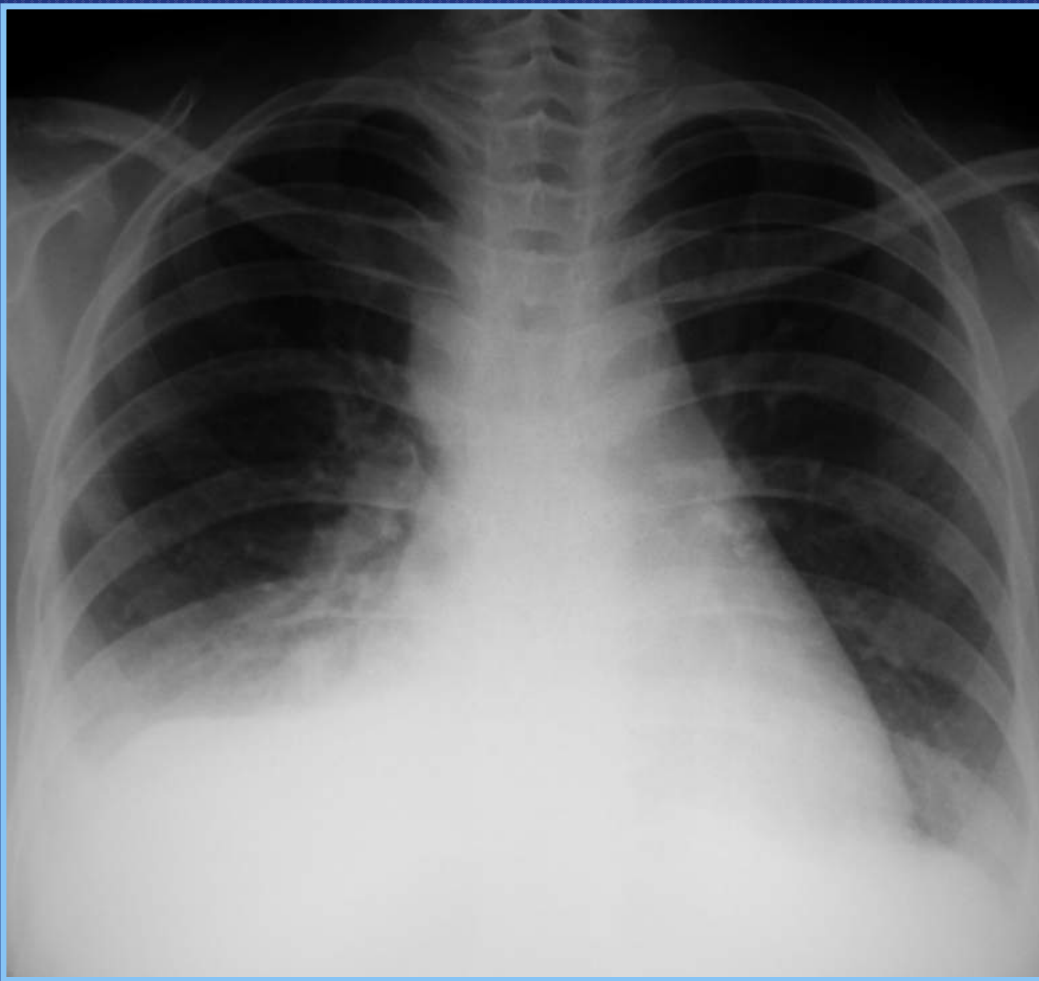


IRREGULAR NARROWING



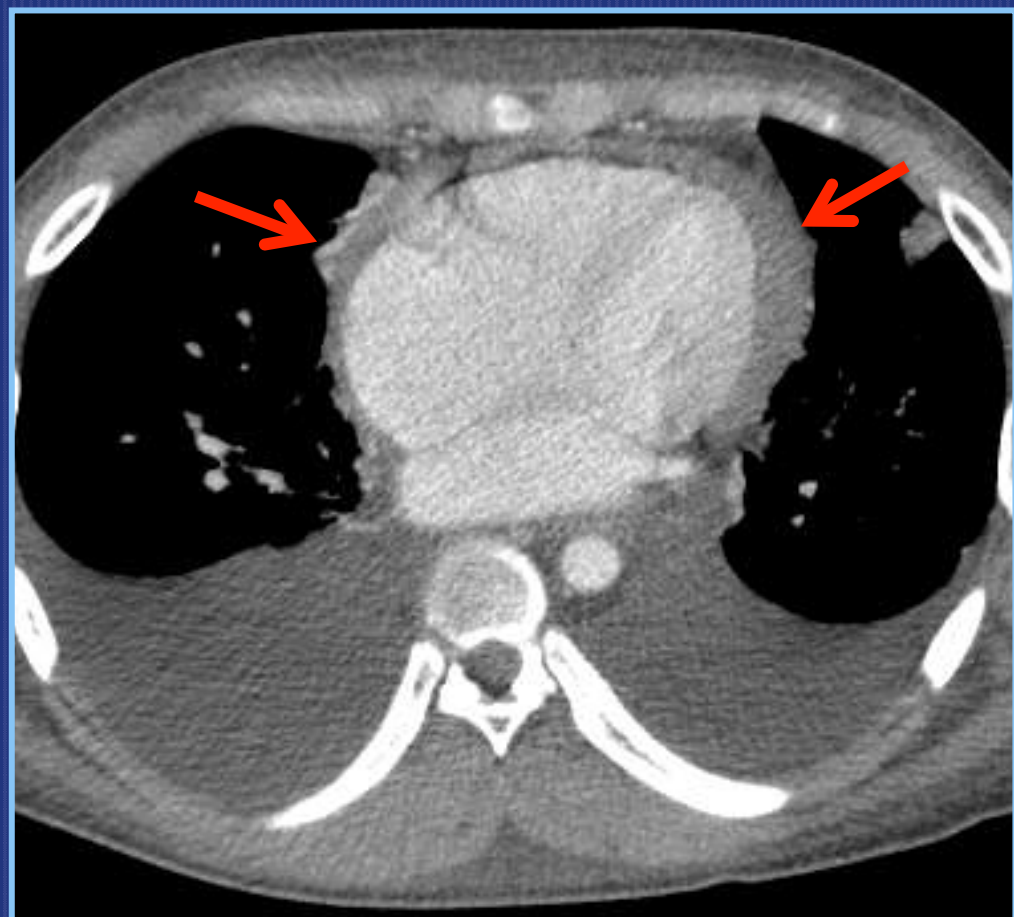
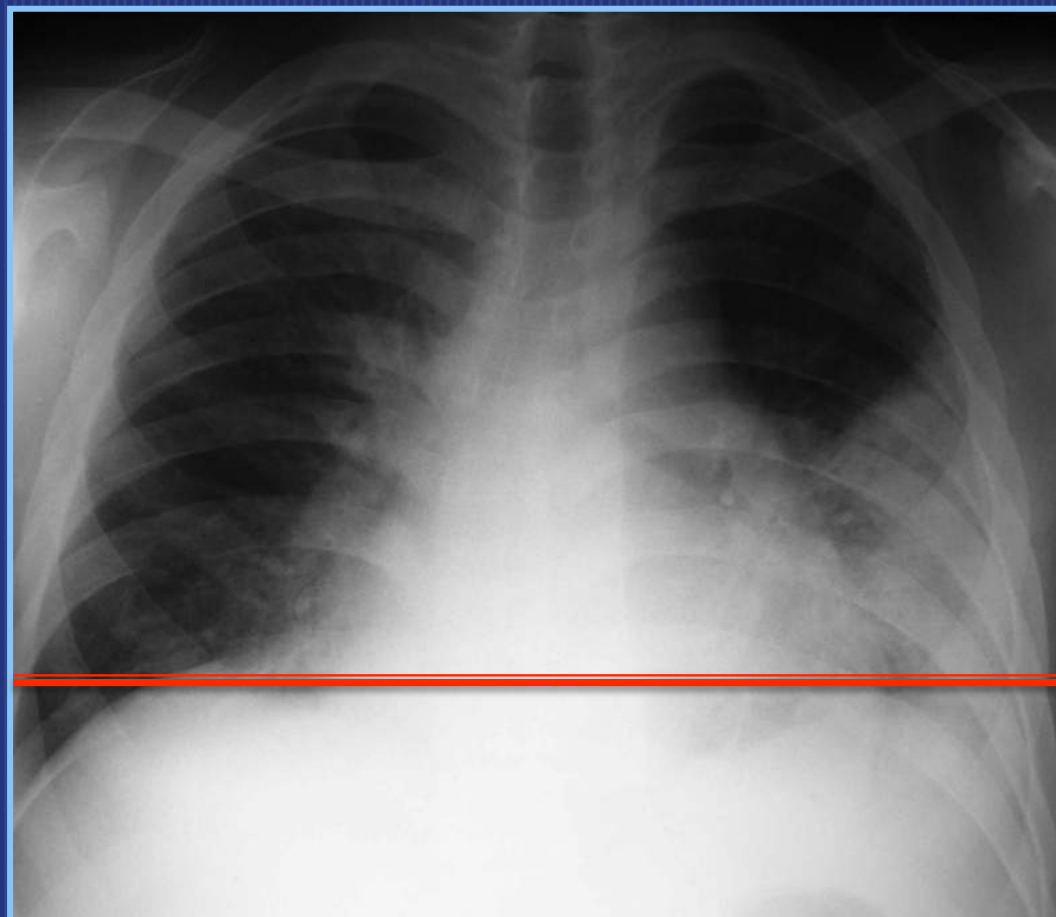
AIRWAY AMPUTATION

PLEURAL DISEASE



- 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

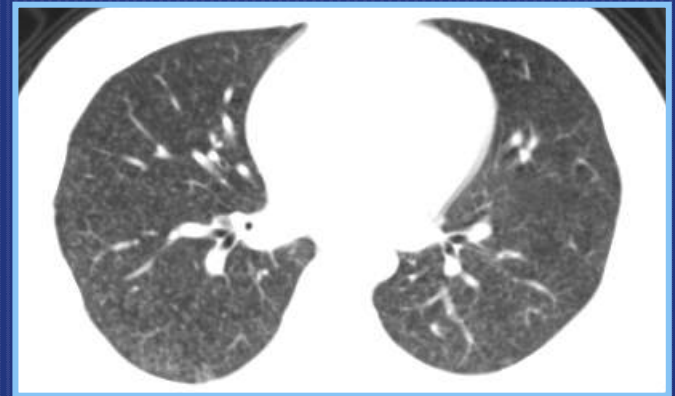
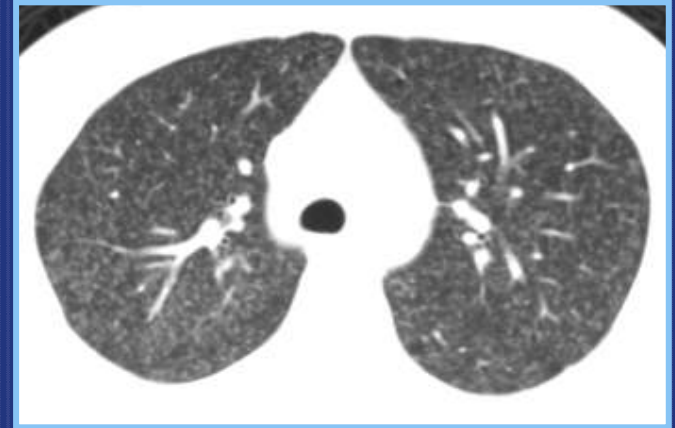
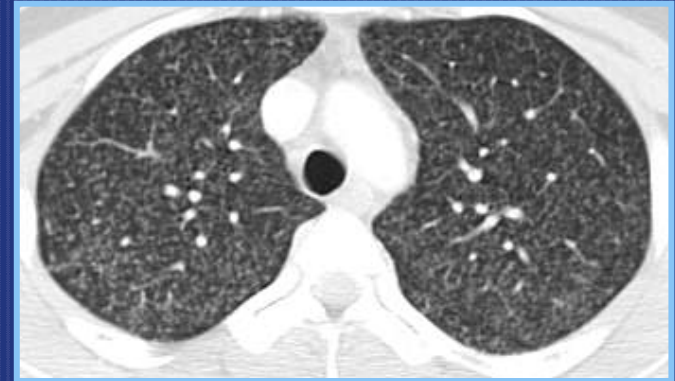
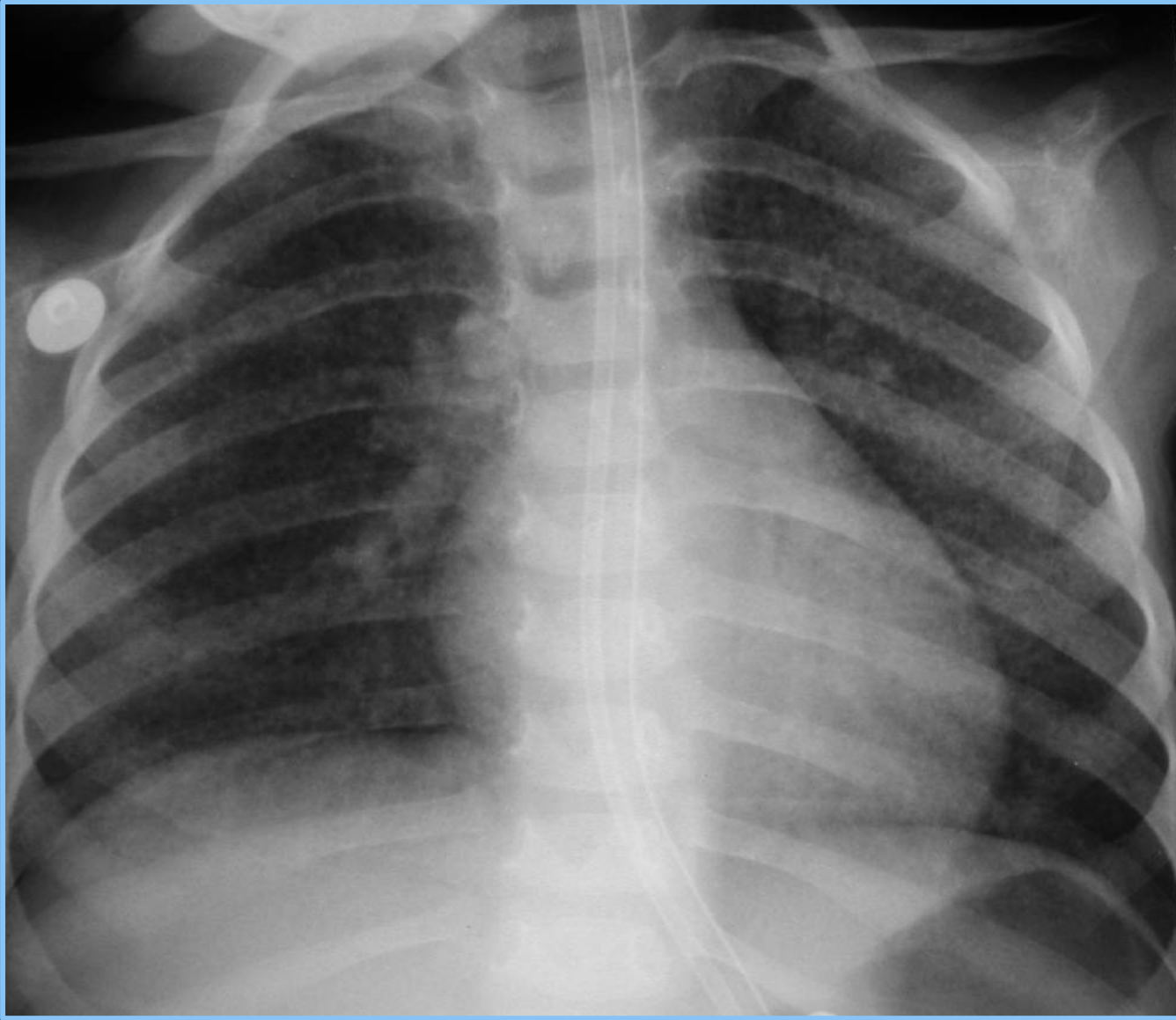
PLEURAL AND PERICARDIAL TB



**CONSTRICTIVE PERICARDITIS:
IRREGULAR, THICK, ENHANCING PERICARDIUM**

MILIARY PATTERN

- 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 TUBERCULOSIS

CONGENITAL TUBERCULOSIS

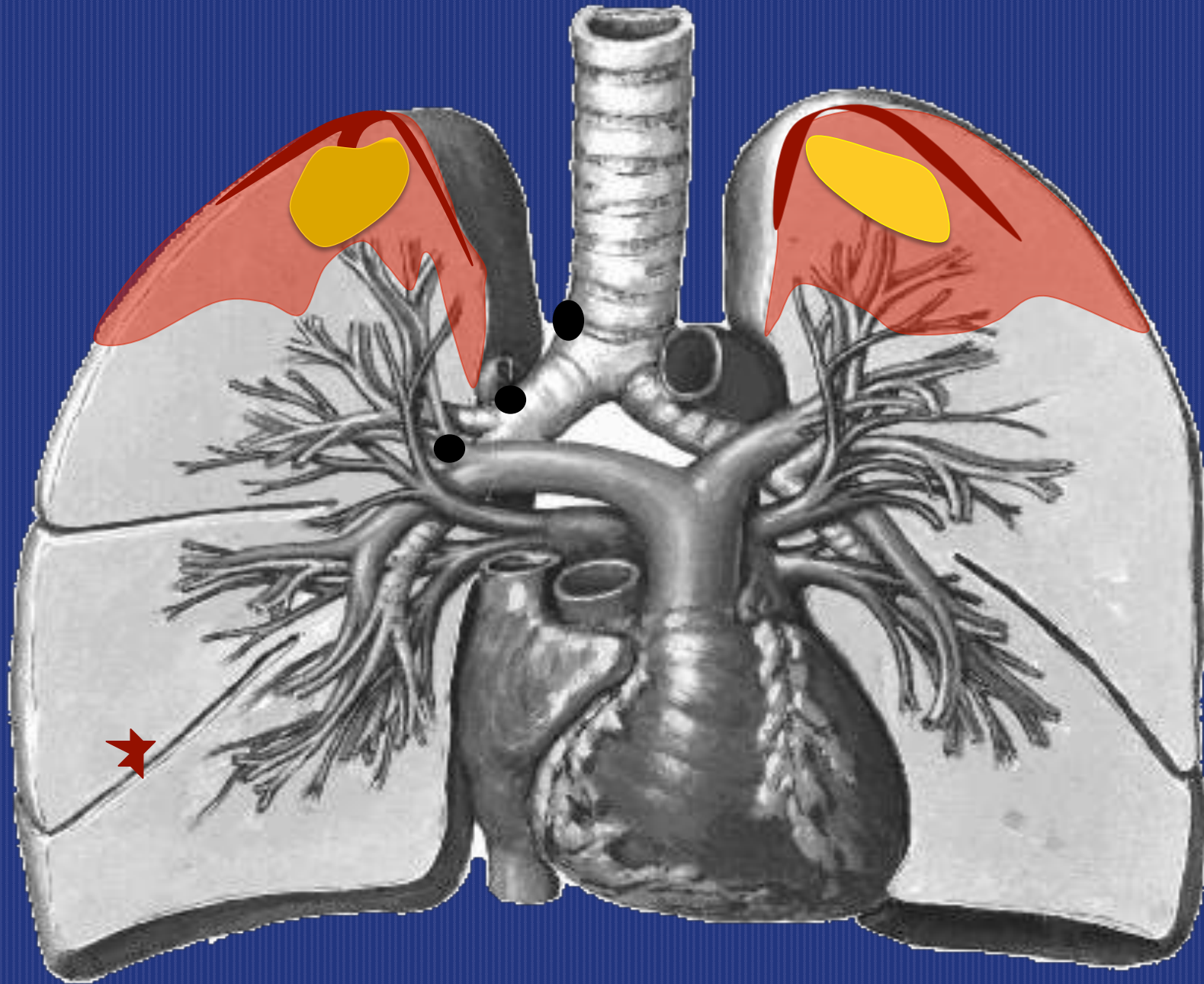


- Etiology
 - TB spread across placenta
 - Fetal ingestion or aspiration of infected amniotic fluid
- Symptoms are nonspecific
- Importance of clinical suspicion and imaging
- Imaging manifestation
 - Disseminated / miliary pattern

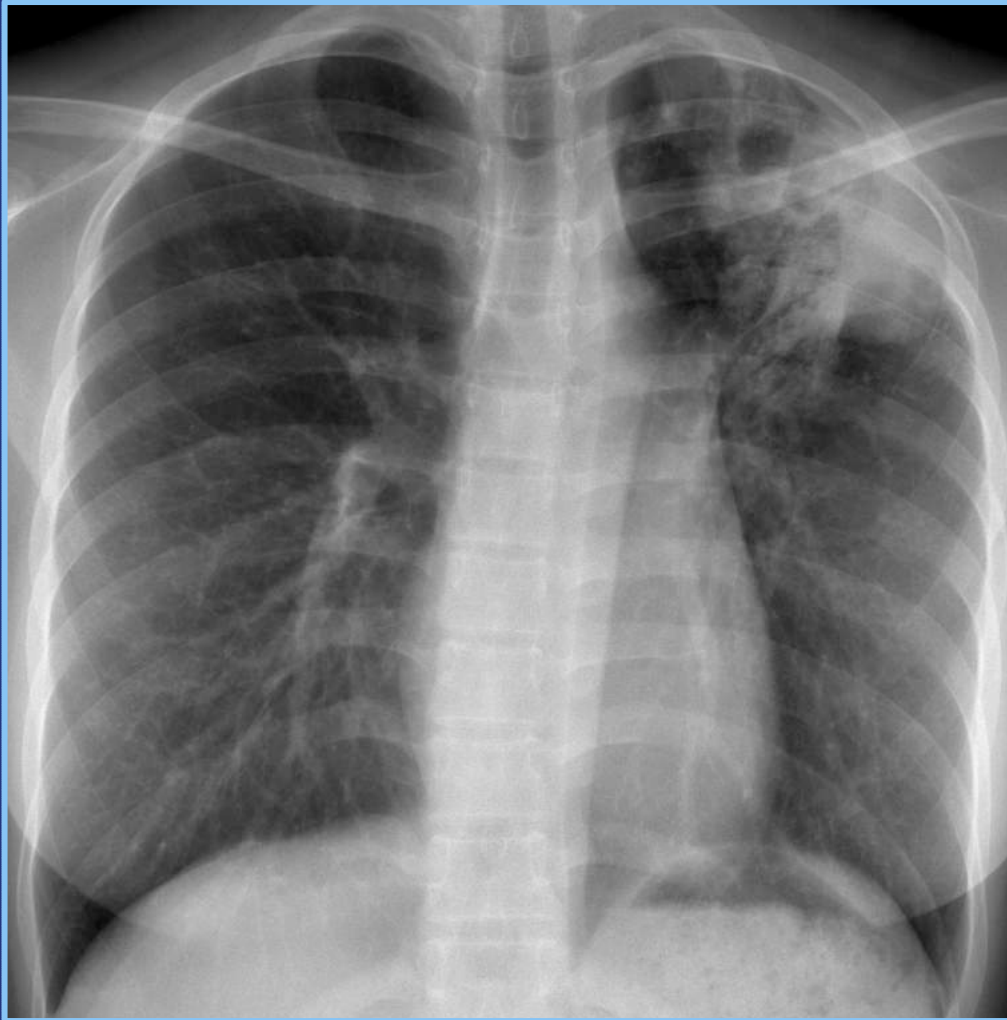
POST-PRIMARY TUBERCULOSIS

- Also referred to as Adult-type or Reactivation TB
- After dormancy, organisms 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

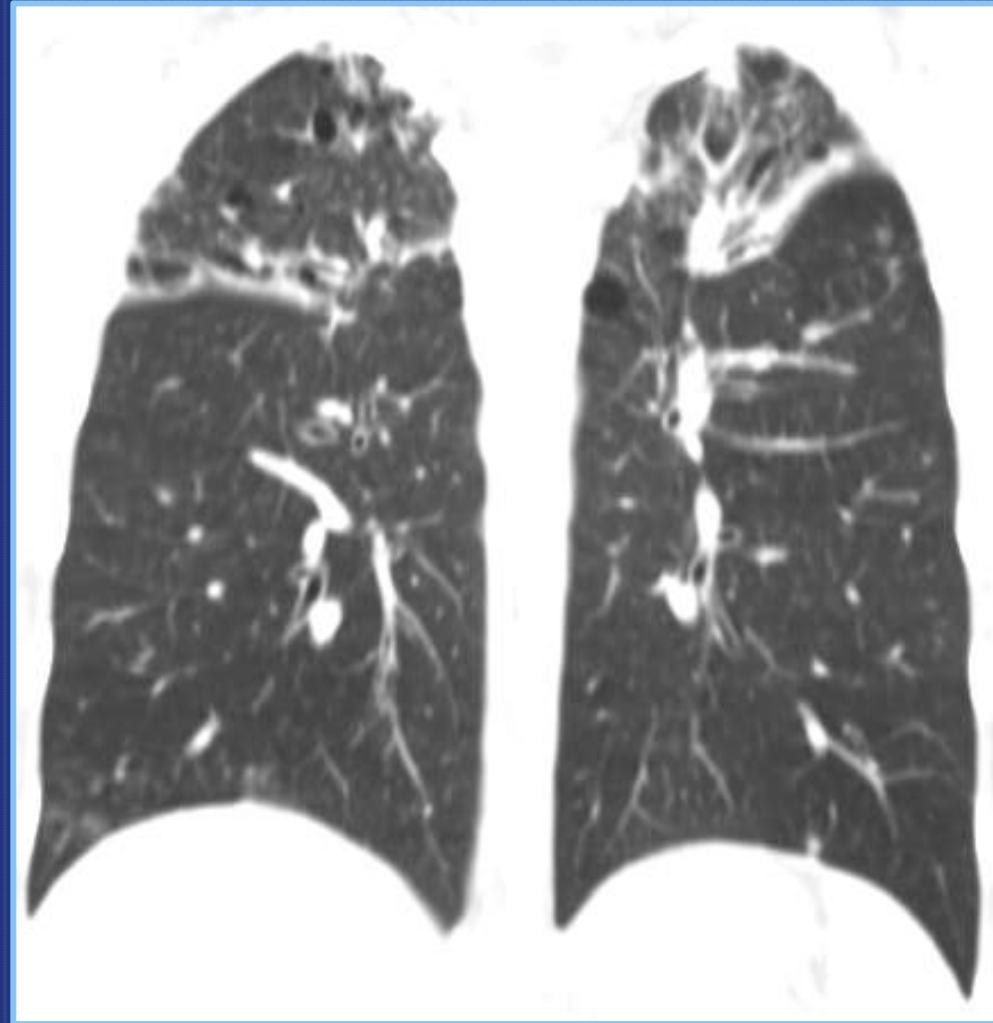
POST PRIMARY OR REACTIVATION TB



POST PRIMARY OR ADULT TYPE TB

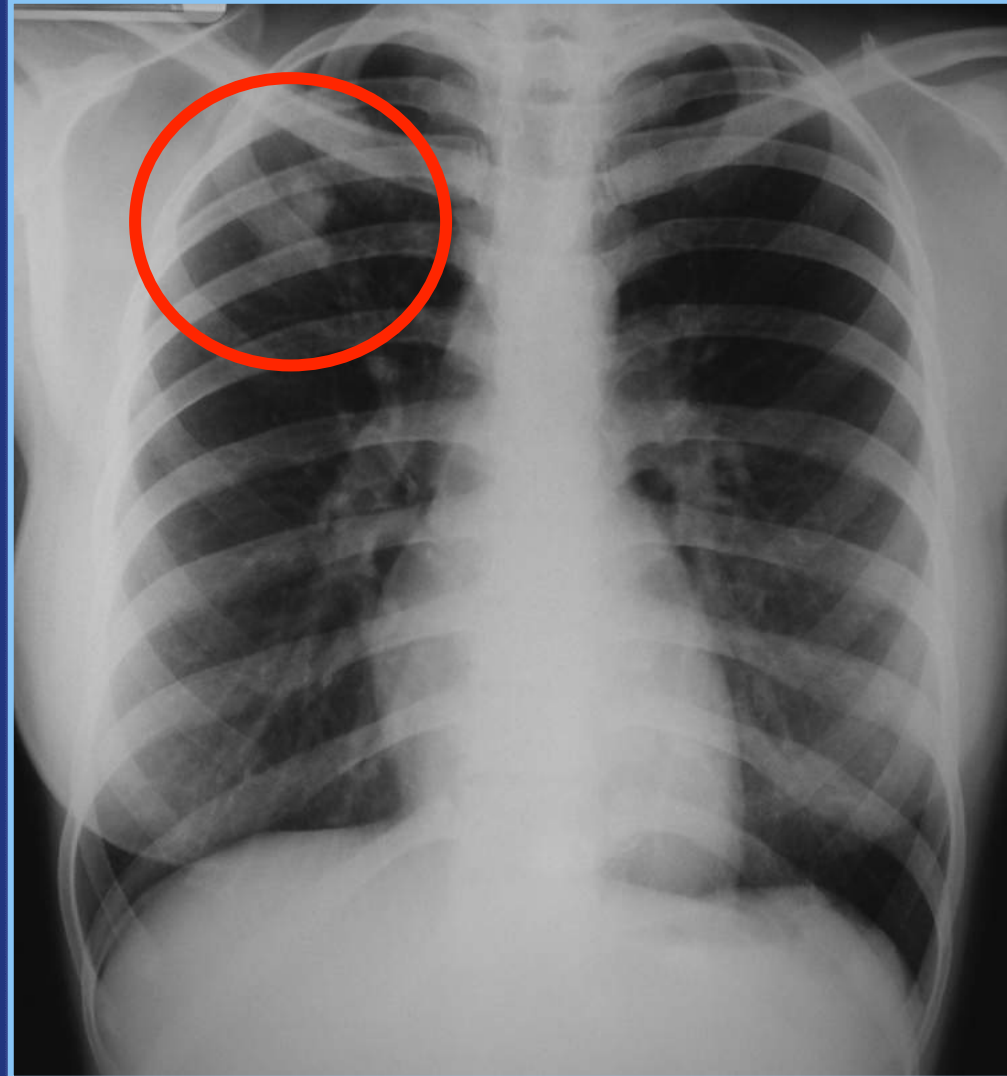
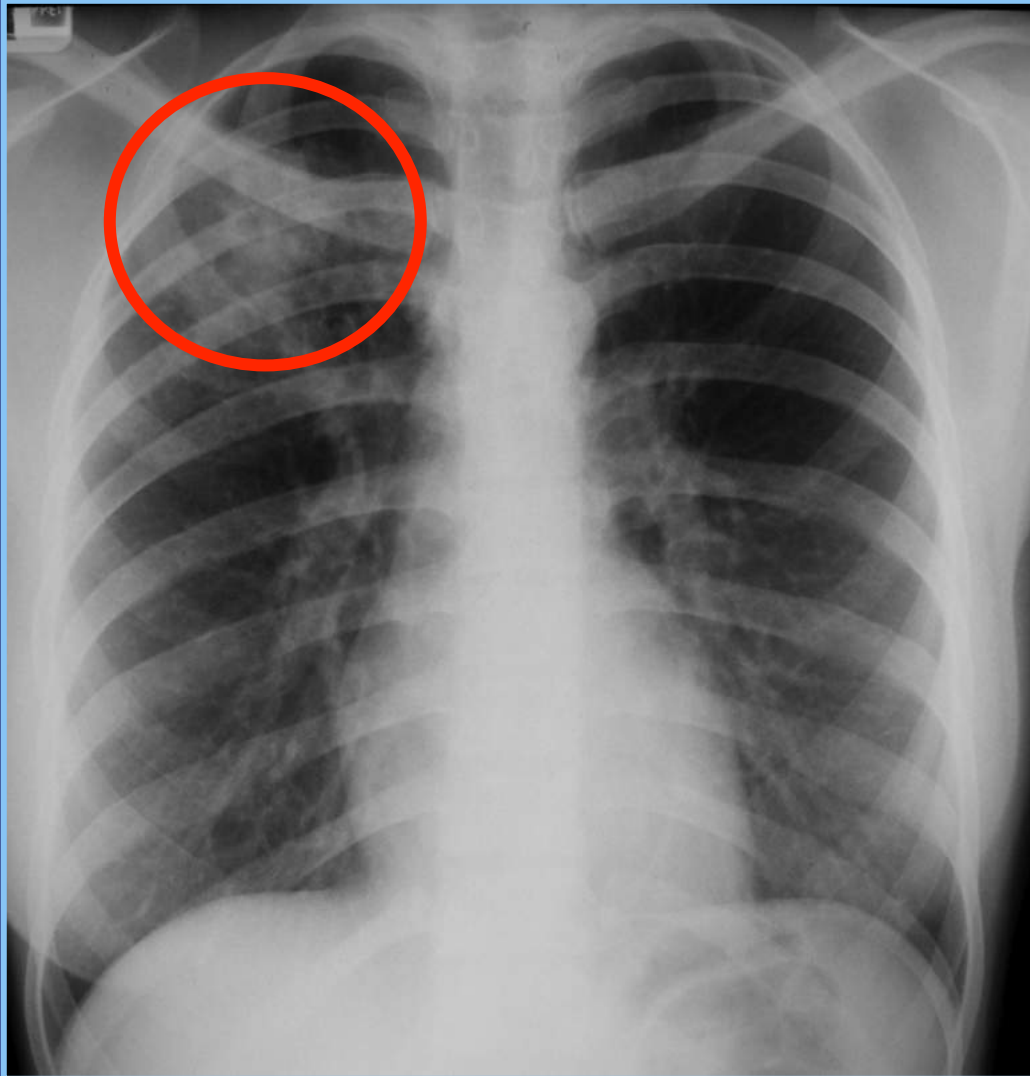


**RADIOGRAPH SHOWING
LEFT APICAL CAVITARY CONSOLIDATION**



**CORONAL RECONSTRUCTION CT:
APICAL FIBROSIS AND CAVITIES**

POST PRIMARY OR ADULT TYPE TB



FOLLOWING ANTI-TB TREATMENT

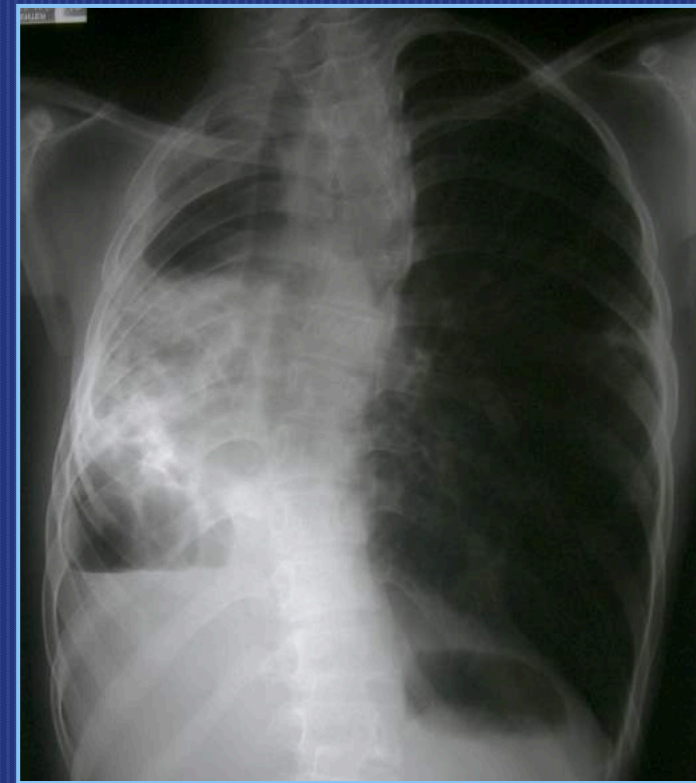
SEQUELAE OF CHRONIC TB: SPECTRUM OF ABNORMALITIES



**BASILAR FIBROSIS
& BRONCHIECTASIS**

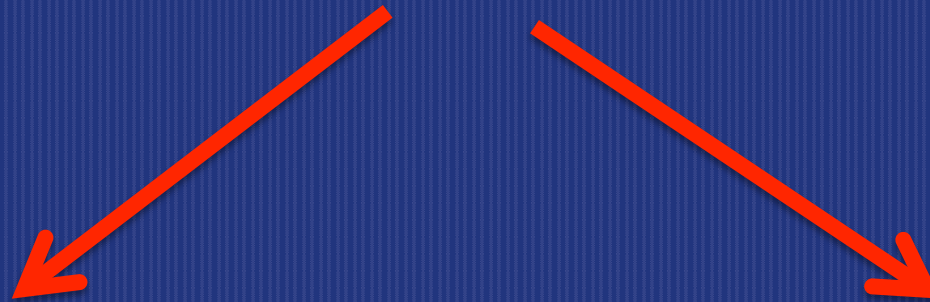


**RIGHT APICAL FIBROSIS
& VOLUME LOSS**



DESTROYED LUNG

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**

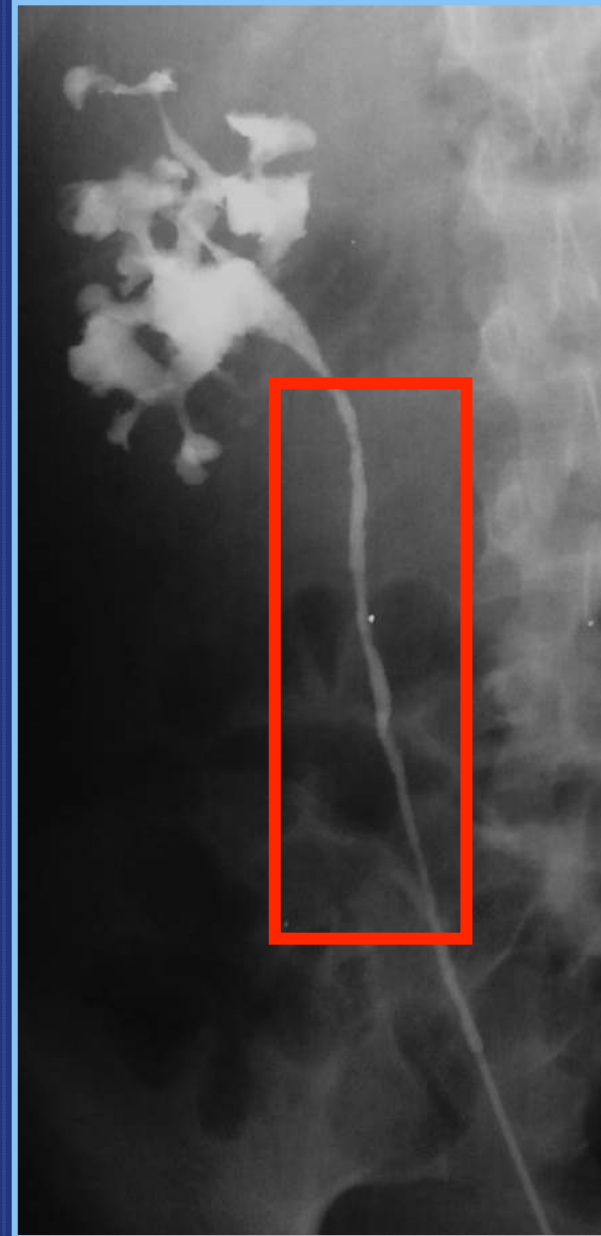
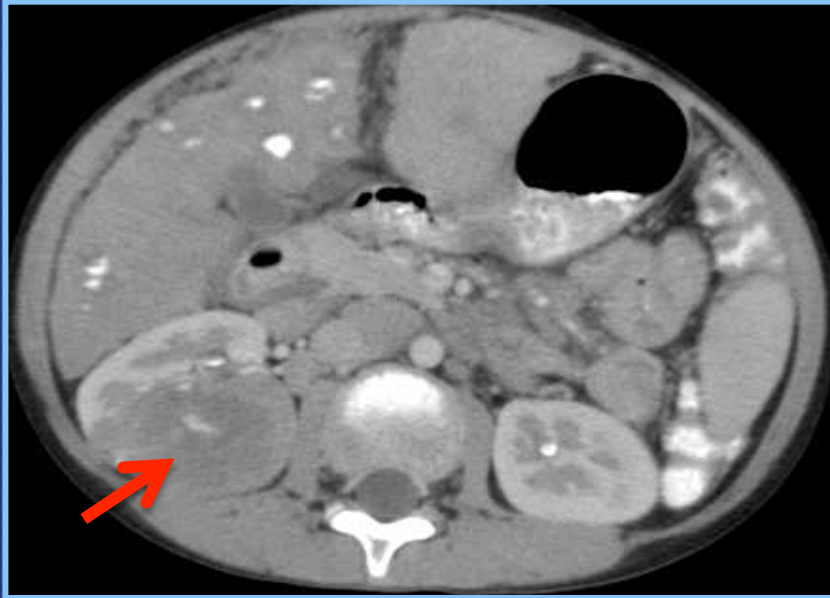
IMPORTANT IMAGING CONSIDERATIONS

- 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**

ABDOMINAL TUBERCULOSIS

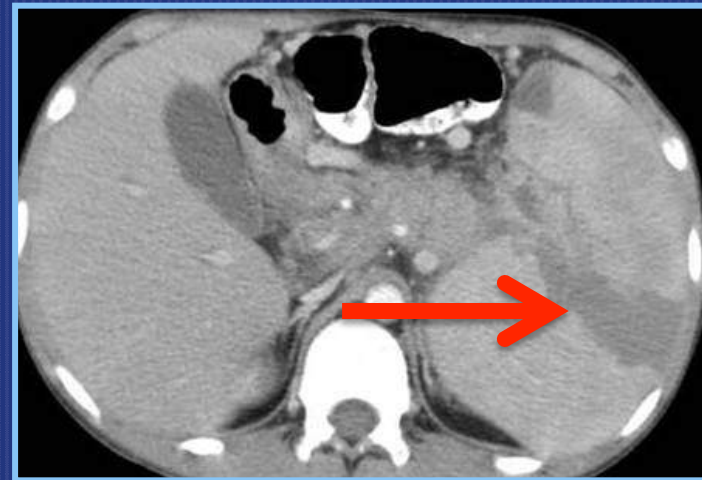
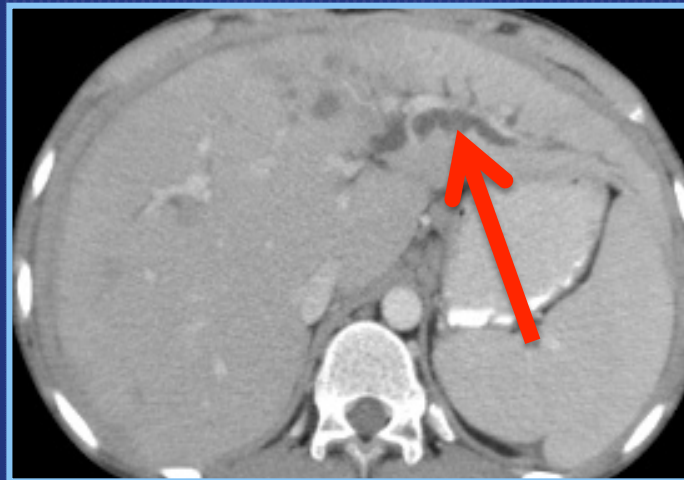
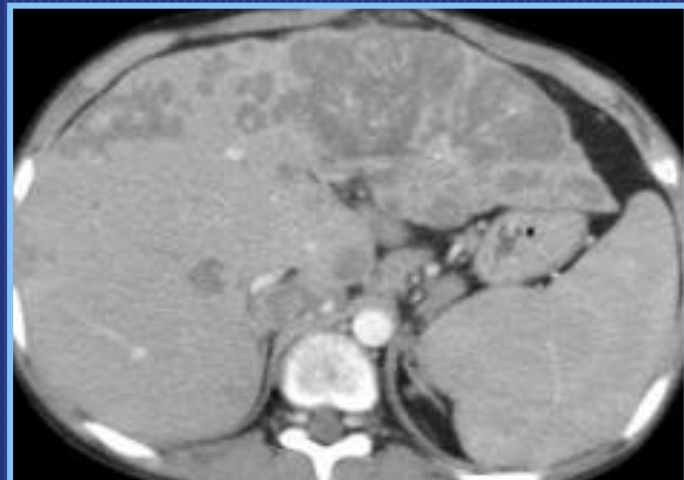
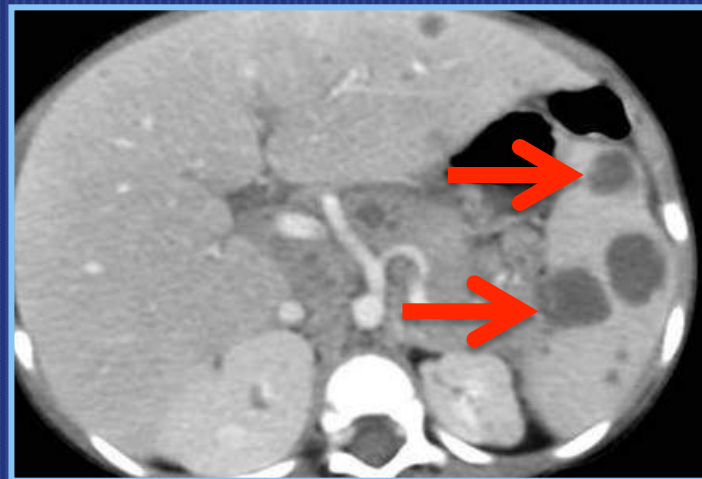
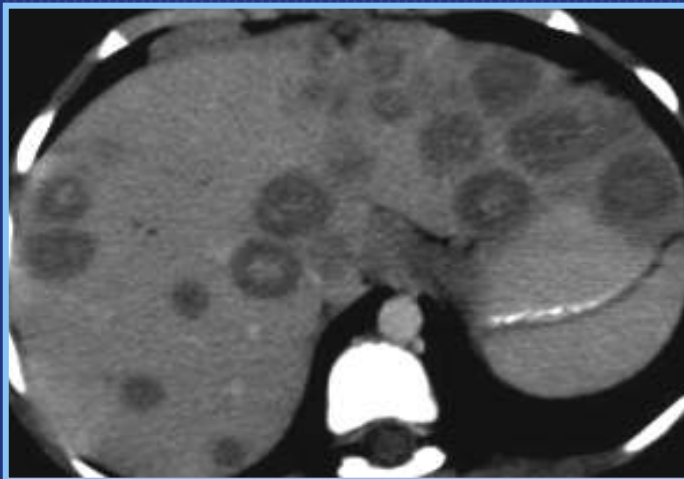
- Genitourinary TB is commonly encountered
- Intestinal involvement in 55-90% of fatal cases
- Hepatobiliary, lymphadenopathy and peritonitis
- A minority of patients (<50%) with abdominal TB have abnormal chest radiographic findings
- Clinical symptoms are diverse and non-specific
- Clinical presentation does not correlate with the severity and extent of imaging findings



GENTOURINARY TUBERCULOSIS

HEPATOSPLENIC TUBERCULOSIS

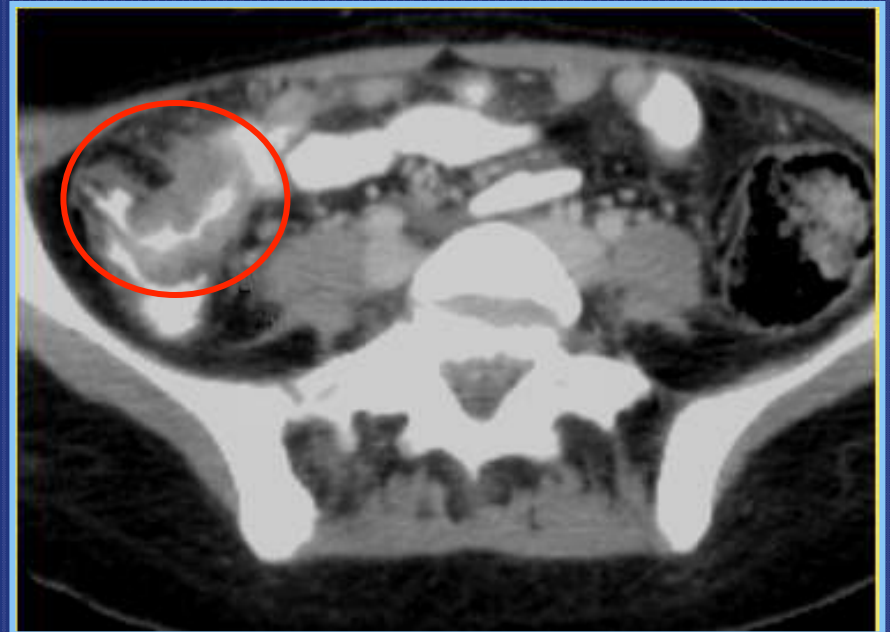
- Hematogenous dissemination
- Imaging appearance
 - Micronodular
 - Macronodular
 - Mass – like
 - May contain calcifications
- DDX: neoplasm, abscess, fungal infections



HEPATO-SPLENIC TUBERCULOSIS

GASTROINTESTINAL TB

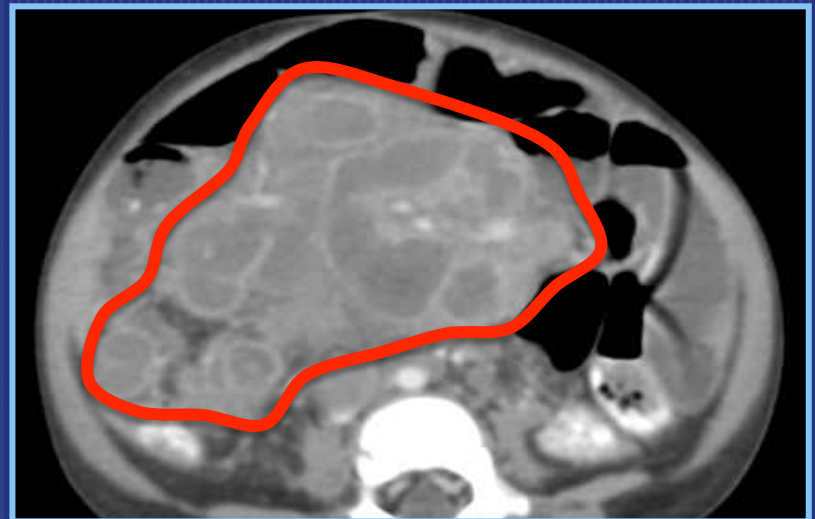
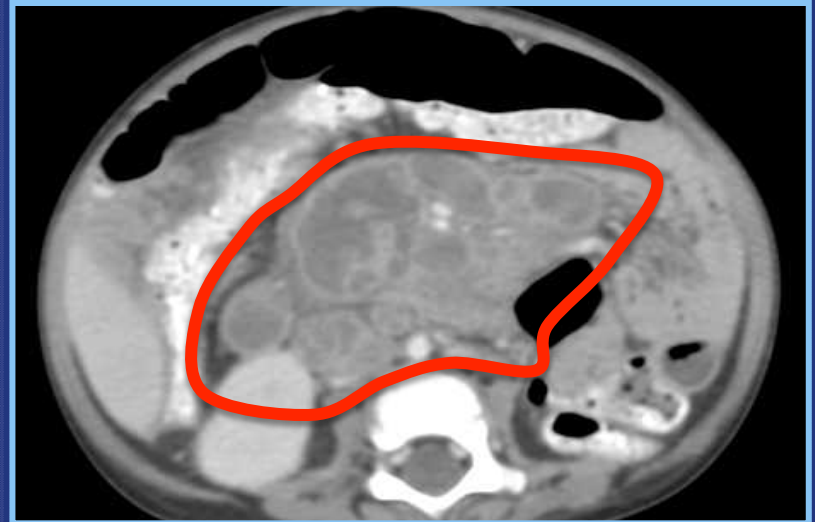
- Routes
 - Ingestion of the tubercle bacilli
 - Direct extension from an adjacent infected organ
 - Hematogenous spread
- Presentation: abdominal pain, weight loss, anemia, and fever with night sweats, obstruction, palpable mass RLQ
 - Hemorrhage, perforation, and malabsorption
- Ileocecal involvement in 80 – 90%
- Imaging: Inflammation causing mucosal thickening and irregularity, luminal narrowing, and obstruction
- DDX: amebiasis, crohn's disease, ileocecal malignancy



**ILEOCECAL TUBERCULOSIS
OR
TB TERMINAL ILEITIS**

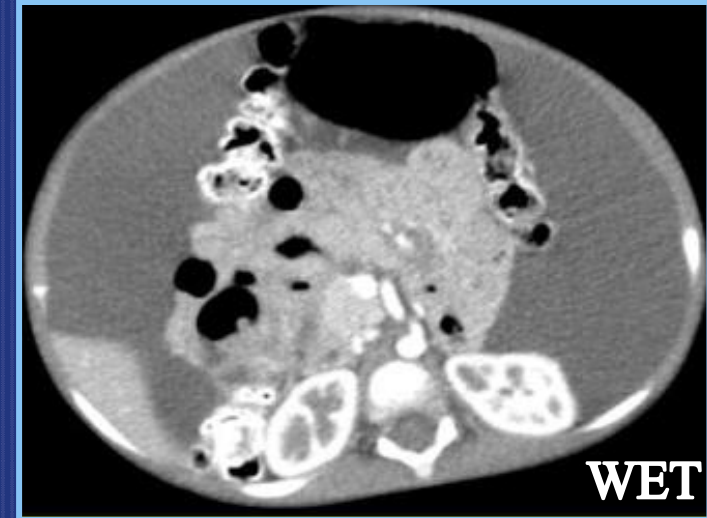
TB LYMPHADENOPATHY

- 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



TB PERITONITIS

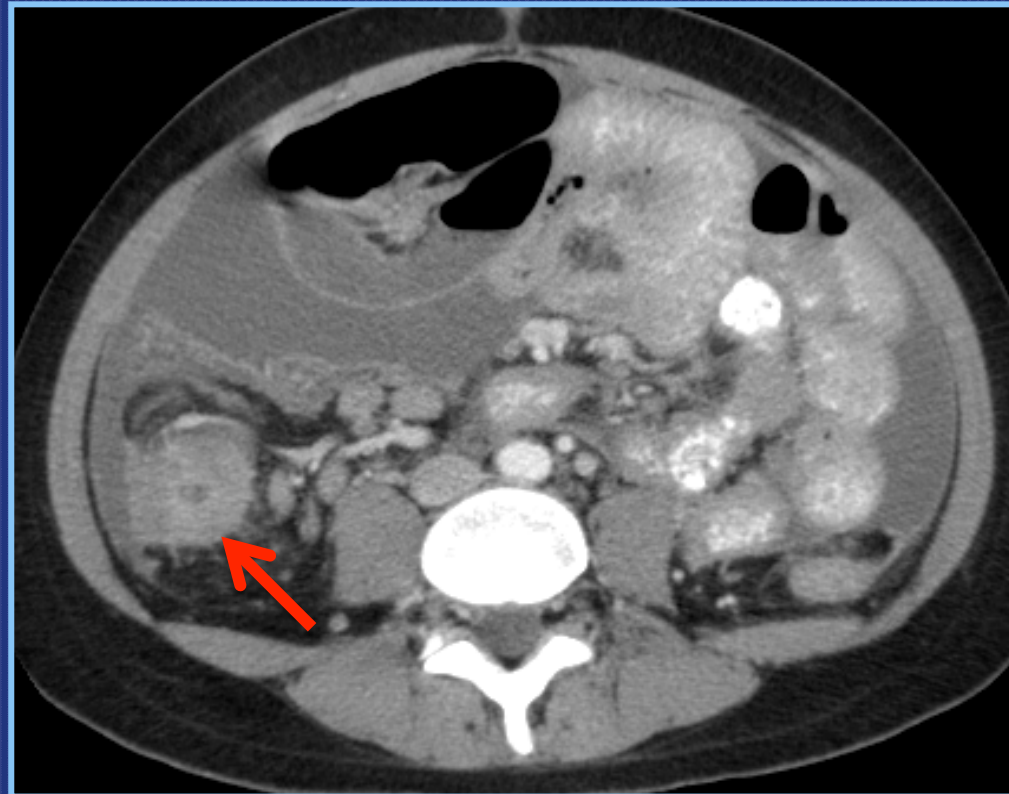
- Diffuse or focal inflammatory reaction
- Associated with widespread abdominal TB
- Types
 - Wet type : large viscous ascitis
 - Dry or plastic : caseous nodules, fibrous reaction and dense adhesions
 - Fibrotic fixed: omental masses, matted bowel



WET TB PERITONITIS

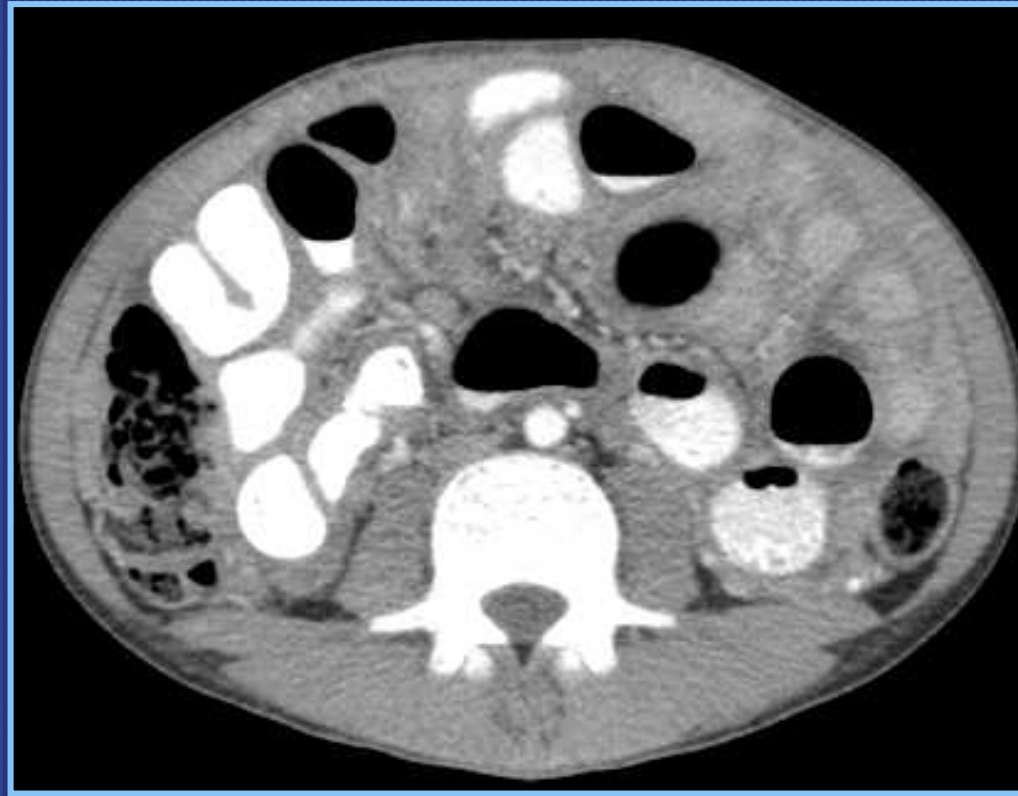
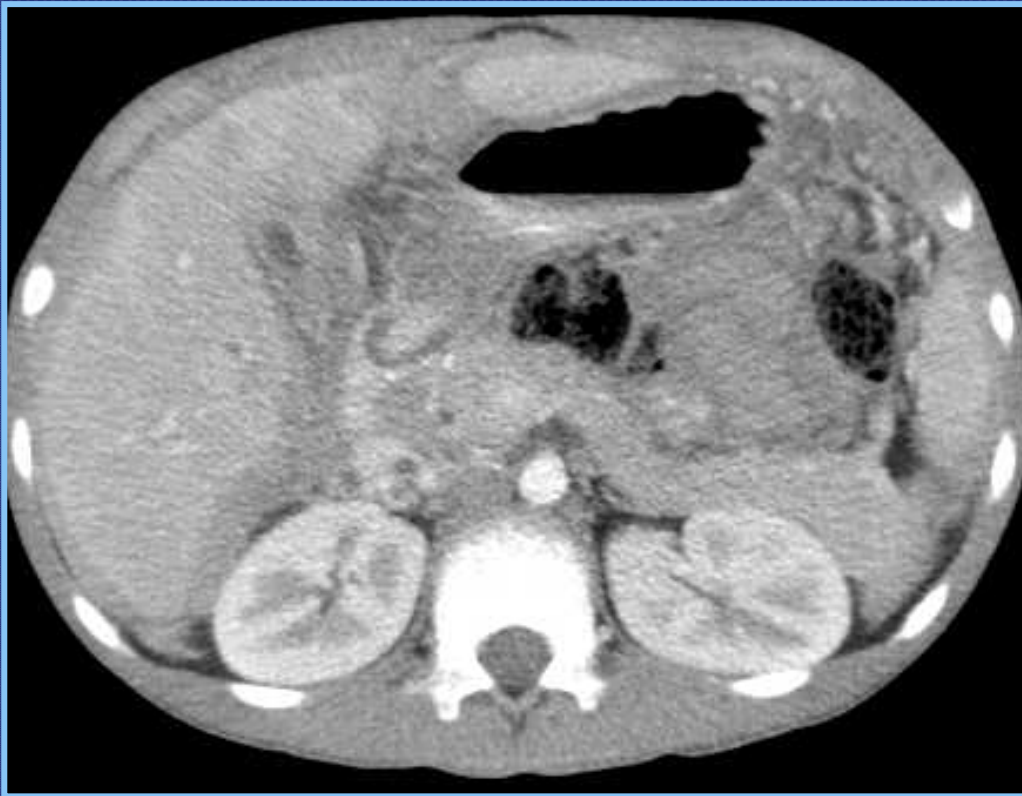


SIGNIFICANT ASCITES



ASCITES WITH
THICKENED CECAL WALL

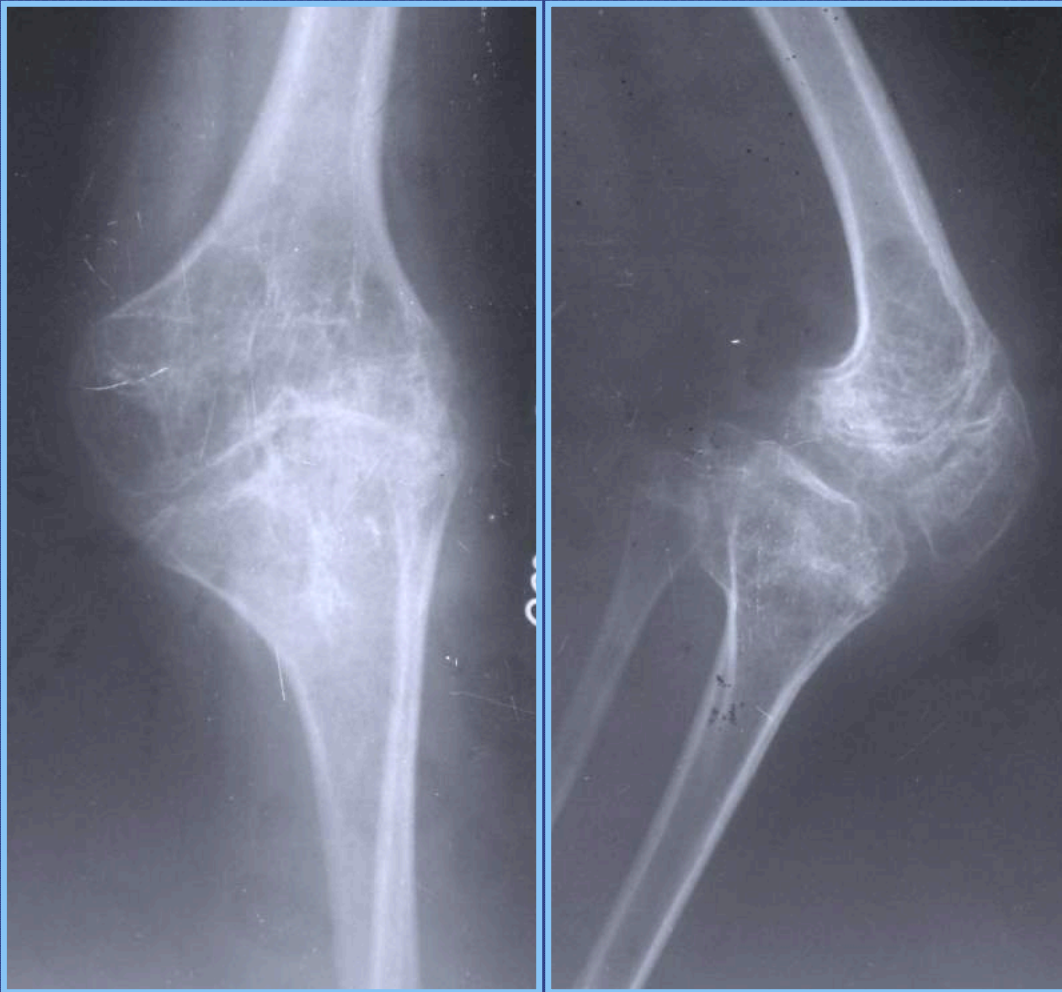
DRY TB PERITONITIS



MUSCULOSKELETAL TB

- 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
 - Pnemister triad, usually affects hips and knees
- Osteomyelitis: unifocal or multifocal
 - Cystic, infiltrative, erosive, spina ventosa

TUBERCULOUS ARTHRITIS



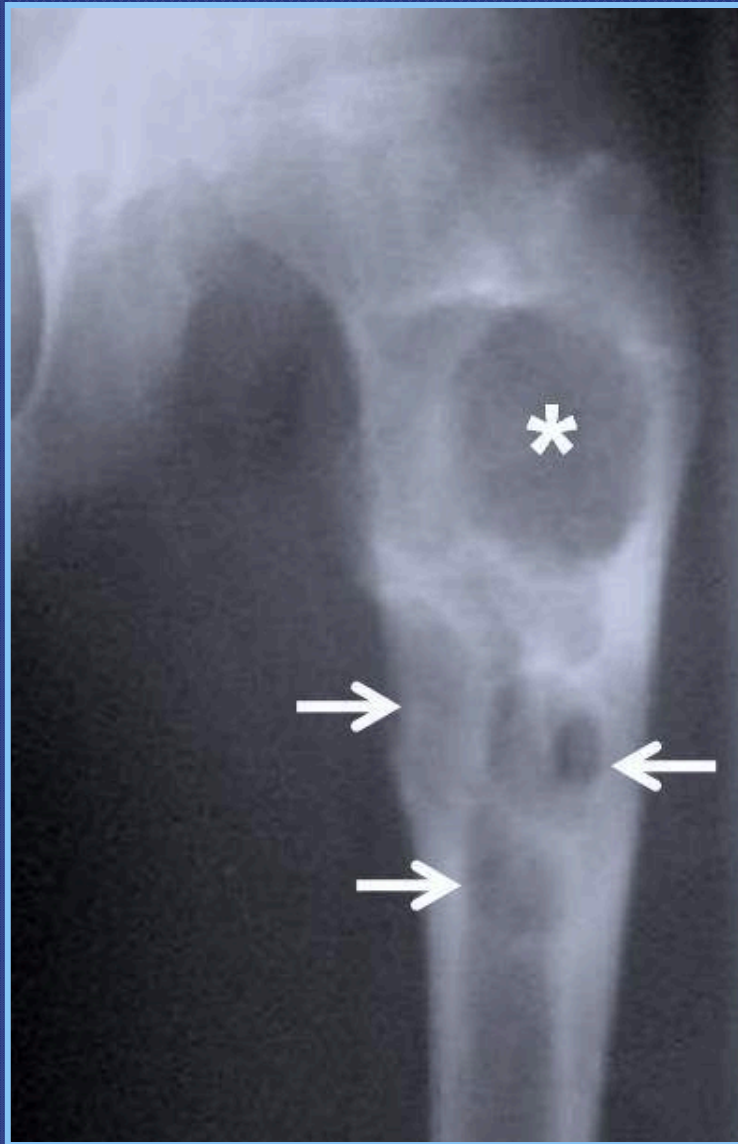
**PHEMISTER TRIAD:
OSTEOPENIA, EROSION, JOINT SPACE NARROWING**



**PATIENT HAS DESTROYED LUNG
FROM TB**

TUBERCULOUS ARTHRITIS





CYSTIC TB OSTEOMYELITIS

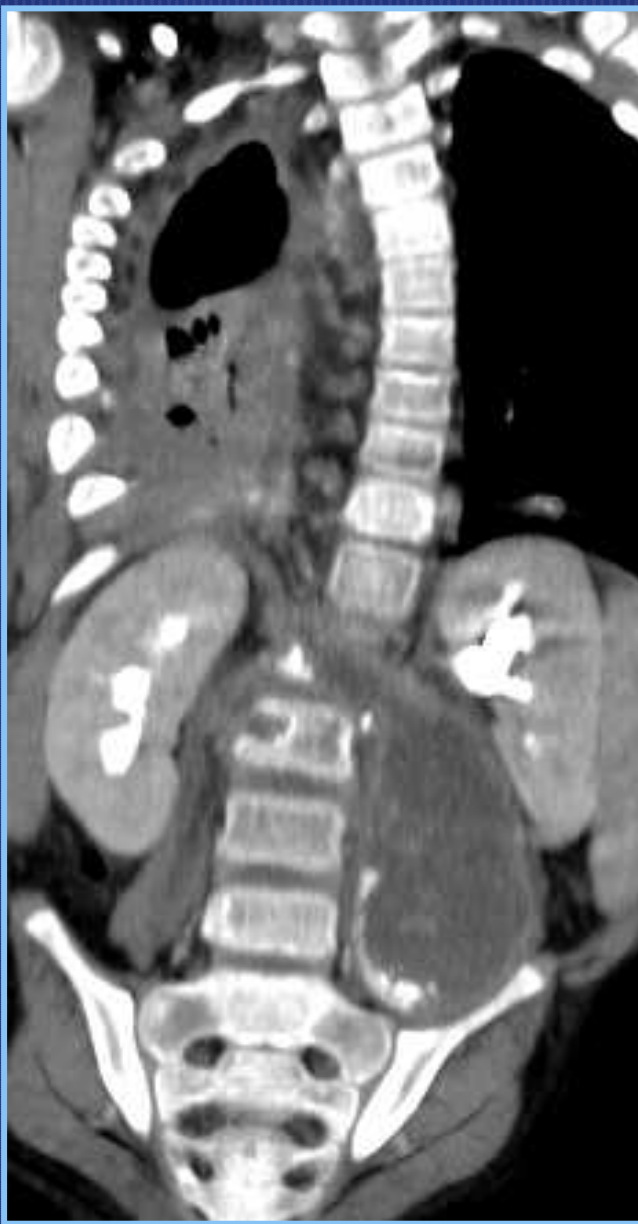
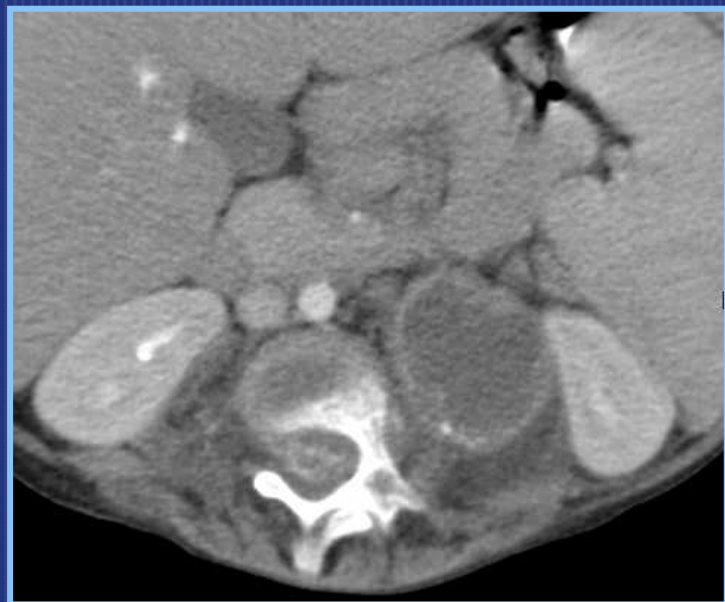


EROSIVE TB OSTEOMYELITIS

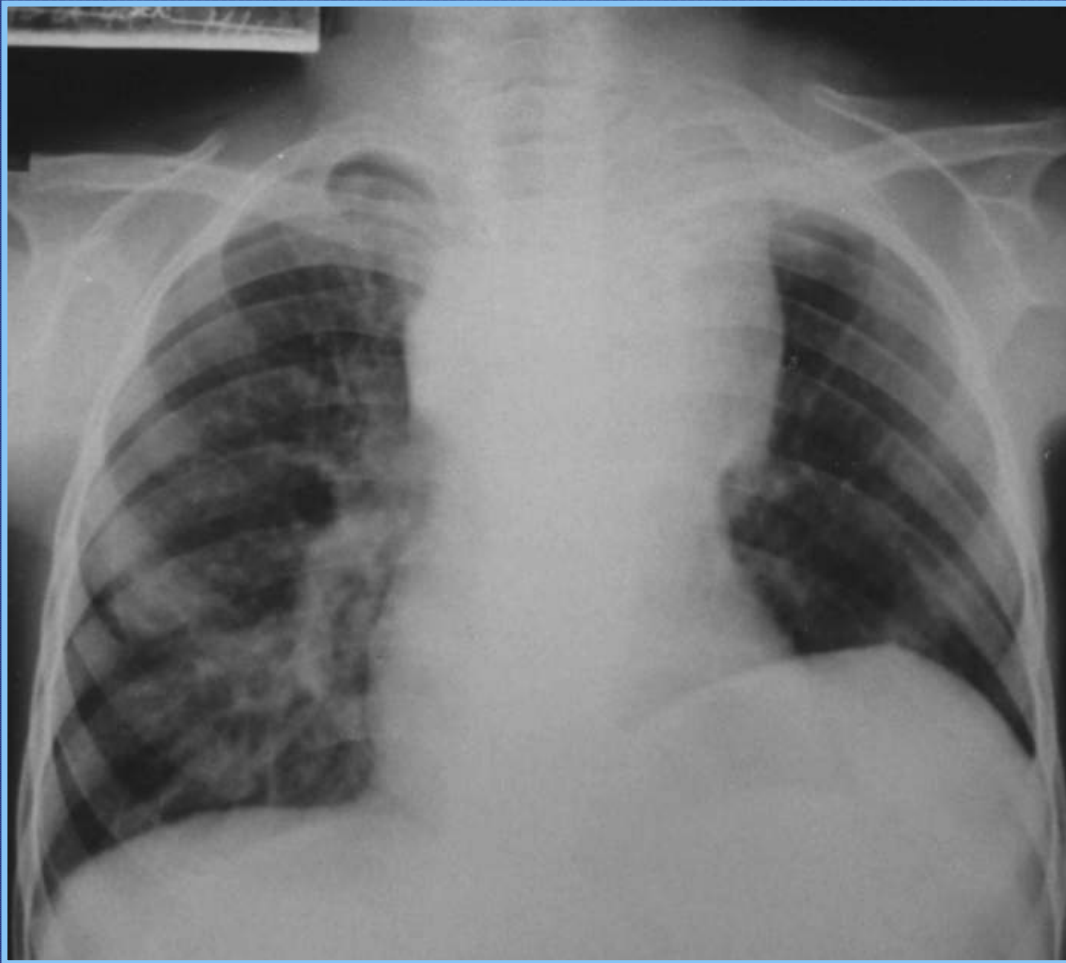
TUBERCULOUS SPONDYLITIS (POTT'S DISEASE)

- 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



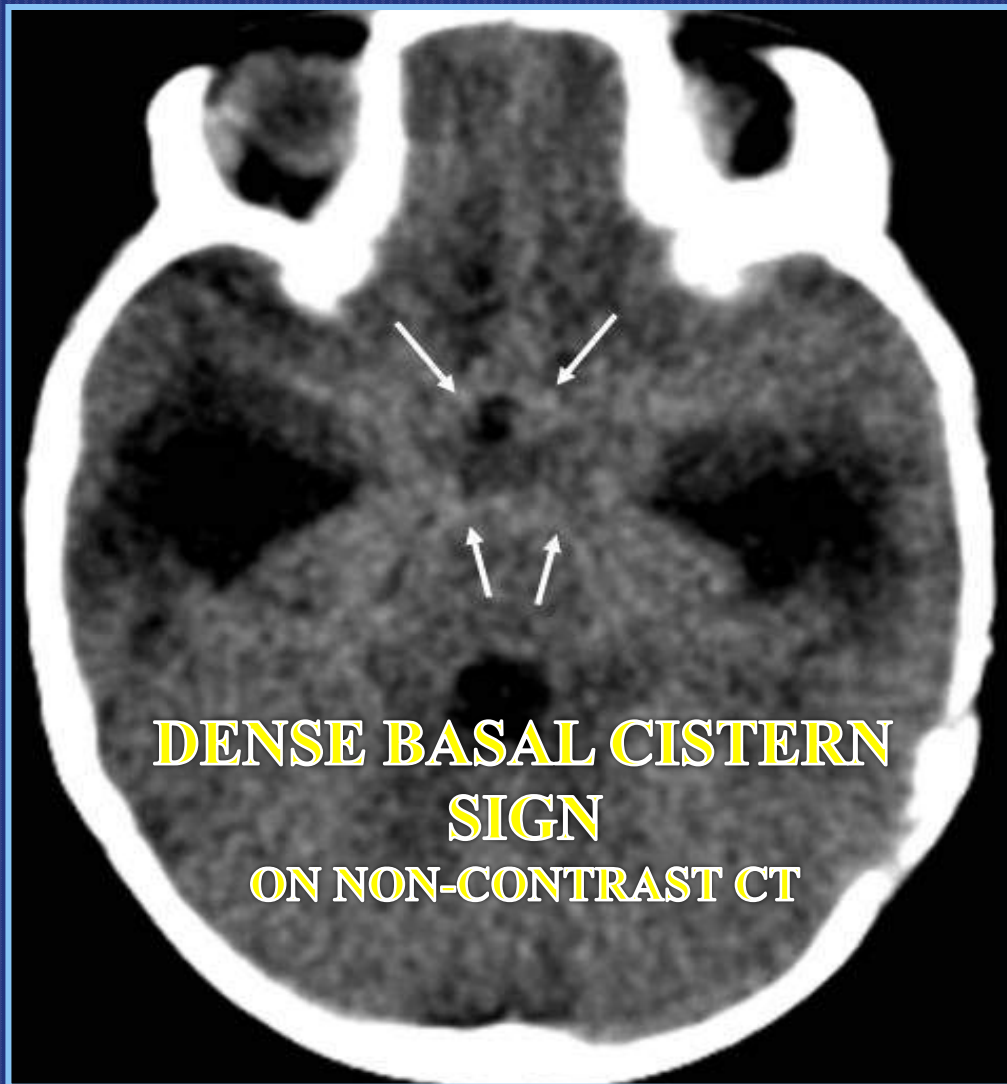
TUBERCULOUS SPONDYLITIS



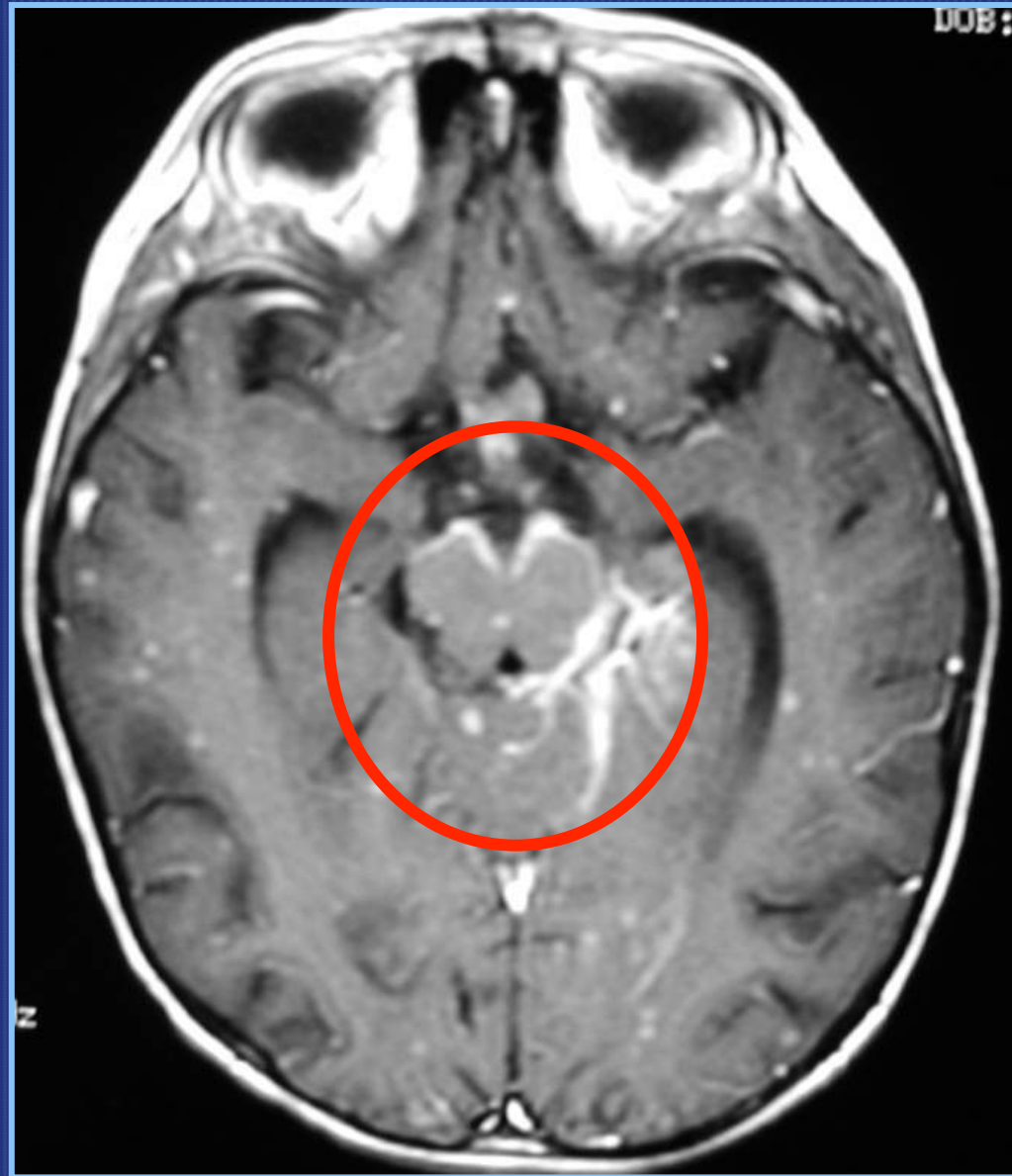
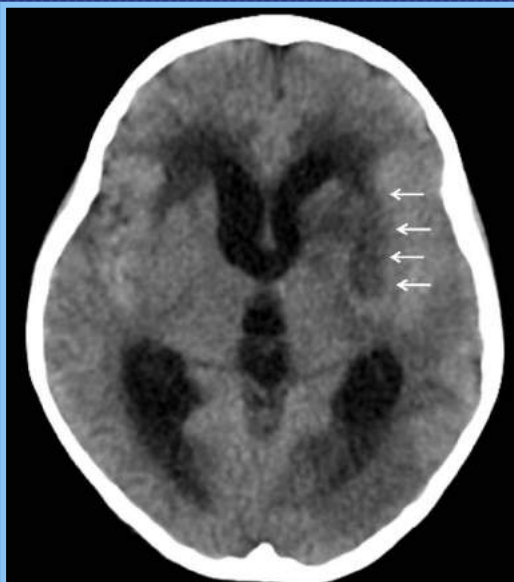
CNS TUBERCULOSIS

- 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



CNS TUBERCULOSIS: SPECTRUM OF IMAGING FINDINGS



CONCLUSION

- 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
- Clinico-radiologic approach is needed for more accurate interpretation of imaging findings

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