

Pulmonary Tuberculosis

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CHESTRAD 2023

A Case Review and Lecture Series
Saturday 15th July - Sunday 16th July - Monday 17th July
27 CPD Points

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Objectives

- Illustrate CT and radiographic findings of tuberculosis
- Describe complications of tuberculosis
- Provide an update on imaging of TB, particularly non-morphologic techniques

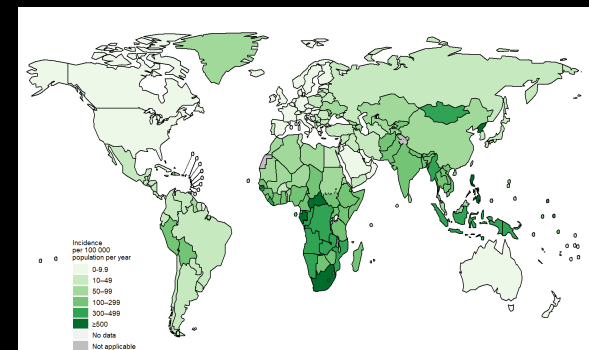
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Epidemiology

- Majority of cases in Asia
 - India and China have largest number of cases
- Largest number of active cases per capita
 - Sub-Saharan Africa: HIV epidemic
- U.S. and Western Europe
 - Foreign born residents
 - Recent immigrants from endemic regions

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Estimated Incidence 2021

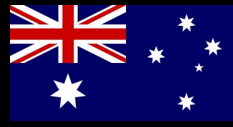


World Health Organization 2022 Global Tuberculosis Report

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Australia

- Australia has one of the lowest rates of TB in the world
 - 5.2 - 7.0 cases per 100,000 since 1980s,
 - ~90% of cases in people born overseas
 - First Nations (Australian Aboriginal and Torres Strait Islanders)
 - 3.8-7.5 per 100,000
 - Nonindigenous native born
 - <1.0 per 100,000
 - Highest rates in Northern Territory

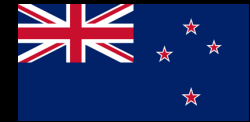


Meumann EM et al. *Lancet Reg Health – West* 2021

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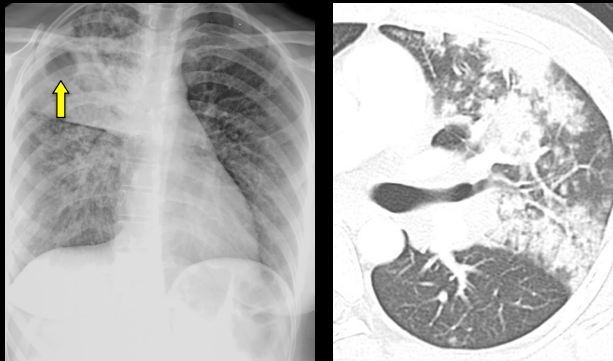
New Zealand

- New Zealand also has one of the lowest rates of TB in the world
 - ~6.0 per 100,000
 - 300 cases per year
 - 80% in those born outside of New Zealand
 - 50% of cases in NZ born are of Māori ethnicity



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Imaging



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Imaging

- CT more sensitive than radiography
 - Miliary nodules with normal radiograph
 - Mediastinal lymphadenopathy
 - Subtle cavitation
 - Endobronchial spread
- CT useful for evaluating pleural, mediastinal, and chest wall complications

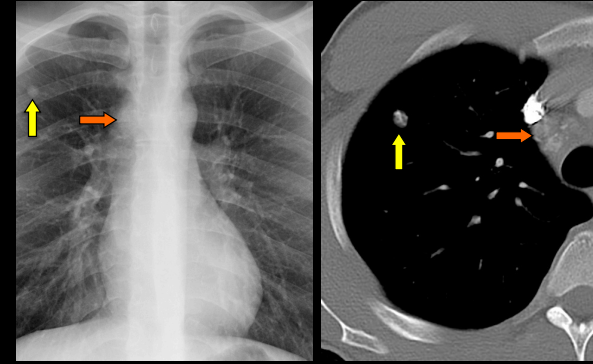
8

Primary Infection

- Ghon focus: initial site of infection
 - Heals and forms calcified nodule
 - May expand to cause consolidation
- Ranke complex:
 - Ghon focus *and*
 - Regional lymphadenitis

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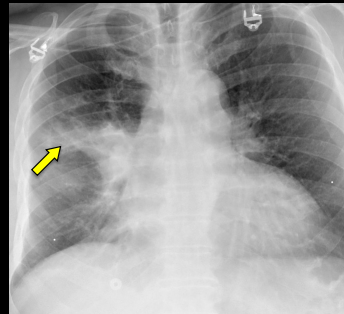
Ranke Complex



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Primary Tuberculosis

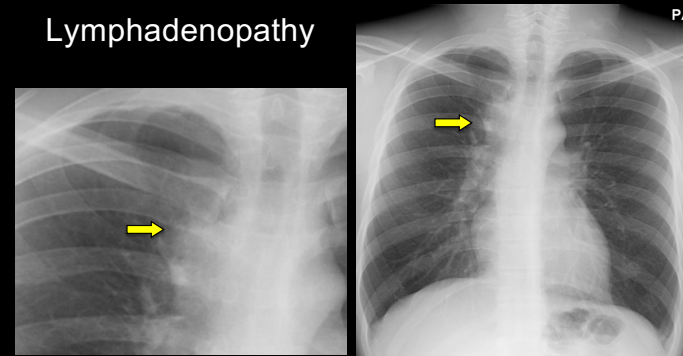
- Consolidation
- Occurs in most adults with primary infection
- Expansion of initial Ghon focus



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Primary Tuberculosis

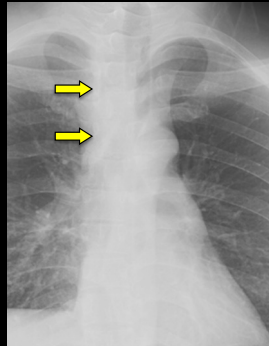
Lymphadenopathy



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Primary Tuberculosis

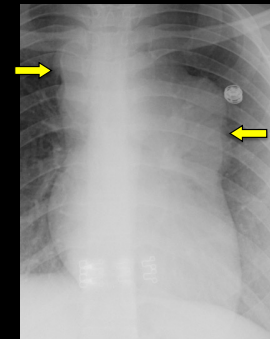
Lymphadenopathy



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Primary Tuberculosis

Lymphadenopathy



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Primary Tuberculosis



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Primary Tuberculosis

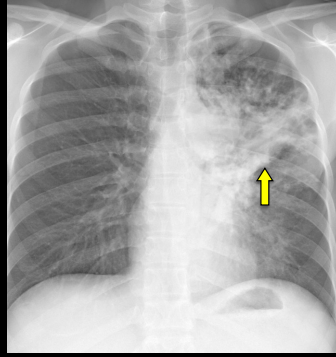
- Most commonly occurs in children
- Increasing number of cases in adults because of HIV infection

| Radiographic Finding | Adults | Children |
|----------------------|---------|----------|
| Lymphadenopathy | 10%-30% | 95% |
| Consolidation | 90% | 70% |
| Pleural effusion | 30%-40% | 5%-10% |

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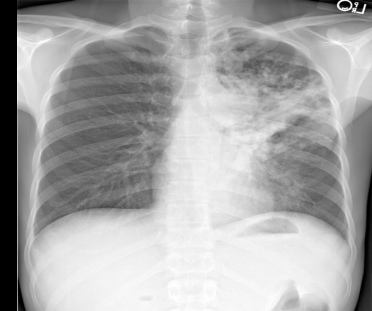
Post-Primary TB

- Consolidation in approximately 50%
- Posterior and apical segments of upper lobes
- Superior segments of lower lobes



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Post-Primary TB



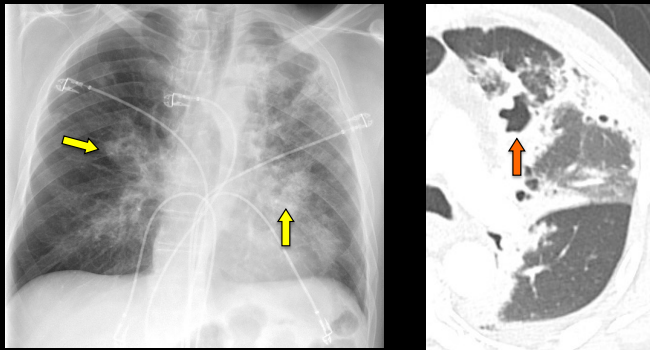
Initial radiograph



8 days later

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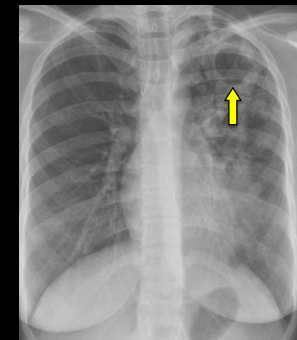
Post-Primary TB



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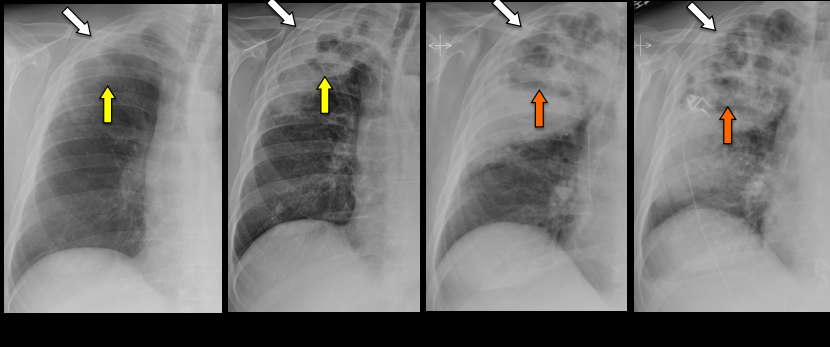
Post-Primary TB

- Cavities
- 20%-40% of patients
- 10%-20% contain fluid levels
- Apical and poster segments of upper lobes
- Superior segments of lower lobes



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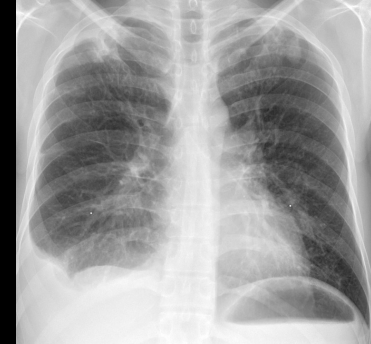
Post-Primary TB



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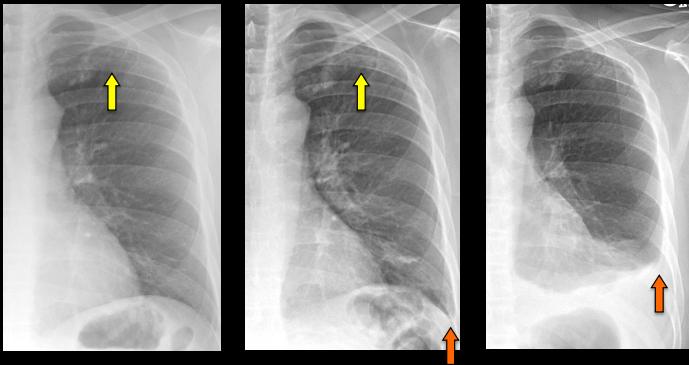
Post-Primary TB

- Pleural disease
- Effusion
- Emphyema
- Bronchopleural fistula



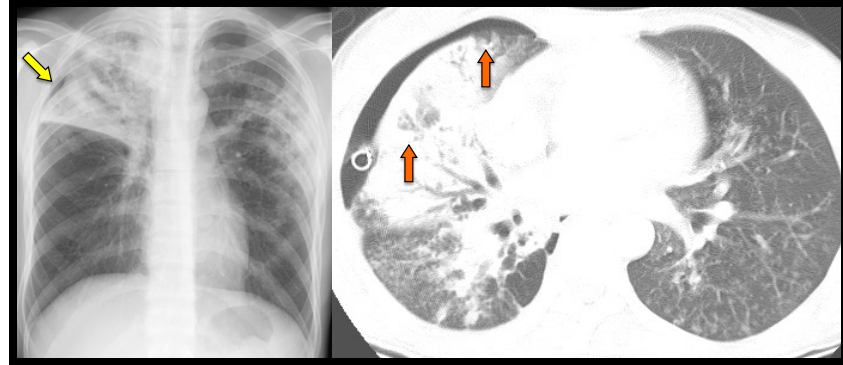
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Post-Primary TB



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Post-Primary TB



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Post-Primary TB

| Finding | Frequency |
|--|----------------------|
| Consolidation | 55% |
| Cavitation (Fluid levels) | 20%-45% (10%-20%) |
| Small nodules away from primary focus | 20%-25% |
| Lymphadenopathy | 5%-10% |
| Pleural effusion | 15%-25% |
| Tuberculoma | 5% |

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TB with HIV Co-Infection

CD4+ > 200 cells/mm³

- Reinfection
- Reactivation

CD4+ > 50 cells/mm³ and < 200 cells/mm³

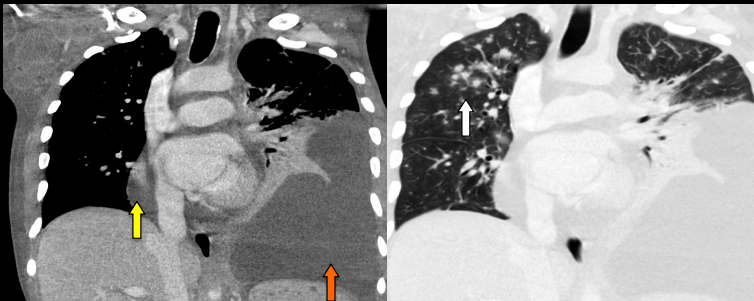
- Primary

CD4+ < 50 cells/mm³

- Atypical manifestations
- Disseminated

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TB with HIV Co-Infection



CD4+ T-cell count: 150 cells/mm³

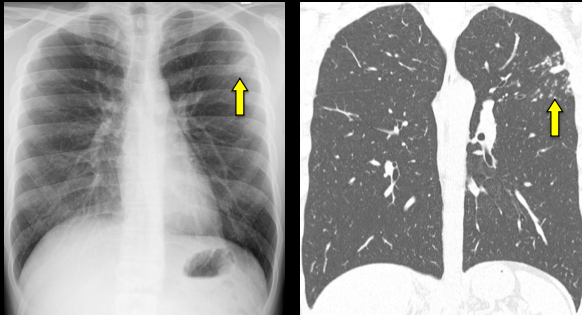
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Active Tuberculosis?

- Many imaging findings of tuberculosis reflect sequela of infection
- Small centrilobular nodules and tree-in-opacities on CT are strong predictors of active infection
- Progression of radiographic abnormalities also strongly favors active infection

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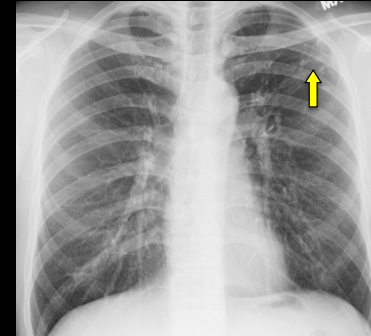
Active Tuberculosis?



Sputum stains and cultures – *M. tuberculosis*

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Active Tuberculosis?



Sputum stains and cultures – no TB

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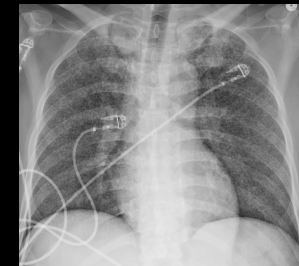
Disseminated TB

- Disseminated or “miliary” TB can occur as primary or post-primary infection
- Other findings of post-primary infection may be apparent
- Most immunocompromised

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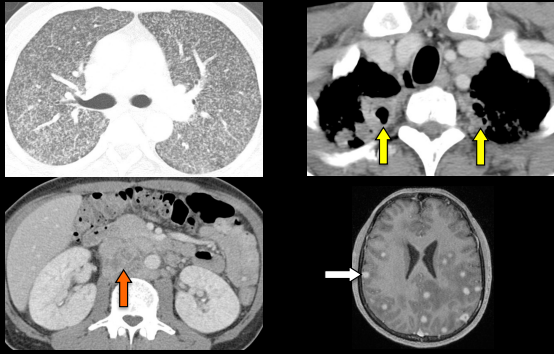
Disseminated TB

- Diffuse tiny lung nodules
- Radiograph may be normal
- Patients typically very ill



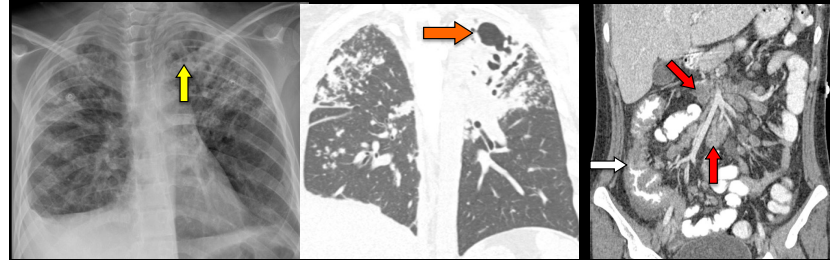
32

Disseminated TB



33

Disseminated TB



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Complications – Lungs

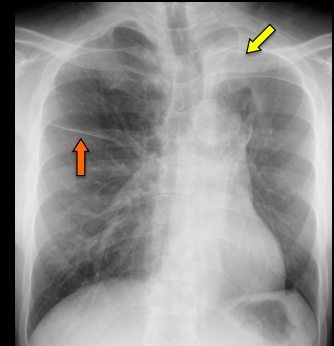
- Scar
- Lung destruction
- Bronchiectasis
- Cavities
- Acute respiratory distress syndrome
- Aspergilloma
- Tracheobronchial stenosis
- Broncholithiasis



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Complications - Lung

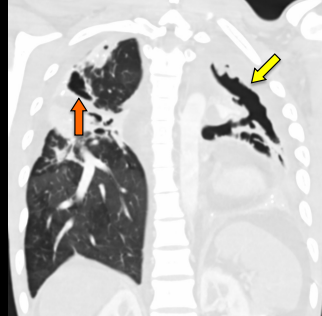
- Scar and destruction of lung
- Up to 40% of patients with post-primary TB
- Result of marked fibrotic response



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Complications - Lung

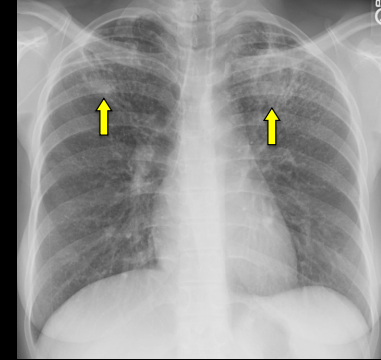
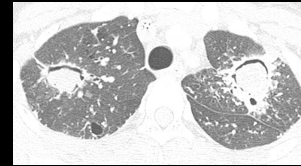
- Scar and destruction of lung
- Up to 40% of patients with post-primary TB
- Result of marked fibrotic response



37

Complications - Lung

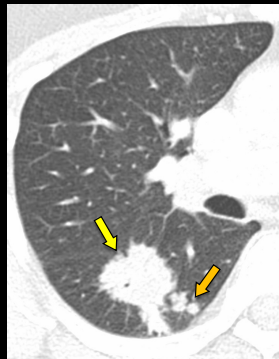
- Chronic cavity following treatment
- Aspergilloma in up to 11% of patients with TB
- Hemoptysis in over 50%



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Complications - Lung

- Tuberculoma
- 5% of patients with TB
- 5 mm - 40 mm
- Satellite nodules
- Calcification in up to 30%



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Complications - Lung

- Tuberculoma
- 5% of patients with TB
- 5 mm - 40 mm
- Satellite nodules
- Calcification in up to 30%

Kim HY et al. *Radiographics* 2001

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Complications - Lung

- Bronchiectasis
- 30% - 60% of patients with post-primary TB
- Up to 85% of patients on CT
- Favors apical and posterior segments of upper lobes



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Complications - Lung

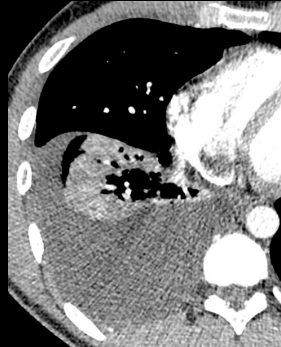
- Tracheobronchial stenosis
 - Compression from lymph nodes
 - Primary airway wall infection
- Left main bronchus most common
- Irregular luminal narrowing



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Complications - Pleura

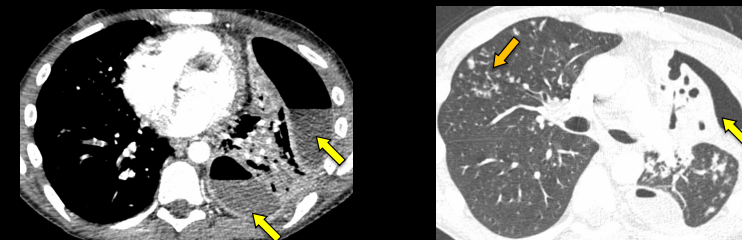
- Pleurisy
- Empyema
- Empyema necessitatis
- Fibrothorax
- Pneumothorax
- Bronchopleural fistula



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Complications - Pleura

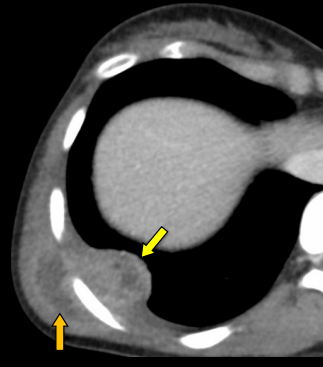
- Empyema
- Bronchopleural fistula



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Complications - Pleura

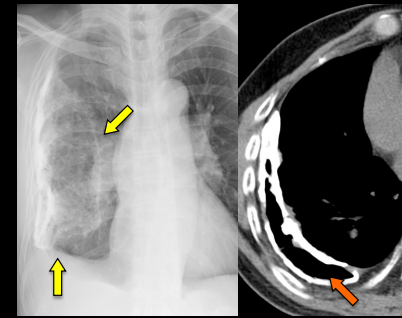
- Empyema necessitatis
- Direct extension of empyema into the chest wall



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Complications - Pleura

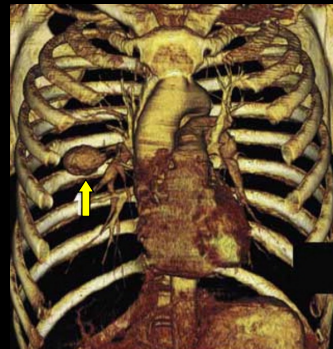
- Fibrothorax
- Sequela of TB empyema or effusion
- Absence of pleural fluid favors inactivity



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Complications - Vascular

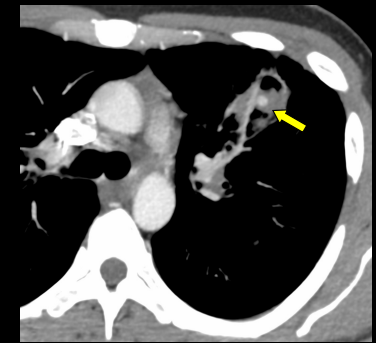
- Pulmonary and bronchial arteritis
- Thrombosis
- Bronchial artery pseudoaneurysm
- Rasmussen aneurysm



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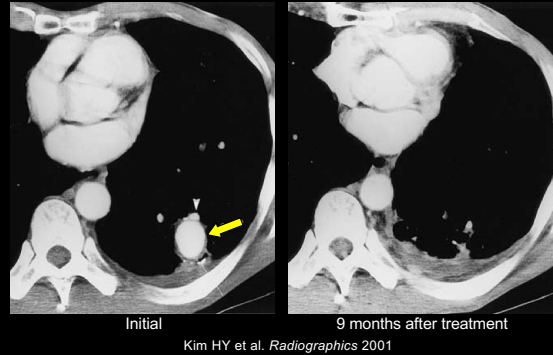
Complications - Vascular

- Rasmussen aneurysm
- Pseudoaneurysm of pulmonary artery from tuberculosis
- 5% of patients with chronic cavitary TB (autopsy series)



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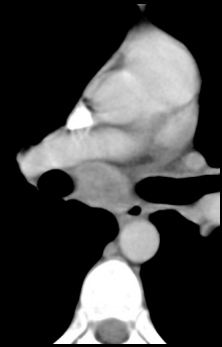
Complications - Vascular



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Complications - Mediastinum

- Esophagomediastinal fistula
- Esophagobronchial fistula
- Constrictive pericarditis
- Mediastinal fibrosis



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Complications - Mediastinum

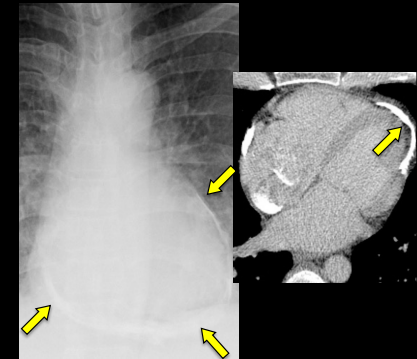
- Esophagomediastinal fistula
- Esophagobronchial fistula
- Constrictive pericarditis
- Mediastinal fibrosis



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Complications - Mediastinum

- Pericardial TB
- 1% of patients
- Direct extension or disseminated disease
- Constrictive pericarditis in 10% of patients with pericardial TB



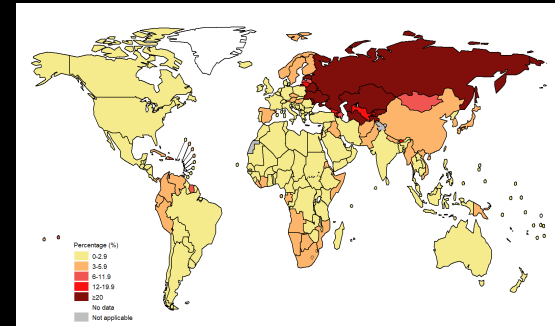
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Multidrug Resistant TB

- Imaging findings identical to those of non-resistant strains of TB
- Infection is prolonged and more difficult to treat
- Resection may be required for advanced cavitory disease

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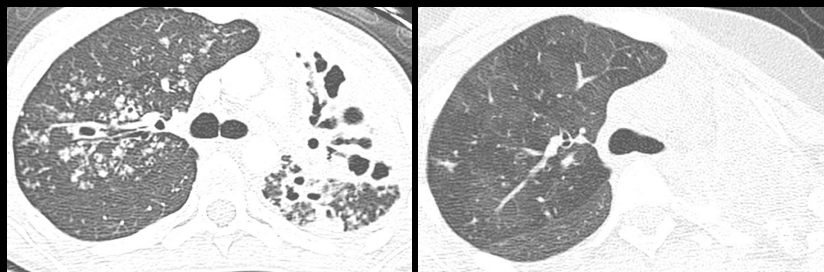
Multidrug Resistant TB



World Health Organization 2022 Global Tuberculosis Report

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Multidrug Resistant TB

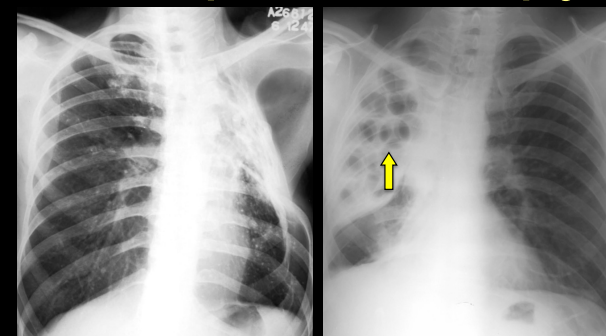


Baseline

Two years later

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Collapse Therapy

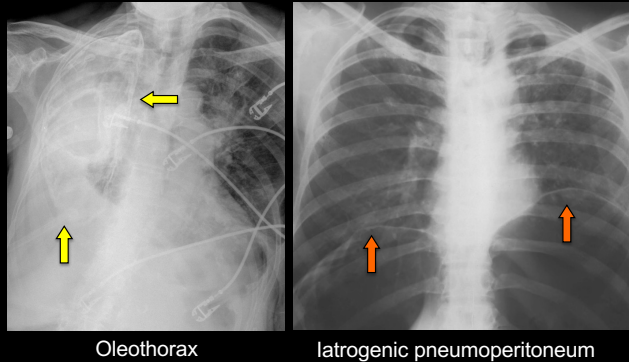


Thoracoplasty

Plombage

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Collapse Therapy



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Update on Imaging

- Chest radiography cornerstone for screening, diagnosis, and follow-up
- Access to CT, MRI, and molecular imaging technology is often limited in tuberculosis endemic areas

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Magnetic Resonance Imaging

- Access to MRI is a major barrier
- MRI useful for assessing TB involvement of spine, CNS, joints, and soft tissues
- Limited data on utility of MRI for pulmonary tuberculosis

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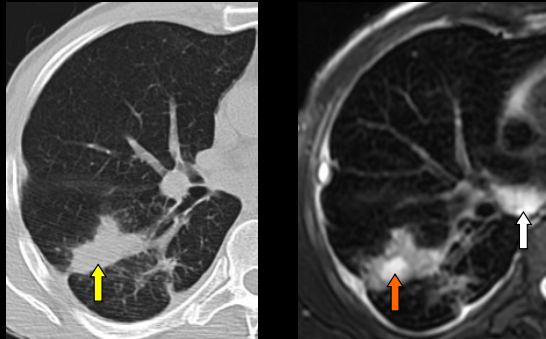
Magnetic Resonance Imaging

- 50 HIV negative patients with active TB and abnormal chest radiographs compared high-resolution CT to MRI¹
- No significant difference in identification of location and distribution of lung lesions
- MRI superior in showing parenchymal inhomogeneity, caseous necrosis, and pleural or lymph node involvement

¹Rizzi EB et al. *BMC Infectious Diseases* 2011, 11:243

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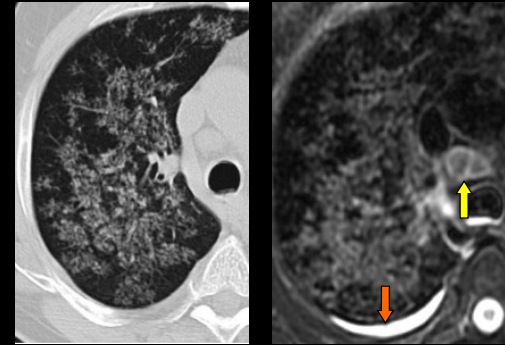
Magnetic Resonance Imaging



Rizzi EB et al. *BMC Infectious Diseases* 2011, 11:243

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Magnetic Resonance Imaging



Rizzi EB et al. *BMC Infectious Diseases* 2011, 11:243

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Nuclear Medicine

- FDG-positron emission tomography (PET) shows areas of increased glycolysis
- Primarily used for oncologic imaging
- Infection and other inflammatory lesions known causes of false positive FDG-PET

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Nuclear Medicine

- Pulmonary tuberculosis causes increase in FDG uptake
- Goo et al.¹ 9 of 10 tuberculomas showed increased FDG uptake
- Mean SUV_{max} value was 4.2 (2.2 SD)



¹Goo et al. *Radiology* 2000;216(1):117-121

Sathekge M et al. *Semin Nuc Med*, 2013;43(5):349-366

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Nuclear Medicine

- Double phase FDG PET
 - 60 minutes and 120 minutes
- 25 patients with pulmonary tuberculoma
- Statistically significant higher values in active tuberculoma vs. inactive tuberculoma
 - Maximal SUV_{max} early
 - SUV_{max} delayed
 - Change in SUV_{max}

Kim et al. *Radiology* 2000;216(1):117-121

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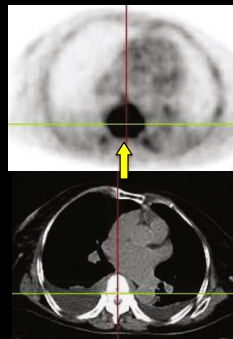
Nuclear Medicine

- Tuberculoma indistinguishable from lung carcinoma on FDG PET
- Investigation into utility double phase FDG PET for distinguishing tuberculosis from cancer
 - Higher rate of FDG retention in malignant lesions
- Particularly problematic in areas with high prevalence of tuberculosis

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Nuclear Medicine

- FDG PET may be useful for extrapulmonary tuberculosis
- Guide for biopsy and aspiration for culture
- Surgical planning
- Follow-up

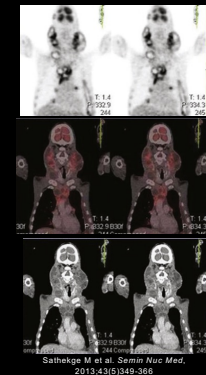


Satheke M et al. *Semin Nuc Med.* 2013;43(5):349-366

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Nuclear Medicine

- FDG PET may be used to monitor effect of therapy
- Tuberculomas can stabilize or grow even when sterile
- Increase in FDG uptake suggests progressive infection
- May guide duration of medical therapy



Satheke M et al. *Semin Nuc Med.* 2013;43(5):349-366

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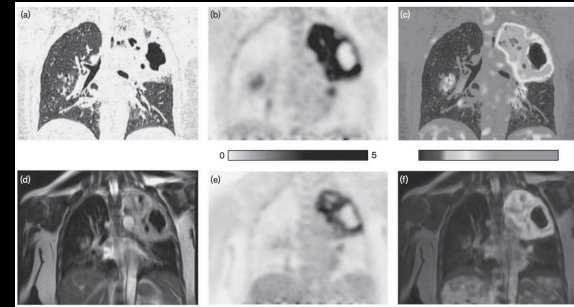
Nuclear Medicine

- FDG-PET/MRI vs. FDG-PET/CT
 - 10 subjects with pulmonary TB
 - PET/MRI identified 108 lesions
 - PET/CT identified 112 lesions

Thomas BA et al. *Nucl Med Commun.* 2017

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Nuclear Medicine



Thomas BA et al. *Nucl Med Commun.* 2017

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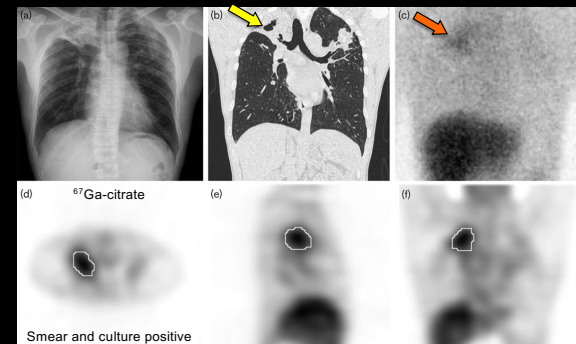
Nuclear Medicine

- ^{67}Ga -citrate non-HIV infection
 - High sensitivity
 - Low specificity
- ^{67}Ga -citrate HIV infection
 - Retrospective review of 220 HIV-positive patients with fever of unknown origin
 - Positive in 114 patients
 - Mycobacteria isolated in 83 (38%)
 - Positive in 75 (sensitivity 90%)

Sathekege M et al. *Nuclear Medicine Communications* 2012, 33:581–590

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Nuclear Medicine

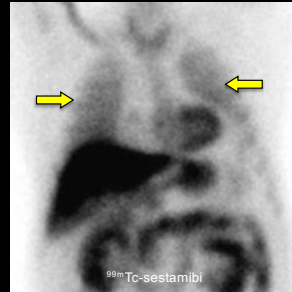


Hsu C-C et al. *Nuclear Medicine Communications* 2012, 33:941–946

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Nuclear Medicine

- Other tracers have been investigated
 - ^{201}Tl
 - $^{99\text{m}}\text{Tc}$ -sestamibi
 - $^{99\text{m}}\text{Tc}$ -tetrofosmin
- Accuracy $\geq 85\%$ negative predictive value $\geq 90\%$ for distinguishing TB from carcinoma



Sathegke M et al. *Nuclear Medicine Communications* 2012, 33:581–590

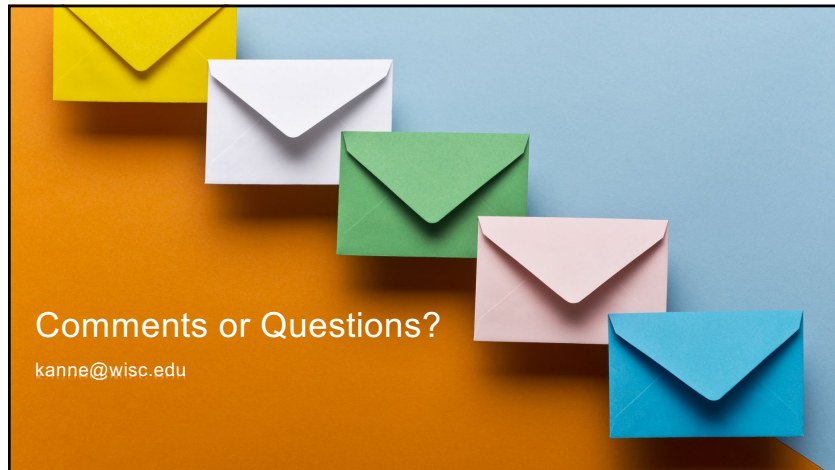
Ahmadihosseini H et al. *Nuclear Medicine Communications* 2008, 29:690–694

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Summary

- Chest radiography still most important imaging test for tuberculosis
- Potential role for PET/CT and other nuclear medicine techniques
- Access to newer imaging techniques very limited in most tuberculosis-endemic regions

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