

Pulmonary Infection II: Immune compromised patients

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Objectives

- Approach to imaging patients
 - Technique
 - Context
- Key findings in important, common infections

Radiographs v. CT

Utility of radiography

- Should be initial imaging study performed!
- Detect gross disease
 - Possibly preventing CT
- Establish baseline to assess for treatment response

Pt with shortness of breath



Need for CT

- Decreased immunologic response may make disease more subtle
- CXR always less sensitive to disease than CT
- CXR normal in 10% of pts with early infections*
- CT indicated if CXR is normal

*Primack, Muller. Radiol Clin N Amer 1994, 731.

Need for CT

- Pattern characterization
 - May be easier with CT
 - Particularly when alternative is portable radiographs
- Anatomic localization easier
 - Direct bronchoscopy to active disease

What kind of CT to order?

- Classically “high-resolution” CT
- However, CT technology has changed substantially

Conventional CT

- Originally, slow images
- Usually 1-cm thick
- Poor spatial resolution

Conventional CT

- AKA "step and shoot"

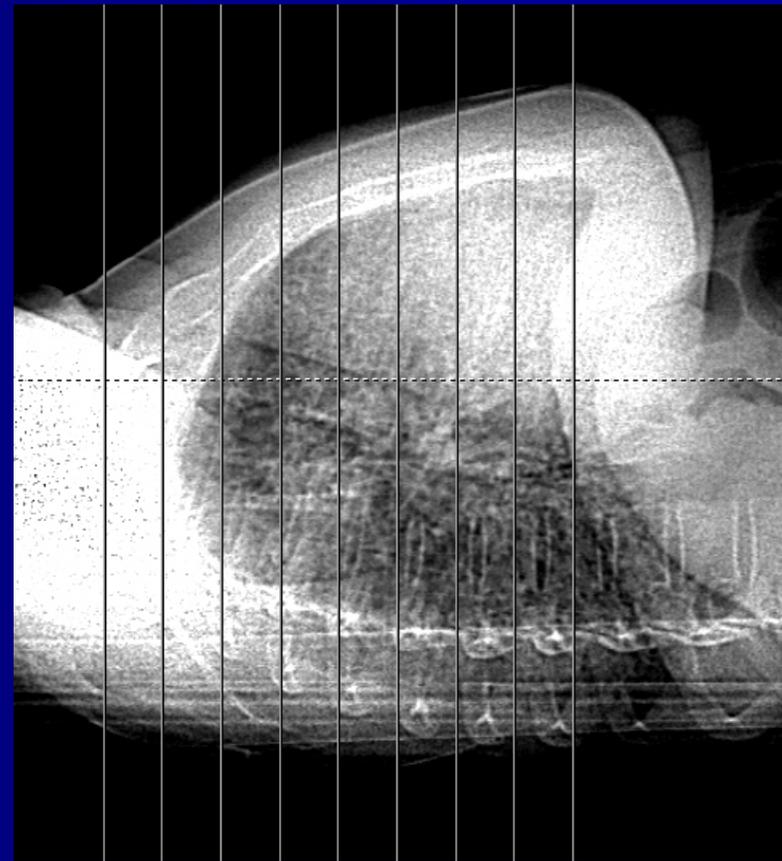


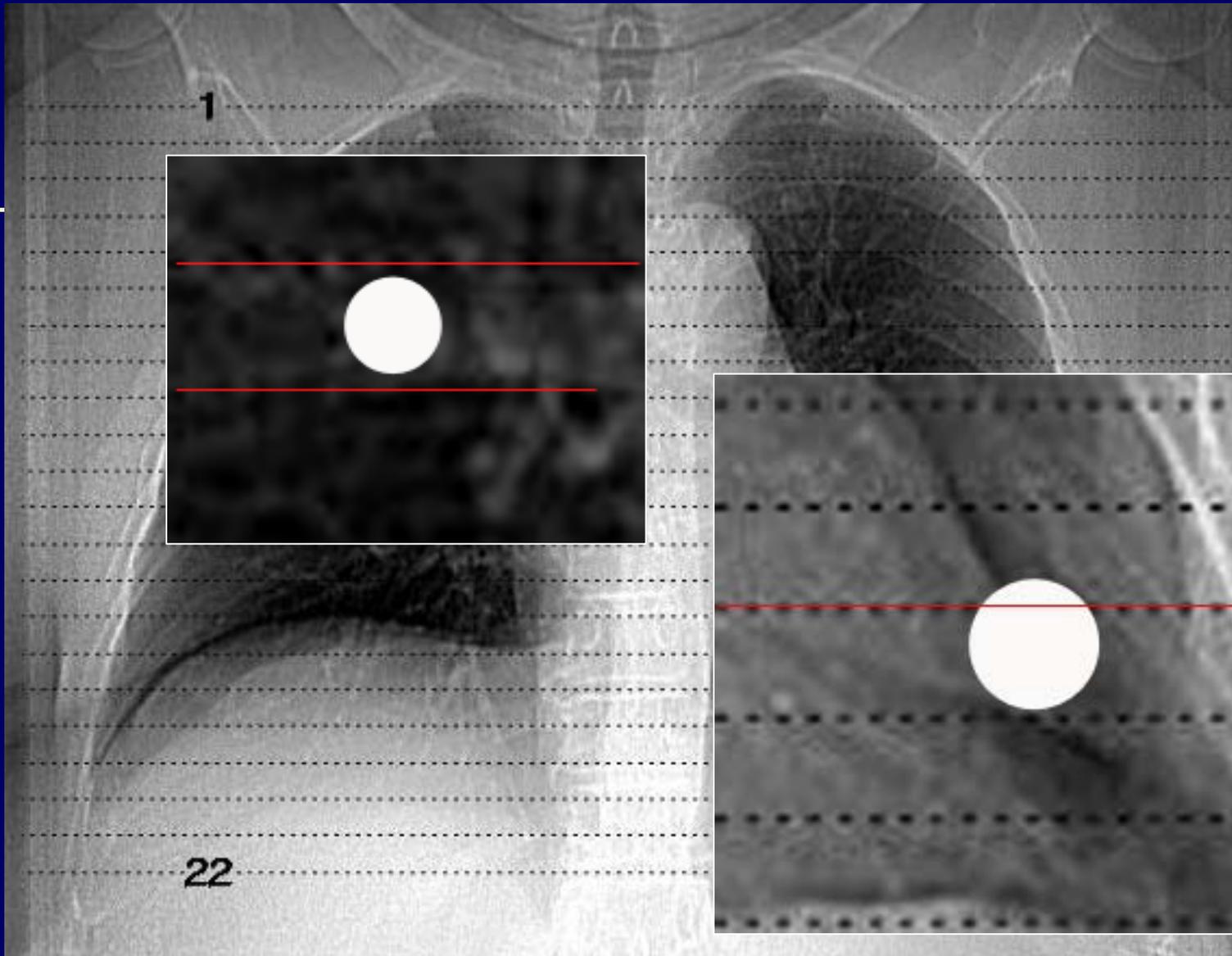
Demand for better detail

- To improve visualization of diffuse lung disease
- Analogous to a gross pathologic section
- Needed high spatial resolution, thin sections
- If disease was diffuse, no need to see the whole lung

High-resolution CT

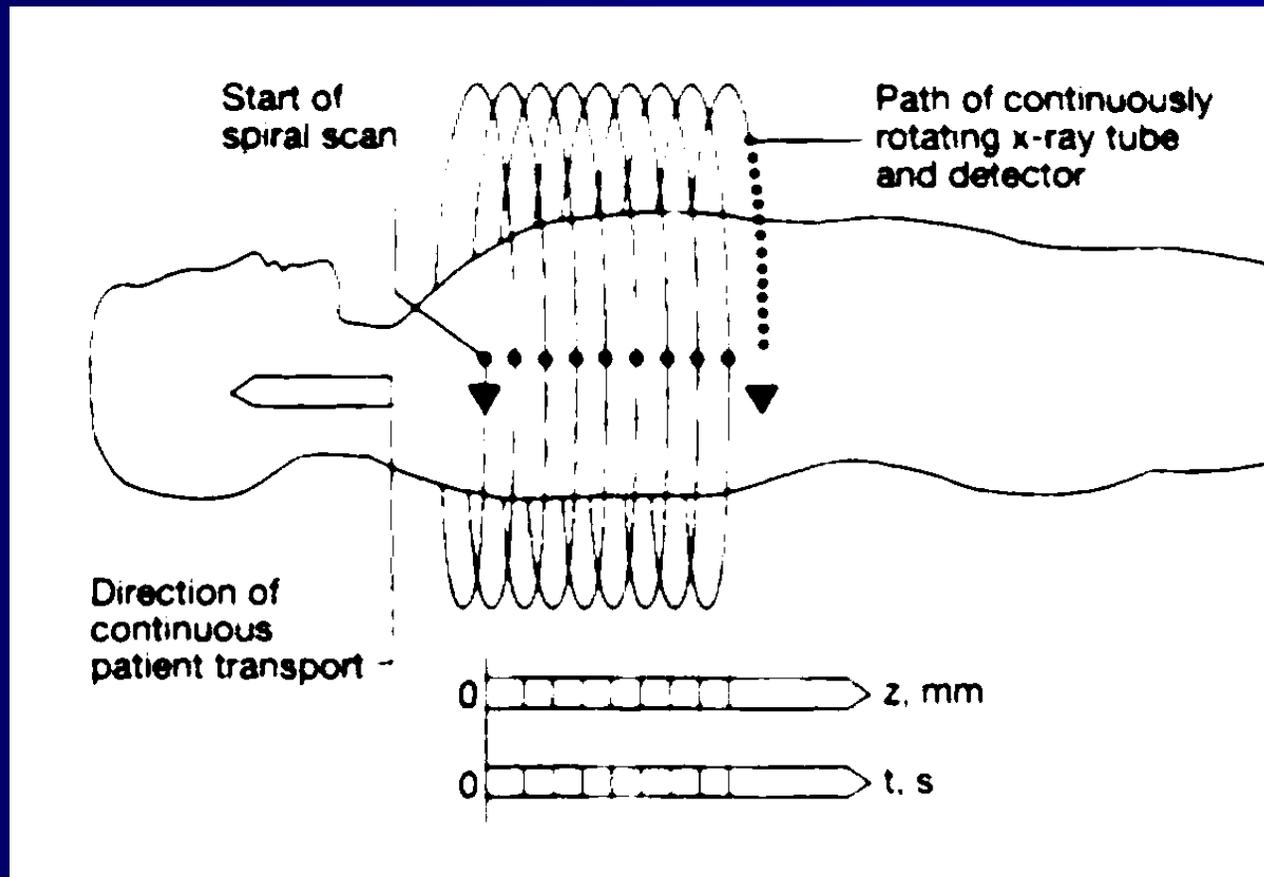
- Step and shoot
- Thin sections
- Noncontiguous (or "at intervals")
- High spatial resolution
- Large amounts of lung (between images) not seen





Circle diameter is a size of diffuse disease

Early 1990s: Spiral/helical



Kalender et al. Radiology 176 (1): 181. (1990)

Single-slice spiral CT

- Images obtained faster than with conventional, "step and shoot"
- Slice thickness fixed
- Protocol choice:
 - Helical, complete imaging, thick sections
 - High-resolution, incomplete (noncontiguous) imaging, thin sections

Single-detector row CT

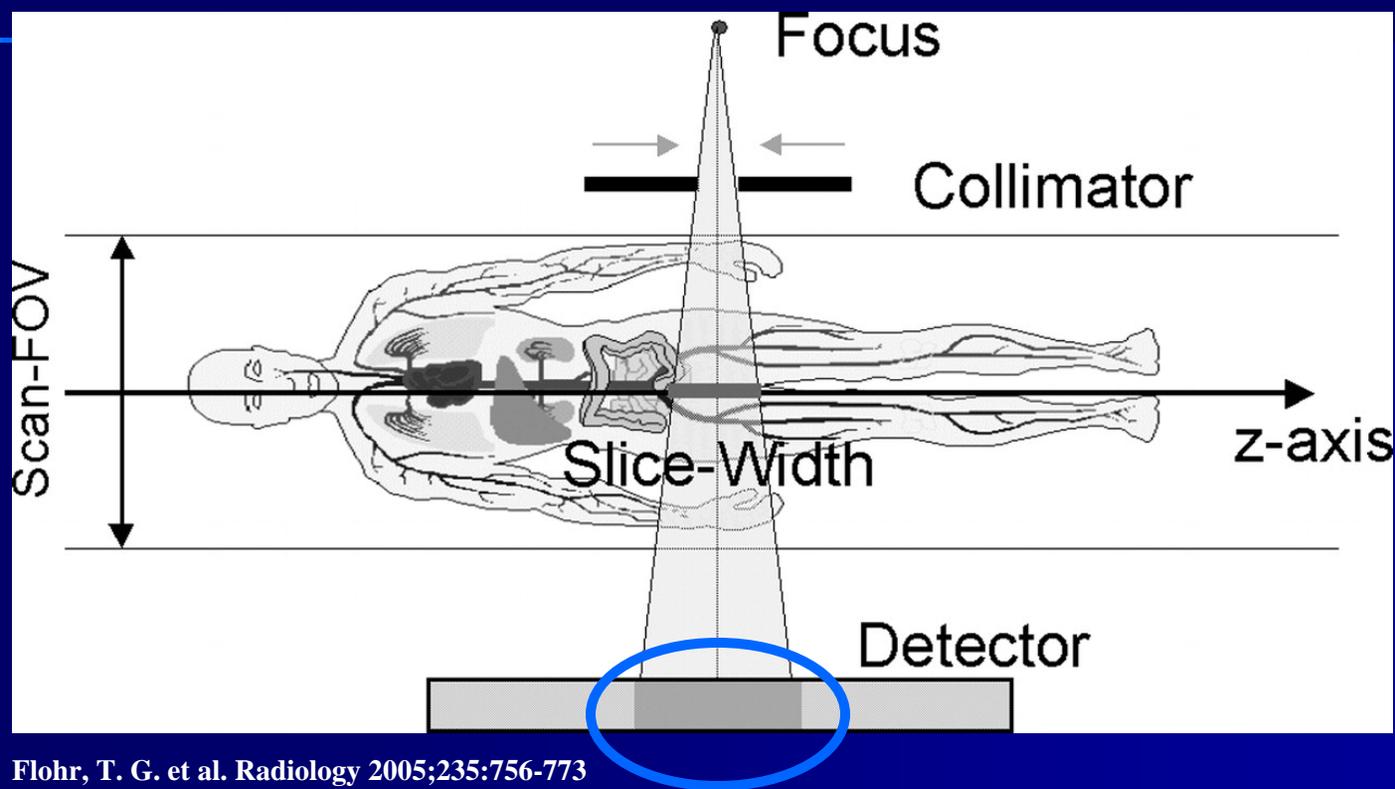
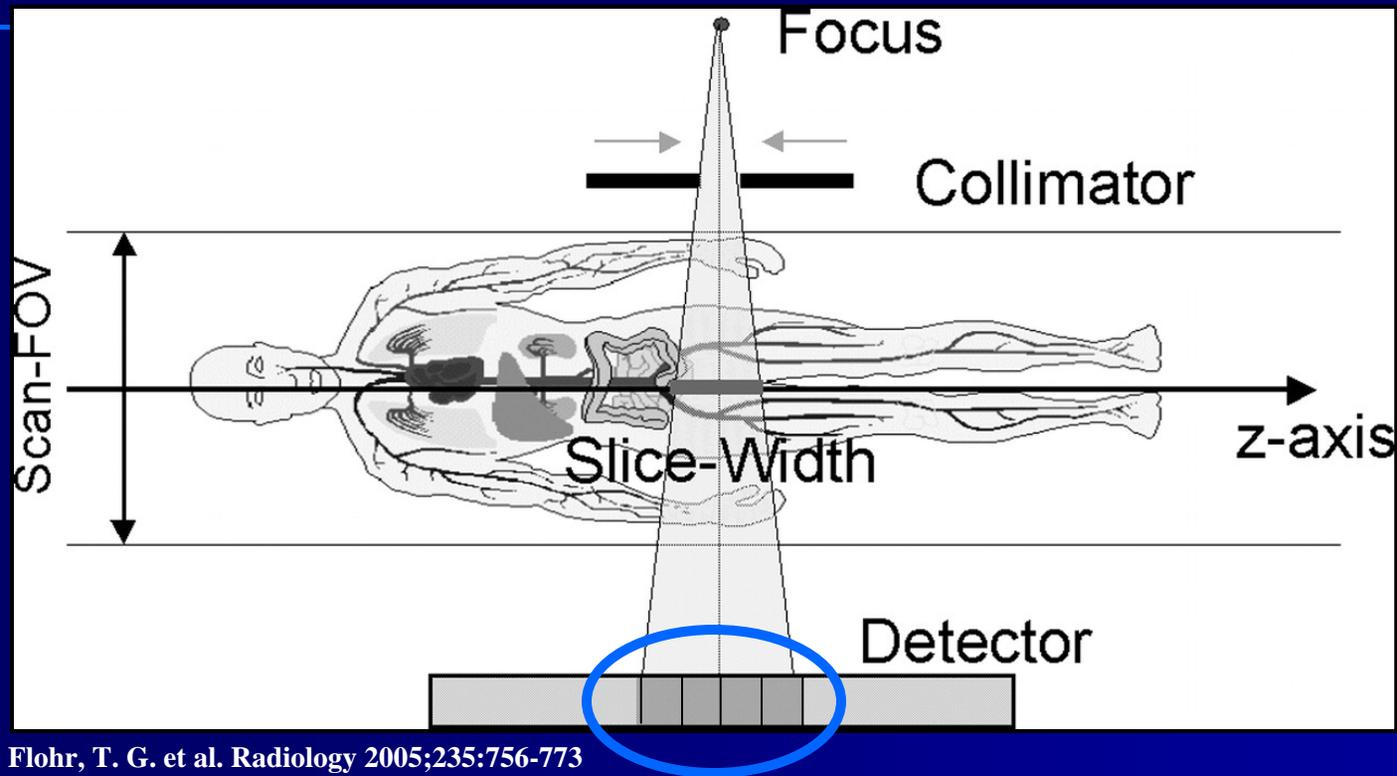


Figure 2. Illustration shows prepatient collimation of the x-ray beam to obtain different collimated section widths with a single-detector row CT detector

Radiology

1998: Multidetector CT



Flohr, T. G. et al. Radiology 2005;235:756-773

Radiology

Multidetector CT advantages

- Much faster
- Can reconstruct one data set with thick and/or thin images
- Can make thin images
 - Contiguous (large data sets)
 - Or noncontiguous
 - \pm Contiguous thick sections
- **In infection, “high-resolution” CT request now unnecessary**

IV contrast

- Almost never indicated in lung imaging
- Misconceptions about need for contrast
 - Abscess
 - Empyema
- Needed for PE assessment

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Differential diagnosis

- In immune compromised patients depends on clinical setting
- Including:
 - Exposure history
 - Type of immune deficiency
 - Severity of immune deficiency

Defect	Infection
Phagocyte	Bacteria, Fungus
B cell	Bacteria (Strep, staph, H. flu, Pseudomonas)
T cell	Legionella, nocardia, fungus, Virus, Pneumocystis, parasites
Splenectomy	Bacteria (Strep, staph, H. flu)
Steroids	Bacteria, Fungus, virus, pneumocystis, parasites

Immune compromised patients

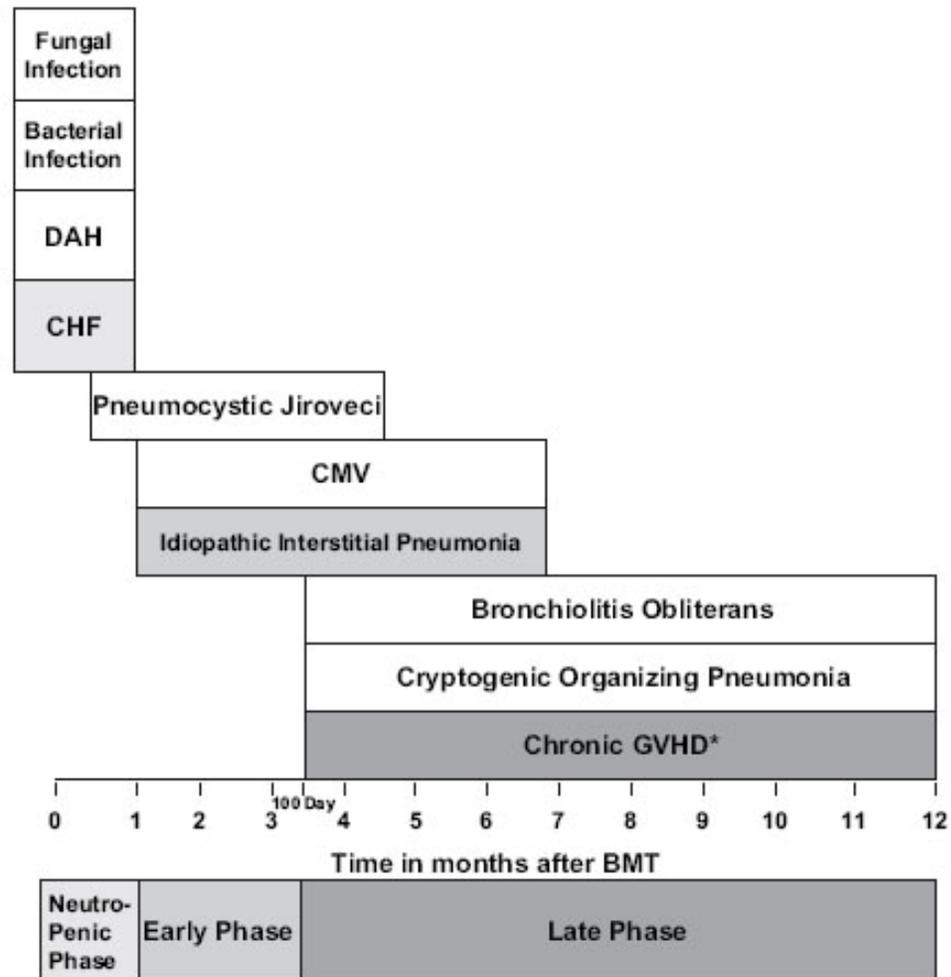
- Non-AIDS
- AIDS

Non-AIDS

- BMT
- Solid-organ transplantation

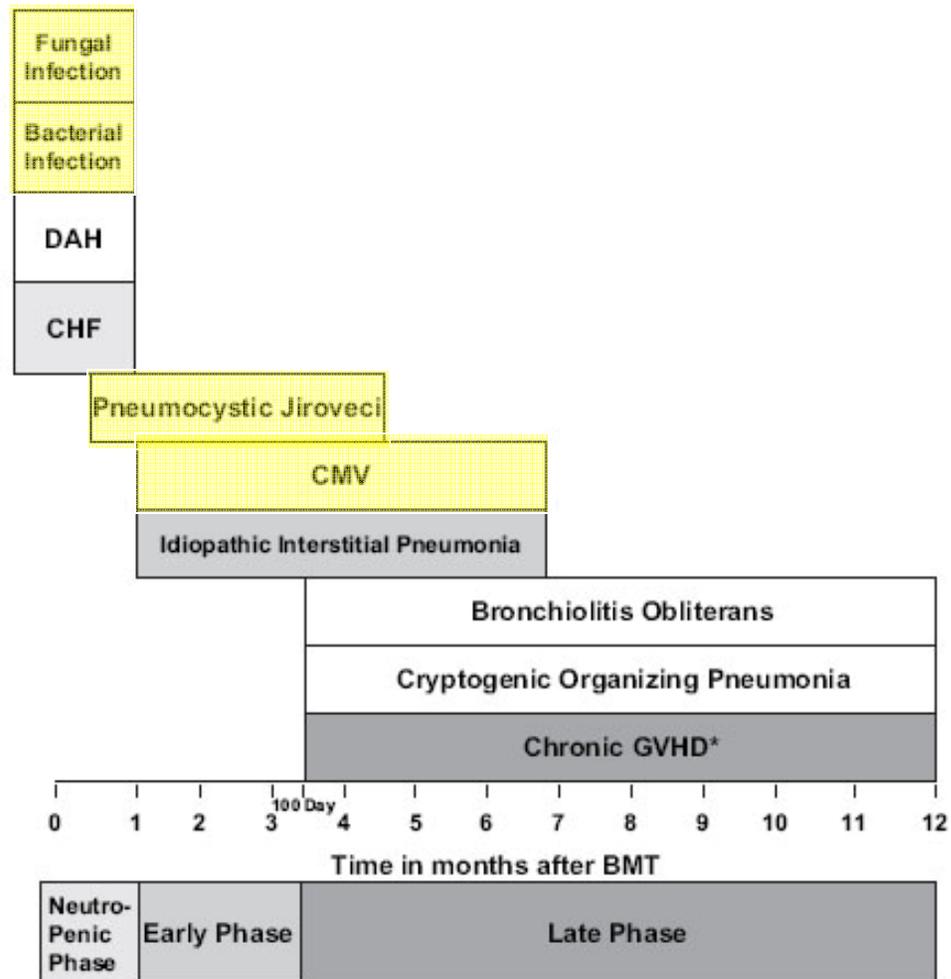
BMT

AJR Am J Roentgenol 2002;178:159–63.



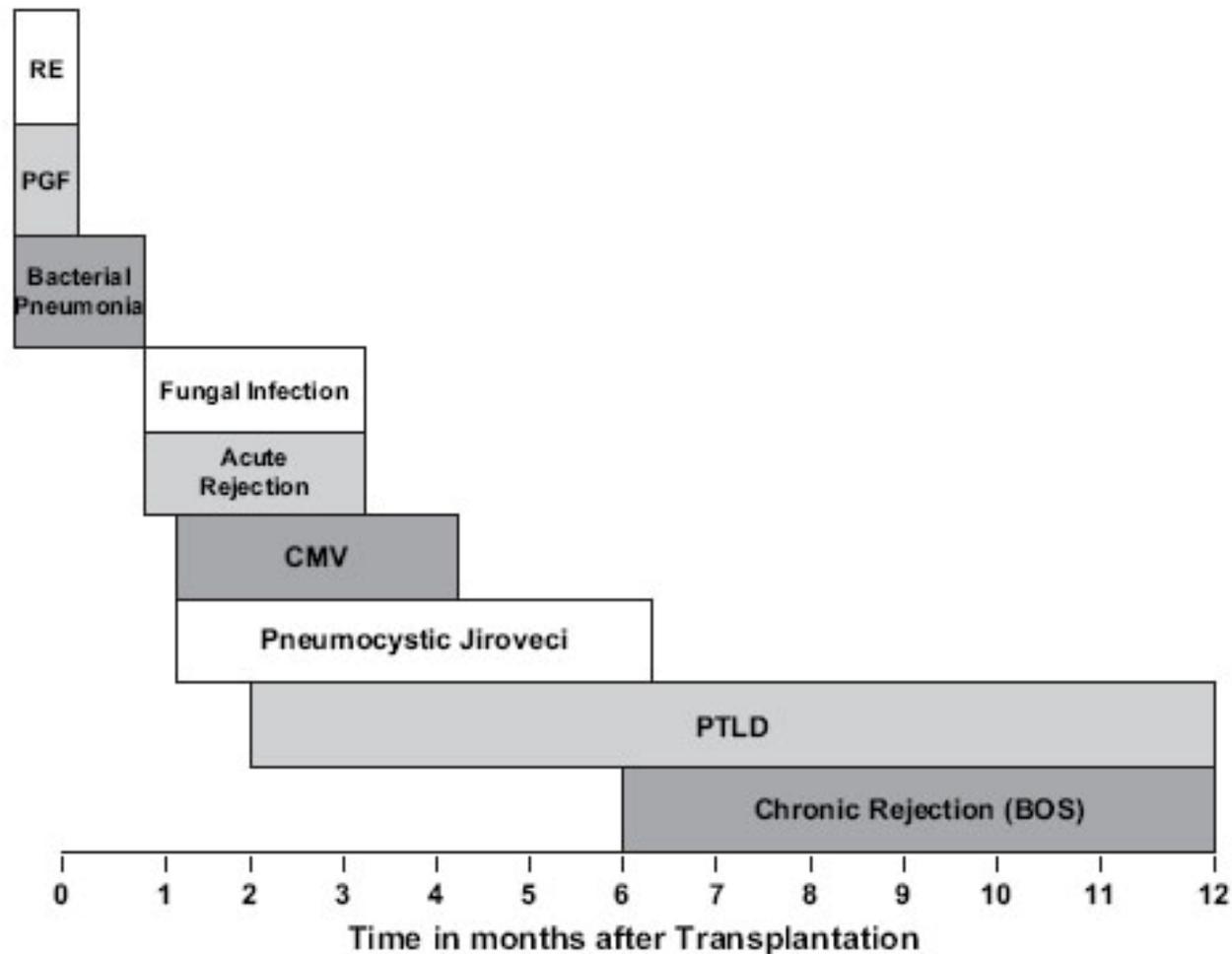
BMT

AJR Am J Roentgenol 2002;178:159–63.



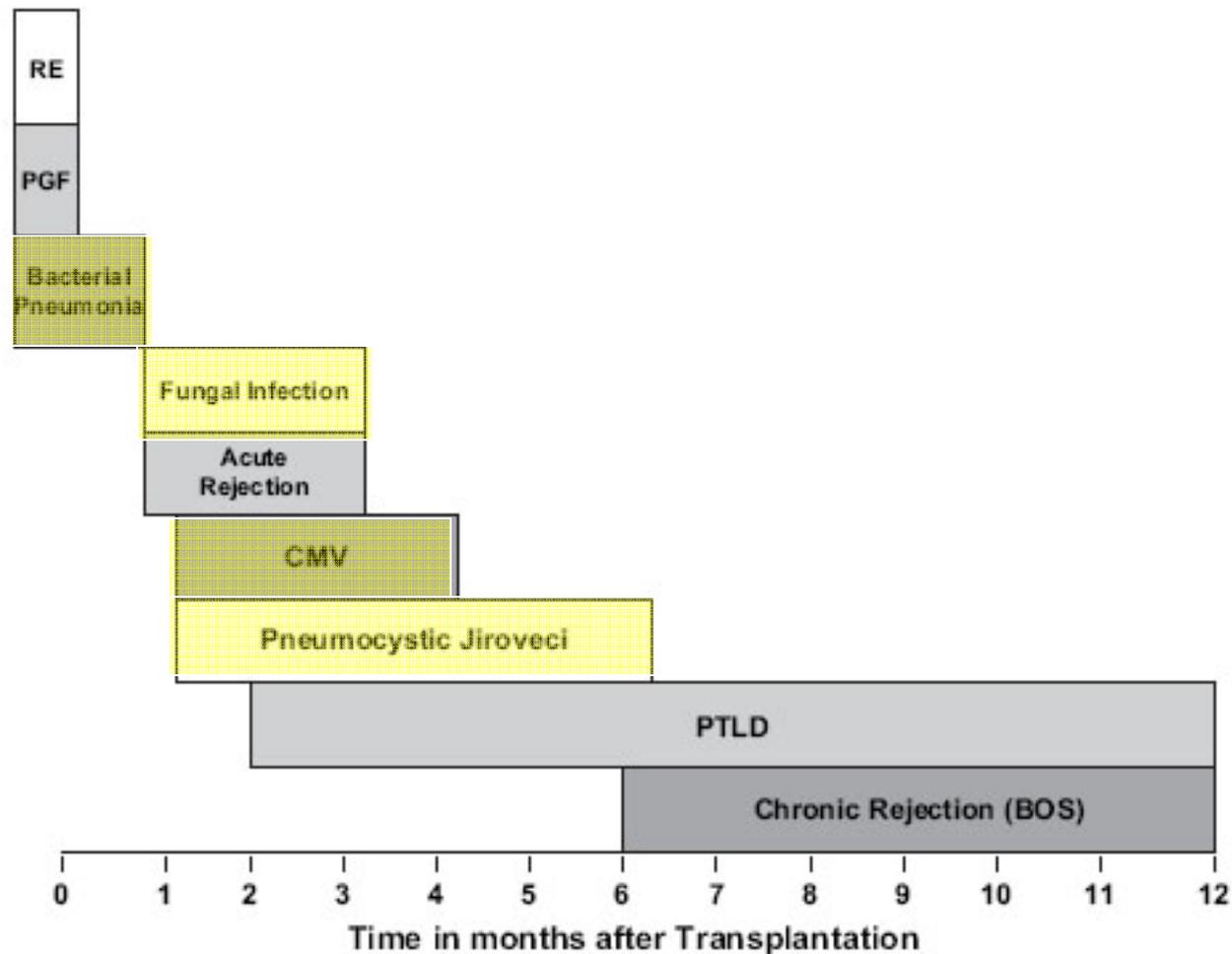
Lung txp

AJR Am J Roentgenol 2002;178:159–63.



Lung txp

AJR Am J Roentgenol 2002;178:159–63.



Timeline summary

- Noninfectious processes are in differential diagnosis at every stage
- Late in course, infection is less likely
 - > 7 months after BMT
 - > 6 months after lung txp
- Bacterial and fungal infections occur earlier
- CMV and pneumocystis later

AIDS

- Bacterial
- Pneumocystis
- Mycobacterial
- Fungal

Disease patterns

- Changed over time
- As in non-AIDS, differential diagnosis includes noninfectious causes

Pneumocystis

- Formerly (before prophylaxis) most common infxn
- Now
 - Less common than bacterial infection
 - Most common opportunistic infection in AIDS

Most helpful

- Communicate to radiologist what patient is at risk for

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Objectives

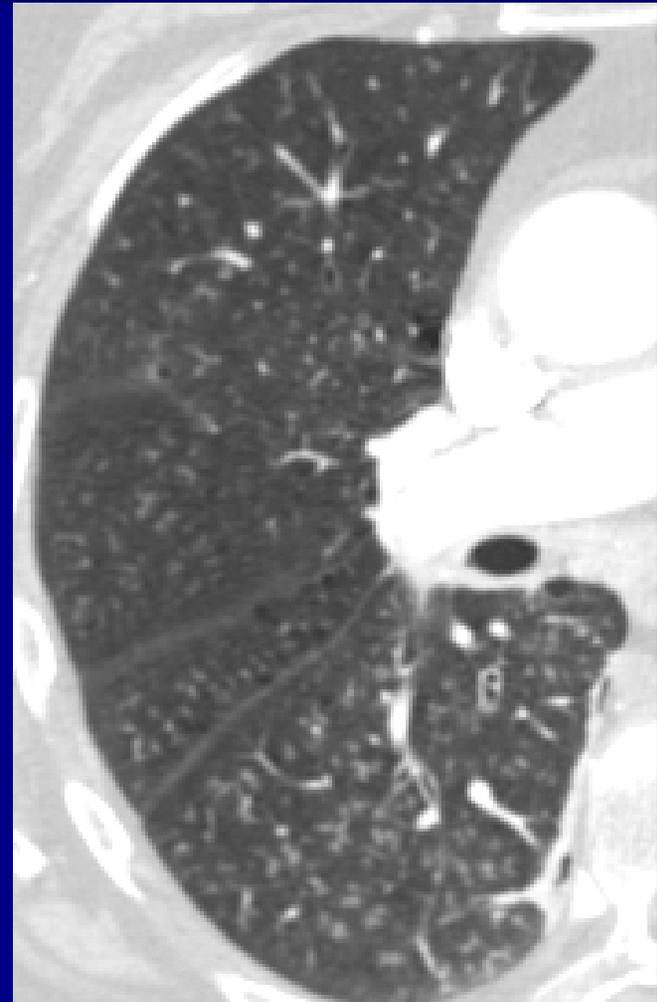
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Most infections

- Nonspecific appearance
- Similar to findings in immunocompetent patients
 - Consolidation
 - Bronchopneumonia patterns
 - Interstitial pneumonia

Interstitial pneumonia

- Probably more commonly seen in immunocompromised
- Possibly because CT imaging is more common and findings are subtle



Fungal infection

- Invasive fungi
 - >10% of infections in BMT pts
 - 1st month
 - 1st 6 months with tx for GVD
 - 5% in solid organ txp pts
 - 1st 2 months
 - Mortality: 80%-90% even with therapy

Most important finding

- Findings on CT now used to diagnose fungal infection in appropriate clinical setting
 - Likelihood of positive cultures low: between 30% and 54%*

*Ketai et al, Clinics in Chest Med 2008: 77-105

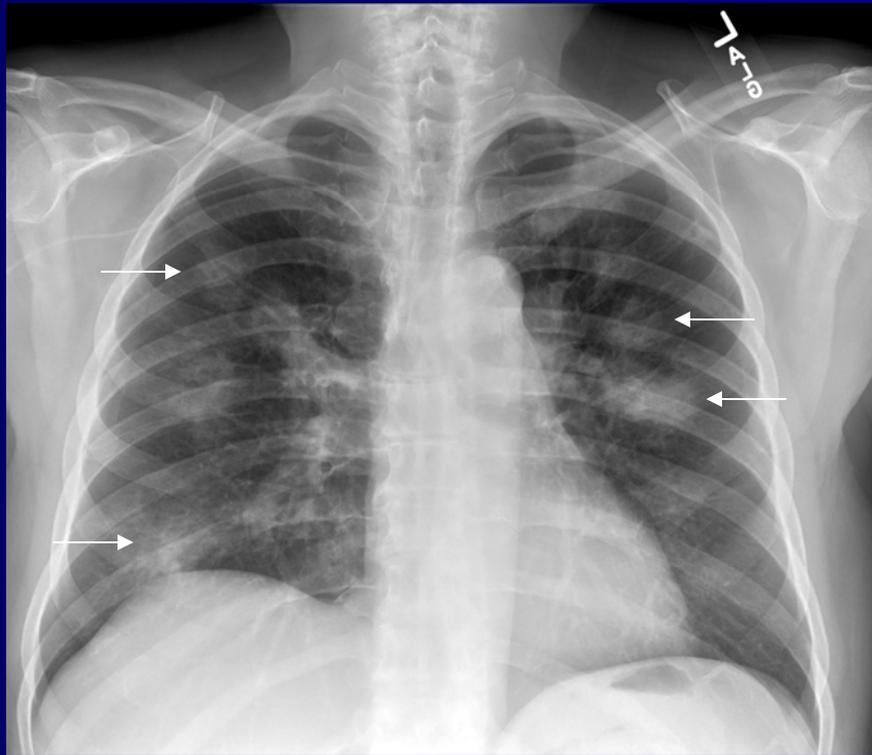
Fungal infection

- Not endemic fungi
- Severe immunocompromise:
 - Aspergillus
 - Fusarium
 - Mucormycosis
 - Candida
 - (Pneumocystis jiroveci)

Radiologic findings

- >90% of pts have nodule or mass
- Usually > 1 cm (=“macronodule”)

Macronodules



Absence of “macronodule”

- In high-risk patients argues against aspergillosis*

*Greene et al: Clin Infect Dis. 2007 Feb 1;44(3):373-9.

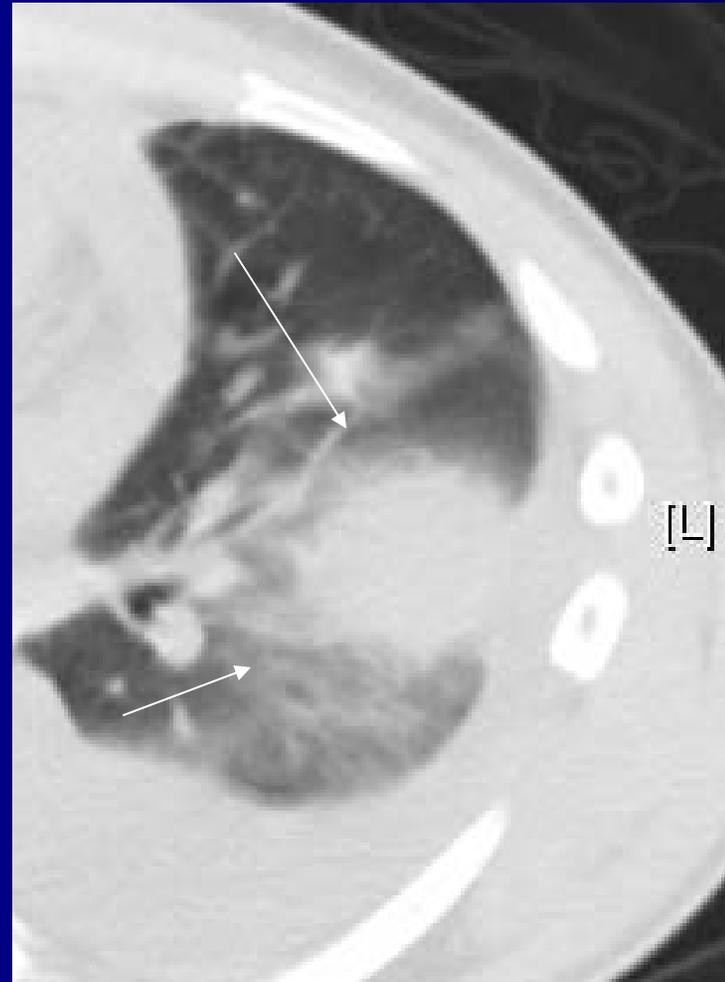
Nodule characteristics

- Early signs
 - >50% halo sign
 - Reverse halo sign also seen

Halo sign

- Ground-glass opacity (haziness)
- Around nodule
- Significantly assoc. w/ fungal infxn
- Associated with better treatment response and prognosis *

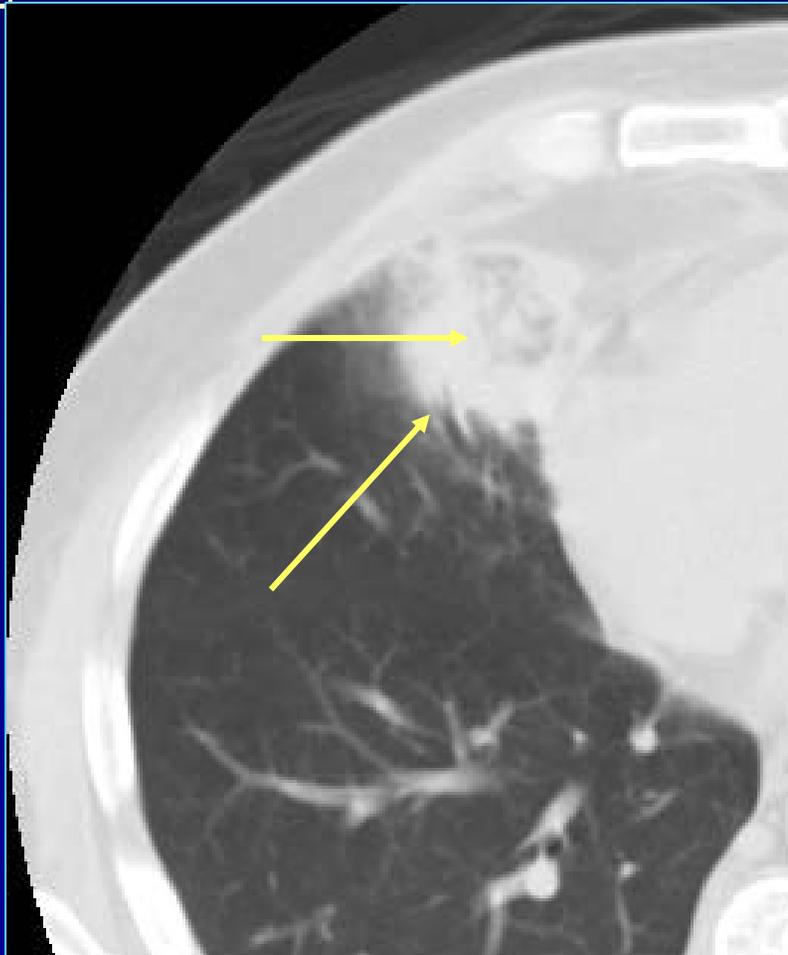
*Greene et al: Clin Infect Dis. 2007 Feb 1;44(3):373-9.



Halo sign

- Not described in fusarium

Reverse halo sign



- Also early sign
- Low attenuation center
- High attenuation rim

Nodule characteristics

- Late signs
 - Hypodense sign
 - Low-attenuation center on contrast enhanced CT
 - Air crescent sign
 - Radiographs
 - CT with or without contrast



Mechanism of signs

- Reflects angioinvasion
- Hemorrhagic infarction
- Lung necrosis

Macronodule

- Absence has reasonable NPV for fungal infection
- Presence has reasonable PPV for infection
- PPV depends on pretest probability of disease

Diffuse disease

- Pneumocystis
- Cytomegalovirus
- Varicella
- Less commonly:
 - Bacteria
 - Mycobacteria
 - Fungi

Value of CT

- Mild disease
- Normal CXR
- Minimally abnormal CT



Classic CT appearance

- Ground-glass opacity
 - Very mild
 - Severe
 - Cysts in 10-38%
- Linear interstitial opacities mimicking edema

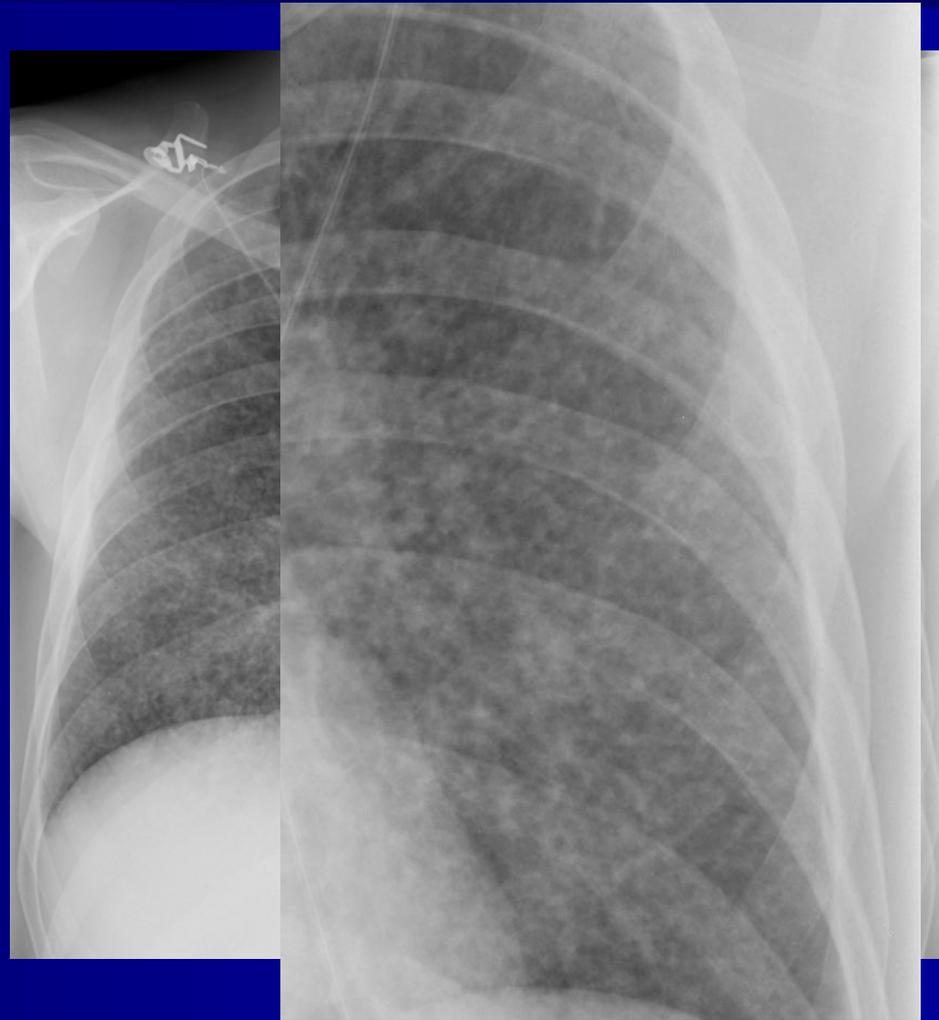


Value of CT

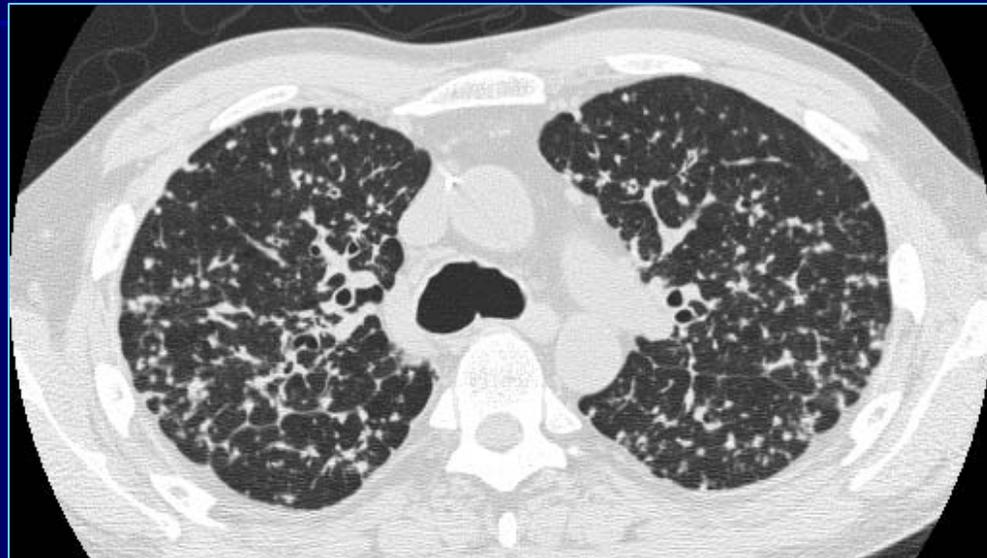
- Distinguishing patterns

AIDS patient

- Diffuse lung disease
- ?Pneumocystis



CT image



- Not ground-glass or reticular opacities
- Other patterns have been described in pneumocystis, but . . .
- Miliary nodules are uncommon

Miliary pattern

- Most commonly
 - TB
 - Fungus such as histoplasmosis, cryptococcus
 - **Coccidioidomycosis**

CT-guided FNA

- Retrospective study
- 67 pts w/ hematologic malignancy (10 yrs)
- Yield: specific diagnosis in 56%
- Complications: 25%
- 1 death from bleeding

Wong et al, Chest 2002 vol. 121 no. 2 527-532

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Approach to imaging

- Start with chest radiography
- CT if needed
 - Normal radiograph
 - Pattern characterization
 - Directing bronchoscopy
- “High-resolution” no longer necessary in infection

Approach to imaging

- Communicate
 - Exposures
 - Type of immune deficiency
 - Degree of immune suppression

Patterns to recognize

- Large nodule in infection: fungus, particularly angioinvasive fungi
- Diffuse disease: viral, pneumocystis
- Diffuse miliary pattern: granulomatous infections
 - Fungus
 - Mycobacteria