Imaging of Community Acquired Pneumonia:

Goals and Objectives
- Know a CT pattern based differential diagnosis for non-infectious alternatives to pneumonia and the relative likelihood of those diagnoses
- Know the spectrum of CT manifestations of viral lower respiratory infections

Community Acquired Pneumonia
- Detection of Infection
  - CXR
  - US
- Differentiation of infections from non-infectious lung disease
  - CT Pattern approach
- Detection of complications
- Identification of Specific Organisms (rarely)
  - Viral pneumonia

Patients Hospitalized with Clinical Diagnosis Pneumonia
- Radiograph = Pneumonia
  - Pos Blood Cultures 8% (Majority Strep Pneumonia)
  - Mortality 10%
- Radiograph ≠ Pneumonia
  - Pos Blood Cultures 6% (Majority GNR)
  - Mortality 8%

Radiographic Detection of Community Acquired Pneumonia
- Reader concordance high for involved lobes and presence of effusion
- Concordance low for specific findings
  - Pattern of involvement (e.g. bronchopneumonia)
  - Presence of bronchial wall thickening
  - Presence of air bronchograms
- Differentiating pneumonia from non-infectious pulmonary disease often difficult

US for the Diagnosis of Pneumonia
- Often performed by non-radiologists
- Euro-centric currently
- Landmarks
  - Pleural line – Echogenic line, sliding with respiration
  - A-Lines – Echogenic parallel lines within the lung
  - B lines ring-down artifacts perpendicular to pleural surface
  - Extending length of field of view
- Pathology
  - Interstitial syndrome – >3 B lines (in field of view)
  - Alveolar syndrome – Loss of pleural line, air or liquid filled bronchograms
- Parlamento, 2009 Am J Emerg Med
US for the Diagnosis of Pneumonia

- Prospective study –
  - 144 patients
  - Either “interstitial” or “alveolar” considered positive
  - Sensitivity, Specificity CXR = 60%, 57%
  - Sensitivity, Specificity US = 95%, 76%
- *Gold standard Dx* = imaging and clinical composite
- Awaits US/CT correlative imaging done by radiologists

CT Patterns: Relevant to Infection

- Septal thickening (extensive)
- Nodules
  - Centrilobular ground glass (GG)
  - Centrilobular soft tissue (acinar nodules)
  - Centrilobular with Tree in Bud (TIB)
  - Random
  - Perilymphatic
  - Lobular ground glass and consolidation
- Consolidation
  - Nonsegmental
  - Segmental

Radiographic Equivalent of Septal Thickenings

- Linear Interstitial Pattern
  - Congestive Failure
  - Hantavirus Pulmonary Syndrome

CT Pattern: Septal Thickening

- Infections - Rare
  - Hantavirus, rickettsial diseases (RMSF)
- Non-infectious - Common
  - CHF
  - Acute eosinophilic pneumonia, Drug reaction*

- *Less likely to have pleural effusion

Acute Eosinophilic Pneumonia

CT Pattern: Centrilobular Ground Glass (GG) Nodules

- Cellular Bronchiolitis
  - 1-3 mm
  - 1 cm
  - Pleura
  - Pleural surfaces spared

Difficult to detect on chest radiograph
CT Pattern: Centrilobular Ground Glass Nodules
- Non-Infectious disease is common
- Hypersensitivity pneumonitis
- Respiratory bronchiolitis
- Pulmonary hemorrhage/vasculitis
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CT Pattern: Centrilobular Nodules
- Acinar consolidation
- Often associated with TIB
- Heterogeneous in size
- Patchy
- Non-infectious causes
- Usually chronic disease
- PLCH, invasive adenoCa

CT Pattern: Centrilobular Soft Tissue
- Centrilobular Nodules
- Ground Glass
- 1-3 mm
- Pleura

CT Pattern: Centrilobular Nodules
- Centrilobular Nodules
- Soft Tissue
- 5-7 mm
- Pleura

CT Pattern: Centrilobular Nodules
- Centrilobular Nodules
- Tree in Bud Pattern (TIB)
- Pleura

CT Pattern: Centrilobular Nodules
- Tree in Bud Pattern (TIB)
- Pleura
**CT Patterns : Centrilobular Nodules with Tree in Bud**
- Infectious: More Common
  - Bacterial - e.g. H. influenza
  - Mycoplasma – usually adults
  - Viral
- Can have associated bronchial wall thickening
- Non Infections: Aspiration

**CT Pattern: Random Nodules (miliary)**
- Diffuse, randomly contact interlobular septa and pleural surfaces
- Infection – Miliary tuberculosis, Disseminated endemic fungi
- Non-infectious – Metastatic neoplasm

**CT Pattern: Nodules Perilymphatic**
- Nodules favor
  - Interlobular Septa
  - Pleural Surfaces
  - Centrilobular area (Peribronchial lymphatics)
- “Clumpy” rather than diffuse

**CT Pattern: Perilymphatic Nodules**
- Sarcoid, lymphangitic cancer, and silicosis
- Usually NOT from infection

**Etiology of Micronodules?**
- Nodule pattern
  - Centrilobular with TIB
  - Centrilobular soft tissue
  - Random
  - Centrilobular GG
  - Perilymphatic
- Etiology
  - Infection >> Non-infection
  - Infectious>Non-infectious
  - Infection/Non-infection
  - Non-infectious > Infection
  - Non-infectious

Okada, Chest 2007
**CT Pattern: Lobular GGO/Consolidation**

Centrilobular Nodules

Lobular Ground Glass or Consolidation

**Non-specific** – Shah AJR 2003

- Pulmonary edema
- Pulmonary hemorrhage
- Drug Toxicity
- Infections

- Bronchopneumonia – Viral, Bacterial
- More specific if accompanied by tree-in-bud nodules or bronchovascular distribution

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**CT Patterns: Consolidation**

Non-segmental

- Infection – Very Common
- Non-Infectious
  - Occasional
  - Usually subacute
    - Lymphoma
    - Vasculitis
    - COP
    - Sarcoid
    - Invasive Mucinous Adeno Ca

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**Invasive Mucinous Adenocarcinoma**

- Nodules – Centrilobular soft tissue
- Remote areas of ground glass
- Stretching/Attenuation of bronchi - specific

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**CT angiogram sign and Non-segmental Consolidation**

- Well delineated pulmonary vessels against low attenuation (airless) parenchyma
- Historically associated with adenocarcinoma
- Seen in about 1/3 of pneumonias
- Present in about 1/4 of obstructive atelectasis cases
  - Volume loss
  - No air bronchograms
  - Uptake
  - Rare in passive atelectasis
  - Usually high attenuation on CE scans

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**Re-expansion edema**

Bronchopneumonia

Granulomatosis and Polyangiitis

Lymphoma

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**Adenocarcinoma**

Pneumonia

Lymphoma
CT angiogram sign and Non-segmental Consolidation

- Pneumonia

FDG PET

Atelectasis

Low post contrast attenuation favors pneumonia or obstructive atelectasis over passive atelectasis

CT Patterns: Segmental Consolidation

- Infection: Common
- Non-Infectious - Occasional
  - Pulmonary Infarction
    - Lower Lobes
    - Peripheral
    - Truncated apex
    - Segmental consolidation with central lucency –
      - 98% Specific 46% sensitive
      - Air bronchograms absent

CT Patterns: Segmental Consolidation

- Pulmonary Infarction
  - Lower Lobes
  - Peripheral
  - Truncated apex
  - Segmental consolidation with central lucency –
    - 98% Specific 46% sensitive
    - Air bronchograms absent
- Vessel sign = enlarged vessel leading to wedge shaped opacity
  - Specific but uncommon

Pneumonia with Adenopathy on CXR

- Enlarged lymph nodes rarely seen on radiographs
- Confines Ddx of organism causing infection
  - Tularemia
  - "Primary" tuberculosis
- Endemic fungi

- > 3000 Hospitalizations/year for “Cocc” in California
- > $55,000 per admission

Coccidioidomycosis

Pneumonia with Adenopathy on CT

- Prevalence of enlarged lymph nodes on CT > CXR
  - Pneumococcal pneumonia, Stein et al Chest 2005
  - Empyema
  - Usually does not confine Ddx
- Exception: Low attenuation nodes with enhancing rim
  - Mycobacteria,
  - Endemic fungi

Community Acquired Pneumonia - 2013

- Houston – (patients admitted)
  - No pathogen found – 50%
  - Bacteria alone - 25%
    - Strep pneumonia, H. influenza
- Chile –
  - No pathogen found – 35%
  - Bacteria alone – 26%
    - Strep - Mycoplasma
- China –
  - No pathogen – 45%
  - Bacterial alone - 40%
    - Mycoplasma >> Other

Pneumococcal pneumonia, Stein et al Chest 2005

Empyema

Mycobacteria

Endemic fungi

Coccidioidomycosis

Mycoplasma
Community Acquired Pneumonia - 2013
- Virus present in 15-40%
- Sole pathogen slightly more common than mixed infection (with bacteria)
- Detected with polymerase chain reactions (PCR)
- Various organisms
  - Influenza, RSV, Rhinovirus

CT imaging of Viral Pneumonia
- CT of PCR Positive Viral Lower Respiratory Infections
  - Shiley JTI 2010
  - Normal and immunocompromised patients
- 1/3 Normal
- 1/3 Bronchiolitis/Branchitis
- 1/3 Pneumonia

CT of Viral Pneumonia
- CT findings of viral and bacterial pneumonia overlap
  - Miller AJR 2011
  - Herbst AJR 2013
  - RSV - Airway centric pattern
  - Parainfluenza - Similar to RSV

Adenovirus Pneumonia
- Multifocal consolidation or GGO > airway centric pattern
- Pattern may be accentuated in infections with novel adenovirus strains
  - Adenovirus-14 outbreak aka “Bootcamp Flu”
  - Lobar pneumonia > bronchiolitis/bronchitis pattern

H1N1 Influenza – Normal Hosts
- >50% of circulating influenza Jan 2014
- Bronchopneumonia most common
- Bronchiolitis/bronchitis in mild cases in normal hosts and in immunocompromised patients
- COP-like pattern

H1N1 Influenza – Normal Hosts
- Severe disease in normal patients may be caused by immune response
- High titers of non-protective antibody cause complement activation in middle aged pts.
  - Monsalvo, Nature Medicine 2011
Imaging Community
Acquired Pneumonia

- CT patterns useful identifying non-infectious diseases with similar appearance
- CT useful in identifying complications of community acquired
- Ability and necessity of diagnosing specific organism is limited
- Viral pneumonia is more prevalent and more diverse in imaging appearance than previously understood
  - Dependent on organism
  - Dependent on super-infection
  - Dependent on complexities of host-virus interactions

References


