Clinical Chest Radiography Interpretation

Part 1

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Historical Perspectives

Wilhelm Conrad Roentgen
Dutch Physicist
Discovered form of radiation roentgen ray
First diagnostic radiograph 1896
Roentgen
Won Nobel Prize for Physics 1901
Through the years........
Image Production

• Strahlung Ray (X-Ray) from cathode tube
• Attenuation of the ray
• Radiant energy – short wave – greater ability to penetrate objects
• Cassette
• Image
Radiolucent
Blackening of the film (-1000 HU)
Permits passage of rays, low absorbency

Radiopaque and Radiodense
Less blackening of the film
Doesn’t allow passage of rays, high absorbency (1000 HU)
Radiographic Densities

Gas (air)  
  Black  
Fat  
  Gray-Black  
Soft tissue (water)  
  Gray  
Bone (metal)  
  White
Radiographic Contrast
Image Quality

Motion
Scatter
Magnification
Thickness
Distortion
The Basics

Foundational Concepts

Anatomy and Physiology
Pathophysiology
Shades of Gray

2 dimensional image of 3 dimensional body
Plain Radiographs

Air – Fluid Levels

Visualize stones

Identify gross abnormalities that may lead to further testing

Foreign body identification
Diagnosis or Finding

Right Middle Lobe Infiltrate
Pneumonia
Radiopaque Foreign Body
Gangrene
THE RULES

Obtain a thorough history and physical examination
Order when necessary
Evaluate the entire radiograph
Re-examine the patient and the radiograph
Rule of 2s
Failsafe measures
Ionizing Radiation

High energy ionizing radiation
   Atom loses electron – ionized
   Photon with >15 electron volts is capable of ionization

Radiation exposure has been researched since the atomic bomb exposure. However, it has been observed since the early 1900s

Increased use of plain radiographs, nuclear medicine and CT scans has increased population exposure rates

Interrupts cell DNA causing mutations
   Organs and tissues – varying sensitivities
Three measures to describe radiation dose

**Absorbed**
- Amount of energy absorbed/unit mass

**Effective**
- All irradiated tissue and organ risk of exposure

**Organ**
- Organ risk of exposure
X-Ray Equivalent

**Chest X-ray** = 3 days of background radiation

**C-spine** = 1.5 days of background radiation

**Pelvis** = 14 days of background radiation

**Abdomen** = 16 days of background radiation

**Thoracic spine** = 24 days of background radiation

**Lumbar spine** = 60 days of background radiation
Effective Radiation Dose (millisievert - mSv)

Plain Radiographs
  0.02 mSv Chest X-Ray

CT scan
  2.0 mSv Head
  20-60 mSv Chest, Abdomen and Pelvis

Nuclear Medicine
  10-25 mSv (sestamibi scan – dual isotope scanning)
Ionizing Radiation Medical Imaging

Radiation Dose

Classified as carcinogenic
Patients get multiple tests
Statistically significant increases in cancer with doses over 50mSv
Chest Anatomy

- Superior vena cava
- Arch of aorta
- Pulmonary artery
- Auricle of left atrium
- Descending aorta
- Left pulmonary artery
- Right pulmonary artery
- Descending aorta
- Left diaphragm
- Right diaphragm

http://www.medcyclopaedia.com/upload/book%20of%20radiology/chapter18/nic_k18_915.jpg
Positioning

Posterior Anterior (PA)
  Facing the cartridge
Supine Anterior Posterior (AP)
  Only in the critical patient
Lateral Position
Lateral Decubitus
Normal PA and Lateral
PA vs AP

- Lung markings more distinct
- Heart is smaller
- Clavicles are superimposed over upper lungs
- Cervical and thoracic vertebrae more clearly visible

- Heart appears larger than normal
- Lung volumes are shallow
- Clavicles usually higher
Lateral Decubitus Position

Assess volume, mobility or loculation of pleural effusion

Dependent lung should have increased density d/t atelectasis from mediastinal pressure

Airtrapping if not present
ABC’s of Interpretation

Adequacy, Airway
Breathing
Circulation
Diaphragm
Edges
Skeleton, Soft Tissue
Interpretation

Trachea
midline or deviated, caliber, mass

Lungs
abnormal shadowing or lucency

Pulmonary vessels
artery or vein enlargement

Hila
masses, lymphadenopathy

Heart
thorax: heart width > 2:1? Cardiac configuration?

Mediastinal contour
width? mass?

Pleura
effusion, thickening, calcification

Bones
lesions or fractures

Soft tissues
don’t miss a mastectomy

ICU Films
identify tubes first and look for pneumothorax
Adequacy

Normal Inspiration

Penetration

Rotation
Normal Inspiration

Diaphragm at the level of the 8-10\textsuperscript{th} posterior rib or 5-6\textsuperscript{th} anterior rib
Poor Inspiration
Expiration

Desirable to evaluate a patient with:
Suspected pneumothorax
Suspected foreign body in bronchus
Foreign Body

A – Normal Full Inspiration
There is no volume change on the left

B –Expiration mediastinum and heart shift to the right
Obstruction left main stem bronchus

Daffner & Hartman 2014
Pneumothorax

A – Normal Inspiration
Left Pneumothorax

B – Expiration
Enlargement of left pneumothorax

Daffner & Hartman 2014
Penetration

**PA**
Thoracic disc spaces should be barely visible through the heart with vertebral bodies not visible
Over-penetration = Dark
Under-penetration = Light

**Lateral**
Should see 2 sets of ribs
Sternal edge may be visible
Vertebrae appear darker as you move caudally
Over and Penetrated Penetration
Rotation

• May result in distortion of normal anatomic structures

• Clavicle heads and spinal processes should be symmetrical
Airway

Trachea midline and seen to the carina (bifurcation T4-T5)
  Slowly angles downward to the thoracic inlet (retrotracheal line 3mm)
Bronchogram
  may be normal or abnormal
Air filled tube surrounded by soft tissue
The Rest of the A, B, Cs

B: Breathing (Bird cages)
C: Cardiac/circulation
D: Diaphragm
E: Edges
S: Skeleton and Soft Tissue
What do you see???
Okay now for the Lateral
Mediastinum

Central chest between lungs and heart

Divided into three regions

**Anterior** – area between sternum and front of heart and great vessels

**Middle** – area between anterior and posterior pericardium

*Includes: pericardium, heart, aortic arch, proximal brachialcephalic vessels, pulmonary veins/arteries, trachea, main bronchus, and lymph nodes*

**Posterior** – area behind the heart and trachea including vertebral bodies
Mediastinum
Pediatric Considerations

- Can be challenging
- Look different in children
- Different diseases
- Change with age
- Limited patient cooperation
- Thymus can cause confusion
Adult vs Child
Differences

Heart
Newborn hearts can be more than ½ the width of the chest
Good inspiration needed to judge heart size
Poor inspiration can significantly change the look and position of the heart

Thymus
Increases in size from birth through puberty *BUT* child grows so it appears smaller with age
Can be variable in size and appearance (i.e. shrink rapidly due to illness or grow due to chemotherapy)
Look for a Bronchogram

Outline of airway that is made visible by surrounding alveoli with fluid or exudate

When visualized diagnostic for air space disease

6 causes
- normal expiration
- lung consolidation
- pulmonary edema
- Non-obstructive pulmonary atelectasis
- severe interstitial disease
- Neoplasm
Atelectasis

Condition of volume loss in some portion of lung
May involve sub-segment, segment, lobe or entire lung
Increased density usually linear
Collapse or incomplete expansion of the lung or part of the lung
Segmental and sub-segmental collapse may show linear, curvilinear, wedge shaped opacities
Atelectasis

Causes

**Obstructive**
- Most common
- Bronchus obstructed by mucous plug, neoplasm, or foreign body

**Compressive**
- Normal lung compressed by tumor, emphysematous bulla or heart enlargement

**Cicatrization**
- Organizing scar tissue
- Most often after healing granulomatous disease (i.e. TB), pulmonary infarct or trauma

**Adhesive**
- Inactivation of surfactant (example: hyaline membrane disease)

**Passive**
- Normal compliance of the lung with pneumothorax or pleural effusion
- Airway remains patent
Linear Atelectasis

- Plate-like
- Partial collapse
- Dense line
  - 1 or more lobes
Pulmonary Edema

Two basic types

Cardiogenic

*increased hydrostatic pulmonary capillary pressure*

Non-cardiogenic

*altered capillary membrane permeability or decreased plasma oncotic pressure*

NOT CARDIAC (Pneumonic)

Near-drowning, Oxygen therapy, Transfusion or Trauma, CNS disorder, ARDS, Aspiration, or Altitude sickness, Renal disorder or Resuscitation, Drugs, Inhaled toxins, Allergic Alveolitis, Contrast or Contusion
Cardiogenic

Cephalization of the pulmonary vessels
Kerley A lines
  thin linear opacities in mid and upper zones radiating to hila
Kerley B lines
  linear opacities 1-2cm long and 1-2mm thick perpendicular to pleural surface
  caused by intersitial fluid (septal lines)
Peribronchial cuffing
"bat wing" pattern
  perihilar and medullary consolidation of both lungs
Patchy shadowing with air bronchograms
Heart enlargement
Pleural effusions
Pulmonary Edema
Cephalization of Vessels
Bat Wing Pattern
Pulmonary Edema
Diffuse Pulmonary Edema
Congestive Heart Failure
Pleural Effusion

Causes

- CHF
- Infection (parapneumonic)
- Trauma
- PE
- Tumor
- Autoimmune disease
- Renal failure
88 year old Female

Presents with complaints of shortness of breath

PMH – arthritis, hypercholesterolemia, HTN, CAD, pulmonary HTN,

PSH – CABG, Cataracts, Aortic Valve Repair

Allergy – codeine, PCN

PE – lungs decreased with bibasilar crackles

Vital signs – BP 146/85, HR 85, RR 16, T 97F, pulse Ox 95%

RA
Erect done in wheelchair
78 year old Male

Presents with shortness of breath for 1 day progressively getting worse.

PMH – CAD, HTN, Hypercholesterolemia

PSH – CABG, pacemaker or AICD patient and family not sure

Allergies – none

PE – pale, diaphoretic, in mild respiratory distress. Mild JVD. Lungs with course diffuse rhonchi. S1 S2 no M/G/C

Vital signs – BP148/90, HR 102, RR 28, T 97.9F pulse Ox 94% RA
52 Year Old Male

Complaints of not feeling well, chest tightness, and racing heart. Denied SOB or fever
PMH – alcohol abuse, depression
PSH – none
Allergies – none
Social – alcohol use daily 1 bottle of scotch; tobacco 1-2 PPD
PE – unremarkable
Vital signs – BP 154/103, HR 138, RR 27, T 100.8, pulse Ox 97% RA
Chest X-Ray BASICS AND BEYOND

Part 2

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3 year old female

Fever 102F, sinus congestion and drainage, cough
PMH/PSH negative
Medications – None
Allergy – whole milk
PE – erythema to pharynx,
Vital signs – HR 126; RR 24; T 102.8F, pulse Ox 98% RA
<table>
<thead>
<tr>
<th>Types of Pneumonia</th>
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| **Lobar**                   | • Classically Pneumococcal pneumonia  
• Entire lobe consolidated  
• Air bronchogram            |
| **Lobular**                 | • Often Staphylococcus  
• Multifocal, patchy, sometimes  
• No air bronchogram         |
| **Interstitial**            | • Viral or Mycoplasma  
• Latter starts perihilar and can become confluent and/or patchy as disease progresses  
• No air bronchogram         |
| **Aspiration Pneumonia**    | • Follows gravitational flow of aspirated contents  
• Anaerobic  
  Bacteroides  
  Fusobacterium              |
| **Diffuse Infection**       | • Community acquired  
• Mycoplasma  
  • resolves spontaneously nosocomial  
• Pseudomonas  
  • high mortality rate  
  • patchy opacities, cavitation, ill-defined nodular  
  • immunocompromised host  
• Bacterial, fungal, PCP     |
32 Year Old Male

Aortic Valve Replacement Post-op 5 days
Chest tube removed
C/O mild SOB
Pneumomediastinum

Streaky lucencies over the mediastinum that may extend into the neck, and elevation of the parietal pleura along the mediastinal borders

Causes

- Asthma
- Surgery
- Traumatic tracheobronchial rupture
- Abrupt changes in intrathoracic pressure (vomiting, coughing, exercise, parturition)
- Ruptured esophagus
- Barotrauma
- Smoking crack cocaine
Pneumothorax

**Causes**
- Idiopathic
- Asthma
- COPD
- Pulmonary infection
- Neoplasm
- Marfan syndrome
- Smoking cocaine
- Trauma
- Provider
Pneumothorax
Traumatic Injuries
Thoughts??
Sternum Fracture
Radiographic Findings

“Pruned” vascularity – *most reliable sign*
Decreased vascularity

Hyperlucency

Increased retrosternal clear space

Increased lung volume

Depression/flattening Diaphragmatic curve

\[\downarrow\] Diaphragmatic excursion

Prominent central pulmonary artery with rapid tapering
49 year old female

Arrived to ED via ambulance – swallowed foreign body. Attempted to vomit at home but unsuccessful.

PMH – hypertension takes no medications

No complaints offered but afraid could cause harm

PE – unremarkable

Vital signs – BP 156/96; HR 85, RR 18, T 96.7F, pulse Ox 98% RA
Masses and Tumors

Lung and Mediastinal masses are common
Solitary pulmonary nodules
Tumors
Granulomas
**Common and Uncommon Solitary Pulmonary Nodules**

<table>
<thead>
<tr>
<th>Common</th>
<th>Uncommon</th>
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<tbody>
<tr>
<td>Bronchial adenoma</td>
<td>Abscess</td>
</tr>
<tr>
<td>Primary carcinoma</td>
<td>Hematoma</td>
</tr>
<tr>
<td>Granuloma (fungus, TB)</td>
<td>Infarct</td>
</tr>
<tr>
<td>Hematoma</td>
<td>Loculated pleural fluid</td>
</tr>
<tr>
<td>Metastases</td>
<td>Vascular lesion</td>
</tr>
<tr>
<td>Simulated nodule (nipple,</td>
<td></td>
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<tr>
<td>bone lesion, skin tumor, etc)</td>
<td></td>
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</tbody>
</table>
Cavitary Masses

Pulmonary nodules which may cavitate

Most Common
Carcinoma
Necrotizing infections (abscesses)
Metastatic lesions (usually squamous cell)

Others Causes
Fungal or TB infection
Hematoma
Pneumatoceles
Cavitary Masses

Wall Thickness
>15 mm more likely to be malignant
<4 mm more likely to be benign
Not specific enough further testing needs to be done (i.e. biopsy)
Evaluating Pulmonary Nodules

Need to find the epicenter of the pulmonary mass (nodule)  
*Allows for identification of where the mass began (i.e. lung, mediastinum, pleura, chest wall)*

Spiculated margins

Lesions doubling in diameter actually increase 8-fold in volume

Utilize old studies

- Chest radiograph
- CT
- MRI
- PET imaging
Spiculated Margins
Mediastinal Masses

Can be difficult to differentiate from pulmonary parenchymal masses

Majority of primary mediastinal masses
  Occur anterior compartment
  1/3 middle compartment
  Remainder posterior compartment

Majority show extrapulmonary signs
  Obtuse margins with pleura
  Centered outside the lung
Mediastinal Masses

Anterior compartment
  Lymphoma, thymomas, teratomas – most common
  Hernias and cysts – other abnormalities

Middle mediastinum
  Lymph nodes, metastatic disease, sarcoidosis, infection/inflammation

Behind the heart
  Hiatal/paraesophageal hernia

Posterior compartment
  Neurogenic tumor (paraspinous mass)
Teratoma

Anterior Compartment
Sarcoidosis
Lymphoma
Hiatelic Hernia

- Air/fluid levels
- Posterior to heart
Tuberculosis

**Primary**

*Healthy individuals* – may have no chest x-ray findings even with a positive PPD

Inflammatory response

“Primary inflammatory complex” or “Ranke complex” – calcified nodules and thoracic lymph nodes

*Not reliable sign (i.e. fungal infections, histoplasmosis)*

**Immunocompromised/chronically ill**

Nonspecific consolidation

Cavity nodule/mass with air/fluid levels – **ominous sign for transmissible disease**

Small miliary nodules

Necrotizing adenopathy

Pleural effusions
Tuberculosis

**Secondary**
Reactivation of dormant infection
Infection thrives on oxygen
  Particularly upper lobes
Consolidation with or without cavitation and adenopathy

**End Stage**
Fibrosis
Scarring with volume loss
Shift of fissures and/or vessels
Calcification
Tuberculosis

Pediatrics
Commonly present with thoracic and neck lymphadenopathy

Disseminated
Can occur anywhere in the body
Primary Inflammatory Complex
Ranke Complex
Tuberculosis

Cavitary abscess
Miliary Tuberculosis
Chronic/Old Tuberculosis
Thank you!!

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References

