INTRODUCTION TO THE FUNDAMENTALS OF CHEST RADIOGRAPH INTERPRETATION

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Objectives

- Chest Radiograph technique
- Optimal imaging and limitations
- Chest anatomy
- Proper read technique
- Abnormal Pathology
- The Bizarre and Obscure films
- Review
Safety First

Marie Curie died of aplastic anemia due to radiation exposure. To this day her 1890 transcripts are too radioactive to handle.

Always “Lead Up” if in the room.

Rule of Thumb is for low dose (CXR) you can be 6 feet from the radiation source without an apron.

Use special caution if pregnant.
A PA film is shot with patient chest against film cartridge.

It is the standard position for chest radiograph.
Anterior-Posterior

An AP film is shot with the patient’s back against the film cartridge.

It is reserved for patients who cannot stand erect.

This is the same chest as the previous slide. Note that it appears abnormal with magnification of heart and widening of mediastinum,
Adequate Inspiration

The patient should be examined in full inspiration.

This greatly helps the radiologist to determine if there are intrapulmonary abnormalities.

The diaphragm should be found at about the level of the 8th - 10th posterior rib or 5th - 6th anterior rib on good inspiration.
Inadequate Inspiration

A patient can appear to have a very abnormal chest if the film is taken during expiration.

Look at the case to the left - on the first film, the loss of the right heart border silhouette would lead you to the diagnosis of a possible pneumonia.

However, the patient had taken a poor inspiration.

On repeat exam with improved inspiration, the right heart border is normal.
Adequate penetration of the patient by radiation is also required for a good film. On a good PA film, the thoracic spine disc spaces should be barely visible through the heart but bony details of the spine are not usually seen. On the other hand penetration is sufficient that bronchovascular structures can usually be seen through the heart.
Rotation

The technologists are usually very careful to x-ray the patient flat against the cassette.

If there is rotation of the patient, the mediastinum may look very unusual.

One can assess patient rotation by observing the clavicular heads and determining whether they are equal distance from the spinous process of the thoracic vertebral bodies.
In this rotated film skin folds can be mistaken for a tension pneumothorax. Notice the skewed positioning of the heads of the clavicles and the spinous processes.
Chest Anatomy

You need to know both the structures within the mediastinum forming the mediastinal margins and the lobes of the lungs forming the margins of the lungs along the mediastinum and chest wall.

If a mass or pneumonia "silhouettes" (obscures) a part of the lung/mediastinal margin, you should be able to identify what part of the lung and what organ within the mediastinum are involved.

The margins of the mediastinum are made up of the structures shown below. Trace the margin of the mediastinum with your eye all the way around the margin. Think of the mediastinal structures that comprise this interface. If the margin were abnormal you could diagnose the cause.
This image indicates the locations of each lung margin on chest x-ray.
Anatomy - Airways and Vasculature

You should absolutely know the anatomy of the bronchi.

Look at the drawing and compare it to the chest x-ray below that has superimposed the airways and vasculature.

Just having an idea of where to find anatomical landmarks goes a long way in determining what it may be you are seeing.
The basic diagnostic instance is to detect an abnormality. In both of the cases above, there is an abnormal opacity. It is most useful to state the diagnostic findings as specifically as possible, then try to put these together and construct a useful differential diagnosis using the clinical information to order it.

In each of the cases above, there is an abnormal opacity in the left upper lobe. In the case on the left, the opacity would best be described as a mass because it is well-defined. The case on the right has an opacity that is poorly defined. This is airspace disease such as pneumonia.
How To Read A CXR - Tips

- Turn off stray lights, optimize room lighting, view images in order
- Routine Technique: AP/PA, exposure, rotation, supine or erect
- 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
How To Read A CXR - Comparing

When available, always compare the previous film with the most current so that you can visualize changes.
How To Read A CXR - Looking

It is best to do a directed search of the chest film rather than simply gazing at the film. An abnormality will not likely hit you over the head.

Remember that detail vision is only permitted at the fovea centralis of your retina. This area contains only cones and is the part that you use to read. The remainder of the retina helps you to put this detailed portion in context and helps to determine whether this is a saber tooth tiger sneaking up on you.

Therefore, it is best to look for abnormalities and to have a planned search in mind. Your eye gaze should scan all portions of the film, follow lung/mediastinal interfaces and look again carefully in areas where you know that mistakes are easily made, such as over the spine on the lateral view and in the apex on the PA view.
How To Read A CXR - Looking

You have to focus carefully. Start with the boundaries of the lungs tracing around both lungs. It is here you may find pleural based problems. Then scan across each lung from top to bottom looking for abnormalities.
Don’t Be Overwhelmed by the Obvious!
Silhouette Sign

One of the most useful signs in chest radiology is the silhouette sign. The silhouette sign is in essence elimination of the silhouette or loss of lung/soft tissue interface caused by a mass or fluid in the normally air filled lung.

The right heart border is silhouetted out. This is caused by a pneumonia, can you determine which lobe the pneumonia affects?
Atelectasis

Atelectasis is almost always associated with a linear increased density on chest x-ray. The apex tends to be at the hilum. The density is associated with volume loss.

Some indirect signs of volume loss include vascular crowding or fissural, tracheal, or mediastinal shift, towards the collapse.

There may be compensatory hyperinflation of adjacent lobes, or hilar elevation (upper lobe collapse) or depression (lower lobe collapse).

Note the loss of the right heart border silhouette due to partial atelectasis of the RML.

Atelectasis is usually, but not always, a benign finding as in this example which was caused by an endobronchial mass in the RML.
Right middle lobe atelectasis may cause minimal changes on the frontal chest film. A loss of definition of the right heart border is the key finding.

Right middle lobe collapse is usually more easily seen in the lateral view. The horizontal and lower portion of the major fissures start to approximate with increasing opacity leading to a wedge of opacity pointing to the hilum.

Like other cases of atelectasis, this collapse may by confused with right middle lobe pneumonia.
Right Upper Lobe Atelectasis

Right upper lobe atelectasis is easily detected as the lobe migrates superiomedially toward the apex and mediastinum. The minor fissure elevates and the inferior border of the collapsed lobe is a well demarcated curvilinear border arcing from the hilum towards the apex with inferior concavity.
Silhouetting of the right hemidiaphragm and a triangular density posteromedi-ally are common signs of right lower lobe atelectasis. Right lower lobe atelectasis can be distinguished from right middle lobe atelectasis by the persistence of the right heart border.
Luftsichel Sign

The **Luftsichel sign** is seen in some cases of left upper lobe collapse and refers to the frontal chest radiographic appearance due to hyperinflation of the superior segment of the left lower lobe interposing itself between the mediastinum and the collapsed left upper lobe.

In many cases of left upper lobe collapse the anterior parts of the aortic arch, and thus the aortic knuckle, are abutted by collapsed lung and thus the normal silhouette is lost.

In some cases the apical (superior) segment of the left lower lobe is hyperinflated and becomes interposed between the collapsed lung and the adjacent aortic arch. In such cases the aortic knuckle silhouette remains visible. The collapsed left upper lobe is thus displaced laterally away from the mediastinum.
Left Upper Lobe Atelectasis

The left lung lacks a middle lobe and therefore a minor fissure, so left upper lobe atelectasis presents a different picture from that of the right upper lobe collapse.

The result is predominantly anterior shift of the upper lobe in left upper lobe collapse, with loss of the left upper cardiac border.

The expanded lower lobe will migrate to a location both superior and posterior to the upper lobe in order to occupy the vacated space. As the lower lobe expands, the lower lobe artery shifts superiorly. The left mainstem bronchus also rotates to a nearly horizontal position.
Left Lower Lobe Atelectasis

Atelectasis of either the right or left lower lobe presents a similar appearance. Silhouetting of the corresponding hemidiaphragm, crowding of vessels, and air bronchograms are sometimes seen, and silhouetting of descending aorta is seen on the left.

These radiographs demonstrate left lower lobe atelectasis followed by partial resolution, respectively.
Left Lower Lobe Atelectasis

Another PA film of LLL atelectasis (arrows). Note the elevation of the left hemidiaphragm.
Pulmonary Edema

There are two basic types of pulmonary edema. One is cardiogenic edema caused by increased hydrostatic pulmonary capillary pressure. The other is termed noncardiogenic pulmonary edema, and is caused by either altered capillary membrane permeability or decreased plasma oncotic pressure.
Pulmonary Edema

On a CXR, cardiogenic pulmonary edema can show; cephalization of the pulmonary vessels, Kerley B lines or septal lines, peribronchial cuffing, "bat wing" pattern, patchy shadowing with air bronchograms, and increased cardiac size.

Unilateral, miliary and lobar or lower zone edema are considered atypical patterns of cardiac pulmonary edema. A unilateral pattern may be caused by lying preferentially on one side.

Unusual patterns of edema may be found in patients with COPD who have predominant upper lobe emphysema.
**Cardiothoracic Ratio**

*Cardiothoracic ratio (CTR)*

Cardiac size is measured by dropping parallel lines down both sides of the heart, at the most lateral points on each side, and measuring between them. Thoracic width is measured by dropping parallel lines down the inner aspect of the widest points of the rib cage, and measuring between these. The cardio-thoracic ratio can then be stated.

Here the CTR is approximately 15:33 (arbitrary units) and is therefore within the normal limit (expressed as a percentage) of 50%.

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**Key points**

- The heart size is assessed as the cardiothoracic ratio (CTR)
- A CTR of >50% is abnormal - PA view only
- The left hemidiaphragm should be visible behind the heart
- The hemidiaphragm contours do not represent the lowest part of the lungs
Cardiogenic Pulmonary Edema
What will the lung do when the heart encroaches? It's space?
Non-Cardiogenic Pulmonary Edema
Kerley B-Lines

These are horizontal lines less than 2cm long, commonly found in the lower zone periphery. These lines are the thickened, edematous interlobular septa. Causes of Kerley B lines include: pulmonary edema, lymphangitis carcinomatosa and malignant lymphoma, viral and mycoplasmal pneumonia, interstitial pulmonary fibrosis, pneumoconiosis, sarcoidosis. They can be an evanescent sign on the CXR of a patient in and out of heart failure.
Pneumonia is airspace disease and consolidation. The air spaces are filled with bacteria or other microorganisms and pus. Other causes of airspace filling not distinguishable radiographically would be fluid (inflammatory), cells (cancer), protein (alveolar proteinosis) and blood (pulmonary hemorrhage), Pneumonia is NOT associated with volume loss. Pneumonia is caused by bacteria, viruses, mycoplasmae and fungi.
Pneumonia vs Mass vs Atelectasis

The x-ray findings of pneumonia are airspace opacity, lobar consolidation, or interstitial opacities. There is usually considerable overlap. Again, pneumonias is a space occupying lesion without volume loss. What differentiates it from a mass? Masses are generally more well-defined. Pneumonia may have an associated parapneumonic effusion.

<table>
<thead>
<tr>
<th>Atelectasis</th>
<th>Pneumonia</th>
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</thead>
<tbody>
<tr>
<td>Volume Loss</td>
<td>Normal or Increased Volume</td>
</tr>
<tr>
<td>Associated Ipsilateral Shift</td>
<td>No Shift, or if Present Then Contralateral</td>
</tr>
<tr>
<td>Linear, Wedge-Shaped</td>
<td>Consolidation, Air Space Process</td>
</tr>
<tr>
<td>Apex at Hilum</td>
<td>Not Centered at Hilum</td>
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Air bronchograms can occur in both.
Air Bronchograms

An **air bronchogram** is an air-filled bronchus against surrounding opacified alveoli. It is indicative of an airspace process, and will not be seen when a bronchus is filled with fluid or when the opacification of the alveoli is due to obstruction.
Pulmonary Emboli

The primary purpose of a chest film in suspected PE is to rule out other diagnoses as a cause of dyspnea or hypoxia.

Most CXRs in patients with a PE are normal.

Signs that may be present in PE are; Westermark's sign (oligemia in area of involvement), increased size of a hilum (caused by thrombus impaction), atelectasis with elevation of hemidiaphragm and linear or disk shaped densities, pleural effusion, consolidation, and Hampton's hump (rounded opacity).

In the case of pulmonary infarctions, the main radiographic feature is multifocal consolidation at the pleural base in the lower lungs.
The Westermark sign is dilation of the pulmonary arteries proximal to the embolus.

Only seen in 2% of patients with pulmonary emboli and has a low sensitivity for diagnosis (11%).
Hampton's hump refers to an dome-shaped, pleurally-based opacification in the lung due to pulmonary embolism and lung infarction.

This characteristic appearance is seen because the infarcted pulmonary arteries cause a wedge-shaped infarction but because the bronchial arterial circulation is preserved, the expected apex of the wedge is spared causing a rounded opacification rather than a wedge.
When you have a hypoxic patient and the chest radiograph fails to explain why!
Pleural Effusion

Common causes for a pleural effusion are CHF, infection (parapneumonic), trauma, PE, tumor, autoimmune disease, and renal failure.

On an upright film, an effusion will cause blunting on the lateral and if large enough, the posterior costophrenic sulci. Sometimes a depression of the involved diaphragm will occur. A large effusion can lead to a mediastinal shift away from the effusion and opacify the hemothorax.
Approximately 200 ml of fluid are needed to detect an effusion in the frontal film vs. approximately 75ml for the lateral.

Larger effusions, especially if unilateral, are more likely to be caused by malignancy than smaller ones.
Examine the Soft Tissue!!

This case shows the importance of examining the soft tissues carefully. At first, it may appear that the asymmetry in density between the two hemithoraces is caused by a left pleural effusion, giving the appearance of a graded density. A closer look reveals that the asymmetry is due to the removal of the left breast.
A pneumothorax is defined as air inside the thoracic cavity but outside the lung. A tension pneumothorax is a type of pneumothorax in which air enters the pleural cavity and is trapped during expiration usually by some type of ball valve-like mechanism. This leads to a buildup of air increasing intrathoracic pressure. Eventually the pressure buildup is large enough to collapse the lung and shift the mediastinum away from the tension pneumothorax. If it continues, it can compromise venous filling of the heart and even
A spontaneous pneumothorax (PTX) is one that occurs without an obvious inciting incident. Some causes of spontaneous PTX are: idiopathic, asthma, COPD, pulmonary infection, neoplasm, Marfan's syndrome, and smoking cocaine. However, most pneumothoraces are iatrogenic and caused by a physician during surgery or central line placement.
On CXR, pneumothorax appears as air without lung markings in the least dependant part of the chest. Generally, the air is found peripheral to the white line of the pleura. In an upright film this is most likely seen in the apices.

A pneumothorax is best demonstrated by an expiration film. It can be difficult to see when the patient is in a supine position. In this position, air rises to the medial aspect of the lung and may be seen as a lucency along the mediastinum. It may also collect in the inferior sulci causing a deep sulcus sign.
Hydropneumothorax

A hydropneumothorax is both air and fluid in the pleural space. It is characterized by an air-fluid level on an upright or decubitus film in a patient with a pneumothorax.

Some causes of a hydropneumothorax are trauma, thoracentesis, surgery, ruptured esophagus, and empyema.
Clinically the patient with IPF will present with progressive exertional dyspnea and a nonproductive cough. Radiographically, IPF is associated with hazy "ground glass" opacification early and volume loss with linear opacities bilaterally, and honeycomb lung in the late stages.

Interstitial pulmonary fibrosis has many causes. The six most common causes of diffuse interstitial pulmonary fibrosis are idiopathic (IPF, >50% of cases), collagen vascular disease, cytotoxic agents and nitrofurantoin, pneumoconioses, radiation, and sarcoidosis.
Look Familiar??

Note bilateral flattening of the diaphragms and significant hyperinflation as demonstrated by visualization of 11 posterior ribs.
Note how the heart appears to have been stretched and thinned. In actuality, the heart has been turned on its vertical axis by hyperinflation, making it appear that way.
A reengineered coronal plane CT view of bullous emphysema
Follow the Arrows
The resulting kinetic energy transfer of traumatic rib fractures is injurious to the lung as in this case that shows pulmonary contusion. Notice anything else???
What do you think??
Diaphragmatic Hernia
Anatomically where is the foreign object?  
What makes you say that?
How About This One??
What Do You Think?
Surgical Repair of Penetrating Cardiac Injury

Source: http://www.trauma.org
Chest X-ray in scleroderma showing thoraco-lumbar scoliosis, marked rib crowding, chest wall deformity and bilateral interstitial shadowing.
Let’s Review What We Have Learned.
Any Questions??