



Chest Radiography: A Systematic Approach to Interpretation

The emergency physician is confronted with difficult chest radiographs at all hours of the day and night, when radiology consultants may not be available. Emergency physicians are nevertheless held to the highest standards of interpretation. The proper reading of a chest radiograph requires a systematic approach. This lecture will introduce such an approach and present a series of challenging radiographs for interpretation and discussion.

- Explain how to read a chest radiograph in a systematic way.
- List the areas and diagnoses that are most easily missed.
- Correctly interpret a group of chest radiographs.

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“Is it an Infiltrate ?” Emergency Chest Radiology

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I. DEFINITIONS

Infiltrate: This is a pathological term that connotes infiltration of the lung (airspaces or interstitium) with abnormal cellular material (inflammatory or neoplastic cells). Radiographically, “infiltrate” is often applied to any ill-defined intrapulmonary opacity. (Well-defined opacities, i.e. those with sharp borders, are referred to as masses or nodules.) However, not all radiographic “infiltrates” correspond to infiltrates in the pathological sense. Therefore, “infiltrate” does not always accurately describe the lesion and “terminology purists” avoid this term.

Edema accumulation in the airspaces can look radiographically like a pneumonic infiltrate but, because it represents fluid accumulation rather than cellular infiltration, pulmonary edema should not be called an “infiltrate.” Some “infiltrates” are due to destruction and fibrosis of lung tissue and do not represent infiltrates at all. Finally, in many diseases in which there is infiltration of the lung interstitial tissues, there is also accumulation of fluid or cellular material within the airspaces, and so these interstitial pathological processes appear radiographically as airspace filling.

Opacity: This is a proper radiographic term that describes the appearance of a lesion (increased radiographic density) without having pathological connotations.

Consolidation: The air spaces of the lung are replaced by cellular material, rendering it a uniform fluid density. Radiographically, it appears as a homogeneous opacity (aside from possible air bronchograms) with little or no loss of volume.

II. HOW TO READ A CHEST X-RAY

Initial quick review

Scan the film for obvious findings or clinically expected abnormalities.

Systematic Analysis

Label: name, date, right/left

Adequacy:

Penetration -- vertebral bodies just visible through the heart shadow.

Rotation -- center point between the medial clavicular heads should align with the spinous processes. Do not use the trachea to assess rotation because it is mobile.

Inspiration -- posterior right 10th or 11th rib visible at the right cardio-phrenic sulcus.

Bones: Chest wall and shoulders (and associated soft tissues), vertebral column

Soft tissues: Heart, mediastinum (and trachea), hila, diaphragm

Lungs: Use left/right symmetry. Compare density and lung markings for each interspace - left to right. Examine the lung periphery for pneumothorax or septal lines.

or

Central zone: Heart, mediastinum, trachea, hila, vertebral column

Middle zone: Lungs

Periphery: Bones and soft tissues of the chest wall and shoulders

The systematic analysis must be moderated by knowledge of various radiographic patterns and the radiographic manifestations of disease processes.

Pattern Recognition Approach

Radiographic abnormalities are grouped into various patterns. A list of diagnostic possibilities is generated by identifying a particular radiographic pattern. Patterns are divided into those with increased and decreased pulmonary radiodensity, as well as

cardiovascular abnormalities. Familiarity with these radiographic patterns is acquired by studying large numbers of radiographs.

Diagnosis Based Approach

This is based on knowledge of the radiographic appearance of various diseases. It is useful to the clinician who suspects one or more diagnoses based on the history and physical examination. In addition, the clinician must know the sensitivity and specificity of plain radiography for each disorder, i.e., to what extent the radiograph can confirm or exclude a particular diagnosis.

THE LATERAL FILM

Useful to **confirm** and localize:

- Intrapulmonary opacities (e.g., pneumonia)
- Hilar abnormalities (adenopathy, masses, increased **vascularity**)
- Cardiomegaly, heart chamber enlargement and **aortic** abnormalities
- Small pleural **effusions**
- Pulmonary edema -- thickened interlobar fissures

The retrosternal and retrocardiac regions are better seen on the lateral than on the PA film.

Systematic Approach to reading the lateral film

- Adequacy -- rotation, **penetration**, inspiration
- Bones -- vertebral bodies, **ribs**, sternum and scapulae
- Soft** tissues -- **heart, aorta**, hilum, trachea, diaphragm (**left** and right sides)
- Lungs -- fissures and lung markings. Review from front to back:
 - retrosternal area, overlying the heart, retrocardiac area, adjacent to the diaphragm, and overlying the vertebral bodies (vertebral bodies normally appear more radiolucent moving from T-1 to T-12 because there is less overlying **soft** tissue and more overlying lung tissue).

THE AP PORTABLE FILM -- supine or upright position.

Only one view of the **thorax is** obtained; there is no lateral view to confirm or localize abnormalities seen on the frontal view. The “silhouette sign” is especially useful to identify pulmonary opacities that lie adjacent to the heart, the diaphragm and aorta (descending aorta and arch).

Distortions that are seen on the AP portable film include:

- Cardiac enlargement
- Widening of the mediastinum
- Rotation of the patient (apparent shift of trachea and mediastinum)
- Poor inspiration (crowded lung markings at the bases and horizontal heart)
- Suboptimal exposure (over or under penetrated)
- Slower exposure times causes blurring due to patient movement
- Lower energy x-rays increases the radiographic density of overlying bones

Overlying extrathoracic objects are common -- clothing, spine immobilization boards, tubes, monitoring wires and clips, etc.

Pneumothorax and pleural **effusions** are difficult to see on supine or even upright portable films.

Upright AP **films** rather **than** supine films should be obtained whenever possible because there is less mediastinal distortion and the patient will be able to take a more complete inspiration.

III. PULMONARY CHEST RADIOLOGY-PATTERN RECOGNITION

pathological **processes** can either increase or decrease the radiographic density **of the** lung (or cause no change in radiographic density). Correctly interpreting these changes is the basis of the radiographic diagnosis of chest disorders.

Increased Opacity -- The **first** task is to localize the lesion, i.e., confirm that it is intrapulmonary and not pleural, chest wall (skin folds, breast tissue, nipples, pectoralis muscles) or **extra-thoracic** (clothing or bedsheets).

Intrapulmonary localization is confirmed by **Silhouette Signs** of airspace filling.

Obliteration **of the** interface between a fluid density (heart, diaphragm, aorta) and the air filled lung. The "silhouette sign" is actually a misnomer because there is loss of a normal radiographic silhouette. The silhouette sign is not entirely specific for intrapulmonary lesions because it also occurs with pleural **effusions** that obliterate the normal lung/diaphragm interface. The silhouette sign only occurs if the intrapulmonary opacity lies directly against the **heart, diaphragm** or aorta.

Air **bronchogram** -- an air-filled bronchus is rendered visible because it is surrounded by fluid filled lung.

Air **alveologram** -- some alveoli within a region of airspace **filling** remain aerated.. This causes the radiographic opacity to appear mottled, and inhomogeneous.

Obliteration of the normal lung vascular markings.

Patterns of Pulmonary Opacities -- The recognition of various patterns is the basis for formulating a differential diagnosis. There are several classification schemes.

Air-Space Filling

Localized = segmental (**lobar**)

Diffuse or Multifocal

Interstitial Patterns

Reticular -- (fine, coarse) and line shadows

Reticulo-nodular

Nodular-small (miliary), medium, large (masses > 3 cm.)

Atelectasis -- diminished aeration of the lung

Limitations of the Pattern Recognition Approach to Radiographic Diagnosis, i.e., using airspace filling and interstitial patterns to diagnose pulmonary disorders:

Poor correlation between radiographic pattern and pathologic entity.

Mixed patterns (airspace and interstitial) are common -- interstitial pneumonitis often has fluid or cellular accumulation within the airspaces.

Compound patterns are unreliable -- a histologically reticular pattern often seems to have radiographic **nodularity** even though nodules are not pathologically present. The **reticulonodular** pattern is common,

Airspace filling masks interstitial disease.

Superimposed acute illness on chronic disease distorts expected patterns. For example, pneumonia or pulmonary edema in a patient with emphysema will appear as a reticular pattern (fine or coarse-honeycomb)

Nodularity is not necessarily due to interstitial disease. Inhomogeneous airspace filling can appear nodular. Both fluid filling individual acini and aeration of acini within fluid-filled lung can appear nodular. In some schemes, the nodular pattern is not classified as interstitial but is given a separate category.

Many pulmonary disorders can present with various radiographic patterns. A given radiographic pattern is rarely diagnostic of a particular disease.

A. Segmental **Airspace Disease**

Pneumonia: bacterial, viral, mycoplasma, **TB**, etc.

Pulmonary embolism: infarction or **intrapulmonary** hemorrhage.

Neoplasm: post-obstructive, **bronchoalveolar** cell carcinoma, lymphoma (usually **diffuse**).

Atelectasis (segmental) -- opacity accompanied by signs of volume loss.

Fluid filled lung can appear homogeneously radiopaque or inhomogeneous (mottled) **if it** contains air filled alveoli, cavities or cysts.

Pseudo-infiltrates-don't mistake these for lung lesions:

Overlying soft tissue (breast, pectoralis muscle, chest wall lesions, clothing)

Skeletal lesions (vertebral body osteophytes, healed rib fractures)

Pleural effusion or fibrosis

Poor inspiration

B. Diffuse or **Multifocal Airspace Disease**

Pulmonary edema (CHF and **non-cardiogenic**)

Pneumonia: **bacterial, viral**, mycoplasma, PCP, etc.

Hemorrhage: trauma (contusion), immunologic (**Goodpasture's**), bleeding diathesis, **pulm.** emboli

Neoplasm: alveolar cell, lymphoma

DIP (Desquamative Interstitial Pneumonitis), alveolar proteinosis

Bat-wing pattern -- central opacity and peripheral clearing. Seen, with pulmonary edema (**CHF**, renal failure) and other **diffuse** airspace filling disorders (**PCP**, aspiration pneumonia, etc.)

C. Reticular Pattern and Line Shadows

Acute onset

Pulmonary edema

Infection: viral, Mycoplasma

Chronic

Lymphangitic metastasis, sarcoidosis, eosinophilic **granuloma**, collagen vascular, inhalational injuries, idiopathic pulmonary fibrosis ("**fibrosing alveolitis**"), resolving pneumonia

D. Coarse Reticular Pattern

Honeycomb lung -- End stage pulmonary fibrosis

Also seen with pneumonia or pulmonary edema in patients with emphysema.

E. Reticulo-nodular **Pattern**

A common radiographic pattern that encompasses the same disorders as reticular patterns

F. **Miliary Pattern** -- 2-3 mm. well-defined nodules:

Tuberculosis

Fungal, Nocardia, Varicella

Inhalational (silicosis, Coal-Worker's lung)

Sarcoidosis, Eosinophilic granuloma

Neoplastic (adenocarcinoma, thyroid)

G. Multinodular Pattern -- margins **of the** lesions are generally well defined.

Neoplasm: metastatic, lymphoma

Benign lesions

Fungal, parasites

Septic emboli

Rheumatoid nodules, **Wegener's**

H. **Atelectasis** -- Loss of **pulmonary** volume and decreased aeration of lung tissue. Also called "collapse."

Atelectasis can involve an entire lobe, a segment or be **subsegmental**.

The cause of greatest clinical concern is obstruction of a bronchus. In an adult, bronchial obstruction is usually due to a mass lesion such as a tumor. In children, mucus impaction and foreign bodies are more common.

Signs of **lobar** atelectasis (collapse) are:

Displaced fissure (the principal direct sign)

Loss of aeration causing increased opacity (not always present)

Indirect signs of volume loss:

Elevated **hemidiaphragm**

Shift of the trachea, heart or hilum

Rib cage narrowing

Compensatory hyperinflation

Collapse of each lobe creates a characteristic radiographic pattern.

Segmental Atelectasis -- Appears as an infiltrate with diminished volume.

Discoid Atelectasis -- Horizontal linear densities at the lung bases. Associated with hypoventilation due to various causes.

THE RADIOLOGY OF SPECIFIC CLINICAL DISORDERS

N. PNEUMONIA

Radiographic Patterns -- poor correlation with etiologic agent.

Lobar (segmental) pneumonia -- pneumococcus, **Klebsiella**, etc.

Infection originates in alveolar sacs and spreads via interconnecting passages.

Bronchopneumonia (lobular) -- staph. **aureus**, aspiration, pseudomonas, etc.

Nidus of infection in bronchus spreads distally producing a multifocal, patchy airspace pattern often in a segmental distribution. Bronchopneumonia is more accurately distinguished from **lobar** pneumonia pathologically than **radiographically**.

Interstitial -- viral, mycoplasma, etc. "Atypical" pneumonia can have an interstitial pattern, diffuse or patchy airspace filling, or segmental consolidation.

Lobar Pneumonia -- Radiographic signs:

Mostly homogeneous opacity except for:

Air bronchogram

Air **alveologram** (0.5-1 cm. lucent areas due to an air filled acinus)

Border is indistinct and distribution is non-segmental because infection spreads via interconnecting pores.

Sharp border where it abuts a fissure

Silhouette Sign - obliterates the normal air/fluid interface where the infiltrate abuts a fluid density (heart, diaphragm, aorta).

Obliterates normal vascular markings

Hard to find infiltrates:

Retrocardiac

Retroclavicular

Posterior costo-phrenic **sulcus** -- below/behind the domes of the diaphragm.

Densities that could be misinterpreted as infiltrates:

Lower lobe pulmonary arteries

Overlying soft tissue -- skin folds, breasts, pectoralis muscles, nipple shadows

Rib crossings and healed fractures, vertebral body osteophytes

Poor inspiration

Causes of treatment failure in community acquired pneumonia:

1. resistant organism - staph., viral, acquired resistance
2. unusual pathogen - TB, fungal, AIDS; animal exposure, travel
3. non-infectious disorder - cancer, CHF, pulmonary embolism, inflammatory lung disease (Wegener's granulomatosis, bronchiolitis obliterans, eosinophilic pneumonitis, etc.)

V. PULMONARY EMBOLISM -- 80% of films are abnormal, although most abnormalities are non-specific.

The role of a CXR in patients with suspected pulmonary embolism is limited.

1. Normal film in a patient in "dire straits"
2. Diagnose other disorders: pneumothorax, rib fracture, pneumonia (caution!)
3. Abnormalities suggestive of pulmonary embolism (non-specific and specific findings)
4. Correlation with lung scan

CXR Signs of Pulmonary Embolism

Nonspecific findings: common

Loss of lung volume: elevated hemidiaphragm

Line shadows-plate-like atelectasis, parenchymal scarring from prior infarction

Pleural effusion-usually small and unilateral

Specific findings: uncommon and difficult to identify reliably.

Oligemia (Westermarck's Sign -when combined with a dilated pulmonary artery)

Distended pulmonary artery which rapidly tapers (Knuckle sign) *

Pulmonary opacity (Hampton's Hump) -- can look like pneumonia (caution!)

Hampton's Hump -- intrapulmonary hemorrhage or infarction. Radiographic features:

Peripheral (pleural based)

Wedge-shaped (pointing to hilum)

Homogeneous (usually no air bronchogram)

Disappears like a "melting ice-cube" (not patchy resolution as occurs with a pneumonia)

VI. CONGESTIVE HEART FAILURE -- progressive elevation of pulmonary venous pressure

Upper zone vascular distention -- "cephalization" (mechanism unclear)

Hilar enlargement due to pulmonary venous hypertension -- distended upper lobe pulmonary veins
enlarge upper hila

Interstitial edema -- "increased interstitial markings" (two components)

Peri-broncho-vascular edema

Indistinct vascular markings

Peribronchial "cuffing"

Perihilar haze

Septal interstitial edema

Thickened interlobular septa (Kerley B lines)

Thickened deep septal bands (Kerley A lines)

Fine reticular pattern (Kerley C lines = overlapping Kerley B lines seen en-face)

Thickened interlobar fissures (subpleural edema)

Airspace-tilling edema

Bat-wing distribution or diffuse, patchy, ill-defined densities

Kerley B Lines--thickened interlobular septa (also called "septal lines") are fine lines seen at the periphery of the lung, perpendicular to the pleural surface. They are approximately 1 mm. thick and 1-2 cm. long. Normal lung markings (vessels) disappear within 1 cm. of the pleural surface.

Kerley B Lines are seen in:

- Pulmonary edema (**CHF**) - found at the lung bases due to gravitational forces,
- Lymphangitic** spread of cancer
- Lymphoma**
- Sarcoidosis
- Pneumoconiosis

(In the last four **disorders**, the **septal** lines (Kerley B lines) can occur anywhere along the pleural **surface**, including the apex or **axillary** region.)

VII. HILAR ENLARGEMENT

The normal hilum is composed of the main pulmonary arteries, the superior pulmonary veins **and the mainstem** bronchi. Hilar enlargement, especially adenopathy, can often be more easily detected on the lateral **film**.

Criteria to Evaluate the Hilum on the PA Chest Film

- 1) **Shape:** A branching vascular pattern is normal. Rounded contours that are not part of vessels are mass lesions (tumors or lymph nodes). The margins of the hilum are continuous with pulmonary blood vessels. The lower lobe pulmonary arteries extend **into** the lung two to four centimeters before dividing.
- 2) **Radiodensity:** Radiodensity progressively diminishes towards the periphery. Density falls off more rapidly in the upper than lower lobes. The right and **left** sides should be similar in density (density of the right side is slightly greater than **of the** left).
- 3) **Proportionate size:** The size of the lower half of the hilum is greater than the upper half, reflecting the greater volume of lung in the lower half **of the thorax**. **Normally, two-thirds** of the radiodensity is in the lower half **of the** hilum and one-third of the radiodensity is in the upper half.
- 4) **Absolute size:** Obviously enlarged hila are likely to be abnormal, but there are no definite measurements that serve as a guide. **Left** and right should be roughly the same size.

The Abnormal Hilum -- Radiographic Diagnosis

Tumor masses (i.e., bronchogenic carcinoma) and **lymphadenopathy** are **rounded, non-branching** structures. The radiodensity falls off abruptly at the margin of the tumor or lymph node. The proportionate size of the hilum is usually abnormal, with relatively greater than expected radiodensity where the mass or node is located.

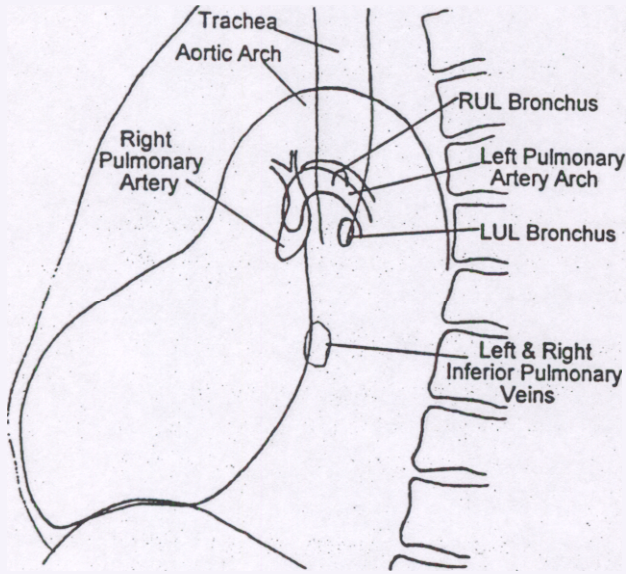
Increased pulmonary venous pressure is caused by congestive heart failure, mitral stenosis and mitral regurgitation. Radiographically, there is relatively increased radiodensity in the upper half of the hilum due to venous congestion in the upper lobe pulmonary veins. The lower lobe pulmonary veins enter the left atrium below the level of the hilum and therefore do not contribute radiodensity to the hilum on the PA **film**.

Increased pulmonary arterial pressure (pulmonary hypertension): The central pulmonary arteries are enlarged and hilar density tapers abruptly. Etiologies include primary pulmonary hypertension, pulmonary embolism, chronic lung diseases, etc.

Increased pulmonary blood flow occurs in left-to-right intracardiac shunts (VSD, ASD), high fever, pregnancy, etc. It causes increased central and peripheral pulmonary vascular markings (peripheral lung markings become readily visible in the most peripheral one-to-two centimeters **of the** lung). **Increased** pulmonary blood flow must be two to three times greater than normal to be radiographically visible.

Decreased pulmonary blood flow causes small hila and diminished vascular lung markings. This is seen in cyanotic congenital heart diseases, such as **tetralogy** of **Fallot**.

The Hilum as seen on the Lateral Film



The trachea and portions of the aortic arch are seen in all patients. Anterior to the distal trachea/carina is a radiodense region representing the right main pulmonary artery seen on end. The proximal left pulmonary artery and the superior pulmonary veins also contribute to the radiodensity of this area. The left main pulmonary artery forms an arch located inferior to the aorta.

The LUL bronchus is a radiolucent oval and is seen in a majority of cases. Its superior border is outlined by the arch of the left main pulmonary artery. The lumen of the bronchus is often crossed by a thin vertical line representing the posterior wall of the bronchus intermedius (branch of the right mainstem bronchus). The RUL bronchus is seen less often and is usually incomplete because it is not entirely surrounded by vessels. It is located superior to the LUL bronchus.

Inferior to the hilum, along the posterior cardiac border, is a radiodense area where the right and left inferior pulmonary veins are seen on end. This should not be confused with a mass lesion.

Hilar adenopathy and mass lesions can be readily identified on the lateral view. They are seen as areas of increased radiodensity and are easily visualized because they are adjacent to the air-filled trachea and bronchi. Adenopathy makes the walls of the airways especially visible. The upper lobe bronchi may be highlighted by a surrounding mass lesion. The posterior wall of the trachea and posterior wall of the bronchus intermedius will be thickened. The region just inferior to the LUL bronchus should be radiolucent unless there is subcarinal adenopathy.

Do not mistake normal vascular structures for pathological lesions. Radiodense vessels are normally seen anterior to the tracheal bifurcation (right pulmonary artery shadow) and the region of the inferior pulmonary veins (see diagram). The left and right lower lobe pulmonary arteries extend inferior and posterior from the hilum toward the vertebral column and should not be improperly identified as an infiltrate.

Hilar Adenopathy - Differential Diagnosis

Bilateral

- Sarcoidosis - the prime diagnosis for bilateral symmetrical adenopathy
- Lymphoma - (usually asymmetrical)
- Infection - viral, TB, fungal, etc. (usually asymmetrical)
- Metastatic - oat cell, renal, melanoma, breast (usually asymmetrical)

Unilateral (also bilateral asymmetrical)

- Tuberculosis ("primary")
- Fungal, atypical mycobacterium, viral, tularemia
- Metastatic or primary hilar tumor (bronchogenic carcinoma)
- Lymphoma
- Sarcoidosis, silicosis, drug reaction, etc.

VIII. TRAUMATIC AORTIC TEAR -- Plain chest radiography is used in conjunction with the clinical scenario to select patients for definitive diagnostic testing -- aortography. What are the findings on chest film that suggest aortic injury and should prompt ordering an **aortogram**? How does the usual portable technique influence interpretation of the film? Does a normal chest film exclude aortic injury?

CXR Signs: identify hemorrhage into the **mediastinum**, not the aortic tear itself.

1. Mediastinal **hematoma** -- the source of bleeding is branch vessels, not the aorta itself.

Wide mediastinum

"subjective impression," >8 cm. on supine **film**, **mediastinal/chest** width ratio $> 25\%$

Dependent on technique of the film: AP, supine and level of inspiration

Up to 10% of aortic injury cases will **not** have mediastinal widening on good quality chest **films**

Obliteration or distortion of normal mediastinal contours: aortic knob, descending aorta

(This can also be **caused by** suboptimal radiographic technique)

Opacification of the aortico-pulmonary window

Wide right paratracheal stripe

Left paraspinal line widened or extending above aortic knob

Left apical pleural cap

Mass effect of blood surrounding the aortic arch:

Tracheal or NG tube displacement

Depressed left **mainstem** bronchus

2. Signs of severe chest trauma

Rib fractures - 1st or 2nd ribs

Pulmonary contusion

Hemothorax

Pneumothorax

Diaphragm rupture

Causes of mediastinal widening on portable films

AP vs PA technique

Short distance between **film** and x-ray source

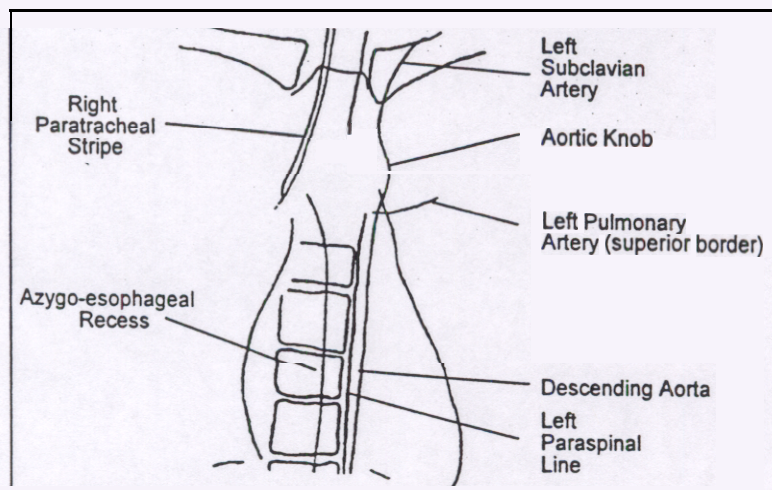
Supine vs upright (repeat film, if possible)

Poor inspiration (repeat film, if possible)

Lordotic projection

Rotation

The **aortogram** is currently the "gold standard" for diagnosing aortic injury. An aortic injury is found in only about **15%** of patients selected for aortography. CT and TEE are being used experimentally to help select patients for aortography or to diagnose the aortic injury itself.



Normal Mediastinal Pleural Lines

The **left subclavian artery** shadow disappears at the superior border of the clavicle.

The **right paratracheal stripe** is **normally** <5 mm. wide. It **terminates** inferiorly at the arch of the **azygos** vein.

The **left paraspinal line** can be up to 15 mm. wide. It normally disappears above the aortic knob.

The **aortico-pulmonary window** is the clear space under the aortic arch and above the superior border of the left pulmonary artery.

The **azygo-esophageal** recess is the medial border of the right lung under the arch of the **azygos** vein. It is located just anterior to the vertebral column. The lung surface lies against the esophagus (not the medial border of the descending aorta).

IX. **AORTIC DISSECTION** (distinguish 'aortic dissection from thoracic aortic aneurysm)

Chest Radiography -- 80-95% are abnormal, although the abnormalities are non-specific.

Role: Increase or decrease the estimated clinical likelihood of aortic dissection;
Suggest the diagnosis when it was not suspected.

Enlarged Aortic Contour (ascending, **arch** (knob), descending) -- the most frequent finding but non-specific - common in elderly individuals especially those with hypertension (**tortuous aorta**), i.e., the patients at risk for **dissection**. **Note:** mediastinal widening due to hemorrhage into the mediastinum is not seen with aortic dissection except when leakage is occurring from the thoracic aorta.

Progressive Aortic Enlargement -- in comparison to prior **films** (seen in 47%).

Calcium Sign -- intimal calcium **>10** mm. from edge of aorta (ascending and descending aorta only, not reliable at the aortic arch). Infrequently seen,

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Pulmonary Embolism

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Data from the PIOPED study (**117** patients with PE, and 248 without PE). The chest **film** was abnormal in 84% of patients with PE and in 66% of those without PE. Most had **atelectasis** or a pulmonary parenchymal abnormality (68% vs 48%). Many signs believed to be highly suggestive of PE were seen in only a minority of patients with PE and were also seen in patients without PE.

These signs included pleural based opacity (seen in 35% with and 21% without PE), decreased vascularity (21% vs 12%), prominent central pulmonary artery (15% vs 11%), Westermark's sign (7% vs 2%).

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Accuracy was low. The chest film cannot be used to diagnose or exclude PE. The chest film is useful in detecting other causes for the patient's symptoms.

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Acute Traumatic Aortic Injury

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A detailed analysis of the alterations in mediastinal lines that occur with mediastinal hematoma in traumatic aortic injuries. The author contends that a normal chest film excludes aortic injury. However, the reader of the film must be able to detect subtle findings.

White CS, Mirvis SE, Templeton PA: Subtle chest radiographic abnormalities in patients with traumatic aortic rupture. Emerg Radiol 1994;1:72-77.

Thirteen (12%) of 107 aortic injury cases seen at the University of Maryland (1982-1992) had subtle CXR findings. Technically suboptimal films were excluded. All of these patients except one had normal mediastinal width (< 8 cm.) although the mediastinal to chest width ratio was > 25% in 6 cases. All had either an abnormal aortic contour and/or loss of the aortic silhouette. No films had been interpreted as normal although the authors are expert at trauma radiology. The authors conclude that a negative good quality chest film excludes aortic injury, although the abnormalities can be very subtle.

Woodring JH: The normal mediastinum in blunt traumatic rupture of the thoracic aorta and brachiocephalic arteries. J Emerg Med 1990;8:467-476.

A review of 52 prior studies with 656 patients. 48 (7.3%) had a normal mediastinum on their chest film. 37 of these patients had accessory signs of severe chest trauma. Eleven patients (1.7%) would otherwise have been missed. The author notes that these patients were diagnosed by the later development of chest film abnormalities and advocates serial radiographic studies to detect these injuries that would otherwise have been missed.

Lee FT, Katzberg RW, Gutierrez OH, et al: Reevaluation of plain radiographic findings in the diagnosis of aortic rupture: the role of inspiration and positioning on mediastinal width. J Emerg Med 1993;11:289-296.

A mediastinal width of 8 cm. is often considered abnormal and indicative of mediastinal hemorrhage and aortic injury in a trauma patient. However, this study found that in normal subjects, mediastinal width is 8 cm (+/- 1 cm.) on supine AP films in expiration; 6.6 cm. (+/- 0.8 cm.) in inspiration; and 5.3 cm. on upright PA films in inspiration. In 16 patients with

proven traumatic aortic tears, the average mediastinal width was 9.1 (**+/-1.2** cm.) (13 of these were AP supine films). There is therefore great overlap between aortic patients and normal supine AP films, especially those with poor inspiration. Four of **the** aortic injury cases had mediastinal widths less than 8 cm. (three **of these** had grossly deformed aortic knobs). Analysis of the degree of inspiration in the trauma patients revealed that their level of inspiration was similar to that of the normal subjects during full inspiration as measured by the level of the right hemidiaphragm with reference to the thoracic vertebrae. The mediastinal width in the trauma patients was, in **most cases**, significantly greater than the normal AP supine films taken at full inspiration.

Schwab CW, Lawson RB, Lind JF, Garland LW: Aortic injury: comparison of supine and upright portable chest films to evaluate the widened mediastinum. Ann **Emerg Med** **1984;13:896-899.**

Mirvis SE, **Bidwell** K, Buddemeyer EU, et al: Imaging diagnosis of traumatic aortic rupture. Invest **Radiol** **1987;22:187-196.** (Critical review **of the literature**)

Mirvis SE, **Bidwell** JK, Buddemeyer EU, et al: Value of chest radiography in excluding traumatic aortic rupture. Radiology **1987;163:487-493.**

White CS, Mirvis SE: Pictorial review: imaging of traumatic aortic injury. Clin **Radiol** **1995;50:281-287.**

Creasy JD, **Chiles** C, Routh WD, Dyer RB: Overview of traumatic injury of the thoracic aorta. Radiographics **1997;17:27-45.** Pictorial review.

Clinical Aspects

Pretre R, **Chilcott** M: Blunt trauma to the heart and great vessels. New Engl J Mkd **1997; 336: 626-632.**

Fabian TC, Richardson JD, **Croce** MA, et al: Prospective study of blunt aortic injury: Multicenter trial of the American Association for the Surgery of Trauma. J Trauma **1997;42:374-80.** 7% of patients had "normal" **chesst** radiographs.

Hunt JP, Baker CC, **Lentz** CW, et al: **Thoracic** aorta injuries: management and outcome of 144 patients. J Trauma **1996;40:547-555.** 5% of patients had "normal" chesst radiographs.

Pate JW, Fabian TC, Walker W: Traumatic rupture **of the** aortic isthmus: an emergency? World J Surg **1995;19:119-25.**

Imaging Modalities: CT, TEE

Mirvis SE, Shanmuganathan K, Miller B, et al: Traumatic aortic injury: diagnosis with contrast enhanced thoracic CT: five year experience at a major trauma center. Radiology **1996; 200: 413-422.**

Gavant ML, Flick P, Menke P, Gold **RE**: CT aortography of thoracic aortic rupture. AJR **1996; 166: 955-961.** (Helical CT)

Raptopoulos V: Chest CT for aortic injury: maybe not for everyone. AJR **1994;162:1053-1055.**

Hollerman JJ: A rational approach for imaging of blunt thoracic trauma to exclude aortic injury. **Emerg Radiol** **1994;1:206-208.**

CT could be used to screen patients for possible **aortic injury**. This is especially true for patients who are undergoing another CT study, i.e., abdominal, and in whom the initial chest radiograph is not clearly normal. If the chest CT is abnormal (mediastinal blood or abnormality of mediastinal contour), an **aortogram** must **be** done to diagnose aortic injury. If the chest CT is normal, aortography is not necessary. Contrast CT is advocated.

Harris JH, Horowitz **DR**, **Zelitt DL**: **Unenhanced** dynamic mediastinal computed tomography in the selection of patients requiring aortography for the detection of acute traumatic aortic injury. **Emerg Radiol** **1995;2:67-76.**

The authors advocate non-contrast CT to detect mediastinal hematoma in patients with equivocal plain chest films. Their approach differs with Hollerman who feels that contrast is necessary to detect subtle abnormalities of the aorta contour in cases without mediastinal hemorrhage. Harris' approach has the advantage of not requiring two contrast studies.

- Smith MD, Cassidy JM, Souther S, et al: **Transesophageal echocardiography** in the diagnosis of traumatic rupture of the aorta. *New Engl J Med* **1995;332:356-62**. Editorial pp. 389. TEE could potentially supplant aortography, although the margin for error must be, exceedingly low. (Other authors have used TEE to screen patients for aortography.)
- Minard G, Schurr MJ, Croce MA, et al: A prospective analysis of **transesophageal echocardiography** in the diagnosis of traumatic disruption of the aorta. *J Trauma* **1996;40:225-230**. (Not 100% reliable)-
- Vignon P, Lagrange P, Boncoeur MP, et al: Routine **transesophageal echocardiography** for the diagnosis of aortic disruption in trauma patients without enlarged mediastinum. *J Trauma* **1996;40:422-7**
- Fattori R, Celletti F, Bertaccini P, et al: Delayed surgery of traumatic aortic rupture: role of magnetic resonance imaging. *Circulation* **1996;94:2865-2870**.

Aortic Dissection

- Spittell PC, Spittell JA, Joyce JW, et al: Clinical features and differential diagnosis of aortic dissection: experience with 236 cases (1980-1990). *Mayo Clin Proc* **1993;68:642-651**. 80% of patients had an abnormal aortic contour, although only in 9% did the radiologist prospectively interpret the radiograph as suggestive of aortic dissection. A normal chest film did not exclude the diagnosis of aortic dissection.
- Earnest F, Muhm JR, Sheedy PF: Roentgenographic findings in thoracic aortic dissection. *Mayo Clin Proc* **1979;54:43-50**. 82% of 74 cases had abnormal chest films, mainly an enlarged or indistinct aortic contour. The finding were not compared to a control group so the specificity of these findings are unknown.
- Slater EE, DeSanctis RW: The clinical recognition of dissecting aortic aneurysm. *Am, J Med* **1976; 60: 625-633**. 85% of patients had an abnormal chest film, 84% of these had an abnormal aortic contour. This was not compared with age matched normal control subjects. 14% had an abnormal "calcium sign" (displacement of intimal calcification from the outer margin of the aorta). The specificity of these signs was not studied.
- Eagle KA, Quertermous T, Kritzer GA, et al: Spectrum of conditions initially suggesting acute aortic dissection but with negative aortograms. *Am J Cardiol* **1986;57:322-326**. 16% had acute myocardial infarction, 7% (four patients) had falsely negative initial aortic angiograms. 36% had a tortuous or ectatic aorta. 36% had a dilated or aneurysmal aorta on plain chest radiographs.
- Jagannath AS, SOS TA, Lockhart SH, Saddekni KW: Aortic dissection: a statistical analysis of the usefulness of plain radiographic findings. *AJR* **1986;147:1123-1126**. Widening of the aortic knob and widening of the mediastinum were findings useful in predicting aortic dissection. However, interobserver agreement among the radiologists reading the films was poor. Numerical measurements were not applied to these radiographic features because of the wide range of normal values. The subjective impression of the radiologist was used instead. Accuracy of the radiologists reading was found to be quite high (sensitivity 81% and specificity 89%) in the 36 patients and 36 controls. However, details about the x-ray findings that the radiologists used were not given.
- Loscalzo J, Creager MA, Dzau VJ: *Vascular Medicine: A Textbook of Vascular Biology and Diseases*, 2nd ed. Boston, Little Brown, 1996.
- Lindsay J, Hurst JW: *The Aorta*. New York, Grune and Stratton, 1979.
- Doroghazi RM, Slater EE: *Aortic Dissection*. McGraw-Hill, 1983.
- Creager MA: *Atlas of Heart Diseases*, vol 7: Vascular Disease. Mosby, 1996.

Imaging Modalities: Angiography, CT, TEE, MRI

- Sarasin FP, Louis-Simonet M, Gaspoz JM, Junod AF: Detecting acute thoracic aortic dissection in the emergency department: time constraints and choice of the optimal diagnostic test. *Ann Emerg Med* 1996;28:278-88. Wolfson AB, Bessen HA: Thoracic aortic dissection: ruling in and ruling out [editorial]. *Ann Emerg Med* 1996;28:349-51.
- All patients in whom aortic dissection is suspected, even if the clinical probability is very low (4%), should undergo one of the available diagnostic procedures (except TTE). This includes patients in whom the more probable diagnosis (30% or greater likelihood) is coronary ischemia. A patient with a moderate to high probability of disease should undergo a second investigation if the findings of the first are negative. When the probability of dissection is high, the physician must consider delays in obtaining specific diagnostic tests and order those that will be the most quickly available.
- Sommer T, Fehske W, Holzknacht N, et al: Aortic dissection: a comparative study of diagnosis with spiral CT, multiplanar transesophageal echocardiography, and MR imaging. *Radiology* 1996;199:347.
- Sensitivity in the detection of thoracic aortic dissection was 100% for all techniques. Specificity was 100%, 94%, and 94% for spiral CT, multiplanar TEE, and MRI, respectively. In the assessment of aortic arch vessel involvement, sensitivity was 93%, 60%, and 67% respectively, and specificity was 97%, 85%, and 88%, respectively. Spiral CT and multiplanar TEE are as valuable as MR imaging in the detection of thoracic aortic dissection. In the assessment of the supraaortic branches, spiral CT is superior.
- Cigarroa JE, Isselbacher EM, DeSanctis RE, Eagle KA: Diagnostic imaging in the evaluation of suspected aortic dissection. *New Engl J Med* 1993; 328: 35-43. Letters: pg. 1637-1638.
- Compares aortography, CT (non-spiral CT), MRI and transesophageal echocardiography. TEE is recommended for acutely ill patients and MRI is recommended for stable patients.
- Nienaber CA, von Kodolitsch Y, Nicolas V, et al: The diagnosis of thoracic aortic dissection by noninvasive imaging procedures. *New Engl J Med* 1993;328:1-9.
- Krinsky GA, Rofsky NM, DeCorato DR, et al: Thoracic aorta: comparison of gadolinium-enhanced three-dimensional MR angiography with conventional MR imaging. *Radiology* 1997;202:183-93.
- Gadolinium-bolus enhanced three-dimensional MR angiography was found to be rapid and accurate in the diagnosis of thoracic aortic disease. It was sensitive (92%-96%) and specific (100%) for acute and chronic aortic dissection, thoracic aortic aneurysm and arch vessel disease.

Pneumonia

- American Thoracic Society: Guidelines for the initial management of adults with community acquired pneumonia: diagnosis, assessment of severity and initial antimicrobial therapy. *Am Rev Respir Dis* 1993;148:1418-1426.
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- Pomilla PV, Brown RB: Outpatient treatment of community acquired pneumonia in adults. *Arch Internal Med* 1994;154:1793-1802.
- Friedman PJ: Radiologic reporting: The description of alveolar filling. *AJR* 1983;141:617-8.
- Albaum MN, Hill LC, Murphy M, et al: Interobserver reliability of the chest radiograph in community acquired pneumonia. *Chest* 1996;110:343-350.
- Young M, Marrie TJ: Interobserver variability in the interpretation of chest roentgenograms of patients with possible pneumonia. *Arch Intern Med* 1994; 154: 2729-32. (comment 155:1453)
- Kuhlman JE: Pulmonary manifestations of acquired immunodeficiency syndrome. *Semin Roentgenol* 1994;29:242-275.
- Goodman PC: Tuberculosis and AIDS. *Radiol Clin North Am* 1995;33:707-717.
- McAdams HP, Erasmus J, Winter JA: Radiologic manifestations of pulmonary tuberculosis. *Radiol Clin North Am* 1995;33:655-678.
- Miller WT, Miller WT Jr: Tuberculosis in the normal host: radiological findings. *Semin Roentgenol* 1993;28:109-118