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**LEARNING OBJECTIVES:**

1. Anatomy on the chest radiograph.
2. Conceptual approach to interpreting a chest radiograph.

**Radiograph Views:** The standard views of the chest in plain chest radiography are the erect postero-anterior (PA) and lateral projections. The PA chest radiograph is taken at total lung capacity at end inspiration. The patient should be well aligned with the medial heads of the clavicle equidistance from the spinous processes of the thoracic vertebra. The scapula should be held as far to the side of the chest as possible to avoid the scapula projecting over the lungs. The view is termed PA since the direction of the x-ray beam is from posterior to anterior with the film cassette located anteriorly. This allows for decreased magnification of the heart since the film cassette is adjacent to the heart. The lateral radiograph is obtained with the film cassette adjacent to the left side of the patient.

Many radiographs are obtained portably with the patient in the hospital bed. The film/cassette is located behind the patient and the direction of the beam is from anterior to posterior. Therefore, this is termed an anteroposterior (AP) radiograph. The scapula is often overlying the thoracic cavity with this view. There is about a 7-10% magnification of the heart size on the AP view when compared with the PA. On an AP projection, use the right lateral aspect of a thoracic vertebral body to compensate for this mild magnification.

Another radiograph that may be obtained is a decubitus view (left or right). This would be taken with either the left side or right side of the patient down to evaluate for layering pleural effusion or pneumothorax. Try placing the side down that is opposite of the effusion, it offers much more information.

Opacities on a radiograph have an appearance related to how much of the x-ray beam passes through a structure. Metal will be pure white since no x-rays penetrate. Bone is mostly white since some x-rays get through. Water and muscle appear as gray/white. Fat is a darker gray since more x-rays penetrate. Air is black since all x-rays pass through and reach the film/cassette.

Interfaces are critical in chest radiography. *Two structures can be separated on a radiograph only if they have sufficiently different densities (i.e. lung and heart). Two structures cannot be separated if the densities are similar and the structures are adjacent to each other.* Pulmonary vessels can be identified since they are outlined by air. If they are obscured by a process such as pneumonia the vessels will not be visible. If the right heart border is not identified, it generally indicates that an abnormal opacity is present in the right middle lobe since the right middle lobe abuts the right
heart border anatomically. Structures within the mediastinum are difficult to distinguish from each other since there is no air interface. However, they can still be seen, and effectively used, with modern radiographs given the variable densities within the mediastinum. The aortic arch is the most dense structure in the mediastinum and can be used as the standard of reference for the rest of the superior mediastinum.

NORMAL ANATOMY

The trachea divides into two main bronchi at the carina. The right main bronchus has a steeper angle than the left. There is a wide range of angles of the carina ranging from 60 to 90 degrees. The left main bronchus is longer than the right main bronchus since the left upper lobe bronchus arises more caudad than the right upper lobe bronchus. In the right lung there are three lobes (right upper lobe, right middle lobe and right lower lobe). The left lung is divided into the left upper lobe and left lower lobe. Following the takeoff of the right upper lobe bronchus, there is a bronchus intermedius, which then divides into the right middle lobe bronchus and the right lower lobe bronchus. Although there is some variability in segmental bronchial anatomy, most individuals have the following anatomy: the right upper lobe is divided into the apical, posterior and anterior segments. The right middle lobe is divided into the medial and lateral segments. The right lower lobe is divided into the superior segment and the medial, anterior, lateral, and posterior basilar segments. The left upper lobe is divided into the apicoposterior and anterior segments and the superior lingula and inferior lingula segments. The left lower lobe is divided into the superior segment and the anteromedial, lateral and posterior basilar segments.

The structures that make up the hilar opacities include the main pulmonary arteries and veins with visualization of the bronchial walls as well. Normal lymph nodes, nerves and connective tissue do not contribute significantly to the hilar shadow. The left hilum is higher than the right in 90 percent and they are at the same level in 10 percent. The right main bronchus has a more vertical course than the left main bronchus and the right upper lobe bronchus arises more proximally than the left upper lobe bronchus. The right pulmonary artery passes anterior to the major bronchi and the left pulmonary artery arches over the left main bronchus and passes posterior.

Each lung has a major fissure that separates lobes. On the left, the major fissure separates the left upper lobe from the left lower lobe. On the right, the major fissure separates the right upper lobe and right middle lobe from the right lower lobe. The major fissures are generally visible on the lateral view, but not on the PA view. The minor fissure separates the right upper lobe from the right middle lobe. The minor fissure is generally visible on both the PA radiograph and lateral radiograph. Of note, these fissures very often have focal incomplete areas, which allows for some exchange of air to occur between lobes.

The mediastinum is the space between the lungs containing central cardiovascular, tracheal/bronchial structures, esophagus and lymph nodes. There are several mediastinal interfaces that can be identified on the PA chest radiograph. The superior and mid right mediastinal border is normally formed by the SVC. The right paratracheal stripe is due to the pleura and tracheal wall outlined by right upper lobe laterally and air
in the trachea medially. The width should be less than 3mm. The azygos arch is immediately above the right main bronchus and is often less than 1cm in diameter. The right atrium/atrial appendage form the right heart border on the PA chest radiograph.

The left side of the mediastinum is formed superiorly by the aortic arch and left subclavian vein. The pulmonary artery, forming the mid left mediastinal border, should be immediately below the aortic arch. The left heart border is formed by the left atrial appendage superiorly and the left ventricle inferiorly. On the lateral view of the anterior heart border is formed by the right ventricle and the posterior border is formed by the left atrium and left ventricle. The right ventricle can not be seen normally on the PA projection.

It should be kept in mind that a “line” is a structure identified on a radiograph that is a linear structure outlined by air on both sides. An interface is formed by an opacity with an edge outlined by air on one side. The posterior junction line can occasionally be identified and is a vertically oriented line projecting over the upper thoracic spine. This line represents the junction between the posterior aspects of the upper lobes. Another line is the anterior junction line which is an oblique line projecting over the mid thoracic spine and angling inferiorly to the left. This represents the junction of the anterior aspects of the lungs. The anterior and posterior junction lines are occasionally identified. The azygoesophageal recess is an interface between the right lower lobe and the aorta, esophagus and azygos vein posteriorly. This interface projects over the mid and lower thoracic spine with aerated lung identified to the right and opacity representing the mediastinal structures projecting to the left.

The right hemidiaphragm is usually slightly higher than the left hemidiaphragm. Approximately 35% of the population has diaphragmatic eventration, which is a thinning of the muscular-tendon portion. It is most common involving the right anterior hemidiaphragm and presents as elevation. (Note: this normal variant is the basis for the incorrect myth that Pulmonary Embolus can present with an elevated hemidiaphragm. This is wrong!)

The cardiac silhouette should be less than 50% of the width of the measurement from the inner aspects of the rib cage. This measurement is valid for a full inspiration PA chest radiograph. On an AP chest radiograph, the cardiothoracic ratio may be up to 60%. The costophrenic angles, that are where the lateral aspect of the diaphragm abuts the aorta, esophagus and azygos vein posteriorly. This interface projects over the mid and lower thoracic spine with aerated lung identified to the right and opacity representing the mediastinal structures projecting to the left.

Approach and Organization: A systematic approach should be used when interpreting the chest radiograph. Although any order can be used when evaluating the chest radiograph, one should develop a consistent approach. Listed below is one approach:

1. **The Lungs**: The lungs should be evaluated individually as well as for symmetry from side to side. Occasionally asymmetry will be the only clue to identifying a subtle abnormality. They should be dark with sharp branching white vessels
throughout. Abnormal increased opacities in the lung, either focal or diffuse, will cause the nearby vessels margins to become indistinct or even lost. The term “infiltrate” is strongly discouraged as a descriptor for abnormal lung opacity. (A “White Zinfandel” term – AVOID IT!) Deviation of a fissure is indicative of volume loss, also called atelectasis.

2. **Between the Lungs**: Heart, mediastinum and hila. The heart should be evaluated for size and shape. Mediastinum should be evaluated for contour abnormalities and overall width and density. The hila should be evaluated for size and contour as well as position. The position of the heart, mediastinum and hila are important to evaluate for volume loss. For example if there is right upper lobe volume loss, the super mediastinum will be shifted to the right and the right hilum will be shifted superiorly. The trachea will also be shifted to the right with right upper lobe volume loss. Another example would be that a large left pleural effusion would shift the mediastinum and heart to the right whereas left lung collapse would shift the heart and mediastinum to the left. The density of the aortic arch should be greater than the rest of the superior mediastinum.

3. **Outside the Lungs**: Bone and soft tissues. Note that evaluation of the bones and soft tissues using the technique of chest radiography is somewhat limited, although some abnormalities can certainly identified. Always check for a mastectomy in women, since this important information is often missed. The hemidiaphragms should be evaluated for position and contour. Costophrenic angles should be sharp in the absence of pleural fluid or thickening. A pneumothorax will demonstrate a very dark (air-filled) pleural cavity. Masses outside the lung often demonstrate a “Ball under the carpet” appearance.

4. **Disease Distribution**: The distribution or location of an abnormal opacity is of crucial importance when evaluating the radiograph. Diseases often appear in only certain areas of the lung since the microenvironments are so different. For example, TB usually occurs in the posterior upper lobes or in the superior segment of the lower lobe, likely due to poor lymphatic production and clearance (NOT because of O2 tensions – this is likely another long standing myth).

5. **Lateral Projection**: Both the PA and the lateral radiograph need to be evaluated if both are available. On the lateral view the thoracic spine should appear progressively darker inferiorly until the diaphragm. If it becomes more opaque there is probably an abnormality in one of the lower lobes or in the spine. Pleural effusion and enlarged hilar lymph nodes are better seen on this view.

It is beyond the scope in this course to discuss much of Computed Tomography (CT). Most CT scans are obtained following an unusual chest radiograph. However, the use of CT scanning is increasing and in many cases is used as the first thoracic imaging study regardless of the chest radiographic findings due to the increased sensitivity and
specificity of CT findings compared to radiographic findings. But management as well as outcome changes are less common than believed.

Terminology to use when describing a chest radiograph that will be reviewed and demonstrated in the lecture are the following:

**Consolidation**: Increased ill-defined opacity that completely obscures the involved vessels.

**Ground Glass**: Increased ill-defined opacity that partially obscures the involved vessels.

**Reticular** (Septal thickening): Thin, non-branching lines seen in the lungs.

**Nodules**: Well-defined <3cm round opacities.

**Cavitary nodules/masses**: Air within a nodule or mass.

**Peripheral lace-like opacities**: Short, thick reticular opacities that cross each other forming little holes (honeycombing). Seen with Usual Interstitial Pneumonitis (UIP).

**Curved reticular opacities** (“Comma-shaped”): Thin lines that are curved, not straight.

Distribution that is often helpful:

**Upper lobes**: Usually relates to inhalational or lymphatic based diseases.

**Bronchovascular**: Radiates from the hilum into the lungs.

**Dependant**: Gravitational forces important with these diseases.

**Diffuse**: All lobes involved – often result of a systemic injury or disease.

**Focal**: One area involved.

**Multi Focal**: Patchy distinct different areas involved by a disease process.

**Peripheral**: Disease seems to be located mainly along the edges of the lung.

A separate handout with the most common diseases presenting in these categories should be included in these lecture notes. Based on the morphology and distribution of the abnormality, a short differential or even, a single diagnosis can often be made.

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