Using Chest Radiography in the Intensive Care Unit

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In acute care settings, basic chest radiology is still used to quickly detect abnormalities in the chest, and chest imaging is an important tool in managing critically ill patients. In a recent study, Marik and Janower concluded that daily routine chest radiographs affected clinical decisions about patients' care for a large percentage of short-term patients in an intensive care unit (ICU).

However, nurses are often the ones who first view chest radiographs and report an initial interpretation to a physician. Critical care nurses can use the results of chest radiography to confirm other assessment findings and to plan appropriate nursing care.

In this article, I present information that nurses can use in their daily work to interpret chest radiographs. I review basic chest radiography, describe relevant anatomy and physiology, summarize normal findings on chest radiographs, and describe radiographic findings in common pulmonary and cardiac disorders.

BASIC CHEST RADIOGRAPHY

X-rays are very short wavelengths of electromagnetic radiation that penetrate matter. A radiograph is created when x-rays penetrate a structure and produce images on a piece of photographic film. In a person, the different shades of black and white in the images are due to the way the body structures or tissues absorb the x-ray beam. X-rays that penetrate body tissue produce dark or black areas on the film.

Two of the most common radiographs are posteroanterior (PA) and anteroposterior (AP) views of the chest. For PA views, the x-ray beam passes through the chest from the back to the front. For AP views, the beam passes through the chest from the front to the back. For acutely ill patients who cannot stand up for a PA view, AP views are obtained with a portable x-ray machine.

AP views obtained with a portable machine have some disadvantages. Structures in the anterior part of the chest are magnified on AP views, so structures such as the heart are not as distinct as on PA views and may even be distorted. This phenomenon occurs because decreased x-ray energy is available when portable x-ray machines are used to create the images. In addition, PA views are sharper and more distinct
because they are always obtained with the patient 2 m (6 ft) away from the source of the x-rays and at a 90° angle to the beam, whereas shorter distances and angles less than 90° are used for AP radiographs.

In many large medical centers in the United States, up to 50% of all chest radiographs are obtained with portable x-ray machines. Obtaining daily chest radiographs is useful for detecting unexpected problems in ICU patients, and the findings may prompt changes in medical treatment. For example, Marik and Janower found that 66% of intubated patients and 25% of nonintubated patients in an ICU had changes in treatment based on the findings on daily chest radiographs.

Densities
The 4 basic roentgen densities are gas (air), fat, water (soft tissue), and bone (or metal). Areas in which nothing except air lies between the x-ray beam and the x-ray film are radiolucent and appear dark. Areas that cannot be penetrated by the x-ray beam are radiopaque and appear light or white on the x-ray film.

If 2 structures of equal density are adjacent to each other, the border of neither structure can be detected. This phenomenon, the silhouette sign, is used to identify normal chest structures and to diagnose and localize lung disease. The silhouette sign may be used to distinguish anterior from posterior structures on a chest radiograph. For example, it would be expected in an area of consolidation in the left upper lobe because this lobe of the lung borders the left sides of the atrium and mediastinum. Because both the area of consolidation and the heart are water densities, the left border of the atrium cannot be distinguished from the border of the left upper lobe of the lung.

Systematic Method of Viewing
A systematic method should be used to examine chest radiographs. Radiographs may be examined from side to side, from top to bottom, or structure by structure. Table 2 gives a suggested order for structure-by-structure examination, and Figure 3 shows those structures on a PA radiograph.

ALVEOLAR AND CAPILLARY ANATOMY AND PHYSIOLOGY
An understanding of alveolar and capillary anatomy and physiology is essential for interpreting radiographic indications of pulmonary disease of the air spaces and interstitium. Alveoli consist of 2 different types of cells. Most alveoli are lined with type I cells, which are flat, squamous cells. The corners of alveoli contain type II cells, which produce surfactant. Alveolar macrophages are phagocytic cells that clear particles from these air spaces. Openings between alveoli (pores of Kohn) permit movement of gases between adjacent alveoli.

Many structures and substances, such as fluid, connective tissues, leukocytes, and macrophages, are located in the walls between alveoli. Capillaries are

<table>
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<th>Density</th>
<th>Radiographic appearance</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Gas/air</td>
<td>Black</td>
<td>Gas or air in trachea, bronchi, or stomach</td>
</tr>
<tr>
<td>Fat</td>
<td>Gray</td>
<td>Lipid tissue around muscle</td>
</tr>
<tr>
<td>Water</td>
<td>White</td>
<td>Heart, blood vessels, muscle, and diaphragm</td>
</tr>
<tr>
<td>Bone/metal</td>
<td>All white</td>
<td>Bones, calcium deposits, prostheses, and contrast media</td>
</tr>
</tbody>
</table>

Figure 1 Densities on a chest radiograph.
interspersed between alveoli in a network. The contact of alveolar surfaces with capillary surfaces forms the alveolocapillary membrane, the structure through which gas exchange occurs.

The alveolocapillary membrane has a thin side and a thick side. The thin side bulges into the alveolus and is the primary site for gas exchange. The fusion of alveolar and capillary basement membranes creates the thin side of the alveolocapillary membrane does not conduct gas exchange as easily as the thin side does; rather, it promotes fluid exchange in the lung.

Excess fluid in an alveolus is drained via the alveolar interstitial space into the nearby lymphatic system and/or into the connective tissue fibers. The connective tissues of the alveolar interstitial space form the support system for the alveolar and pulmonary capillaries. Excess fluid in the alveolar interstitial space fluid is drained via the connective tissue fibers into the potential peribronchial and perivascular interstitial space. The peribronchial and perivascular interstitial spaces surround the bronchioles, bronchi, pulmonary arterioles, and pulmonary arteries (Figure 4).

### VIEWING OF NORMAL CHEST STRUCTURES

#### Soft Tissues

The soft tissues of the chest consist mainly of fat and some water densities. The tissues should appear symmetric when compared side to side. Breast tissue is an example of soft tissue.

#### Trachea

The trachea appears as a column of radiolucency or gas density midway between the clavicles or over the spine. Tracheal deviation is present when the trachea is positioned to the right or the left of the midline. A common cause of apparent tracheal deviation is chest rotation, which can...
be identified by asymmetry in the distance between the pedicle and clavicle. True tracheal deviation may be caused by the presence of a tumor, mediastinal shift, pneumothorax, or major atelectasis. The carina is normally positioned approximately at the level of the sixth posterior rib (Figures 2 and 3). When an endotracheal tube is placed correctly, the tip of the tube is approximately 3 to 5 cm (approximately 2 in) above the carina.

Bony Thorax

The humeri, scapulae, clavicles, spine, and ribs should be identifiable as bone densities. On a radiograph obtained during inspiration, 9 to 10 posterior ribs to the lateral top of the diaphragm should be visible. Each rib should be followed along its course to assess for any notching or deformities; symmetry of rib structures should be assessed bilaterally. Radiographs of patients with chest trauma should be checked for evidence of rib fractures.

Intercostal Spaces

Each intercostal space is numbered according to the rib above it. The width of the intercostal spaces is determined by measuring the degree of the costovertebral angle relative to the posterior ribs. The normal angle is about 45°; with widened intercostal spaces, the angle may double to more than 90°. Widened intercostal spaces occur in conditions, such as chronic obstructive pulmonary disease, pneumothorax, and pleural effusion, that increase lung volume. Narrowed intercostal spaces, such as occurs in atelectasis and interstitial fibrosis, are associated with conditions that decrease lung volume.

Diaphragm

The diaphragm has a water density, and each hemidiaphragm
is dome-shaped. The right hemidiaphragm is normally higher in the chest than is the left hemidiaphragm because of the liver. Diaphragmatic elevation is evident when fewer than 9 to 10 ribs are visible and can be caused by abdominal distension, phrenic nerve compression, or lung collapse/atelectasis8,11,12,16 (Figure 5). Diaphragmatic depression is present when 11 to 12 ribs are visible.7,8 Depression or flattening of the diaphragm is associated with hyperinflation of the lung, as in chronic obstructive pulmonary disease1,7,8 (Figure 6).

Structures Below the Diaphragm

Almost all of the structures below the diaphragm are primarily water densities. The exception is the gastric air bubble, which may be visible7,8 (Figure 3).

Pleural Surfaces

The pleurae normally appear as thin, hairlike lines along the lateral edges of the chest and along the diaphragm.7 When the pleural line deviates medially and appears in the lung fields, a pneumothorax may be present.4,13 When a pneumothorax is present, the area outside the line to the lateral edge of the chest (ie, the pleural space) will appear more radiolucent or completely black.7,8 The lung itself will appear more radiopaque or more dense. Mediastinal shift toward the affected lung may also occur in a large pneumothorax. In contrast, in tension pneumothorax, the mediastinum shifts away from the affected lung, and the diaphragm commonly is depressed on the affected side.7,8 (Figure 7).

The costophrenic angles (Figure 3) should appear as deep sharp points like a V.9 If the costophrenic angles are not distinct deep points on the lateral sides of the chest, a pleural effusion may be the cause.7,11,13,16 If a horizontal fluid level can be visualized in the area of the costophrenic angles, a pleural effusion most likely has occurred.7,8

Mediastinum

The mediastinum includes the heart, major blood vessels, the trachea, and the right and left main bronchi. The heart and blood vessels are water densities, whereas the trachea and bronchi are air densities. The right atrium forms the right border of the heart. The right ventricle cannot be detected directly on a chest radiograph because this structure is located in the center of the heart shadow.7,8 The ascending aorta is visible as
the aortic knob (Figure 3). The left atrium and the left ventricle form the left border of the heart.7,8

The cardiothoracic ratio can be determined to assess the overall size of the heart. This ratio is determined by measuring the horizontal width of the heart and dividing that width by the widest interval of the thorax.7,8 The normal cardiothoracic ratio is 0.5 or less1,7,11 or 1:2 or less8,16 (Figure 8). A cardiothoracic ratio greater than 0.5 or 1:2 is suggestive of cardiac enlargement.

Cardiac enlargement can be determined more precisely by comparing the findings on serial radiographs. An increase in the diameter of the heart of 1 cm or greater is considered cardiac enlargement.7 If cardiac enlargement is present, right ventricular enlargement must be distinguished from left ventricular enlargement. In right ventricular enlargement, the right atrium protrudes into the right side of the chest and becomes more convex.7,8 In left ventricular enlargement, the left lower border of the heart is moved laterally and becomes rounded7,8,11,12 (Figure 8).

Hila

The hila consist of the pulmonary arteries and veins and appear blotchy because of various areas of radiopacity associated with different sizes and thicknesses of blood vessels. The heart shadow obscures the left hilar area and makes the left hilum appear smaller and higher than the right hilum.11 Bronchovascular markings refer to blood vessels and bronchi that branch out from the hila to the periphery of the lung fields12 (Figure 8). As the markings extend out into the lung fields and gradually taper off in the periphery, the structures consist of mainly pulmonary blood vessels and no bronchi.

Hilar elevation is usually present in collapse of the upper lobes of the lung, whereas hilar depression occurs in collapse of the lower lobes of the lung7,8 (Figure 5). Collapse of the right middle lobe does not cause hilar displacement.7,8 In heart failure, the hila become enlarged and more dense on chest radiographs, with indistinct borders due to edema in the interstitium and alveoli.11

Lung Fields

The lung fields consist mainly of air and very little tissue or blood.11 As a result, lung fields should be visualized as an air/gas density or as a completely radiolucent area. Abnormalities of the lung fields on chest radiographs include interstitial patterns and alveolar consolidation patterns.

Determining the locations of the various lobes of the lungs is useful for diagnosing and localizing pulmonary disease. The right middle lobe is located anteriorly, adjacent to the right side of the heart. The left lingular lobe is in direct contact with the left border of the heart.7,8 The upper lobes and the right middle lobes of the lung are primarily anterior thoracic structures, whereas the lower lobes are primarily posterior structures. Knowing the different locations of the lung lobes makes it possible to use the silhouette sign.

Fissures are separations or spaces between the lung lobes and appear as narrow white lines on a chest radiograph.7,8 In frontal and lateral views, the area where the minor fissure separates the right middle lobe from the right upper lobe may be visible. This area is located almost in the middle of the right lung fields, where it appears as a horizontal line (Figure 9). One of the direct signs of lung collapse in the right upper lobe is elevation of the minor fissure (Figure 5). In collapse of the right middle lobe, downward displacement of the minor fissure may be evident.

The major or oblique fissure separates the upper lobes of the lung from the lower lobes.7,8 The major fissure cannot be seen on a frontal view, but it is visible on a lateral view.7,8 However, the major fissures can be pictured on both sides of the lung fields on
frontal views by imagining arches that have the apex at the level of the aortic arch.

**RADIOGRAPHIC SIGNS OF PULMONARY DISEASE**

Most pulmonary diseases are associated with increased density of the lung fields on chest radiographs. Increased density involves changes in the interstitium, the air spaces, or both.

**Interstitial Pulmonary Disease**

In interstitial pulmonary disease, the volume of the alveolar interstitium increases with no change in the alveolar air volume. The alveolar interstitial space increases in size due to fluid, fibrosis, inflammation, or abnormal tissue growth. Chronic diffuse interstitial lung disease is usually caused by pulmonary fibrosis. Acute diffuse interstitial lung disease is usually due to cardiogenic or noncardiogenic pulmonary edema such as that associated with acute respiratory distress syndrome (ARDS) or to viral or mycoplasmal pneumonia. In ARDS, interstitial edema is due to indirect injury of pulmonary endothelial cells by inflammatory mediators. Gas exchange is impaired by thickening of the thin side of the alveolocapillary membrane, which increases the distance that oxygen and carbon dioxide diffuse between the alveoli and the capillaries.

In interstitial lung disease with normal aeration of the alveoli, chest radiographs typically show increased vascular markings due to more prominent blood vessels. Depending on the type of interstitial lung disease, the markings are as follows:
- reticular or linear, which appear as small lines, sometimes as a net, and when profuse, as a honeycomb or ring pattern;
- nodular, which appear as small round dense opacities;
- reticulonodular, which are a combination of reticular and nodular markings and are the most common type (Figures 8 and 9);
- ground-glass, which have a pattern similar to that of diffuse ground-up glass.

In addition, lines may be visible in the upper or lower lobes because of thickening of fissure lines. In acute interstitial pulmonary disease, the markings are hazy with normal branching of the vascular bed and bronchi. In chronic interstitial pulmonary disease, the markings are sharp and the branching is irregular.

**Air Space Disease (Alveoli)**

Air space or alveolar disease involves reduction of air due to alveolar consolidation, atelectasis, or both. In alveolar consolidation, also termed infiltrates, tissue or fluid replaces air in the alveoli. Decreased lung air volume decreases respiratory gas exchange. Signs of alveolar consolidation on a chest radiograph include the silhouette sign and the air bronchogram sign. An air bronchogram sign is the radiographic
shadow (a radiolucent area) of an air-filled bronchus running through an airless area of lung (an opacified area). Figure 10. Figure 2 illustrates a silhouette sign and consolidation due to pneumonia. Figure 11 shows consolidation due to ARDS.

Common causes of consolidation are bacterial pneumonias and cardiogenic pulmonary edema and noncardiogenic edema such as ARDS. In ARDS, direct injury to the alveoli increases permeability of the alveolar capillary membrane, causing complete lung consolidation, which is visualized as a complete whiteout on chest radiographs (Figure 11).

Atelectasis is due to 4 pathophysiological conditions:
1. air is absorbed from the alveoli (resorptive),
2. alveoli are compressed due to increased intrathoracic pressure (relaxation or passive),
3. alveoli collapse from fibrosis or scarring (cicatrization), and
4. alveoli collapse from loss of surfactant (adhesive).

Hypoventilation can also cause alveoli to lose air volume. In all instances, diminished tissue oxygenation occurs because of lack of oxygen in the alveoli.

Direct signs of atelectasis on a chest radiograph include displaced fissures, crowded bronchovascular markings, and shifted position of a marker structure such as a scar, nodule, or granuloma.

Indirect signs of atelectasis are structural shifts in the positions of the hila, diaphragm, and mediastinum and increased density or radiopacity of the lung tissue. Figure 5 is an example of the radiographic findings in atelectasis.

Patients with ARDS can have a combination of air space disease with both alveolar consolidation and atelectasis. Chest radiographs show a primary alveolar pattern with signs of atelectasis due to reduced lung volume from loss of surfactant. In addition, most likely both indirect and direct lung injury coexist in ARDS. However, the consolidation pattern of direct injury usually predominates over the interstitial pattern attributable to indirect injury. If a patient survives ARDS, a chronic interstitial pattern due to pulmonary fibrosis often becomes apparent on chest radiographs obtained after the acute stage.

RADIOGRAPHIC SIGNS OF HEART FAILURE

In addition to left ventricular enlargement, cephalization or

Figure 10 Lung consolidation with air bronchograms.

Figure 11 Adult respiratory distress syndrome (whiteout).
CASE STUDY

J.C., a 53-year-old woman, was admitted to the ICU with cough, severe dyspnea, chest tightness, hypoxemia, yellow-tinged sputum, and fatigue. In the emergency department, arterial blood gas analysis revealed the following: pH 7.51, Pco2 31 mm Hg, bicarbonate 27 mmol/L, Po2 54 mm Hg, and oxygen saturation 86%. J.C. had a history of moderate persistent asthma. She had daily episodes of wheezing, chest tightness, dyspnea, and cough. She also woke up with symptoms several nights each month. J.C.’s husband provided information that during the preceding 3 days, her peak expiratory flow rate, measured by using a peak flow meter at home, had decreased by 90 L/min, or approximately by 30% of her personal best peak expiratory flow rate.

J.C. also had a 1-year history of mild heart failure due to hypertension, for which she was taking furosemide, 40 mg daily, and captopril, 12.5 mg twice a day. She used a fluticasone inhaler twice a day, a salmeterol inhaler twice a day, and an albuterol inhaler as needed to control her asthma. J.C. had used her albuterol inhaler about 45 minutes before coming to the emergency department, but the medication provided little relief of her chest tightness or dyspnea. J.C. received 2 nebulizer treatments with albuterol and ipratropium in the first hour in the emergency department.

J.C. was then transferred to the ICU, where she experienced sinus tachycardia, with a heart rate of 116/min. Auscultation revealed dry crackles in both lung bases, and expiratory wheezes could be heard throughout the lung fields. J.C. was orthopneic with respirations at 30/min and was using her accessory muscles of respiration. She had a noticeable productive cough with expectoration of small amounts of yellow-tinged sputum. J.C. was given 40% to 60% oxygen through a partial rebreathing mask. Oxygen saturation by pulse oximetry was 91%.

In looking at J.C.’s portable AP chest radiograph, her critical care nurse observed that the lung fields had a white haziness and increased markings in the hilar area. The nurse realized that auscultation of crackles in J.C.’s lower lobes was associated with the white haziness on the chest radiograph.

The nurse followed a systematic order of viewing chest structures on the chest radiograph and reviewed the radiograph for manifestations of either interstitial or air space disease. During the review, the nurse discovered an interstitial process in the lung fields. She determined that interstitial pulmonary edema was present as indicated by cephalization, a reticulonodular interstitial pattern with a butterfly pattern, and an enlarged heart (Figure 12).

J.C.’s signs and symptoms in the emergency department and in the ICU were indicative of an acute asthma exacerbation with possible pneumonia. However, coughing and wheezing are also associated with left ventricular heart failure. The critical care nurse was able to integrate her knowledge of J.C.’s medical history, signs and symptoms, physical assessment, and chest radiographs to understand the clinical picture. Upon arrival of the pulmonary physician, the nurse communicated her assessment findings. Now that she recognized the cause of J.C.’s illness, the nurse was able to plan and prioritize the appropriate nursing interventions.

vascular redistribution is an indication of left ventricular failure. In a patient standing upright, the pulmonary blood vessels are larger in the lower lobes of the lung than in the upper lobes. If the blood vessels in the upper lobes are larger than the blood vessels in the lower lobes, the condition is termed cephalization. Cephalization occurs because of increasing left ventricular pressure. When the pulmonary capillary wedge pressure (PCWP) become elevated, cephalization occurs.

In addition, as PCWP continues to increase to between 18 and 25 mm Hg, interstitial edema begins. Kerley B lines may now become evident on chest radiographs. Kerley B lines are horizontal lines no more than 2 cm long that appear in the lung periphery near the costophrenic angles (Figure 9). Kerley A lines are oblique lines approximately 2 to 6 cm long that appear in the upper lobes. Kerley lines are due to thickening of interlobular septa caused by increased tissue or fluid, as in interstitial pulmonary edema.

During interstitial pulmonary edema due to heart failure, a butterfly pattern may begin become apparent on chest radiographs (Figure 9). The butterfly pattern is due to the fluid engorgement of the interstitium adjacent to the hilar blood vessels.

Once edema due to heart failure involves the entire alveolar interstitium as a result of increasing PCWP and increased left ventricular pressure, the alveoli start to become edematous. At this point, the PCWP is usually greater than 25 mm Hg. At this time, an alveolar consolidation pattern becomes evident on chest radiographs. However, not all patients
with high PCWP have evidence of heart failure on chest radiographs.\textsuperscript{1,7} Pleural effusions are also common in moderate to severe heart failure as indicated by shallow costophrenic angles.\textsuperscript{7,8,11,15} The 3 stages of pulmonary edema are cephalization, interstitial edema, and alveolar edema.\textsuperscript{1,7,11,17}

**IMPLICATIONS FOR CRITICAL CARE NURSES**

Signs and symptoms that patients have during acute illness may be indicative of many different types of pathophysiological or disease processes. Critical care nurses can use chest radiographs as an additional bedside assessment tool to assist in determining pathophysiological abnormalities. By learning some basic skills in interpreting chest radiographs, nurses can recognize and localize gross pathological changes visible on a chest radiograph.

Nurses are the care providers who are consistently present at the bedside and have up-to-date information on patients’ clinical status. For example, changes in densities in the lung fields on a patient’s chest radiograph along with auscultation of crackles and a PCWP pressure of 25 mm Hg may prompt changes in fluid management for the patient. Using a stethoscope, hemodynamic information, and chest radiographs together for chest assessments enables nurses to recognize additional important clues concerning a patient’s current clinical status. By incorporating the chest radiograph as an additional bedside assessment tool, critical care nurses can more completely monitor patients’ clinical status and be able to plan and prioritize nursing interventions.

**Acknowledgments**

Thanks to Dave Garrow, Ball State University School of Nursing computer lab coordinator, for his development of the alveoli and interstitium graphic, Figure 4.

**References**


**Figure 12** J.C’s portable chest radiograph.
CE Test Form

Using Chest Radiography in the Intensive Care Unit

Objectives:
1. Identify characteristics of the 4 basic roentgen densities
2. Distinguish the radiographic signs of pulmonary disease
3. Discuss the radiographic signs of heart failure

Mark your answers clearly in the appropriate box. There is only 1 correct answer. You may photocopy this form.

1. a  2. a  3. a  4. a  5. a  6. a  7. a  8. a  9. a  10. a
   b b b b b b b b b b
   c c c c c c c c c c
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Program evaluation

Objective 1 was met
Objective 2 was met
Objective 3 was met
The content was appropriate
My expectations were met
This method of CE is effective for this content

The level of difficulty of this test was:
   easy    medium    difficult

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| **1.** A black radiographic appearance indicates what kind of roentgen density?  
  a. Gas/air  
  b. Fat  
  c. Water  
  d. Bone/metal | **6.** When a pneumothorax is present, how will the lung appear on a radiograph?  
  a. More radiolucent  
  b. Completely black  
  c. More radiopaque  
  d. Less radiolucent |
| **2.** A grey radiographic appearance indicates what kind of roentgen density?  
  a. Gas/air  
  b. Fat  
  c. Water  
  d. Bone/metal | **7.** What is one of the direct signs of lung collapse on a radiograph?  
  a. Downward displacement of the minor fissure  
  b. Elevation of the minor fissure  
  c. Downward displacement of the oblique fissure  
  d. Elevation of the major fissure |
| **3.** On a radiograph, a silhouette sign indicates which of the following?  
  a. Two structures are radiolucent  
  b. Two structures are radiopaque  
  c. Two structures are of opposite density  
  d. Two structures are of equal density | **8.** Which one of the following describes a radiolucent area of air-filled bronchus in an opacified area of lung?  
  a. Silhouette sign  
  b. Air bronchogram  
  c. Cephalization  
  d. Atelectasis |
| **4.** What is the normal cardiothoracic ratio?  
  a. 1:2 or less  
  b. 1:3 or less  
  c. 1:4 or less  
  d. 1:5 or less | **9.** What is a direct sign of atelectasis on a chest radiograph?  
  a. Increased radiopacity of lung  
  b. Structural shifts in diaphragm position  
  c. Displaced fissures  
  d. Depressed bronchovascular markings |
| **5.** When comparing serial radiographs, cardiac enlargement is present when the diameter of the heart increases by how many centimeters?  
  a. 25 cm or more  
  b. 5 cm or more  
  c. 75 cm or more  
  d. 1 cm or more | **10.** What is the term used to describe radiographic vascular redistribution indicating left ventricular failure?  
  a. Air bronchogram  
  b. Silhouette sign  
  c. Cephalization  
  d. Kerly A lines |
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