How to Read a Chest X-Ray, Part 1
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The goal of this chest X-ray continuing education program is to provide nurses, radiologic technologists and physicians with adequate information on how to interpret a chest X-ray. After studying the information presented here, you will be able to:

- List structures that are usually visible on a chest X-ray
- Discuss the proper way to obtain a chest X-ray
- Describe how the lungs, mediastinum and heart are assessed on a plain chest X-ray

Understanding a chest X-ray (CXR), although not difficult, requires basic anatomical knowledge. The CXR is made up of important organ systems: the lungs, heart and mediastinum. In addition, other structures, such as the ribs, diaphragm, pleura and clavicle, can also be assessed.

It is important to understand some of the technical details on how the image is reproduced to interpret the CXR correctly.¹⁻⁷ The CXR is not a very sensitive technique, and findings must be assessed in regard to patient history and/or physical findings.¹⁻⁷ The only way to become proficient in understanding CXR is to practice the art regularly.

Technical Details

Image 1: Brightness

In digital imaging, the term “brightness” is used instead of density. When examining a properly exposed and window-level CXR, keep in mind that:

- Air appears black
- Bone appears white
- Fat, soft tissue and water appear grey
Before making a diagnosis, it is important to note the penetration of the image by X-rays. Penetration is the intensity to which X-rays have penetrated the tissues.

If the penetration is excessive, the outline of the lung markings is difficult to identify, and the area appears black. If the image is underpenetrated, outlines will be blurred. The image should be high contrast with easy differentiation among the lungs, heart, and ribs.

Digital imaging will correct for minor over- or underpenetration errors caused by poor exposure factors. Overexposure will be seen as grey image (poor contrast), with very little differentiation between the heart and lungs. Images with excess underexposure will show a mottled appearance. Assessment of penetration has always been a standard aspect of assessing CXR quality; however, with modern digital and computerized technology, under- or overpenetrated/overexposed X-ray images are rarely encountered today.
When assessing a CXR, it is important to know if the image was obtained during inspiration or expiration. A proper image in inspiration will reveal lung fields with about nine to 10 ribs visible. Images taken in expiration (lungs are airless, diaphragm is raised) are often difficult to interpret, and can lead to false-positive results. Always count the number of ribs to determine if the chest was imaged in inspiration. In obese patients and those with muscular disorders, a full inspiration chest image may be difficult to obtain.

Image 3B: Inspiration Vs. Expiration

Here is another image of the chest in inspiration and expiration. In expiration, the diaphragm levels are elevated, and the lung fields are not clear.
In posteroanterior (PA) imaging (Image 4A), the heart is closer to the image detector, which produces less magnification on the final image. The technique, therefore, will not produce an artificially enlarged heart. The X-ray beam travels from the posterior (back) and exits at the anterior (sternum). Whenever possible, all chest images should be obtained with the patient in PA position.

In anteroposterior (AP) imaging (Image 4B), the heart often appears enlarged. The beam of X-rays travels from the anterior (sternum) and exits at the posterior (back). Here the cardiac silhouette often appears falsely enlarged. This technique is often used during mobile (portable) chest imaging in the ICU or when imaging stretcher patients who are bedridden. Whenever a CXR is taken AP, the technologist must record this in the patient’s medical notes. (Note: The term “projection” is used in the U.S. to describe the travel of the X-ray beam. In some countries, the term “view” is used).
The images above show the difference in PA and AP projections. In general, projections obtained in AP show a slightly enlarged cardiac silhouette. Unless marked, all chest imaging is assumed to be obtained in the PA position.
**Image 6: Supine Chest Imaging**

The majority of chest imaging is obtained with the patient in the PA position. If the chest radiograph is obtained in any other position, this should be stated on the image. A supine chest radiograph, even in a healthy patient, will show slight enlargement of the cardiac silhouette. The normal PA chest X-ray is imaged at 72 inches (about 180 cm), which creates minimal magnification. The supine chest X-ray is imaged at 40 inches (about 100 cm), which will result in magnification of the cardiac structures.

These two images are of the same patient in two different positions (PA and supine). If “supine” is not indicated on the chest image above, it would appear that the patient has mild pulmonary edema with cardiac enlargement.

**Image 7A: Rotation**

It is important to know if the chest image is obtained with the patient rotated. In general, the distance from the medial ends of both clavicles and midline must be the same. If the patient is rotated, it may appear as if the mediastinum is enlarged. Most healthcare providers/technologists use the spine as the midline.
If the patient is rotated, the mediastinum may appear artificially large. This is often a common scenario in patients in the ICU who are imaged in the supine position. In addition, some patients with an abnormal spine curvature may also appear to have rotational changes in the mediastinum.
This image shows gross anatomy of the lungs without the heart contents. This is exactly what is seen on a chest image; note the fissure lines in the right and left lung. This helps to identify the lobe of the lung on the CXR. When looking closely at the CXR, the trachea and the division into the right and left bronchi may be visible.
This is a gross outline of the heart and lungs, and is what is seen when looking at a chest image. It is crucial to know where each organ system is located to make a diagnosis.
Image 10 shows the ribs and sternum. This is the anatomical view that is seen on a CXR; however, the first rib is not always seen on a plain chest radiograph. On a physical exam, the angle of Louis (also called the sternal angle) must be identified to count the ribs. The sternal notch is identified at the top of the sternum and by walking the fingers down 1 cm to 2 cm; a distinct bony ridge is palpated. The second rib is continuous with the sternal angle (angle of Louis). The angle of Louis also marks the site of tracheal bifurcation into the right and left main bronchi, and corresponds with the upper atrial border of the heart. Pathology of the sternum is best seen on a lateral chest radiograph.
In Image 11, RA means right atrium and LA means left atrium. The lateral bulging of the aortic arch on the CXR is the aortic knob. The area between the aortic knob and the left atrium (see purple arrow) is the aorto-pulmonary (AP) window. Enlarged lymph nodes are often found in this area. The most common cause of enlarged lymph nodes in the AP window is lung cancer. The AP window is best seen on a CT scan; on this CXR, an arrow points to its location.
Before looking at abnormal chest radiographs, it is important to know what normal looks like. Image 12 is an example of a normal CXR. Whether beginning at the top of the CXR, with the lungs, or from inside to outside is not important; the most important factor is to establish a personal routine so that every CXR can be viewed the same way every time. The absolute first item to check when looking at a chest radiograph, however, is the patient’s name, date of birth and date when the CXR was taken. If this data is missing, the CXR is not useful and should not be read, as it could be anyone’s CXR.
In Image 13A, the chest is clear, and ribs are visible. Penetration is adequate. The diaphragm is concave, and the edges visible.

A = Trachea  
B = Right diaphragm  
C = Carina: where the trachea divides into right and left main stem bronchi. Look closely.  
D = Clavicle: fractures are missed when the CXR is looked at in a hurry  
E = Aortic knob: often calcification is seen on the aorta  
F = Air in stomach (air underneath the right diaphragm is usually abnormal and signifies perforation of a viscus)  
G = Lateral border of heart and indicative of location of left ventricle  
H = Right atrium
Chest radiograph is of good penetration; of note is the enlarged superior mediastinum.

**A** = Right lung fields  
**B** = Superior mediastinum  
**C** = Right ventricle surface  
**D** = Left lung field (upper lobe)  
**E** = Diaphragm posterior leaflet  
**F** = Right atrium
This CXR has poor penetration. The heart border is not clear, and the lung fields are not clearly visible. There is diffuse haziness. This patient may be obese.

This CXR shows the diaphragm and stomach bubble. The diaphragm is usually concave in shape. The hemidiaphragm tends to be flat in people who retain air, such as those with chronic obstructive pulmonary disease or emphysema. The heart shadow appears slightly enlarged, and the lung markings appear increased (white streaks projecting in the lung). Lung markings may be seen in patients with COPD or heart failure.

When looking at CXR, although the position of the hemidiaphragm is almost never stated, it should be examined. The hemidiaphragm is usually concave. When flat, as in Image 15, it is indicative of air retention. Patients with asthma, COPD and emphysema often have a flat diaphragm. If the hemidiaphragm on either side is elevated, it may indicate phrenic nerve paralysis or subpulmonic pleural effusion.
A = Esophagus: always runs behind the trachea
B = Trachea
C = Right ventricle: look for enlargement of the right ventricle; it will be adherent to the sternum. This is vital for open-heart surgery because the surgeon can easily cut the right ventricle.
D = Left ventricle: look for left ventricle enlargement. The enlarged chamber will abut the spine.
E = Descending aorta: usually runs alongside the spine
The right hemidiaphragm is always slightly more elevated than the left hemidiaphragm. The trachea is in front of the esophagus. The lateral chest radiograph is used to assess the pericardium. Calcification of the mitral valve can be seen on a lateral chest radiograph.

This lateral chest radiograph shows the position of the sternum, heart chambers, descending aorta and right costophrenic angle.
This chest radiograph shows the relative position of different lobes of the lungs.

**Image 17: CXR With Lung Markings**

**Image 18: Right Upper Lobe on CXR**
Knowing the general location of different lung lobes is important. Remember, the left lung has only an upper and lower lobe. The right middle lobes extend to the right heart border on a frontal view. The right lower lobe is seen more fully on a lateral view.

The RA is on the right lateral border. When enlarged, it may show a bump. The left ventricle (LV) is the lateral aspect of the heart silhouette. The right ventricle (RV) makes up the majority of the anterior cardiac silhouette. When a patient is stabbed in the chest with a knife, the RV is usually injured. The AK may appear calcified in patients with longstanding atherosclerosis.
The right hilum is slightly lower than the left hilum. The hila become enlarged in many disorders. This is the area where lymph nodes often become enlarged and prominent. The ideal test to assess for hilar enlargement is a CT scan.
This chest radiograph shows enlarged hila. Bilateral enlargement may be due to lymphoma, tuberculosis or sarcoidosis. Unilateral enlargement may be due to lung cancer. Access to this area is often difficult, and biopsy may be done by mediastinoscopy. CT scan of the chest is always used to assess the hila for enlarged lymph nodes.
This chest radiograph shows the mediastinal silhouette. If the width is greater than 8 cm on a PA view, then the mediastinum is widened. The widening may be due to aortic pathology or a mass in the mediastinum.

The chest radiograph reveals a widened mediastinum. There may be a number of causes for this pathology, including masses and aortic aneurysms. Technically, if the mediastinum width is greater than 8 cm on a PA image, this is defined as a widened mediastinum. The most common next step in the investigation is a CT scan of the chest.
Assessments

*Image 25. Assessing the Heart on CXR*

**HEART**

Focus on size of chambers

Look at pulmonary vessels

Look for valves, pacing wires, stents

Look at aortic knob and outline of aorta

A = Diameter of right atrium from the right of midspine

B = Diameter of left ventricular apex from the left of midspine

C = The largest horizontal width of the chest

Each organ system must be assessed carefully. When looking at the heart, focus on the size of the chambers. There may be calcification of the aortic or mitral valves. Look for calcification of the aortic knob. Enlargement of the RA, LA and LV can be identified on chest radiographs by experienced readers. If the A + B/C ratio is greater than 50%, then the heart size is enlarged. Heart failure is a likely cause, so look for pleural effusions and pleural edema in such scenarios.
When looking at the lungs, always note if the CXR was taken in inspiration, or PA or AP. Look for any orientation changes or rotational changes. Look at the depth of penetration and lung density. Look for symmetry. If a lung lesion is present, do not jump to a definitive diagnosis. Instead, always ask to review an older CXR, if available. The patient may have had a scar or benign lung lesion for many years.
The mediastinum is often the most difficult area to assess on a plain chest radiograph. Look at the width and the aorto-pulmonary (AP) window. In the AP window, there are lymph nodes, which often become enlarged, especially in patients with lung cancer. Look at the hilum area and note size and symmetry. Look for calcification. The lymph nodes may appear calcified in patients with tuberculosis.
### Assessing Other Areas

After assessing the lungs, heart and mediastinum, look at the other areas. The costophrenic angle should be sharp; if blunted, there may be fluid collection. Look below the diaphragm. If there is air and the patient has abdominal pain, think about perforated viscus. Look at the apex of the lung (the area above the clavicle), as a mass may be present (Pancoast tumor). Tuberculosis often tends to occur in the lung apex where oxygenation is better. Look at the ribs, clavicles and vertebrae.

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### References


