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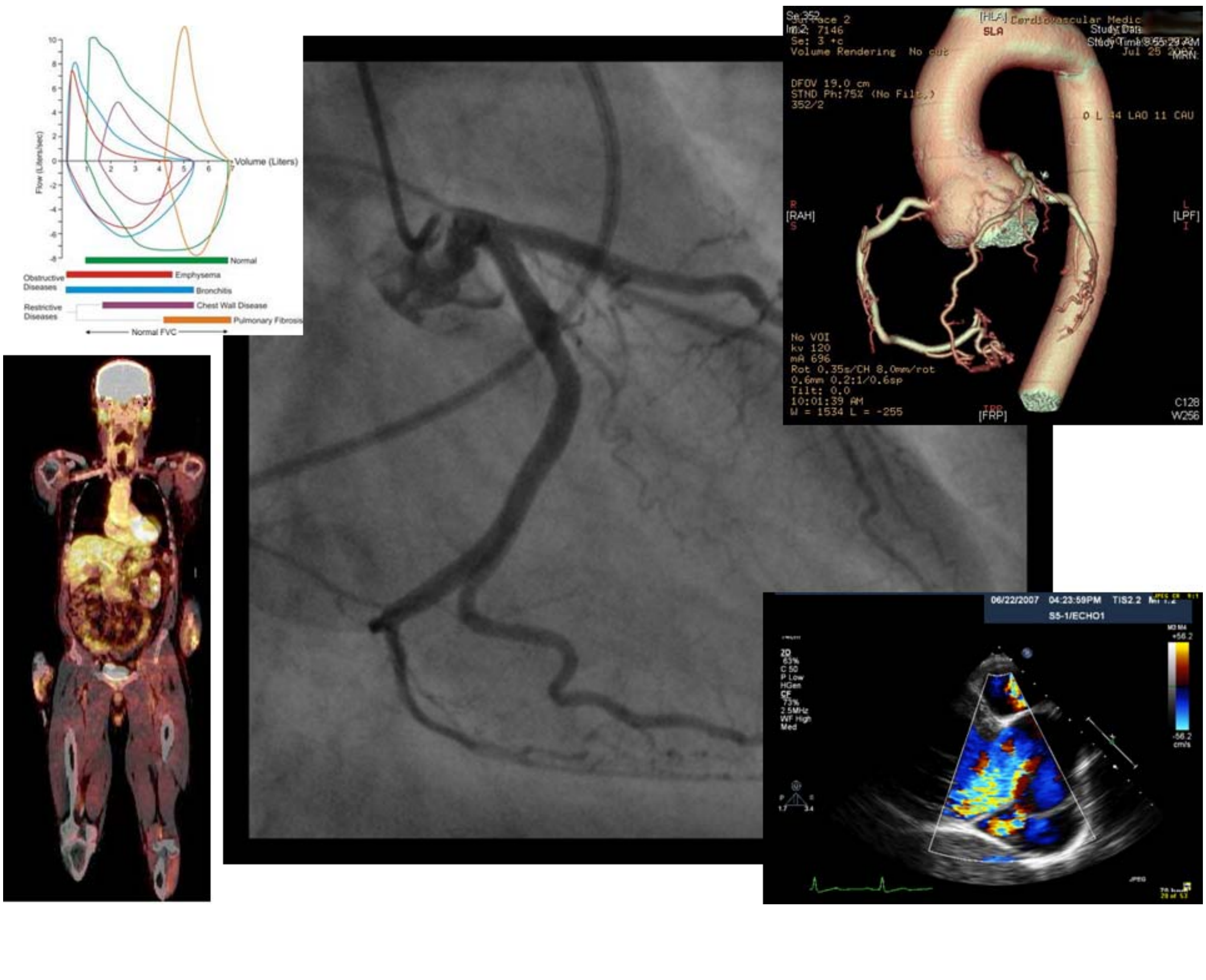
Shades of Gray

Interpretation of Perioperative Imaging

Installment I: X-Rays



Purpose

As Advanced Practice Nurses (APNs), we often order and rely on perioperative imaging to guide our decision making and plan our operative interventions. However, almost no BSN, RNFA, or even MSN curricula include interpretation of medical imaging. This forces us to abdicate our autonomy and rely on either the interpreting physician's "read" or our supervising physician's opinion. Learning to interpret medical imaging studies can increase our confidence and autonomy as well as increase our marketability and professional stature.

The medical imaging that will be covered by this series includes X-ray, CT, MR, US, and angiography. The interpretation series will review the history and evolution of the methodology, briefly discuss the current state of the technology, highlight patient education surrounding the imaging modality, and systematically cover basic interpretation of each study. This will be a three-part series covering X-ray initially, CT and MR in the second installation, and echocardiography and miscellaneous procedures such as angiography and PET in the final presentation.

Introduction

Wilhelm Röntgen stumbled upon X-rays, initially named using the mathematical designation for something unknown—"X"—while studying the external effects of Crooke's tubes, vacuum tubes with an electrical charge passed through them. Wikipedia notes Röntgen is credited with the first X-ray, of his wife's hand, on December 22, 1895. He presented the film to the Physik Institut, University of Freiburg, on January 1, 1896. Wilhelm subsequently won the very first Nobel Prize for physics in 1901. He was also awarded an honorary Doctor of Medicine from the University of Würzburg[5].

X-rays are electromagnetic radiation similar in properties to light, with shorter wavelengths than ultraviolet (UV) light. "X-rays are generated by an X-ray tube, a vacuum tube that uses a high voltage to accelerate electrons released by a hot cathode to a high velocity. The high velocity electrons collide with a metal target…creating X-rays."[5] The resulting X-rays are aimed at a target and projected onto a phosporous screen and then developed in numerous ways, previously on film though most facilities are transitioning to web-based systems. The "film" is darkened by exposure to photons. The target (patient in our instance) affects the photon "throughput" and results in various shades of white, gray, and black. Denser materials will show up white and less dense materials will be shades of gray or black. It is also important to note that light energy, including X-rays, expands as it travels. This means objects closer to the X-ray tube will be smaller while those that are farther away will be enlarged. This will be important when viewing chest X-rays, i.e., PA (the X-rays enter through the posterior or back side and exit through the anterior or front side) versus AP.

Radiographs are named based on the beam projection entry and then exit of the target. "There are only five categories of opacity visible on a radiograph, though there are varying levels of opacity within the primary categories. These categories are mineral (calcium and phosphorous as seen in bone), soft tissue and fluid (as they have the same radiographic opacity), fat, gas [the most radiolucent opacity on X-ray], and metal [the most radiopaque images on X-ray]."[4]

How to Approach an X-Ray Image

When approaching an X-ray film, or any imaging modality, it is important to proceed systematically. This requires a firm knowledge of anatomy and physiology and the ability to translate that knowledge into three- and four- dimensional thought. You should cross-check the name, medical record number, and date on the radiograph to your patient and current date. Next, check the position of the patient in relation to the film. The radiograph should be labeled with orientation markers of left/right or anterior/posterior.

Orientation plays an important role in how you will mentally evaluate the two-dimensional “shadowgram” in three dimensions. Stokell (n.d.)[4] noted that each shadow must be evaluated for four things:

- Is it a feature of normal anatomy?
- Is it a composite structure formed by the superimposition of structures?
- Is it an artifact produced by poor positioning?
- Is it a pathologic lesion?

As you begin your radiographic evaluation, it is important to NOT go in with preconceptions of what you will see or “tunnel vision” that will keep you from evaluating the full exam after visualizing the “expected abnormality.” We are not training to become radiologists so it is not necessary, nor is it conceivable, to know all of the intricacies of radiographic interpretation. There are; however, some standard guidelines to help you get the basics down. First, is everything there that should be there? Systematically review the X-ray, comparing it to your “mental image” of a normal radiograph and looking for anything missing. Secondly, is there anything there that shouldn’t be there? Again, comparing to “normal” is there anything additional, i.e., hardware, a pacemaker, a shadow where only gas should show, etc.? Third, is everything there consistent with normal? For example, in following the contour of a rib on a chest X-ray, the cortices should be symmetric and well aligned. Any discontinuity in a cortical line should lead you to consider a fracture in your differential diagnosis. Symmetry is congruent with health in terms of evolutionary biology. If you see anything on your radiograph that is not symmetrical, you should consider it abnormal. Let’s examine a “normal” chest X-ray below to get some practice.

Example - Normal

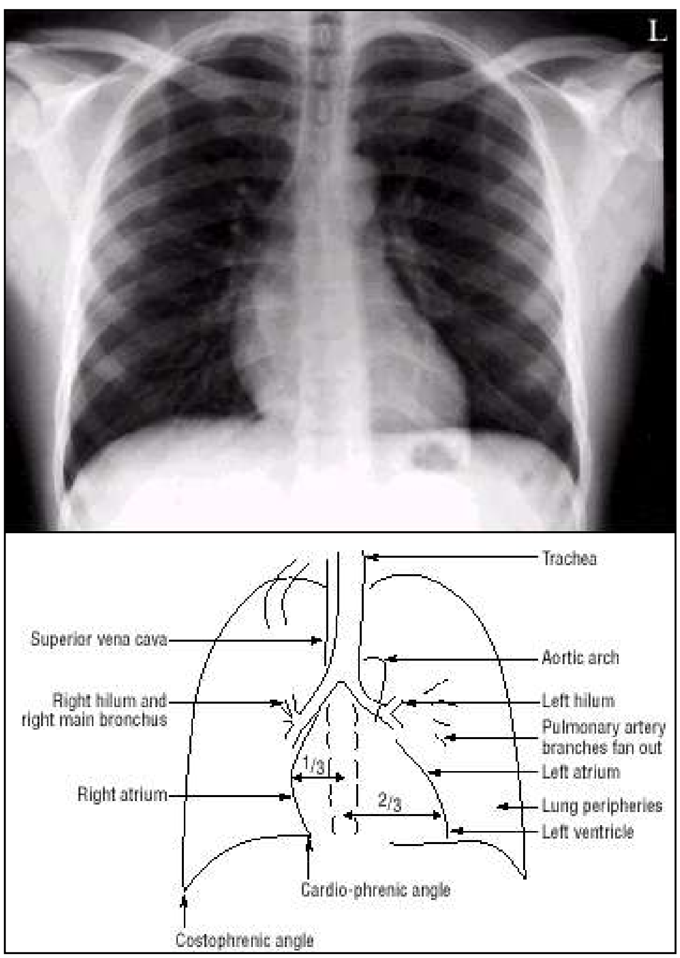


Fig. 1
http://student.bmj.com/issues/00/09/education/images/03.jpg

Look at Fig. 1, left. First, is this your patient? Second, how old is your patient? You should try to use the “patient’s age to your advantage by making sensible suggestions [i.e., a] 20-year old is much less likely to have malignancy than someone who is 70.”[2]

I have removed the identifying information from this radiograph so we will assume that this is our 30-year old patient. Next, is the patient male or female? The example in Fig. 1 does not have the presence of breast shadows, so the patient is male. A chest X-ray should be taken with held inspiration and should penetrate the tissues adequately. You should be able to see the thoracic vertebral bodies through the heart to indicate good X-ray penetration. Also, the image shows no patient rotation, the clavicles are horizontal and the spinous processes of the thoracic vertebrae are midline. This image shows a “L” (left) marker and is not labeled AP or PA. Most chest X-rays are PA so, if it’s not labeled AP, then PA is a “safe assumption.”

As you continue to look more deeply into the radiograph, follow the guidelines above.

Is the radiograph consistent with "normal"? The trachea should be midline. The aortic arch should be smooth and not enlarged or misshapen, i.e., "3" sign with a coarctation of the aorta. The heart should lie mostly to the left and not take up more than ½ of the thoracic cavity. You should be able to see the right and left pulmonary artery branches fanning out from the hilum. The lungs should be a "muted" black, since the lung spaces are full of air-containing alveoli, and should be comparable at similar levels as if you were auscultating the chest with your stethoscope. The diaphragms should be at the level of the 6th rib and the right is usually higher than the left[1]. The costophrenic and cardiophrnenic angles should be sharp. On this well-penetrated PA chest radiograph, you can see the gastric air bubble below the left hemidiaphragm.

Now that you have some practice with a normal chest X-ray, let's look at some examples of abnormal radiographs.

Examples - Abnormal

Look at Fig. 2, right. First, is this your patient? How old is your patient? Is your patient male or female?

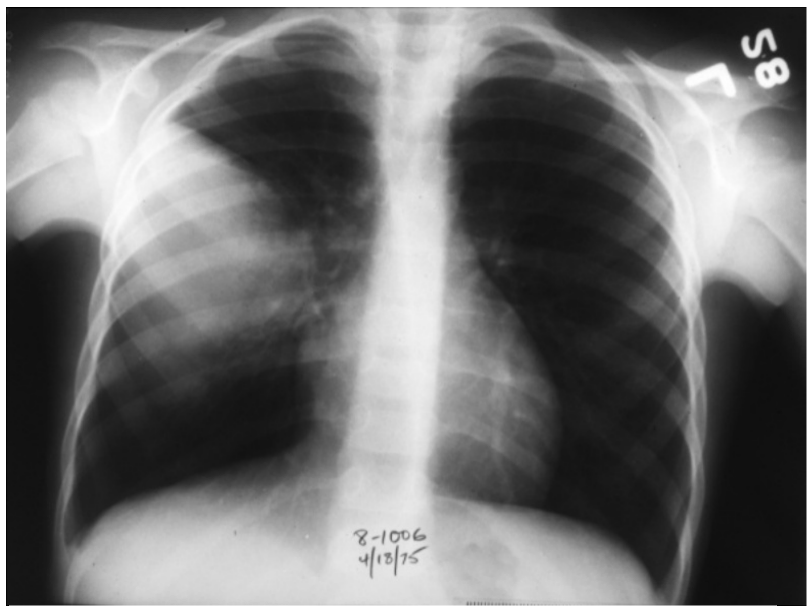
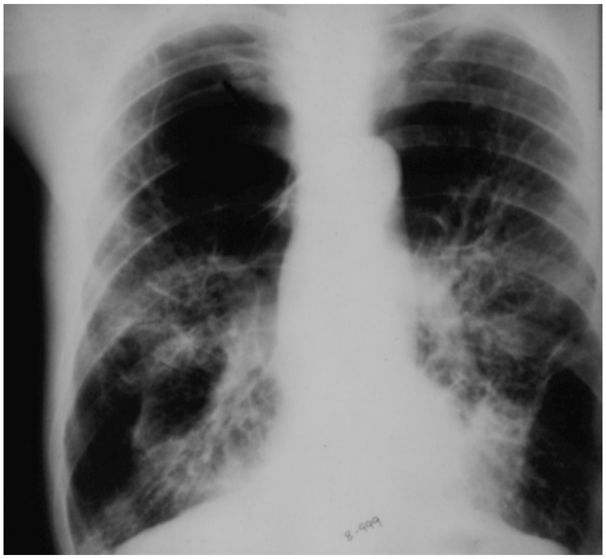
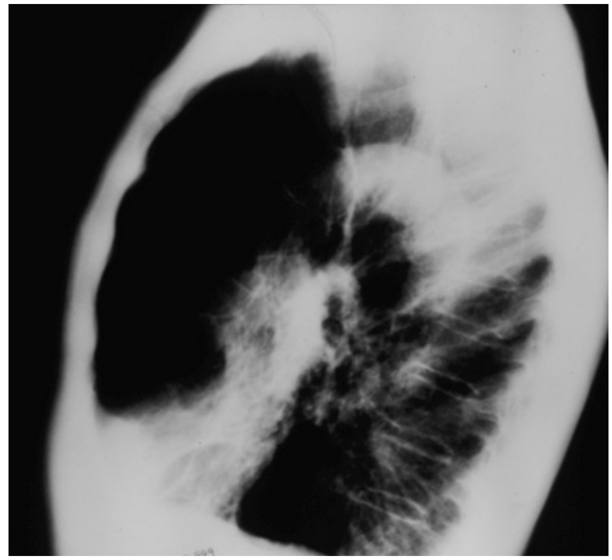


Fig. 2
http://rad.usuhs.mil/rad/handouts/feigin/abnlcxr/case005/findings.htm

This is our 33-year old male patient. There is good inspiration, mild rotation of the patient, and sub-optimal X-ray penetration. The clavicles are not completely horizontal and the vertebral bodies are not "clearly" visible through the heart. The trachea is midline, the aortic arch is normal, and the heart is not enlarged. You can see the branches of the right and left pulmonary arteries. The lungs show a large, consolidative, because it is homogenous and confluent, lesion of the lower portion of the right upper lobe and slightly blunted right costo- and cardiophrenic angles with good curvature of the hemidiaphragms. The right sided consolidation has a sharp lower border consistent with a fissure of the lung, indicating that it is isolated to a single lobe. This is typical of exudate. In this case, the 33-year old male with a right upper lobe consolidation has pneumonia.

Figs. 3 and 4
http://rad.usuhs.mil/rad/handouts/feigin/abnlcxr/case008/top.htm

Figs. 3 and 4, above, are two X-rays of another patient. We do not know the age of this patient; however, we know it is a male because of the absence of breast shadows. This radiograph shows no malrotation and very poor penetration. The trachea, heart, and vertebral bodies are not fully visualized on these images. What we can see is that the hemidiaphragms are flattened, especially on the lateral film. The lungs are hyper-inflated, evidenced by "black" lungs that are not gray. There are multiple asymmetrical "holes" in the lungs and there is an increased anteriortoposterior distance on the lateral film. This constellation of findings—barrel chest, flat diaphragms, and bullous lungs—is consistent with COPD (chronic obstructive pulmonary disease) with emphysema.

Fig. 5
http://rad.usuhs.mil/rad/handouts/feigin/abnlcxr/case010/top.htm

In Fig. 5, left, first notice this is a female patient due to the presence of bilateral breast shadows. The patient does not show any rotation and the orientation is assumed posterior to anterior. The radiograph is poorly penetrated. However, compare the right and left lung spaces. There are absolutely no right lung markings, no tissue or vascularity markings and the right hilum has a "triangular" shaped bulge. The right lung space is completely filled with air and no tissue. If there were secretions or fluid, the right lung would be "whited out." Instead, the absence of any lung markings is due to air in the right chest compressing the lung, the small bulge in the right hilum. This is consistent with a pneumothorax.

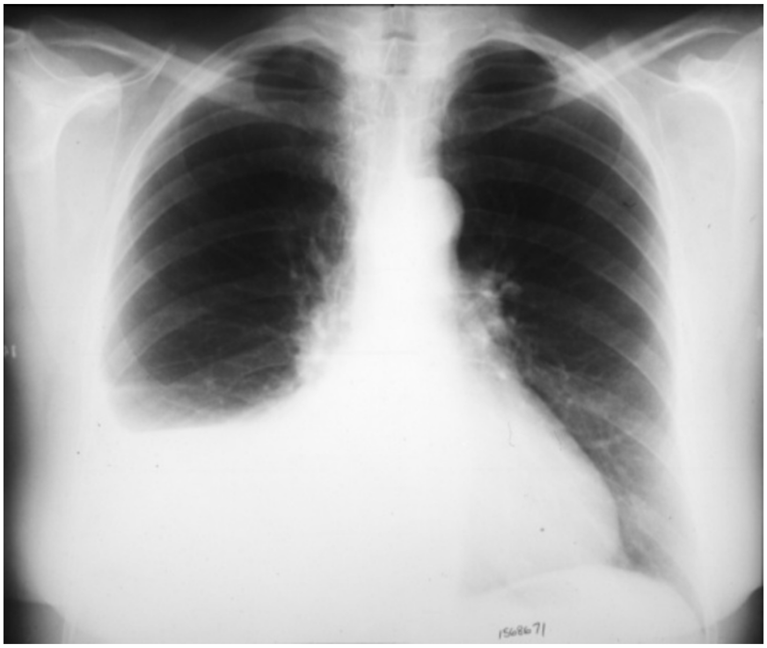


Fig. 6
http://rad.usuhs.mil/rad/handouts/feigin/abnlcxr/case011/top.htm

In Fig. 6, our patient is female, note the low-set breast shadows below the hemidiaphragms. This radiograph is not penetrated well. The clavicles are horizontal and are not rotated. The visualized portion of the trachea is midline. The heart is mildly enlarged. You can see the branches of the right and left pulmonary arteries emanating from the hilum. The cardiophrenic and left costophrenic angles are normal with a normally curved left hemidiaphragm. The base of the right lung is obviously elevated and the space is radiopaque with rounded lung margins, or "meniscus sign." This is typical of a right pleural effusion.

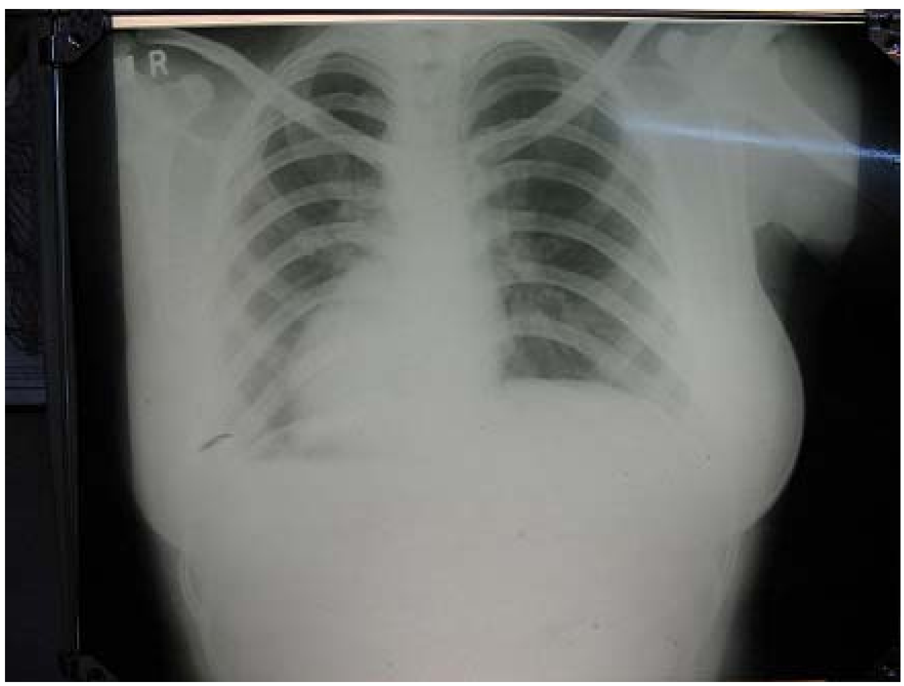


Fig. 7
http://en.wikipedia.org/wiki/File:Dextrocardia.jpg

In Fig. 7, right, we do not know how old our patient is but we know that the patient is female due to the breast shadows below the level of the hemidiaphragms. There is no mal-rotation; however, the arms are not by her side and the clavicles are symmetrically elevated to form a shallow "V." The radiograph is poorly penetrated because the hilar structures and vertebral bodies are not well visualized. The visualized portion of the trachea is midline and the heart is not enlarged. The right hemidiaphragm is lower than the left and the heart shadow is to the right. Ordinarily it would be prudent to flip this film around; however, the radiograph marker clearly is an "R" on the right side of the body. You can see the aortic arch shadow through the tracheal shadow. This is a female patient with dextrocardia.

These are all common things that you may see on a chest radiograph. I have not gone on to cover different anatomical radiographs because they are much more specialized and this is the introduction to interpretation. Using the same principles and understanding of anatomy and pathophysiology, you can practice reading other X-rays. The final installation of this series will include many references available for your learning and clinical use.

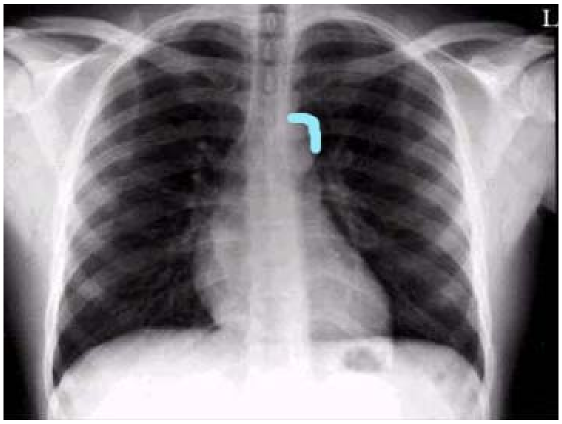
Information for the Patient

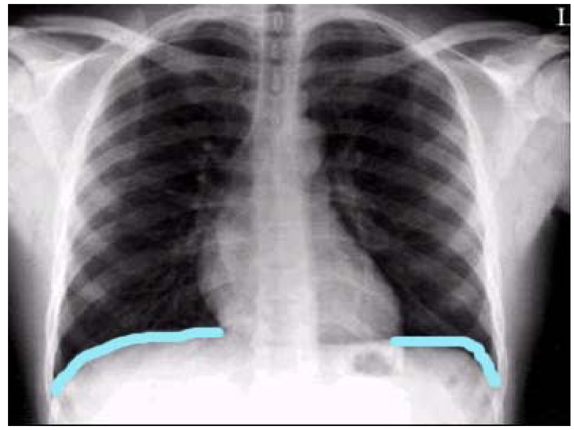
Patients often suffer anxiety regarding any medical procedure. As the APRN, we can reduce stress by providing current information regarding any diagnostic imaging. Here are some points to make for your patients' education[6]:

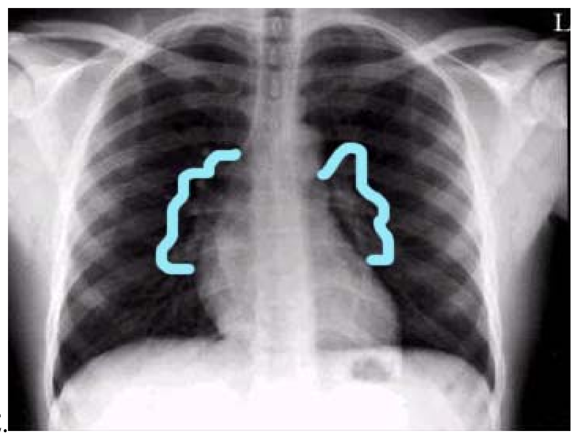
- Chest X-rays are the most commonly performed diagnostic X-ray
- A chest X-ray makes images of the heart, lungs, airways, blood vessels and the bones of the spine and chest
- Imaging with X-rays involves exposing a part of the body to a small dose of radiation
- A chest radiograph is often the first diagnostic imaging for a persistent cough, shortness of breath, chest pain, or fever
- A chest X-ray requires no special preparation
- You must hold very still and may be asked to keep from breathing for a few seconds while the X-ray picture is taken to reduce the possibility of a blurred image
- The chest X-ray is one of the lowest radiation exposure medical examinations performed today. The effective radiation dose from this procedure is about 0.1 mSv, which is about the same as the average person receives from background radiation in 10 days. Women should always tell their technician or radiologist if they are pregnant or think they may be pregnant

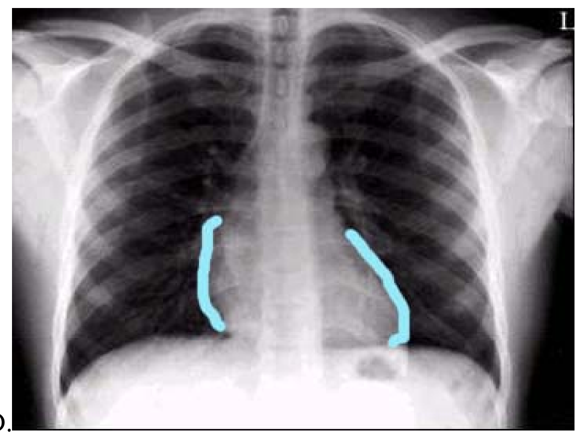
Review
(see answers on page 10)

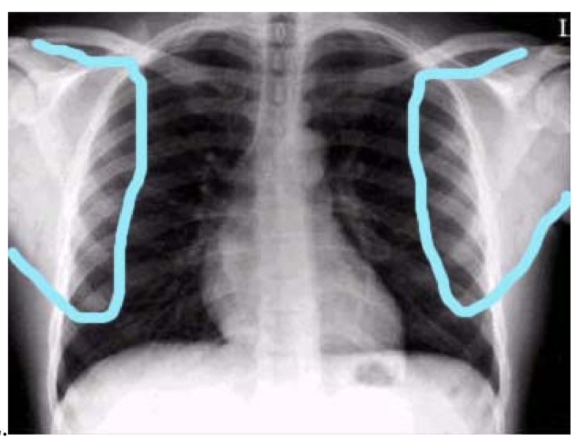
1. Name the following structures:

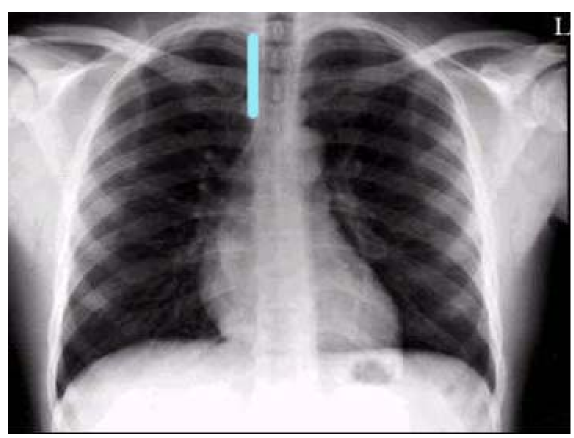
A. 

B. 

C. 

D. 

E. 

F. 

A.
B.
C.

D.
E.
F.

2. Most chest radiographs are taken ________ to _________.
3. You should be able to visualize the _________ ______ through the heart in a well-penetrated chest radiograph.
4. The heart should occupy no more than ½, ¾, or ¼ the distance of the chest on a radiograph?
5. The _____ hemi-diaphragm should be slightly higher than the ____ hemi-diaphragm on a normal CXR.
6. The hemi-diaphragms should lie at the level of the 6^{th}, 7^{th}, or 8^{th} ribs?
7. On the images above, the bubble below the left ventricle is the _______ air bubble.
8. The _________ _______ compromise the right and left hila.
9. The right lung is composed of _____ lobes and the left lung is composed of ___ lobes.
10. These lobes can be identified by their borders, or ________, on a CXR.
11. How are radiographs named in terms of orientation?
12. Radiopaque structures show up denser on a radiograph: true false
13. Radiolucent structures show up denser on a radiograph: true false
14. What are 3 things to check for prior to interpreting a patient's images?
15. What are the 5 categories of opacity seen on a radiograph?
16. What is the densest of the 5 categories?
17. What is the least dense of the 5 categories?
18. Summarize your findings on the CXR below (Fig. 8) in a coherent and comprehensive manner:

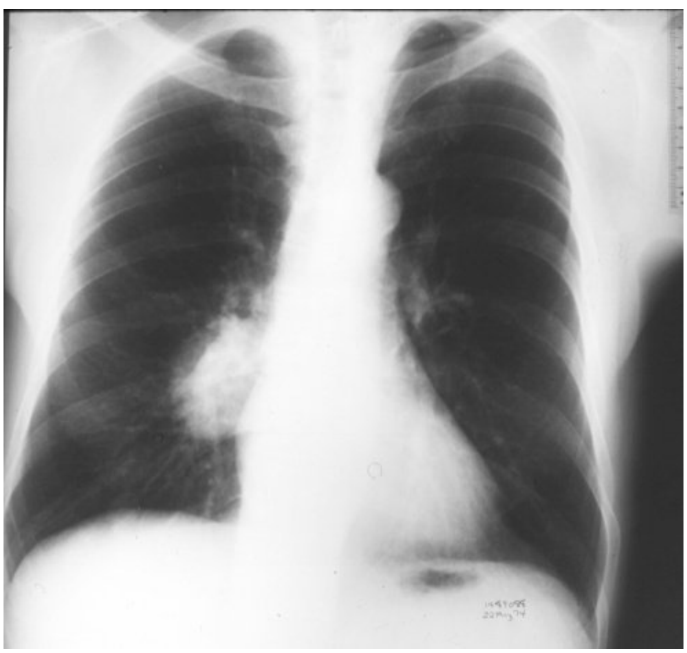


Fig. 8
http://rad.usuhs.mil/rad/handouts/feigin/abnlcxr/case001/top.htm

Answers to Review Questions:

1.A. aortic arch
1.B. hemidiaphragms
1.C. hila
1.D. right atrium and left ventricle or "heart"
1.E. scapula
1.F. SVC
2. posterior, anterior
3. vertebral bodies
4. 1/2
5. right, left
6. 6th
7. gastric
8. pulmonary arteries or pulmonary vessels
9. 3, 2
10. fissures
11. how they enter and then exit the object
12. true
13. false
14. right patient, right date, right exam, right orientation
15. mineral, soft tissue, fat, air, and metal
16. metal
17. air
18. The radiograph is poorly penetrated and slightly rotated. The gastric bubble is seen and the hemidiaphragms are curved normally with normal costophrenic angles. An oval opacity is present in the region of the right hilum. The opacity is a mass because it is reasonably well defined and is not the shape of any anatomic structure of the lung. The borders of the opacity are not entirely composed of fissures or the pleura; only the anterior border lies along a fissure.

References

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