3 Introduction to Radiology Concepts

Objectives:
1. Identify the four (4) naturally occurring densities visible on a conventional radiograph in order from the highest to lowest density.
2. Define and give two examples of the silhouette sign on a frontal chest radiograph.

Radiographic Densities

Let us disregard the anatomy seen on the radiograph for now and concentrate on basic radiographic principles. In Fig. 3.1, you can see examples of the four basic densities, bone, soft tissue, fat, and air, which are visible on a conventional radiograph.

Main Radiographic Densities

1. *Bone* – this is the densest of the four basic densities and appears white or "radiodense" as radiologists prefer to say.
2. *Soft Tissue* – all fluids and soft tissues have the same density on a conventional radiograph. This density is slightly less than the bone but slightly greater than fat. One advantage of CT scanning is that various soft tissues and fluids can be discriminated as different radiographic densities to a much greater degree than conventional radiographs.

J. Kissane et al. (eds.), *Radiology Fundamentals: Introduction to Imaging & Technology*, https://doi.org/10.1007/978-3-030-22173-7_3

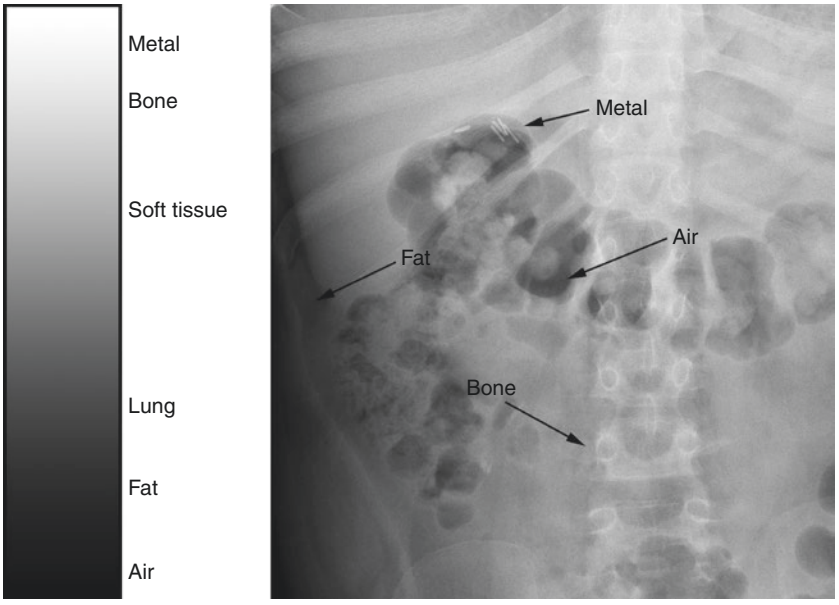

FIGURE 3.1 - RADIOGRAPHIC DENSITIES
Note how the four basic densities are visible on an abdominal radiograph

3. *Fat* – this density may seem the least obvious to you. Fat can be seen interposed between various soft tissue and fluid densities. Abdominal fat allows us to see the edges of various soft tissue structures since the fat is slightly less dense than the organs themselves.
4. *Air* – the lungs, "bowel gas," and the air surrounding the patient are examples of air densities. Air densities are generally quite dark, almost black, on the radiograph. Thus, the lungs are not radiodense but are instead said to be "radiolucent." Why does the air in the lungs appear less black (more radiodense) than the air around the patient? This is because the air density in the lungs is added to the densities of the superimposed chest wall structures.

There is an additional density on some radiographs which may be denser than bone: metal density. This is not included in the above classification because it is not a naturally occurring density. Examples of metallic density on the radiograph include orthopedic hardware, wire sutures in the sternum in patients who have undergone cardiac surgery, and wire leads seen in a pacemaker.

Radiographic densities are normally additive in an arithmetic way. This means that a soft tissue density which is twice as thick as an adjacent soft tissue structure will be twice as white. Conversely, a structure which is half as dense as an adjacent structure but twice as thick will demonstrate an identical radiographic density.

The Silhouette Sign

What is the effect of juxtaposition of structures of varying density upon each other? When two structures of *different densities* are adjacent (i.e., abutting each other), the interface between them will be clearly delineated on the radiograph. For example, the soft tissue density of the heart is clearly delineated from the air density of the lung along the cardiac border. However, when two structures of the *same density* are adjacent or overlapping, their margins cannot be distinguished. For example, when pneumonia fills the alveoli of the right lung with fluid, the lung becomes fluid density, and the normal interface between the right heart border (soft tissue density) and the lung (air) may become invisible; the right heart border can no longer be seen (Fig. 3.2).

This is called the silhouette sign and is one of the most useful principles in radiology.

Other examples of the silhouette sign include the following:

1. The heart cannot be distinguished separately from the blood within the cardiac chambers because both have soft tissue/fluid density.
2. The dome of the liver and the inferior aspect of the right hemidiaphragm cannot be distinguished radiographically since both have soft tissue density. You would

FIGURE 3.2 - THE SILHOUETTE SIGN
Right middle lobe pneumonia illustrates silhouetting of the right heart border by the area of consolidation. Compare to the crisp left heart border

only see the dome of the liver and the right hemidiaphragm separately when free intraperitoneal air is present. This is because the air density is interposed between the two soft tissue densities.

The silhouette sign will be used repeatedly in many sections of this course and in interpreting radiographs clinically. It is very important that you have a clear understanding of this principle.

S: Recognizing densities on conventional imaging may result in cancelling advanced imaging that could cause harm. For example, recognizing metal within the eye on an x-ray would result in cancellation of a brain MRI as the strong magnetic field of the MRI can cause the metal to heat up or migrate, causing blindness.

A: Conventional imaging, such as x-rays of chest, abdomen, and bones, is often the first-line modality to decide if further imaging is needed. ACR Appropriateness Criteria is a good place to start learning about the appropriate order of imaging or if imaging is even necessary.

F: Conventional radiography is dependent on experts such as radiology technologists to acquire images with techniques that allow different densities to be displayed. Improper techniques, large and small patients, or uncooperative patients may contribute to images that are difficult to interpret.

E: Identifying unexpected densities such as air outside of an expected location (pneumothorax or pneumoperitoneum) or metal density such as bullet fragments or foreign bodies will result in appropriate identification and management.