CHAPTER THREE ULTRASOUND

3.0 Goals: Understanding how ultrasound works; its uses, strengths, and weaknesses

Objective questions:

3.1 What is ultrasound?
3.2 How does ultrasound work?
3.3 How is an image created with ultrasound?
3.4 When is ultrasound most useful?
3.5 What are the regions of the body and/or diagnoses best imaged with ultrasound?
3.6 What are safety considerations with ultrasound?
3.7 What are 3D and 4D ultrasound?

3.1 What is ultrasound?

Ultrasound is defined as high-frequency sound waves of 20 thousand to 1 million Hz (cycles per second) or greater. (Each peak in a sound wave represents one cycle.) Diagnostic ultrasound operates between 3.5 and 10 million Hz (3.5 and 10 MHz).

3.2 How does ultrasound work?

Ultrasound is created by the high-frequency vibration of a crystal located in the ultrasound transducer, which is a piece of equipment about the size of a small cell phone that fits easily into the hand. The soft, curved end of the transducer is placed on the patient, and gel is used to improve its contact with the skin. During the scanning process, the crystal is stimulated electronically to vibrate. This occurs in an instant, and the crystal then becomes a listening device for the returning echoes from ultrasound reflected back by body tissues. These returning echoes are converted to a gray scale for the creation of an ultrasound image.

Ultrasound

3.3 How is an image created with ultrasound?

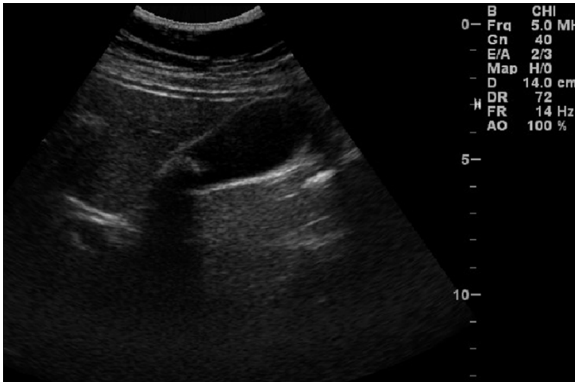
As the ultrasound energy travels through tissues of the body, it is scattered, transmitted, or reflected back to the transducer. Ultrasound that is scattered does not help to create an image. Ultrasound that is transmitted produces an echo-free area on the image. Fluid such as ascites, bile within the gallbladder, and serous water within a cyst all appear as sonolucent (echo-free and black on the film) areas on the ultrasound image. Reflected ultrasound creates a density on the ultrasound image (gray or white on the film). The difference in how much ultrasound a given tissue reflects allows us to see individual structures. For example, the pancreas reflects more ultrasound (is more echogenic) than the liver, the liver reflects more than the spleen, and the spleen reflects more than the kidneys.

Important term 1 "Increased through transmission"

When ultrasound passes through a fluid medium, the intensity of the sound energy is not diminished. Therefore, tissues behind the fluid collection are more echogenic (brighter because there is more acoustic power to reflect back to the transducer).

Important term 2 "Posterior acoustical shadowing"

When ultrasound hits a dense object such as a gallstone and is completely reflected, a posterior acoustical shadow is formed. The gallstone is bright and echogenic. Because no ultrasound energy is left to go beyond the stone, an echo void is created, which appears as a wedge-shaped dark area posterior to the dense object.



Posterior acoustical shadowing (gallstone)

Breast cyst with increase through transmission

Ultrasound

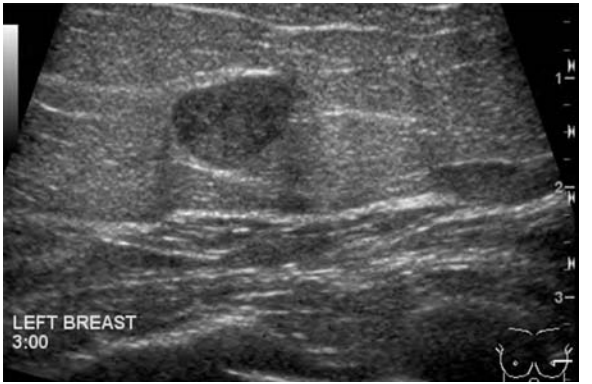
3.4 When is ultrasound most useful?

As a general rule, ultrasound is best at distinguishing the characteristic echo-free appearance seen in fluid collections or cysts. It works best on thin patients and on body parts closest to the skin. Ultrasound does not work well in the presence of gas or air or in larger patients.

3.5 What are the regions of the body and/or diagnoses best imaged with ultrasound?

Appendicitis
Breast
Female pelvis
Gallbladder
Heart
Kidneys
Neonatal brain
Pleural effusion
Pregnancy
Scrotum
Soft tissue masses
Thyroid
Upper abdomen
Vascular structures (venous and arterial)

Cyst—right ovary



Solid left breast nodule

Ultrasound

3.6 What are the safety considerations for ultrasound?

Ultrasound is the safest of all current imaging modalities. There is no magnetic field and no radiation to be concerned about. No harmful effects have been proven when ultrasound is performed at diagnostic frequencies.

3.7 What are 3D and 4D ultrasound?

Three-dimensional ultrasound uses the same principles as 2D ultrasound but adds a position-sensing component to produce the effect of a 3D image. As with CT, 3D imaging is helpful to examine contour. Currently, 3D ultrasound is used primarily in pregnancy ultrasound to provide a snapshot of the fetus. The detail possible with 3D ultrasound is incredible, especially in the delicate facial area, but also in the heart chambers and valves. Four-dimensional ultrasound adds the fourth dimension of time. It is essentially a motion video of the three-dimensional fetus. Diaphragm activity, limb movement, and cardiac motion can be seen clearly in real time.