University of Al-Mustaqbal
College of Science
Department of Medical Physics

Phonetics

Second stage

Ultrasound

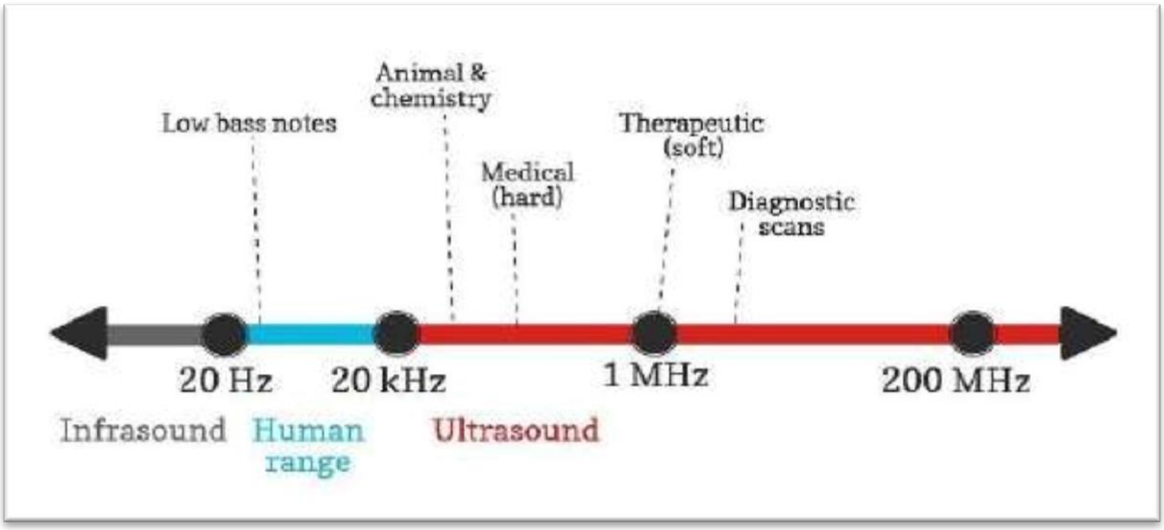
Sixth lecture

Ali Jaafar

2024- 2025

Ultrasound:

They are waves with frequencies higher than the frequency of normal (audible) sound waves. Frequency refers to the number of sound waves emitted by a vibrating body per second. Frequency is measured in units called hertz, and a hertz is one cycle (vibration) per second. The human ear can hear frequencies that fall between 20 - 20,000 Hz. While the ultrasound frequency starts at 20,000 Hz. Scientists have developed a variety of uses for ultrasound in medicine and industry. In addition to high frequencies, these waves have characteristics that distinguish them from the sounds that humans hear. For example, their wavelengths are shorter than audible sound waves, so they are easily reflected when they encounter small obstacles, creating echoes, while longer sound waves pass through these small obstacles with little response. Ultrasound is useful for bats and dolphins, as well as some other animals that can hear frequencies higher than 20,000 Hz. Bats are known to emit short ultrasonic screams that bounce off nearby objects, creating echoes that bats use to locate insects or other materials they eat, and also help them avoid obstacles.



An approximate diagram of the audio frequency range showing the location of ultrasound and some applications

How do ultrasound devices work?

Ultrasound devices consist of the following main parts: probe, pulse control unit, central control unit, display screen, keyboard, mouse, storage unit, printer. The ultrasound device sends waves in the form of high-frequency pulses of the range (1-5) MHz through the probe to the part to be examined. These impulses penetrate the human body at different depths and then return successively to the sensor after being reflected from the boundaries separating the components of the body, such as the boundary separating the skin and bone layers or the fluids between the layers of the skin. . After calculating the distance traveled by the waves inside the human body by the device based on the constant speed of the waves in the body, which is (1540) meters/second, and the time taken, which is usually in the range of (6 - 10) seconds. The device can form an image on the screen through the two-dimensional relationship between the intensity of the reflected signal and the distance traveled. In one imaging session, millions of pulses are sent to the human body. It is possible to obtain different images by moving the sensor from one location to another. Ultrasound can be explained as follows:

2D image of a fetus

2D animated image of a fetus

Two-dimensional imaging devices are what we have discussed so far. There are two other types of ultrasound devices that use the same previous techniques:

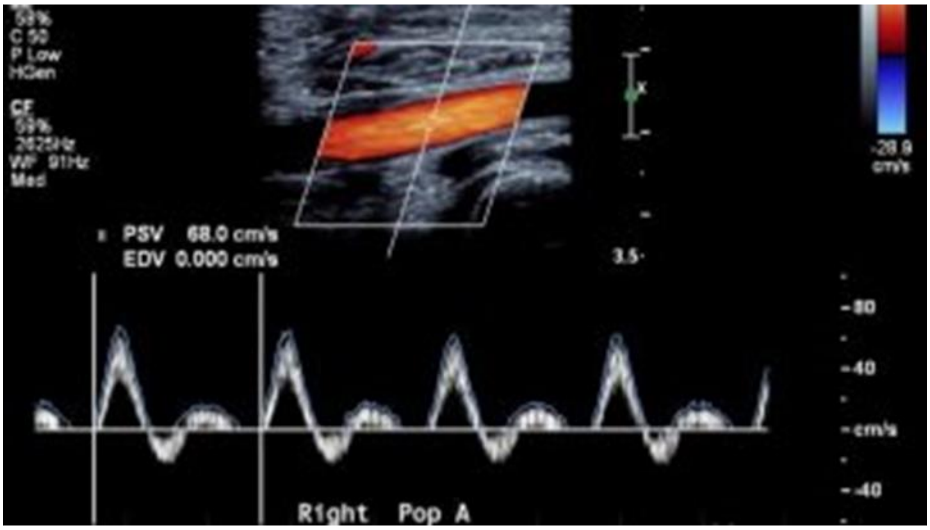
3D imaging devices:

The idea in this type of imaging is to take several pictures of the part to be examined by moving the probe around it, and then these pictures are collected using a computer to produce a three-dimensional three-dimensional image.

3D ultrasound image of a six-month-old baby

Doppler ultrasound devices:

This type of device relies on the Doppler phenomenon, as is clear from its name, as it is possible to measure the speed of blood flowing from the heart to the arteries and blood vessels by calculating the frequency difference between the incident and reflected waves, as the incident waves change their frequency when they are reflected from moving parts.



Vascular Doppler

Medical ultrasound is divided into two distinct categories:

• Diagnostic ultrasound:

It is a non-invasive diagnostic technique used to image the inside of the body. Ultrasound sensors, called transducers, produce waves that have frequencies above 20 kHz, but most of the transducers currently in use operate at much higher frequencies (in the megahertz range). Diagnostic ultrasound sensors are placed on the skin. However, to improve image quality, probes can be placed inside the body via the digestive tract, vagina, or blood vessels. In addition, ultrasound is sometimes used during surgery by placing a sterile probe in the area where the procedure is being performed. Diagnostic ultrasound can also be divided into anatomical and functional ultrasound. Anatomical ultrasound produces images of internal organs or other structures. Functional ultrasound collects information such as the movement and velocity of blood, softness or hardness of tissue, and other physical properties. By combining both types, information maps can be created. They help doctors visualize changes or differences in function within a structure or organ.

Therapeutic ultrasound:

This type of wave does not produce an image and its purpose is to interact with tissues in the body so that they are modified or destroyed. Possible modifications include: moving or pushing tissue, heating tissue, dissolving blood clots, and delivering medications to specific locations in the body. Destruction and resection are made possible through the use of high-intensity beams that can destroy diseased or abnormal tissue such as tumors. The advantage of using ultrasound therapy is that in most cases it is non-surgical and there is no need to make incisions in the skin, that is, without leaving wounds or scars.

Benefits versus risks:

Most ultrasound examinations are uncomfortable but painless because they do not require surgical intervention (needles or injections). Ultrasound is widely used and less expensive compared to other imaging methods, in addition to being very safe and does not expose patients to any ionizing radiation like other imaging methods. Soft tissues can be clearly visible on ultrasound examinations that are not well visible on X-ray examinations, and ultrasound examinations are also the best method for follow-up and diagnosis during pregnancy. The real-time imaging advantage provided by ultrasound makes it a useful tool for minimally invasive medical techniques such as fluid aspiration and needle biopsy.

Although no pathological cases have been recorded with ultrasound examination so far, however, it is recommended to use it only when necessary to avoid exposing parts of the human body to the high energy generated by ultrasound, which is easily absorbed by water in living tissues. Which leads to an increase in the local temperature in the area exposed to ultrasound. Studies have also indicated that women who use ultrasound as physical therapy are more susceptible to premature birth or miscarriage. It should be noted that some studies indicate that prolonged exposure to ultrasound may have biological effects at the cellular level within the human body.

Limitations of ultrasound imaging:

Gas or air are considered not good media for transmitting ultrasound waves, so it is not an ideal technique for imaging parts filled with air, such as the intestines or an organ obscured by the intestine, as well as the lungs, because they are filled with air, but it is good for detecting fluids in and around the lungs. Ultrasound imaging of large patients is difficult because there are larger amounts of tissue and therefore the waves will travel greater distances within the body, which leads to a weakening of the energy of the waves reflected back to the sensor.

It can be used to view the outside of the bone and thus it can image the tissues around the bone in addition to identifying fractures, but it cannot image the inside of the bone because it has difficulty penetrating it (except in children because they have more cartilage in their bones than older children or adults). Doctors often use other imaging methods, such as MRI, to visualize the internal structures of specific bones or joints.