Ultrasound

What is an Ultrasound?

Ultrasound refers to a sound wave with a frequency greater than the upper limit of human hearing, which is generally over 20 kHz.
In general, humans can hear sounds with a frequency between 20 Hz and 20 kHz.
Any sound with a frequency higher than 20,000 hertz (20 kHz = 20,000 cycles of oscillation per second) cannot be sensed by a human's ear. Among audible sounds not higher than 20 kHz, those not intended to be heard by humans have also come to be called ultrasound.

Some animals including bats and dolphins rely on ultrasound to live.
Bats emit ultrasound from their mouths and receive its echo. From the time interval between sending the sound and receiving the echo as well as the angle of the echo received, they can determine the distance to targets and their location. Bats can thus sense the terrain and detect their prey.
Similarly dolphins use ultrasound to capture the surrounding conditions and communicate with their peers.

History

Acoustics, the science of sound, starts as far back as Pythagoras in the 6th century BC, who wrote on the mathematical properties of stringed instruments. Echolocation in bats was discovered by Lazzaro Spallanzani in 1794, when he demonstrated that bats hunted and navigated by inaudible sound and not vision.

Francis Galton in 1893 invented the Galton whistle, an adjustable whistle which produced ultrasound, which he used to measure the hearing range of humans and other animals, demonstrating that many animals could hear sounds above the hearing range of humans. The first technological application of ultrasound was an attempt to detect submarines by Paul Langevin in 1917. The piezoelectric effect, discovered by Jacques and Pierre Curie in 1880, was useful in transducers to generate and detect ultrasonic waves in air and water.

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What are some common uses of the Procedure?

Ultrasound examinations can help to diagnose a variety of conditions and to assess organ damage following illness.

Ultrasound is used to help physicians evaluate symptoms such as:

- pain
- swelling
- infection

Ultrasound is a useful way of examining many of the body's internal organs, including but not limited to the:

- heart and blood vessels, including the abdominal aorta and its major branches
- liver
- gallbladder
- spleen
- pancreas
- kidneys
- bladder
- uterus, ovaries, and unborn child (fetus) in pregnant patients
- eyes
- thyroid and parathyroid glands
- scrotum (testicles)
- brain in infants
- hips in infants
- spine in infants

Ultrasound is also used to:

- guide procedures such as needle biopsies, in which needles are used to sample cells from an abnormal area for laboratory testing.
- image the breasts and guide biopsy of breast cancer
- diagnose a variety of heart conditions, including valve problems and congestive heart failure, and to assess damage after a heart attack. Ultrasound of the heart is commonly called an “echocardiogram” or “echo” for short.

Doppler ultrasound images can help the physician to see and evaluate:

- blockages to blood flow (such as clots)
- narrowing of vessels
- tumors and congenital vascular malformations
- reduced or absent blood flow to various organs

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- greater than normal blood flow to different areas, which is sometimes seen in infections

With knowledge about the speed and volume of blood flow gained from a Doppler ultrasound image, the physician can often determine whether a patient is a good candidate for a procedure like angioplasty.

How does the Procedure Work?

Ultrasound imaging is based on the same principles involved in the sonar used by bats, ships and fishermen. When a sound wave strikes an object, it bounces back, or echoes. By measuring these echo waves, it is possible to determine how far away the object is as well as the object's size, shape and consistency (whether the object is solid or filled with fluid).

In medicine, ultrasound is used to detect changes in appearance, size or contour of organs, tissues, and vessels or to detect abnormal masses, such as tumors.

In an ultrasound examination, a transducer both sends the sound waves into the body and receives the echoing waves. When the transducer is pressed against the skin, it directs small pulses of inaudible, high-frequency sound waves into the body. As the sound waves bounce off internal organs, fluids and tissues, the sensitive receiver in the transducer records tiny changes in the sound's pitch and direction. These signature waves are instantly measured and displayed by a computer, which in turn creates a real-time picture on the monitor. One or more frames of the moving pictures are typically captured as still images. Short video loops of the images may also be saved.

Doppler ultrasound, a special application of ultrasound, measures the direction and speed of blood cells as they move through vessels. The movement of blood cells causes a change in pitch of the reflected sound waves (called the Doppler effect). A computer collects and processes the sounds and creates graphs or color pictures that represent the flow of blood through the blood vessels.

How is the Procedure Performed?

For most ultrasound exams, you will be positioned lying face-up on an examination table that can be tilted or moved. Patients may be turned to either side to improve the quality of the images.

After you are positioned on the examination table, the radiologist (a physician specifically trained to supervise and interpret radiology examinations) or sonographer will apply a warm water-based gel to the area of the body being studied. The gel will help the transducer make secure contact with the body and eliminate air pockets between the transducer and the skin that can block the sound waves from passing into your body. The transducer is placed on the body and moved back and forth over the area of interest until the desired images are captured.

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There is usually no discomfort from pressure as the transducer is pressed against the area being examined. However, if scanning is performed over an area of tenderness, you may feel pressure or minor pain from the transducer.

Doppler sonography is performed using the same transducer.

Rarely, young children may need to be sedated in order to hold still for the procedure. Parents should ask about this beforehand and be made aware of food and drink restrictions that may be needed prior to sedation.

Once the imaging is complete, the clear ultrasound gel will be wiped off your skin. Any portions that are not wiped off will dry quickly. The ultrasound gel does not usually stain or discolor clothing.

In some ultrasound studies, the transducer is attached to a probe and inserted into a natural opening in the body. These exams include:

- **Transesophageal echocardiogram.** The transducer is inserted into the esophagus to obtain images of the heart.
- **Transrectal ultrasound.** The transducer is inserted into a man's rectum to view the prostate.
- **Transvaginal ultrasound.** The transducer is inserted into a woman's vagina to view the uterus and ovaries.

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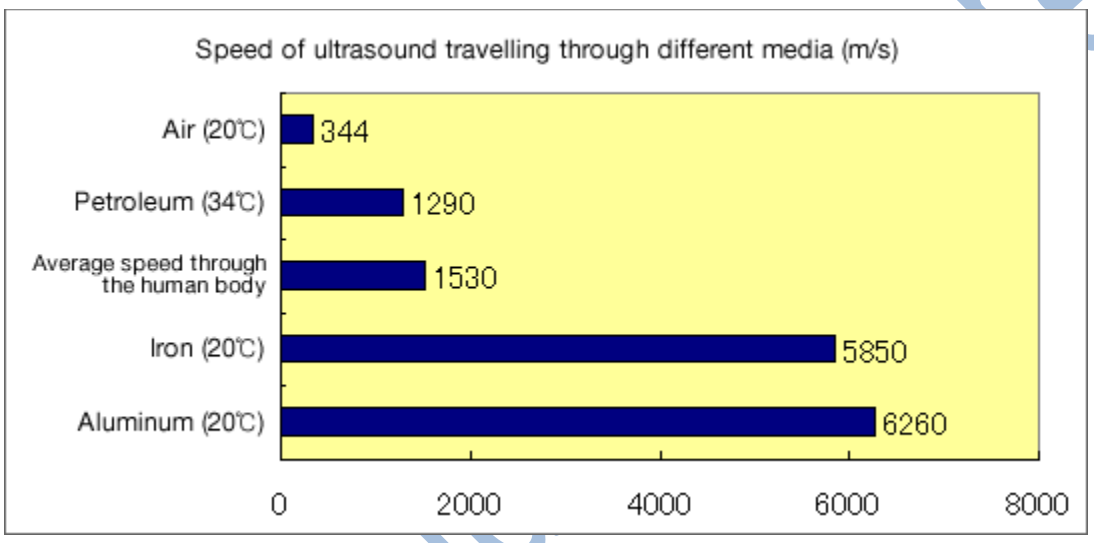
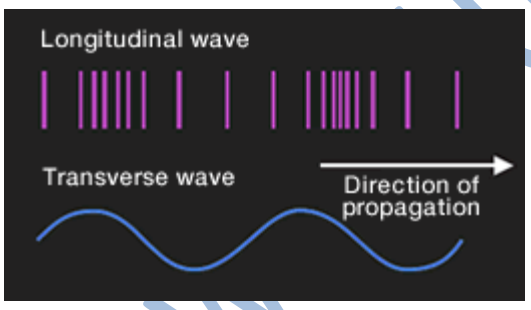
Major Properties of Ultrasound

Ultrasound travels through various media including gases, liquids and solids, but cannot travel through a vacuum. The speed of sound varies by the medium it travels through. Sound is likely to travel faster through solids, followed by liquids and gases.
For example, the speed of sound in the air is about 340 meters per second (m/s). That in water is about 1530 m/s and that in iron as high as about 5,850 m/s.
Another typical property of sound is that its energy is more likely to be lost in gases while it travels through liquids or solids more efficiently.





The type of sound waves also depends on the medium. Sound travels through the air and liquids as longitudinal waves (i.e., waves vibrating in the same direction as that of propagation). Through solids, however, it can be transmitted as both longitudinal waves and transverse waves (i.e., waves vibrating at the right angle to the direction of propagation) as well as surface waves.

Ultrasound travels in a very straight line. An ultrasonic wave is reflected when it strikes an interface between materials with different speeds of sound (acoustic impedance). Furthermore, an interface between materials with a larger difference in acoustic impedance reflects ultrasonic waves more strongly and that with a smaller difference in acoustic impedance reflects them less strongly and lets part of them travel through.

For example, the human body consists of a variety of cells and tissues with their acoustic impedance different from each other. Ultrasonic waves striking these cells or tissues are reflected differently. Using the difference in energy level of the echoes makes it possible to image the internal tissues of the body.
Ultrasonic waves are gradually attenuated to become weaker while travelling through the medium. Those with a higher frequency show a higher attenuation factor.

What are the Benefits vs. Risks?

Benefits

- Most ultrasound scanning is noninvasive (no needles or injections).
- Occasionally, an ultrasound exam may be temporarily uncomfortable, but it should not be painful.
- Ultrasound is widely available, easy-to-use and less expensive than other imaging methods.
- Ultrasound imaging is extremely safe and does not use any ionizing radiation.
- Ultrasound scanning gives a clear picture of soft tissues that do not show up well on x-ray images.
- Ultrasound is the preferred imaging modality for the diagnosis and monitoring of pregnant women and their unborn babies.
- Ultrasound provides real-time imaging, making it a good tool for guiding minimally invasive procedures such as needle biopsies and fluid aspiration.

Risks

- For standard diagnostic ultrasound, there are no known harmful effects on humans.

Reference

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www.wikipedia.org

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