

م. ساره حامد دانه

كلية المستقبل الجامعة

قسم الفيزياء الطبية

مختبر الفيزياء الطبية

مرحلة رابعة

تجربة

(( Ultrasound scan ))

د. نور الهدى طالب

م. ساره حامد دانه

## Ultrasound scan

**An ultrasound scan, sometimes called a sonogram, is a procedure that uses high-frequency sound waves to create an image of part of the inside of the body.**

An ultrasound scan can be used to monitor an unborn baby, diagnose a condition, or guide a surgeon during certain procedures

### How ultrasound scans work

A small device called an ultrasound probe is used, which gives off high-frequency sound waves.

You can't hear these sound waves, but when they bounce off different parts of the body, they create "echoes" that are picked up by the probe and turned into a moving image.

This image is displayed on a monitor while the scan is carried out.

### What is Ultrasound?

**Ultrasound** or **ultrasonography** is a medical imaging technique that uses high frequency sound waves and their echoes. The technique is similar to the echolocation used by bats, whales and dolphins, as well as SONAR used by submarines. In ultrasound, the following events happen:

1. The ultrasound machine transmits high-frequency (1 to 5 megahertz) sound pulses into your body using a probe.
2. The sound waves travel into your body and hit a boundary between tissues (e.g. between fluid and soft tissue, soft tissue and bone).
3. Some of the sound waves get reflected back to the probe, while some travel on further until they reach another boundary and get reflected.
4. The reflected waves are picked up by the probe and relayed to the machine.

5. The machine calculates the distance from the probe to the tissue or organ (boundaries) using the speed of sound in tissue (5,005 ft/s or 1,540 m/s) and the time of the each echo's return (usually on the order of millionths of a second).
6. The machine displays the distances and intensities of the echoes on the screen, forming a two dimensional image like the one shown below.



**Ultrasound image of a growing fetus (approximately 12 weeks old) inside a mother's uterus. This is a side view of the baby, showing (right to left) the head, neck, torso and legs.**

In a typical ultrasound, millions of pulses and echoes are sent and received each second. The probe can be moved along the surface of the body and angled to obtain various views.

## The Ultrasound Machine

A basic ultrasound machine has the following parts:

- **transducer probe** - probe that sends and receives the sound waves
- **central processing unit (CPU)** - computer that does all of the calculations and contains the electrical power supplies for itself and the transducer probe
- **transducer pulse controls** - changes the amplitude, frequency and duration of the pulses emitted from the transducer probe
- **display** - displays the image from the ultrasound data processed by the CPU
- **keyboard/cursor** - inputs data and takes measurements from the display
- **disk storage device** (hard, floppy, CD) - stores the acquired images
- **printer** - prints the image from the displayed data



Ultrasound machine with various transducer probes

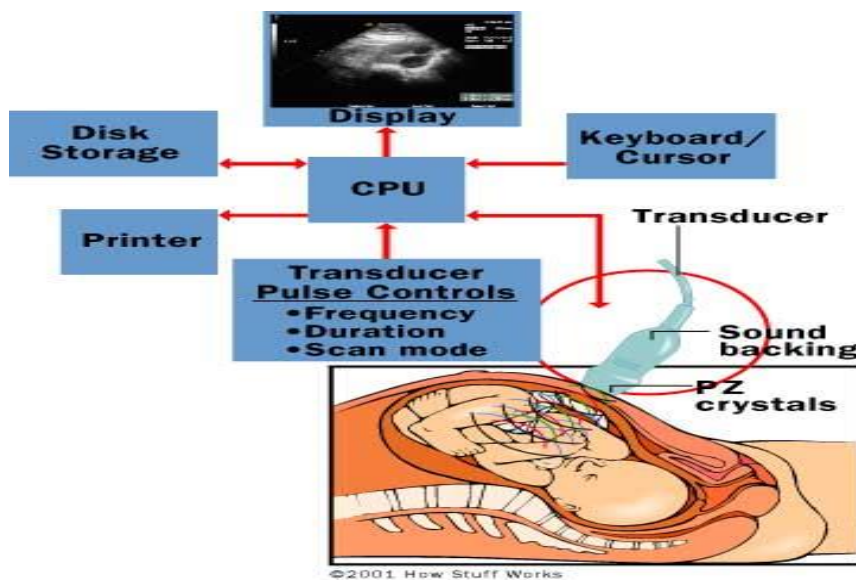
### Transducer Probe

The transducer probe is the main part of the ultrasound machine. The transducer probe makes the sound waves and receives the echoes. It is, so to speak, the mouth and ears of the ultrasound machine. The transducer probe generates and receives sound waves using a principle called the **piezoelectric (pressure electricity) effect**, which was discovered by Pierre and Jacques Curie in 1880. In the probe, there are one or more quartz crystals called **piezoelectric crystals**. When an electric current is applied to these crystals, they change shape rapidly. The rapid shape changes, or vibrations, of the crystals produce sound waves that travel outward. Conversely, when sound or pressure waves hit the crystals, they emit electrical currents.

Therefore, the same crystals can be used to .

send and receive sound waves. The probe also has a sound absorbing substance to eliminate back reflections from the probe itself, and an acoustic lens to help focus the emitted sound waves.

Transducer probes come in many shapes and sizes, as shown in the photo above. The shape of the probe determines its field of view, and the frequency of emitted sound waves determines how deep the sound waves penetrate and the resolution of the image. Transducer probes may contain one or more crystal elements; in multiple-element probes, each crystal has its own circuit. Multiple-element probes have the advantage that the ultrasound beam can be "steered" by changing the timing in which each element gets pulsed; steering the beam is especially important for cardiac ultrasound (see Basic Principles of Ultrasound for details on transducers). In addition to probes that can be moved across the surface of the body, some probes are designed to be inserted through various openings of the body (vagina, rectum, esophagus) so that they can get closer to the organ being examined (uterus, prostate gland, stomach); getting closer to the organ can allow for more detailed views.



The parts of an ultrasound machine

### Central Processing Unit (CPU)

The CPU is the brain of the ultrasound machine. The CPU is basically a computer that contains the microprocessor, memory, amplifiers and power supplies for the microprocessor and transducer probe. The CPU

sends electrical currents to the transducer probe to emit sound waves, and also receives the electrical pulses from the probes that were created from the returning echoes. The CPU does all of the calculations involved in processing the data. Once the raw data are processed, the CPU forms the image on the monitor. The CPU can also store the processed data and/or image on disk.

### **Transducer Pulse Controls**

The transducer pulse controls allow the operator, called the **ultrasonographer**, to set and change the frequency and duration of the ultrasound pulses, as well as the scan mode of the machine. The commands from the operator are translated into changing electric currents that are applied to the piezoelectric crystals in the transducer probe.

### **Display**

The display is a computer monitor that shows the processed data from the CPU. Displays can be black-and-white or color, depending upon the model of the ultrasound machine.

### **Keyboard/Cursor**

Ultrasound machines have a keyboard and a cursor, such as a trackball, built in. These devices allow the operator to add notes to and take measurements from the data.

### **Disk Storage**

The processed data and/ or images can be stored on disk. The disks can be hard disks, floppy disks, compact discs (CDs) or digital video discs (DVDs). Typically, a patient's ultrasound scans are stored on a floppy disk and archived with the patient's medical records.

### **Printers**

Many ultrasound machines have thermal printers that can be used to capture a hard copy of the image from the display.

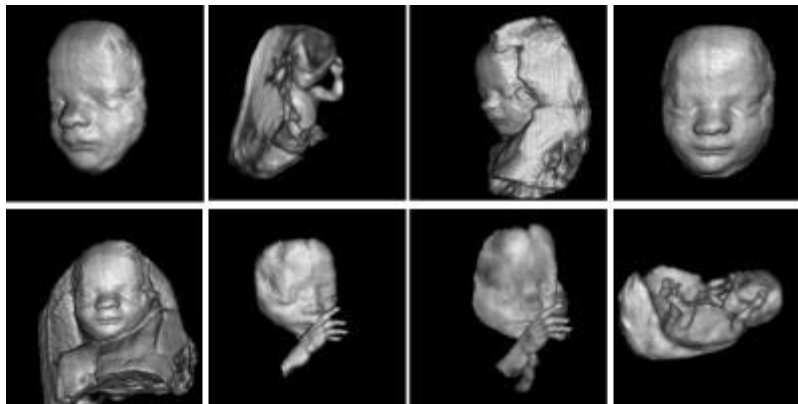
## Different Types of Ultrasound

1-3D Ultrasound Imaging

2- Doppler Ultrasound

### 3D Ultrasound Imaging

several two-dimensional images are acquired by moving the probes across the body surface or rotating inserted probes. The two-dimensional scans are then combined by specialized computer software to form 3D images.



3D ultrasound images

3D imaging allows you to get a better look at the organ being examined and is best used for:

- Early detection of cancerous and benign tumors
  - examining the prostate gland for early detection of tumors
  - looking for masses in the colon and rectum
  - detecting breast lesions for possible biopsies
- Visualizing a fetus to assess its development, especially for observing abnormal development of the face and limbs
- Visualizing blood flow in various organs or a fetus

## **Doppler Ultrasound**

Doppler ultrasound is based upon the Doppler Effect. When the object reflecting the ultrasound waves is moving, it changes the frequency of the echoes, creating a higher frequency if it is moving toward the probe and a lower frequency if it is moving away from the probe. How much the frequency is changed depends upon how fast the object is moving. Doppler ultrasound measures the change in frequency of the echoes to calculate how fast an object is moving. Doppler ultrasound has been used mostly to measure the rate of blood flow through the heart and major arteries.



**Doppler ultrasound used to measure blood flow through the heart. The direction of blood flow is shown in different colors on the screen.**

## **Major Uses of Ultrasound**

Ultrasound has been used in a variety of clinical settings, including obstetrics and gynecology, cardiology and cancer detection. The main advantage of ultrasound is that certain structures can be observed without using radiation. Ultrasound can also be done much faster than X-rays or other radiographic techniques. Here is a short list of some uses for ultrasound:



- **Obstetrics and Gynecology**
  - measuring the size of the fetus to determine the due date
  - determining the position of the fetus to see if it is in the normal head down position or breech
  - checking the position of the placenta to see if it is improperly developing over the opening to the uterus (cervix)
  - seeing the number of fetuses in the uterus
  - checking the sex of the baby (if the genital area can be clearly seen)
  - checking the fetus's growth rate by making many measurements over time
  - detecting ectopic pregnancy, the life-threatening situation in which the baby is implanted in the mother's Fallopian tubes instead of in the uterus
  - determining whether there is an appropriate amount of amniotic fluid cushioning the baby
  - monitoring the baby during specialized procedures - ultrasound has been helpful in seeing and avoiding the baby during amniocentesis (sampling of the amniotic fluid with a needle for genetic testing). Years ago, doctors use to perform this procedure blindly; however, with accompanying use of ultrasound, the risks of this procedure have dropped dramatically.
  - seeing tumors of the ovary and breast
- **Cardiology**
  - seeing the inside of the heart to identify abnormal structures or functions
  - measuring blood flow through the heart and major blood vessels
- **Urology**
  - measuring blood flow through the kidney
  - seeing kidney stones
  - detecting prostate cancer early

In addition to these areas, there is a growing use for ultrasound as a rapid imaging tool for diagnosis in emergency rooms

## Dangers of Ultrasound

- development of heat - tissues or water absorb the ultrasound energy which increases their temperature locally
- formation of bubbles (**cavitation**) - when dissolved gases come out of solution due to local heat caused by ultrasound

However, there have been no substantiated ill-effects of ultrasound documented in studies in either humans or animals. This being said, ultrasound should still be used only when necessary (i.e. better to be cautious).