Physics of Sound & Ultrasound/ Part2

6. Mechanism of ultrasound imaging:

1- The vibrating crystal is placed in close contact with the body by using a jelly paste or water.

The advantage of the jelly paste are:

a. To eliminate the air and give a good coupling at the surface of the skin.
b. Increase the transmission of ultrasound into the body and of the echoes to the detector

2- The basis of ultrasound imaging is the partial of reflection of sound at the surface of the media that have different acoustical properties, **the amount of reflection depends on:**

a. The difference in the acoustical impedance of the two materials, for good reflection Z_2 must be greater than Z_1

b. The orientation of the surface with respect to the beam (angle of incident). The perpendicular surface gives more intense beam.

c. No obstructions in the path way of the ultrasonic beam.

3- For the medical diagnosis, the ultrasound source gives a beam of (1-20) MHz, the time required for the sound to be reflected give information on the distance about various organs on the path of the ultrasound beam

7. Types of ultrasound modes:

7.1. A- scan (Amplitude scan):

a. It is used to obtain diagnostic information about the depth of tissue.

b. The ultrasound pulses emitted from the source at 400-1000 pulse/ sec.

c. As the pulse passes through the body it is reflected to the transducer from each tissue interface.

d. The time required for the reflected pulse (echo) is measured. The depth of the interface recorded is proportional to the time it takes for the echo to return.

Depth= Velocity x time

- Using a sound velocity of **1540 m/sec** in average soft tissue, the echo takes 13 µsec at a depth of 1 cm

f. The body and the transducer are stationary.

g. One transducer is used.

h. It gives one dimensional image.

i. The echoes are displayed as a vertical deflection; its height is proportional to the intensity of the detected echoes

7.2. Applications of A- mode scan:

1. Echo encephalography:

- It is used in the detection of brain tumors.

- Pulses of ultrasound are sent to a thin region of the skull above the ear and the echoes from different structures are displayed on the oscilloscope.

- Compare the echoes from the left side of the head to the right side, and find the shift in the middle structure:-

- If the shift > 3 mm for an adult → **abnormal**

- If the shift > 2 mm for a child → **abnormal**

Echo encephalography

2. Opthalmology:

- It is used ultrasound frequencies of up to 20 MHz, this high frequency is used because:

a. It gives good resolution.
b. It isn't hazard because there is no bone in the eye.

In this case the A- mode is used for:

- The diagnosis of the eye tumors, foreign bodies and detachment of retina.

- It is used in **biometry** (measurements of the distances in the eye e.g. lens thickness, depth from the cornea to the eye lens)

7.3. B- mode scan (Brightness scan):

- It provides two dimensional cross-sectional image.

- The transducer is moved in continuous motion in scanning across the abdomen.

- The echoes displayed as illuminating spots, the brightness of the illuminating spots is proportional to the amplitude of echoes.

7.4. The applications of the B- mode

- Diagnosis of the eye, liver, and the heart.

- It can detect pregnancy as early as fifth weeks.

- It can provide information about uterine anomalies.

- It can provide informations about the size, location and change with time of a fetus in normal deliveries, abnormal bleeding and threatened abortion.

3. Gray scale mode:

- It can display the great variation of the echoes amplitudes so that large echoes appear brighter than weak echoes.

- It was used to show the tumors in the liver.

7.5. Ultrasound to measure motion:

1- M- (motion) scan.
2- Doppler technique.

M- (Motion scan):

- It is combined of A- scan and B- scan.

- The transducer is stationary as in A- scan and the echoes appear as dots as in B- scan.

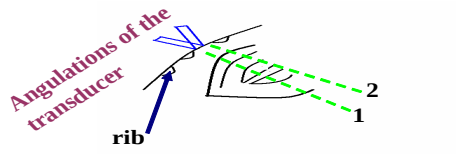
- It is used to study the motion of the heart and heart valves.

7.6. Applications of M- scan:

a. M- scan of the mitral valve.
b. Accumulation of fluids in the heart sac (pericardial effusion)

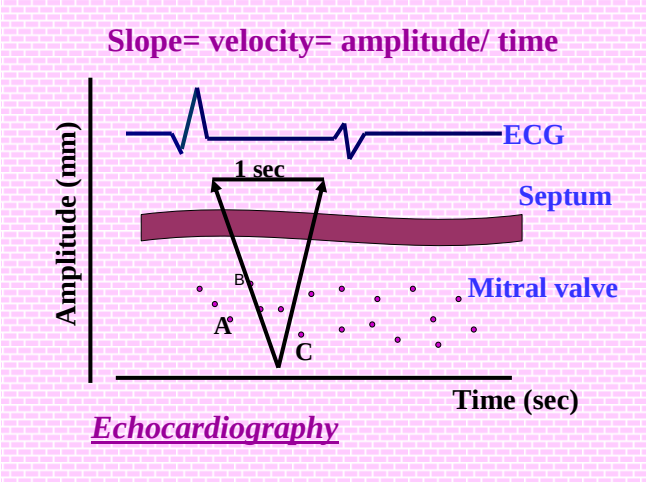
M- scan of the mitral valve.

- The transducer is put on the patient left side, between the ribs over the heart, and tip it at different angles to explore various regions of the heart (because of the poor transmission of ultrasound the lung tissue and bone)



- The mitral valve is usually found at depth of (5-8.5 cm) from the chest wall.

- The rate of closing the mitral valve for the normal value is 72 mm/sec, below 35 mm/sec indicating ***(mitral stenosis)***. The slower the rate of closer indicates a large amount of stenosis.



Doppler technique

The Doppler Effect is the perceived frequency of sound emitted by a moving source. The doppler technique is used for:

a. Study the blood motion in the circulatory system.

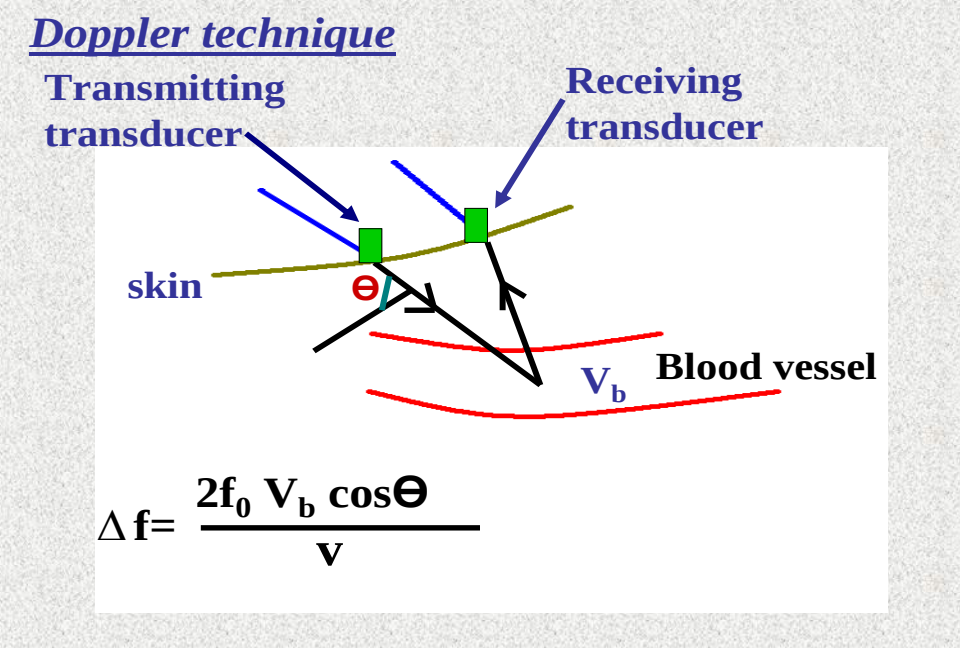
- Two transducers are used in the audio mode, one as a transmitter and the other as a receiver.

- Continuous ultrasound wave is sending to the artery with a frequency ***(f_0).***

- The blood moves with a speed **Vb** at an angle **Θ** from the direction of the sound waves of speed.

- When the fetal heart is moving a variation in the frequency give the fetal heart rate.

- The output can be audible or displayed on an oscilloscope.



b. The doppler technique is also used to locate the point of the entry of the umbilical cord into the placenta to detect if there is bleeding due to misplaced placenta or if there is an intrauterine transfusion for Rh incompatibility