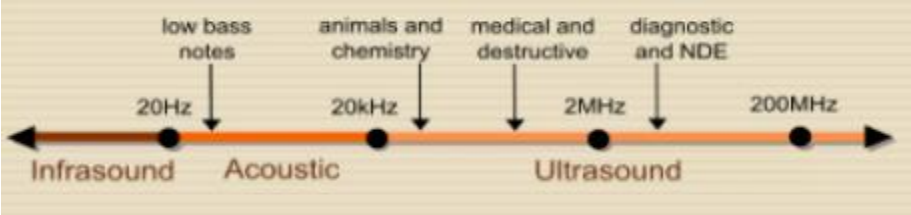
Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Msc. Forqan Ali Wahhab
Lecture: Ultrasound Imaging

1. Ultrasound

- Ultrasound is sound waves with frequencies higher than the upper audible limit of human hearing.
- Ultrasound is a way of using sound waves to look the human body.
- This limit varies from person to person and is approximately 20 kilohertz (20,000 hertz) in healthy young adults.



- Ultrasound devices operate with frequencies from 20 kHz up to several gigahertz.
- Ultrasound is used in many different fields. Ultrasonic devices are used to detect objects and measure distances. Ultrasound imaging or sonography is often used in medicine. In the nondestructive testing of products and structures, ultrasound is used to detect invisible flaws. Industrially, ultrasound is used for cleaning, mixing, and accelerating chemical processes. Animals such as bats and porpoises use ultrasound for locating prey and obstacles.

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- All professional ultrasound scanners will use ultrasound gel at time of scanning. The purpose of this acoustic couplant is to allow the ultrasound waves to pass into the body without reflecting off intervening air.

2. The part of Ultrasound

A basic ultrasound machine has the following parts:

- transducer probe : probe that sends and receives the sound waves using a principle called the piezoelectric (pressure electricity) effect.

  Types of probes:

  1. Linear Probe: it uses a high sound frequency of 7 MHz and produces parallel linear sound waves to visualize the surface parts of the body such as the thyroid gland.

  2. Curved probes: The frequency of the sound waves used in it ranges from 2-5 MHz to enable it to enter deeper areas in the body such as the abdominal organs of the liver and kidneys.

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3. The probe used for 3D imaging: The array probe's wave frequency is between 1-3 MHz, it performs imaging in two different directions with high quality at the same time, or stereoscopic images of the body's organs or the fetus at the same moment.

- 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.

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- printer : prints the image from the displayed data.

3. The scanning modes

1. Bistable scanning:

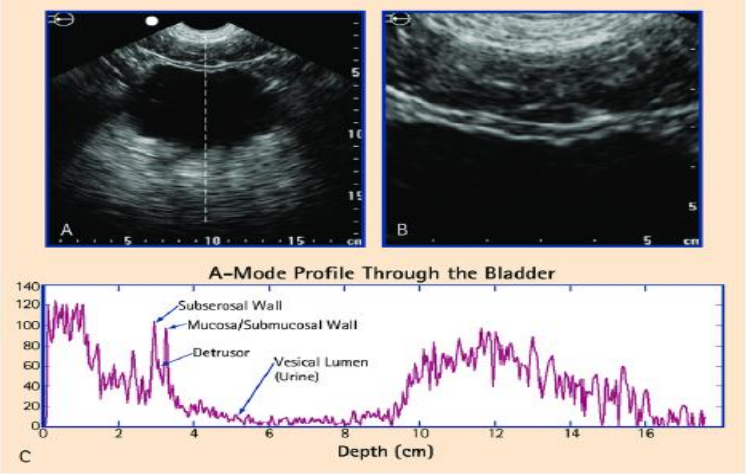
Display images in black and white.

2. Gray scale imaging:

is commonly used in which an analog to digital scan converter transfers information from the receiver to the computer. Multiple shades of grey enhance tissue characteristics and make the ultrasound image more aesthetic and realistic. Human eye can discern up to 32 shades of grey. Therefore most systems employ 32 shades of grey only.

3. A-mode (amplitude mode):

Displays the amplitude of individual echoes as a function of distance or time on cathode ray tube. The display is shown alongside the image which is helpful in determining the type of tissue i.e., cystic or solid. Used for echoencephalogram this can determine the location of the problem of the brain.



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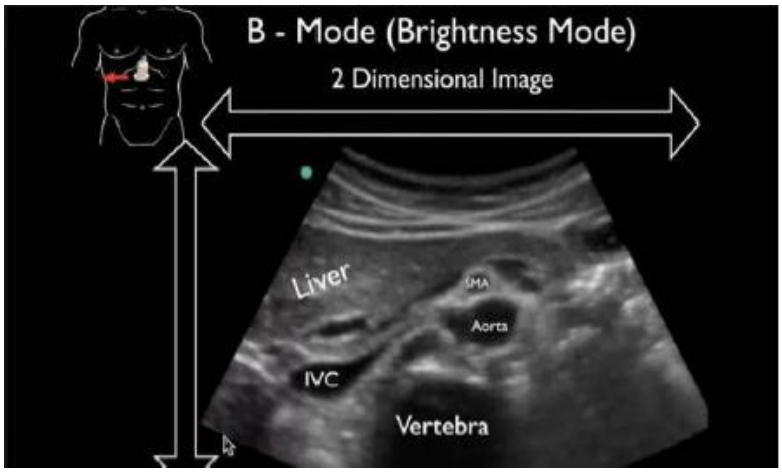
4. B-mode (brightness mode):

Displays echoes as individual spots on the screen corresponding to the points of origin in the tissue. Differences in amplitudes of returning echoes manifest as different brightness of the dots. Using many pixels (picture elements), these numerous dots can be arranged in such a way as to appear in different shades of grey for good visualization. B-mode is used for visualizing various organs and structures of human body which include breasts, kidneys, ovaries and ureters. It permits examination of fetus as early as the 4- week stage.



5. M-mode (motion mode):

Is nothing but the application of B-mode to a moving structure varying with time. M-mode is used to obtain movement of valves and other structures of the heart which are displayed as a function of time resulted by the brightness dots moving on the monitor screen.

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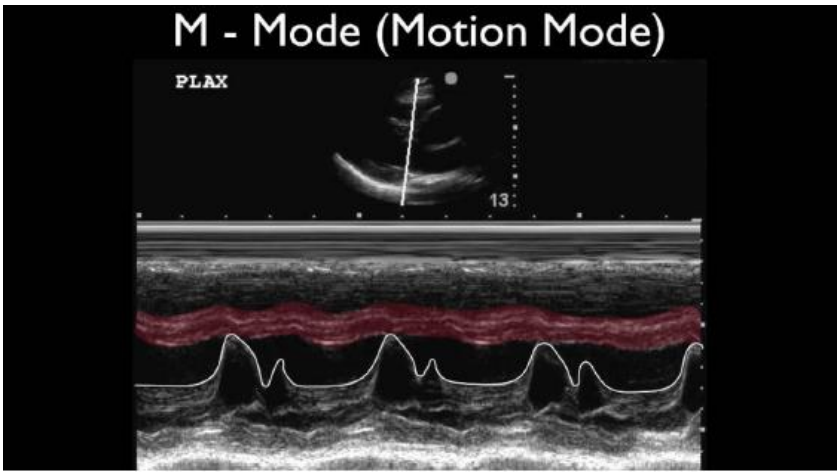

6. Real time imaging:

Allow the processing of the grey scale characteristics and the motion of interfaces.

4. Doppler Ultrasound

Doppler ultrasound is based on the principle that sound reflected by a moving target like blood has a different frequency from the incident sound wave. The difference in frequencies is known as Doppler shift which is proportional to the velocity of the target.

Doppler shift is the useful information with the echoes which helps in the detection of flowing blood. It also enables to quantify the velocity of the blood. It is possible to give colour coding to the Doppler information and superimpose it on a real time B-mode image facility which can help in identification of blood vessels or blood vessels having abnormal flow. This technique can also be used to diagnose coronary stenosis.

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5. Malfunctions and problem Ultrasound

One may be facing several types of problems while using the ultrasound machine probes. They may be one or more of the following:

i. Poor quality image: Poor image may be due to:

- Cracked or air bubbles on lens
- Connector issue
- Crystal damage
- Tears on the sheath

ii. Physical damage or broken housing: Physical damage may be due improper handling, dropping of probe, poor storage etc.

iii. Noise: Noise may be due to broken cable, damaged / broken pins in connector or electrical interference.

1. Breakage of probe connector pins may be caused by improper insertion or connection.
2. Damage to cable occurs due to cables being ridden by some wheels or closure of drawers without proper placement of the probe inside, etc.

iv. No image: If there is image being received, it could be a result of probe cable – connector breakage, probe compatibility issue or software issue.

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Cracks in ultrasound probe lens

Sheath tear

Bubble or crack in ultrasound probe lens

Lens damage with bubbles in ultrasound probe

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