LATEST 2024 MARROW NEET-SS NOTES

UPDATED OBSGYNE RESIDENCY NOTES

OBSGYNE IMAGING

ULTRASOUND PHYSICS AND KNOBOLOGY

Active space

Introduction :

Ultrasound (US) is vital to the practice of OBG.

- Always used as first-line investigation for decision making.
- Based on real-time interpretation.
- Interpretation based on the skills of the person performing the scan.

Hence it is important to gain the knowledge and skills in-line with standards laid down for the same.

USG physics

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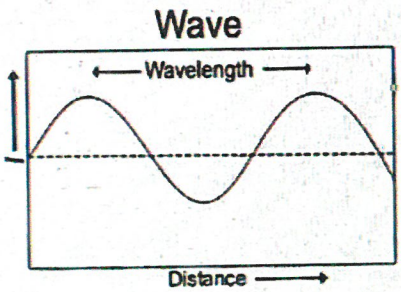
USG principle :



- Sound which is beyond the range what an ear can hear is ultrasound.
- The physics of US is based on SONAR (Sound navigation & ranging).
- The sound waves emitted returns as echoes after hitting an object :
  - Identifying the object.
  - Distance of object from the source.

Physics of sound :

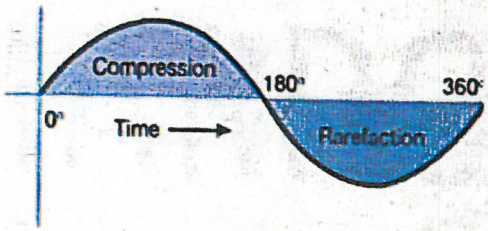
- Sound is a mechanical energy.
- For transmission of sound, a medium is required.
- Energy gets transmitted from one molecule to the other, thereby transmitting the sound.
- Sound cannot travel through a vacuum.
- Hence, gel is applied between the transducer and skin/mucosal surface.

Wavelength/cycle :

- As sound travels through a medium → Particles in the medium do not move forward or backward → They get squeezed (Compressed) and stretched (Rarified).
- Compression causes → Area of high pressure and density.
- Rarefaction causes → Area of low pressure and density.
- This alternating areas of high and low pressure results in a wave.
- The upward area is a compression and the downward area of a wave is rarefaction.

Wavelength definition :

- Start of the wave to the end of the wave.
- Distance between two consecutive compressions or two consecutive rarefactions is a wavelength or cycle



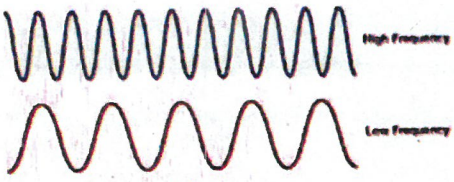
Wavelength

Frequency :

- The number of times the cycle or wavelength is repeated in 1 second is called frequency.
- The unit of frequency is hertz (Hz).
- The sound heard by our ears has a frequency in the range of 20 Hz to 20 Kilohertz (KHz).
- Sound of a higher frequency is called ultrasound (Designated in megahertz (MHz)).
- Frequency has a bearing on the clarity of the US image.

Types of frequency :

- Wavelength is less, hence there are more number of cycles in one second → Hence high frequency.
- Wavelength is more, hence there are less number of cycles in one second → Hence low frequency.



Types of frequency.

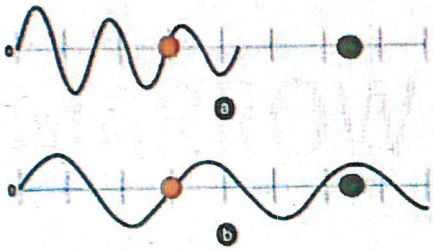
Frequency vs resolution :

Resolution → Image clarity : All details are clear and distinct.

High frequency → Better resolution → Less penetration.

Low frequency → Less resolution → Better penetration.

Helps in choosing the US transducer/probe as well as route of scan.



Frequency vs resolution.

Choice of frequency :

1. Resolution :
   - Thin patient.
   - Imaging superficial structures.
   - Near field is good.
   - Far field is dark.

2. Penetration :
   - High BMI patient.
   - Large uterus/pelvic mass.
   - Image deep structures.
   - Far field is good.

3. General (Normal) :
   - Mid-range frequencies.
   - Often default setting.
   - Useful in normal gynecological scans.

Working of ultrasound :

Production of USG image :

1. Creating and transmitting a sound wave, known as a pulse.
2. Receiving and analyzing the reflections of the sound ie echoes.

In a typical ultrasound : millions of pulses & echoes are sent & received per sec.

Creating a sound wave :

- The sound wave is produced from the US transducer, also known as probe.
- The front face of the probe contains piezoelectric crystals.

- When electric current passes → The crystals undergo some physical changes → Produce sound waves → Transmitted from the transducer in the form of pulses.

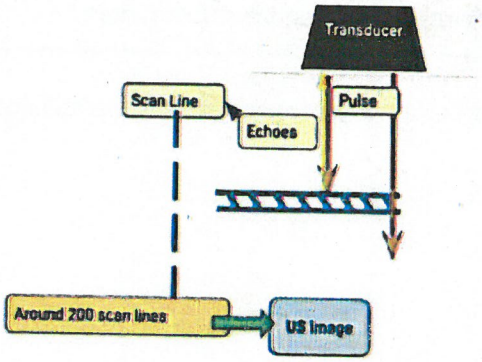
Formation of echoes :

- Pulses hit an object → They bounce back → Another set of waves formed called echoes.
- Piezoelectric crystals → Receives echoes → Converts them into electrical impulses → Processed by the software in the US machine → Displayed as an US image.
- Resolution of the image depends on :
  a. Distance the echoes travel.
  b. Intensity of echo (Depends on the nature of the structure the pulse has bounced off).

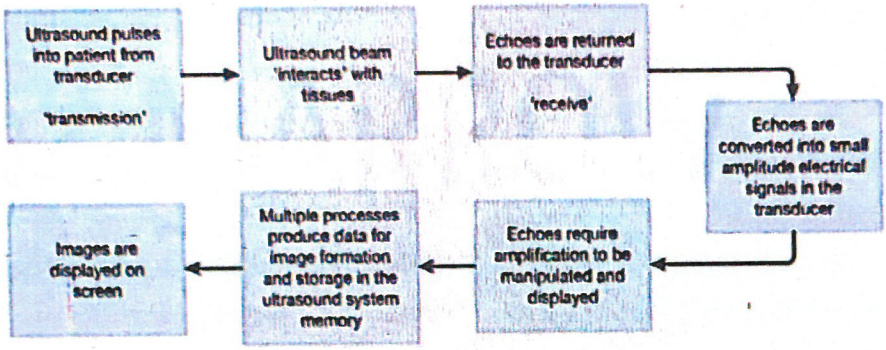
Transducer :

- Responsible for generating & receiving US waves.
- Convert electrical energy into mechanical (sound) energy.
- Electric current hits piezoelectric crystals → Formation of pulse → Hit an object, goes back as an echo.
- Damage to these crystals by improper handling will result in dropout areas which will come in the way of obtaining a good image.
- A good picture starts with a well cared for transducer.

Damage to the crystals leading to dropout areas.

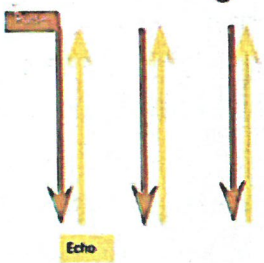


Stages in formation of a diagnostic ultrasound image :



Frame rate :

- Frame = image.
- Frame rate : Number of times the image is produced in a second.
- Frame rate depends on the scan area (depth and width) & scan line density.
- Number of scan lines per frame : Line density.
- more lines per frame → more line density → better resolution.



Production of sound waves :

Attenuation :

- As sound waves pass through a medium → Loss of energy → Intensity diminishes → Loss of some echoes (Attenuation).
- Attenuation can also result from the sound waves getting scattered or absorbed in the medium.

Absorption : When some pulses are absorbed in a tissue though which it passes, its intensity reduces and structures beyond it appear dark.

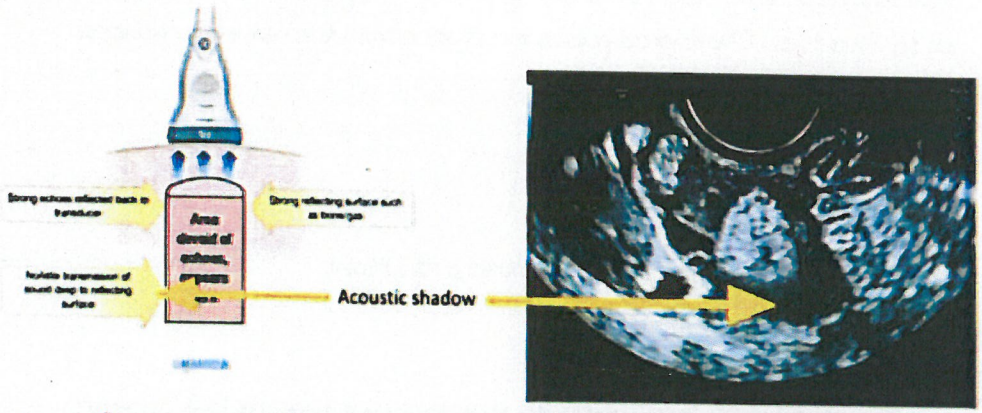
Scattering : Sound being reflected in directions other than its original direction of propagation.

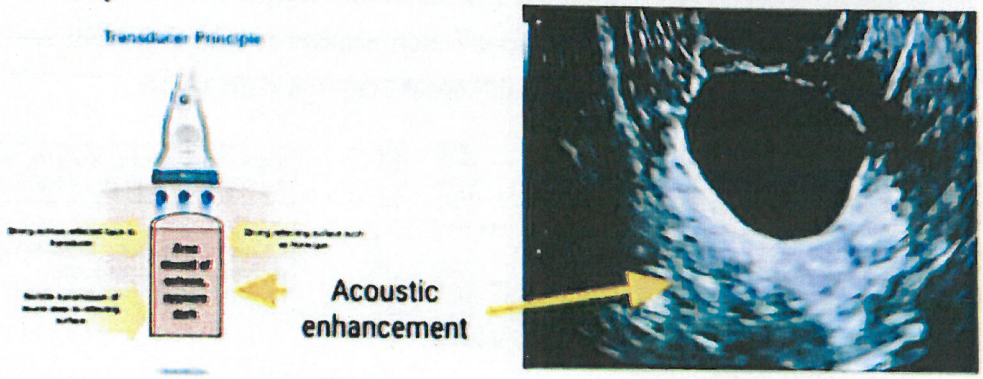
Echogenicity :

- The ability of a structure to form echoes when a sound wave or pulse hits it.
- Pulses hit a soft tissue → some are reflected back (Echoes), some pass through the structure → Reflected back but there is a loss of energy or intensity.
- Difference in intensity of the echoes from the respective areas noted.

Variation in echogenicity :

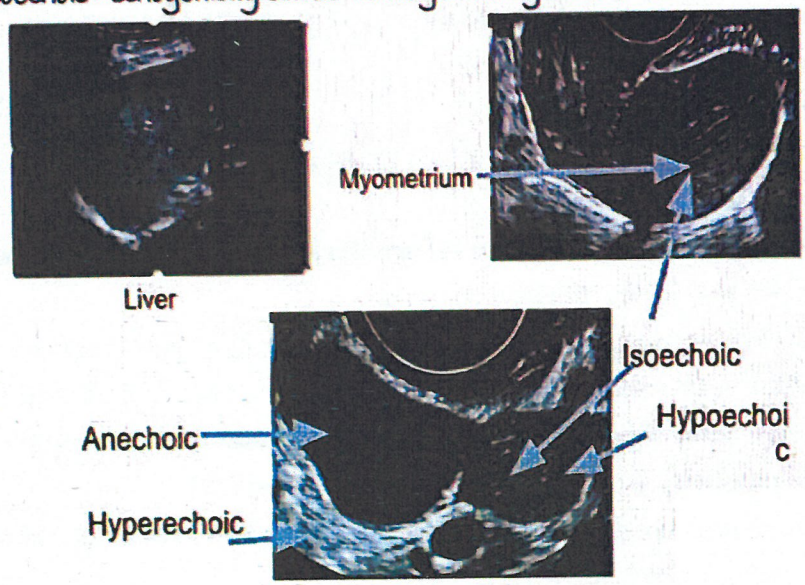
- Echogenic : The echoes from the soft tissue will be good (Adequate), and hence displayed well.
- Hypoechoic : The echoes returning from the structure beyond will be less as there are less pulses reaching that region.
- Hyperechoic : when pulses hit a dense tissue (Bone) all pulses are either reflected or scattered → more returning echoes → Displayed as very bright.
- Acoustic (sound) shadows : Dense tissue → No pulses going beyond it → No returning echoes from that area beyond → Appears dark.
- Anechoic : When pulses hit fluid → Passes freely → No returning echoes from that area → Appears black on USG.
- Posterior enhancement : All the pulses go to the area beyond the fluid (mostly soft tissue) → Plenty of echoes return from this region → Appears enhanced.





USG terminologies :

- Anechoic : No echoes, structure appears black.
- Hypoechoic : Less echoes, appears as varying shades of dark gray.
- Hyperechoic : Lots of echoes, appears as varying shades of light gray.
- Isoechoic : Echogenicity similar to neighbouring structures.



Note :

Liver has normal echogenicity, hence used for comparing.

Scanning/sweeping : Way of directing pulses through the tissues is termed.

Noise (Speckles) : Scattered pulses interfering with the returning echoes.

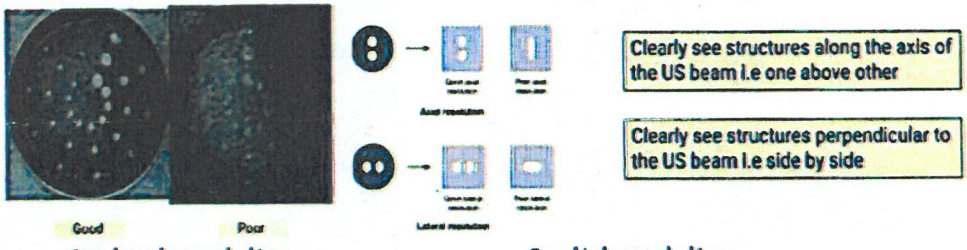
Resolution :

Good resolution implies :

- Structures seen clearly.
- Able to differentiate features within a structure.

Types :

1. Temporal : Important for moving structure over time, as in fetal scans.
2. Contrast : Distinguishing between different shades of gray in an image.
3. Spatial : Distinguishing between different features in an image.



Contrast resolution Spatial resolution

----- Active space -----

Modes of USG

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USG information may be processed and displayed in several ways.
In routine use are :

1. Two dimensional Imaging : 2D.
2. Motion mode (m-mode).
3. Three dimensional imaging : 3D.
4. Doppler Imaging.

2D mode US imaging :

- Image is displayed in two dimensions(Height and width).
- 2D is also referred to as B-mode (B for brightness).
- US image is made of bright specks, but specks aren't uniform in brightness. (Resulting in shades of grey, black and white in the image).
- The specks are the echoes which return to the transducer and are then processed to create an image.
- The 2D image is usually displayed in shades of grey.
- There is an option of displaying 2D image in color.

3D mode US Imaging :

- The image is displayed in 3 dimensions (Width, height and depth).
- The data processed by the returning echoes is in the form of a volume.
- 3D images may be obtained by a separate probe for transabdominal scans. For transvaginal scans a single probe has the option of obtaining a 2D and a 3D image

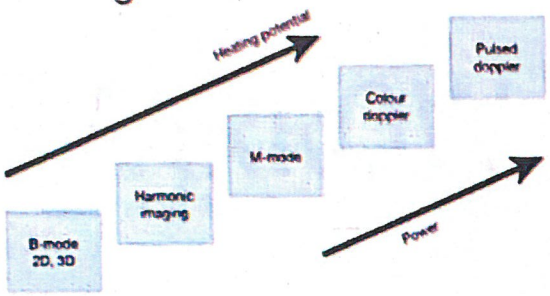
m-mode :

- This mode displays movement of structures.
- It is usually used to display the cardiac activity in early pregnancy scans, as the use of doppler is not recommended at this stage.

Safety of USG :

US has an excellent safety profile as some thermal and mechanical effects on tissues are almost negligible.

ALARA (As Low As Reasonably Achievable) :



USG machine

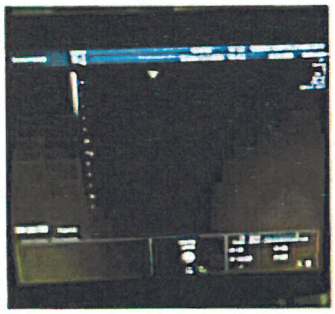
00:38:10

Parts of USG machine :

1. Display monitor.
2. Central processing unit (CPU).
3. US transducer or probe.
4. Console/control Panel

Display monitor :

- Screen which shows the US image.
- Working menu present below or on the sides.
- Direct light facing or just above display monitor will cause poor visual perception of image and proper contrast will be difficult to interpret.



Central processing unit (CPU) :

- The CPU processes the echoes which leads to US image display.
- It provides electric impulses to the probe and receives the same for processing of echoes.
- The CPU can also store the processed data and/or image.

Transducers :

- Responsible for generating & receiving US waves
- Fragile & expensive
- Need to be cleaned after every scan.
- Do not apply gel directly on the transducer.

Clean after use.