NEET SS OBG
OBS GYN IMAGING

CONTENT

ULTRASOUND PHYSICS AND KNOBOLOGY

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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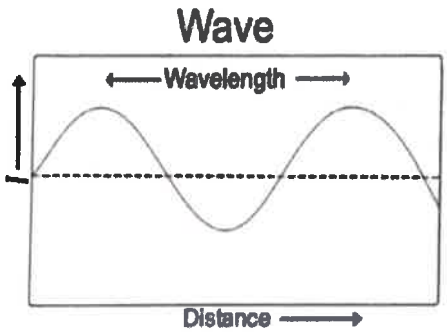
USG principle :



- 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 :

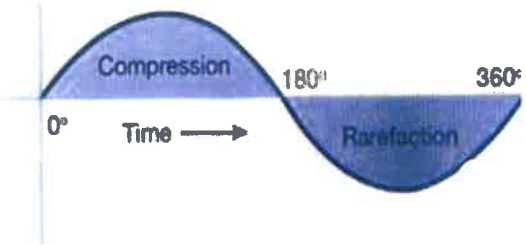
- Sound is a mechanical energy.
- For transmission of sound, a medium is required.
- Energy gets transmitted from one molecule to the other, thereby transmitting the sound.
- Sound cannot travel through a vacuum.
- Hence, gel is applied between the transducer and skin/mucosal surface.

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



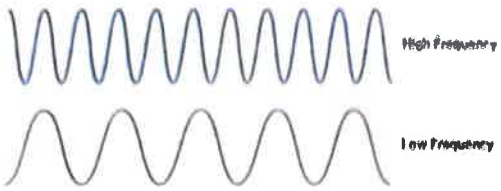
Wavelength

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.

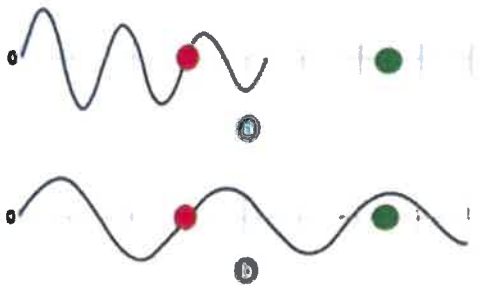
Frequency vs resolution :

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 i.e 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.

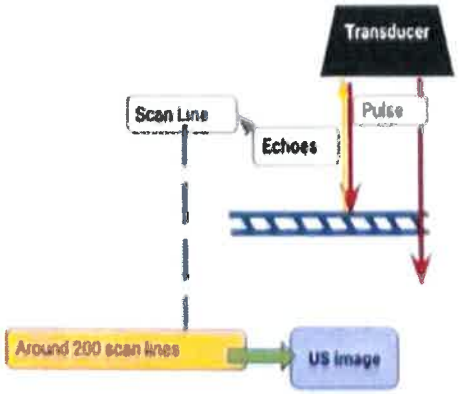
Formation of echoes :

- 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).

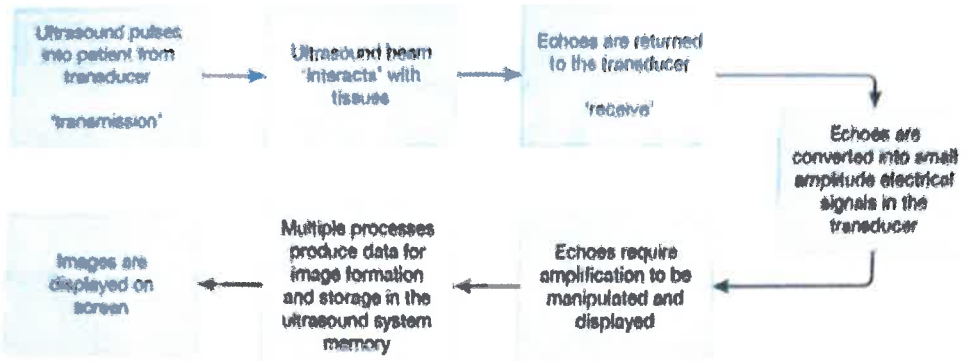
Transducer :

- 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.

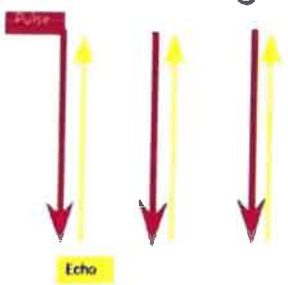


Stages in formation of a diagnostic ultrasound image :



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.

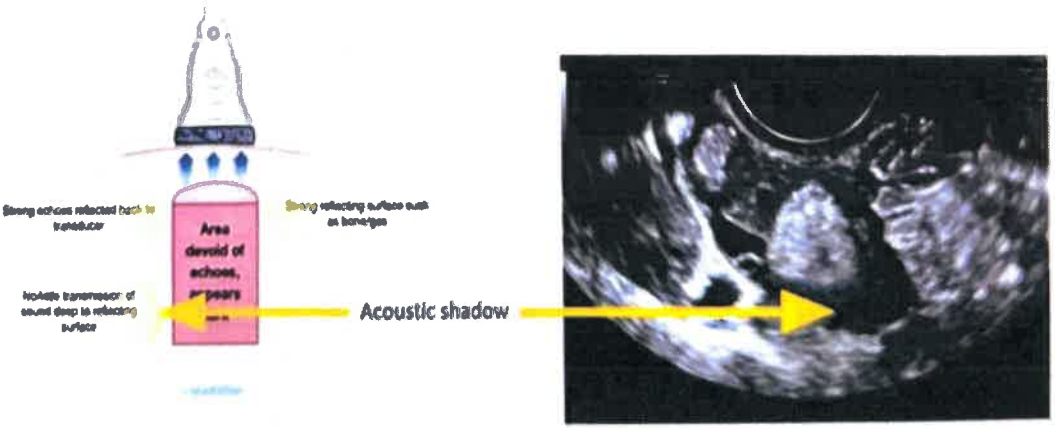
Scattering : Sound being reflected in directions other than its original direction of propagation.

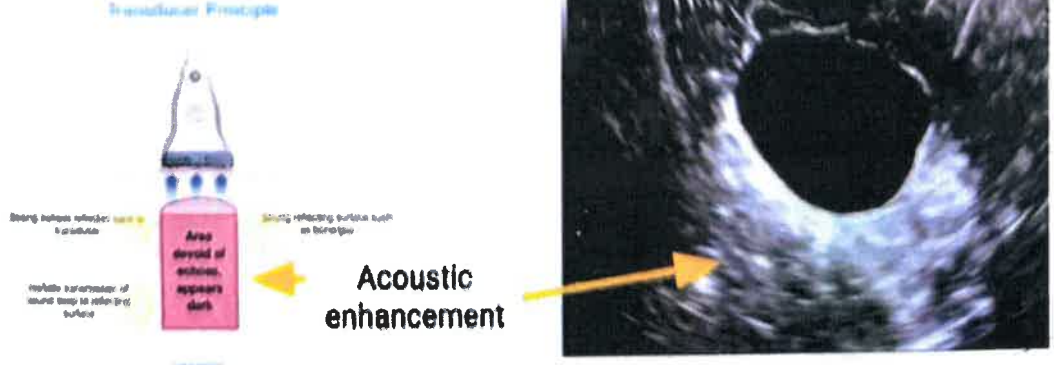
Echogenicity :

- 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.

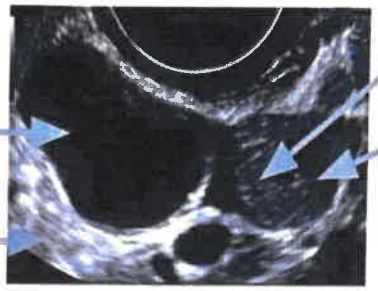




USG terminologies :

- 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.

Liver



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.

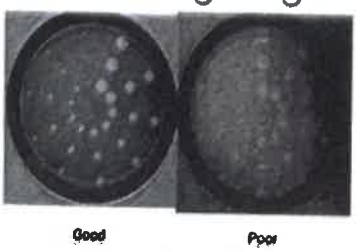
Resolution :

Good resolution implies :

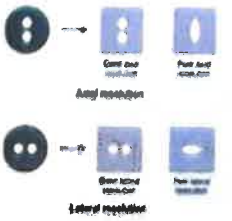
- Structures seen clearly.
- Able to differentiate features within a structure.

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



Clearly see structures along the axis of the US beam i.e one above other

Clearly see structures perpendicular to the US beam i.e side by side

Modes of USG

00:33:30

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

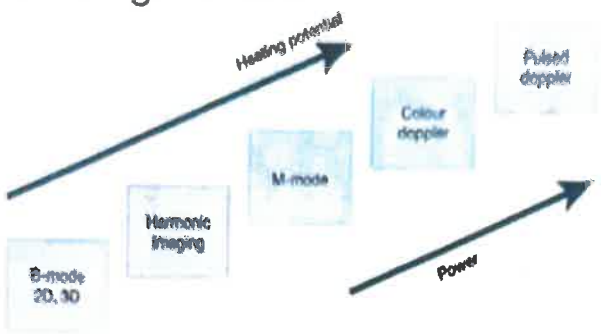
m-mode :

- 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

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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.

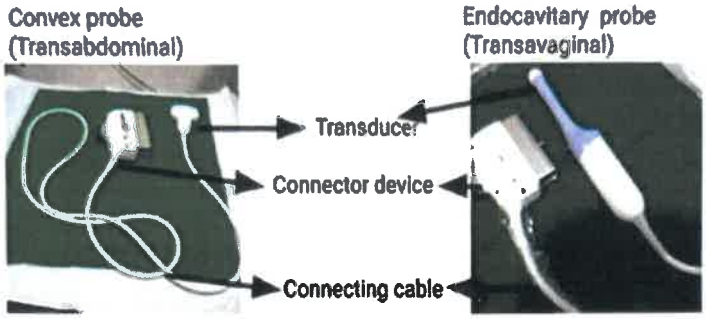
Transducers :

- 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.

Parts :

- Foot print of the probe
- Probe marker/orientation notch
- Peizoelectric crystals



Footprint of the probe :

- Outermost portion of the probe head that is in contact with the patient.
- Whichever structure is in contact with the probe is displayed just below the footprint.

Footprint of the probe

Probe marker/orientation notch/position marker :

- This is a well defined area on the side of the probe head. It is present as a ridge or a notch.
- The probe marker aids in the correct orientation of the probe with relation to the anatomical plane on the screen.

Connecting cable :

The cable connects the transducer to the connector device.

Probe marker

Connecting cable

Types of tranducers :

Transcutaneous (used on the skin) :

- Linear.
- Convex/curvilinear/curved array.

Types of tranducers

Endocavity (inside a cavity) :

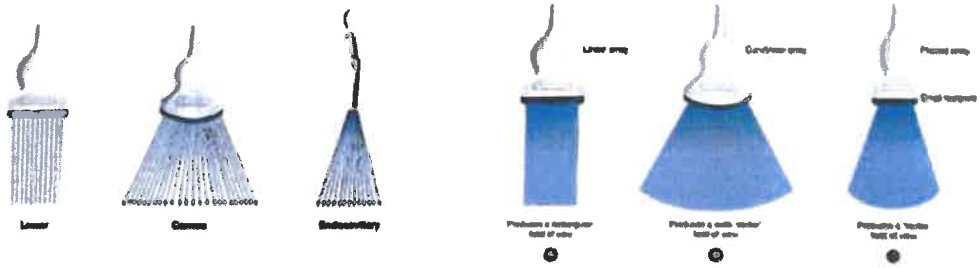
- Transvaginal.
- Transrectal.
- Oesophageal

Types of Transducers	Frequency	Application
Convex	3.5 – 5 MHz	Fetal & Gynae
Linear	6 – 13 MHz	I trimester scan
Transvaginal	5 – 12 MHz	I trim & Gyn

Difference in :

- Shape & size.
- Frequency.
- Field of view (FOV).

Field Of View (FOV) :



In linear probe :

- Scan lines are parallel.
- Uniform width between scan lines from near to far field.
- Useful in low BMI patients.
- Useful for imaging superficial structures (Uterus).

In convex probe :

- Scan lines are closer in the near field.
- The width between the scan lines increase towards the far field.
- Convex probe has a wider scanning field as compared to the transvaginal probe.

Console/control panel :

1. Knobs.
2. Flip switches.
3. Buttons.
4. Trackball.

Trackball :

- AKA Scan mouse.
- Moves cursor (arrow).
- Moves measuring points.
- Moves text.

Cine loop : Useful for retrieving optimal frames after the image has been frozen by pressing the freeze button.

2D Knob :

- Initiate 2D scan.
- Adjust gain of the US image.

Gain :

- Adjusts overall brightness of the image.
- Adjusts intensity/amplitude of the returning echoes.
- Compensates for attenuation.

method :

- Set in preset.
- Customise : Rotate the gain knob.
- Clockwise to increase gain.
- Anti clockwise to decrease gain.

Optimal gain : Gain at which the best contrast is obtained between tissues.

Real time/post processing (after freeze).

Personalized buttons :

- These can be used for :
- Storing 2D images.
- Storing 3D volumes.
- Storing a short clip as in real-time scan.
- For printing images/report via a thermal printer.

Freeze :

- Once an optimal image is obtained press the Freeze button.
- Real time scanning is paused.
- The image is reviewed for taking measurements, study of morphology, and annotate the findings.
- Once the above is done, press the freeze button again. Real-time scanning may be resumed.

Focus :

- Indicates depth at which there is highest resolution.Focus affects lateral resolution i.e ability to differentiate objects lying side by side in the image.
- Tightens up the US beam for a specific image zone.
- Focal zone should be at or just lower than the region of interest (ROI).
- Knob moved up/down.
- Recommended not to have FOCUS at level of gestational sac in early pregnancy scan.

Image display :

- Single screen : One plane, one image.
- Dual or split screen : Two planes of same image or to compare two images.
- 4 quadrant screen : Four images. Useful in follicular study.

Calculations :

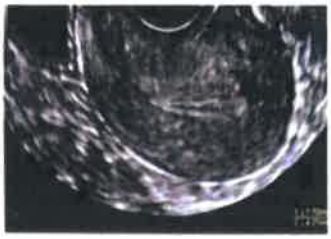
Different calculations can be done by pressing the specific options.

Focus button & variation

Different image display buttons

Calculations button & its options

Measurements :

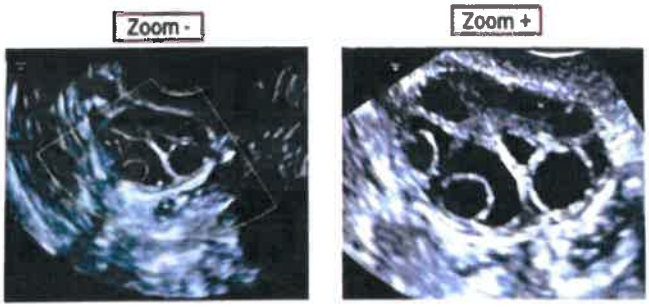


Zoom :

- Knob : Rotatory knob.
- Types : High definition or pan zoom.
- Used for more detailed definition of structures without loss in resolution.
- Frame rate increases and therefore, resolution increases.
- HD : Choose ROI, press knob, adjust zoom box to envelope ROI.
- Pan : Turn clockwise to increase magnification of entire field.

Advantages :

- Easy positioning of calipers.
- Better definition of morphology.
- Real time/post processing (after freeze)

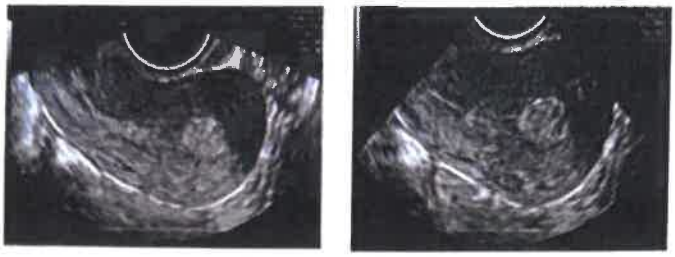


Archive/Store :

- Search through the information stored in the system.
- Double-clicking a stored image in the thumbnail area at the bottom of the screen retrieves the image & displays it.
- In the retrieved exam screen, you can perform measurements or enter text, bodymarkers or indicators.

Angle sector/width :

- Changed by using the Knob.
- Determines how many degrees through which an ultrasound beam is swept.
- Narrow angle increases frame-rate → Improves quality of image.
- Adjusted according to the field required.



Change in angle sector

Patient data :

- Can be useful in follow up.
- To review past history & findings.
- Best to use number for identification.

Image orientation :

Reverse R : Can make it left or right.

Inverse R : Can make it up or down.

Image orientation

Time gain compensation (TGC) :

- 5-10 slide controls grouped together.
- Adjust gain in specific areas of image.
- Upper sliders : Nearfield.
- Middle sliders : Midfield.
- Lower sliders : Farfield.

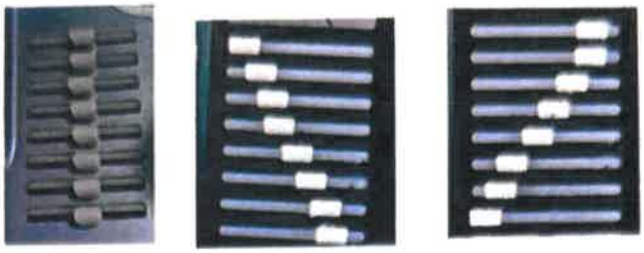
Time gain compensation

Used for :

- Selective amplification of weaker signal returning from far field more than signals returning from near field.
- Creates uniformity of brightness of echoes.

Method :

- Push slider controls to right or left.
- Towards right : Increases brightness.
- Towards left : Decreases brightness.



Slider positions.

Depth :

Knob : By flipswitch.

Used for :

- Distance over which B mode anatomy is displayed.
- Allows us to image entire field/ROI.

Method :

- Start of scan : maximal depth to get an overview of structures.
- Once target structure is localized, decrease depth to display full screen of that image & minimize display of irrelevant deeper structures.

Tint maps :

- Conventional B-mode image displays 256 levels of gray and the sensitivity of the eye is limited to between 8 & 16 levels of gray.
- The eye can perceive 20,000 times more colors than shades of gray.

Advanatges of color maps :

- Enhances visual perception of the difference between normal & abnormal tissues.
- Increases ability of the human eye to distinguish subtle differences in tissue echogenicity, compared to gray scale map.
- Less eye fatigue using color map compared to gray-scale imaging.

Tint maps