


knobs and probes


Dr Avishay Sarfatti
Paediatric Critical Care
Oxford University Hospitals

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Ultrasound

- Ultrasound probes host Piezoelectric crystals
- An electric current passes through a cable to the transducer and is applied to the crystals, causing them to deform and vibrate.
- This vibration produces the ultrasound beam.
- The frequency of the ultrasound waves produced is predetermined by the crystals in the transducer.

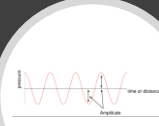


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The ultrasound wave



- Frequency –
 - number of cycles / time
 - 1 / second = 1 Hz
- Wave length – the distance of each cycle
- Amplitude –
 - The difference between the peak value and the average value
 - Measured in dB
 - Amplitude decreases as the wave travels through tissue
 - Amplitude decreases usually by 1 dB per 1 MHz per 1 cm travelled.

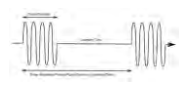


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How it works

- Ultrasound waves are produced in pulses
- The transducer emits ultrasound < 1% of the time
- the rest of the time is spent listening.
- the ultrasound beam enters the patient and is bounced back of a reflective surface.
- The reflected sound wave, or echo, cause the crystals in the transducer to deform again and produce an electrical signal
- The electrical signal is then converted into an image displayed on the monitor.
- The time elapsed from transmitting to receiving = distance.



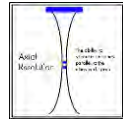
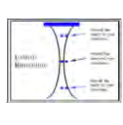
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Ultrasound and the tissues

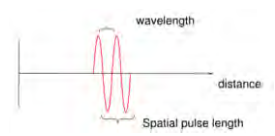
- Attenuation**
 - It is the gradual weakening of the ultrasound beam as it passes through tissue.
 - It is caused by reflection, scattering, or absorption of the sound waves
- Reflection**
 - Ultrasound waves are bounced back to the transducer for image generation
 - The portion of the ultrasound beam that is reflected is determined by the difference in acoustic impedance between tissues
 - Tissue density and stiffness determines impedance
 - And so the biggest change in impedance is between soft tissue and air, and soft tissue and bone
- Scattering**
 - It is the redirection of ultrasound waves
- Absorption**
 - The energy of the ultrasound beam is converted to heat

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About resolution

- **Axial resolution**
 - ability to differentiate objects that are located along the imaging beam axis
 - A pulse is reflected of structures that are equal or bigger than its pulse length
 - the shorter the pulse length, the better picture quality will be
 - Pulse length = wavelength x cycles
 - High frequency means short wavelength and therefore better resolution
- **Lateral resolution**
 - The minimum distance that can be imaged between two objects that are located side to side
 - The narrower the beam is, the better the lateral resolution will be (higher frequency = narrower beams)
 - beam diameter varies with depth, therefore the lateral resolution will vary with depth as well.
- **Temporal resolution**
 - It implies how fast the frame rate is
 - It is determined by image depth and beam frequency



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Know your machine

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Imaging modes

- B-mode (brightness)
 - The main imaging mode
- M-mode (motion)
 - Displays the movement of structures along a single line chosen by the operator
- Doppler
 - Detect frequency shifts created by sound reflections off a moving target (Doppler effect).
- Color Doppler
 - Maps all Doppler shifts in the region of interest (ROI)
 - BART – Blue Away, Red Towards

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Image optimization

1. Choose the correct probe
2. Choose Resolution / Penetration / General
3. Depth
4. Focus
5. Gain & TGC



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Probe selection



- Selecting the appropriate transducer depends mainly on:
 - Physical space
 - Imaging window
 - Depth and resolution needed

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Use the highest-frequency transducer that will penetrate to the desired depth

- Linear
 - 7 to 15 MHz
 - Images are rectangular
 - High resolution
 - Shallow depth
 - Large footprint
- Convex
 - 2 to 6 MHz
 - Different shapes and sizes produce images in a sector-shaped format with a wide apex
 - Small footprint
 - Good penetration
 - Compromise on lateral resolution
- Phased array
 - 2 to 4 MHz
 - Same smaller footprints
 - Produce images of sector format through small acoustic windows
 - Poor lateral resolution
- What do the letters and numbers indicate ??
 - L24-S258

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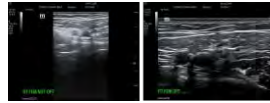
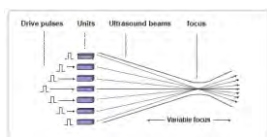
Image optimization – DEPTH

- Controls the depth of view and should be used to keep ROI in the central area of the screen
- Depth (cm) will be displayed along the edge of the screen
- Shallow images allow better frame rate
- Adjust but scan beyond the image



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Image optimization – Focus



Modern machine can have multiple focal zones

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Image optimization – Pen / Res / Gen

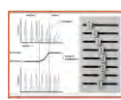
- Pen – Uses lower frequency to priorities tissue penetration
- Res – Uses higher frequency to priorities image resolution
- Gen – A compromise between penetration and resolution



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Image optimization – Gain

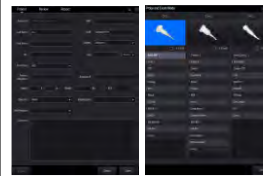
- Gain
 - Uniformly alters the brightness on the monitor
 - The tendency is to over-gain
 - Adjust so that anechoic structures (e.g., fluids) appear black
- Time Gain Compensation
 - Allows the sonographer to adjust the amplification at various depths.
 - A set of sliders
 - The sliders are pushed progressively from left to right.



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How to scan

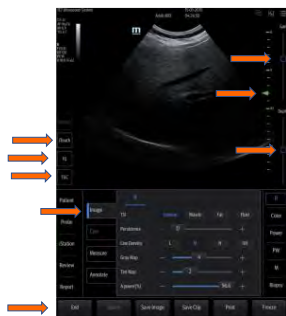
1. Enter patient details
2. Select probe and exam type
3. Select exam mode



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How to scan

- Optimize the image



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How to scan

- Orientation
 - Transducer's marker should be directed toward patient's right side in transverse planes
 - Transducer's marker should be directed toward patient's head in sagittal and coronal planes.
- And then there is cardiac...



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