How to get Good Images?

Professor Samir Gupta

Chief, Division of Neonatology, Sidra medicine, Qatar

Durham University, United Kingdom

Durham University

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سدرة للطب Sidra Medicine

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Disclosure

- I have no financial relationship with commercial interest to disclose
- Steering committee member of NPE, ESPR
- Chair, Non-invasive cardiac output SIG, ESPR

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Preparation

- Position echo machine & yourself
- Time the scan with baby's state of alertness
- Always have the ECG on the screen
- Optimize window to cover at least 2/3 of screen
- Adjust depth, resolution and penetration
- Focus the image for point of interrogation
- Segmental sequential scanning for structure before assessing function
- Know 3D topography of heart

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Best Baby Behavior:
- State of alertness
- Minimize exposure
- Use warm jelly
- Keep duration of scan short

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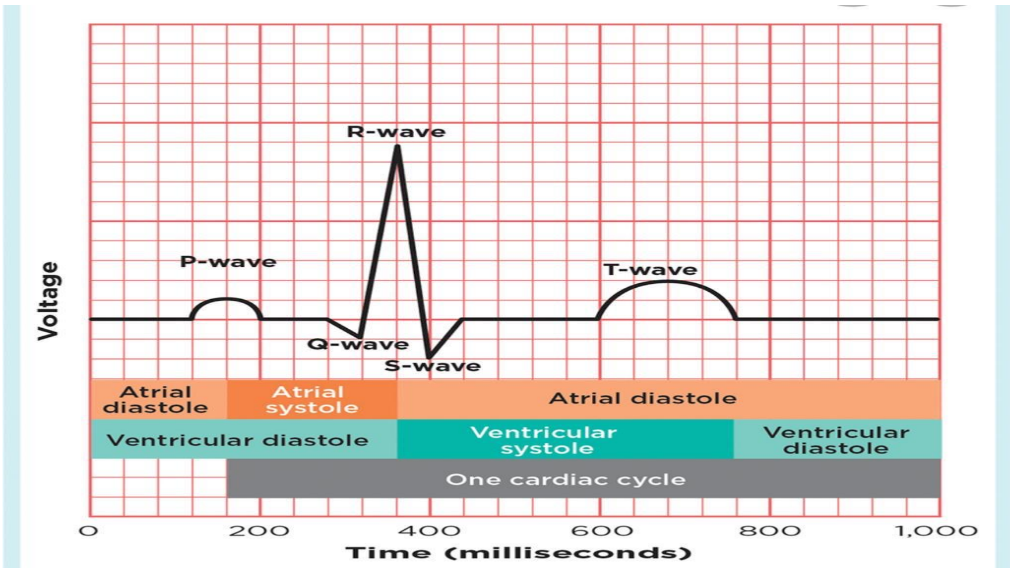
Use ECG for Echo



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Holding the Probe



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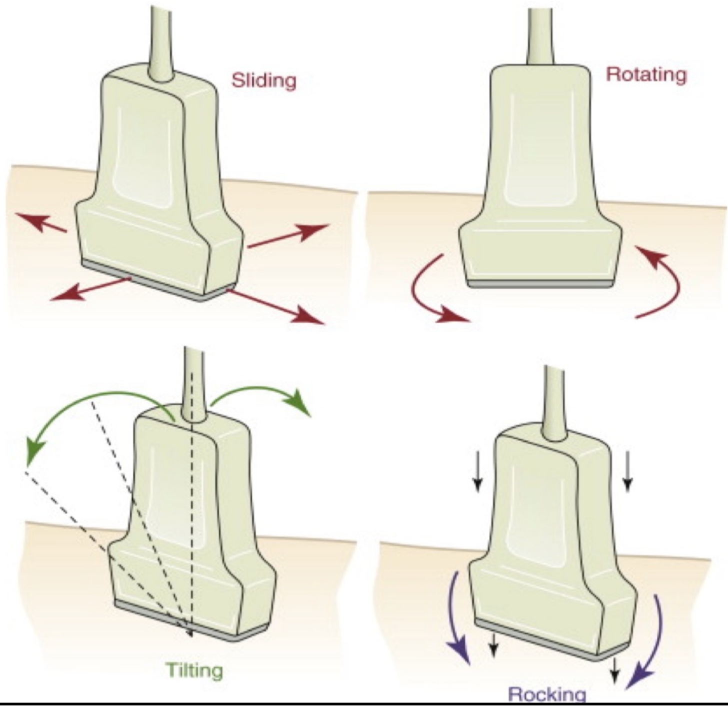
Movement of Transducer



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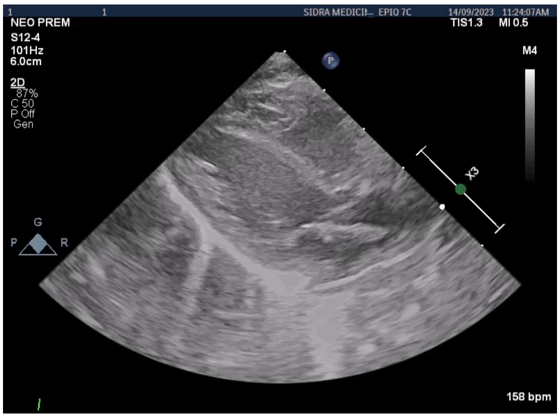

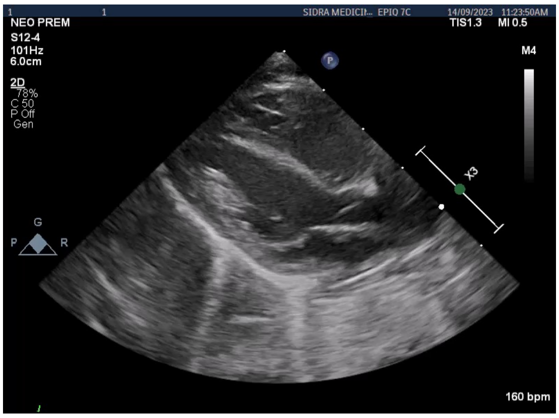

Optimize Gain

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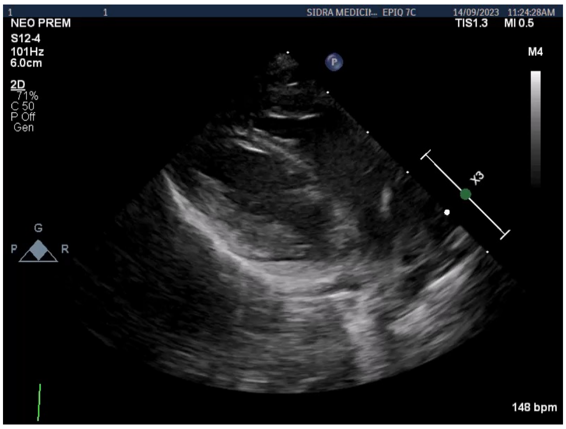
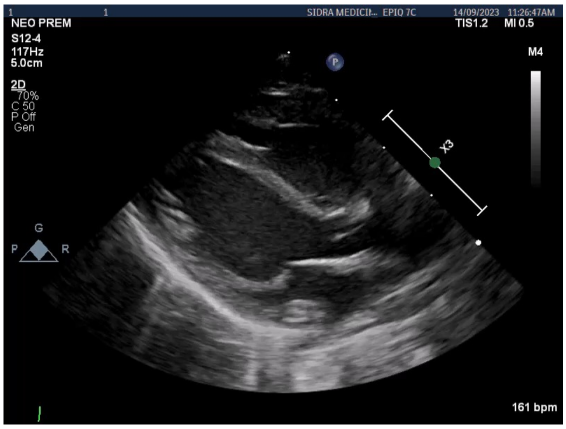
Use 2/3rd of the screen for image (Depth)





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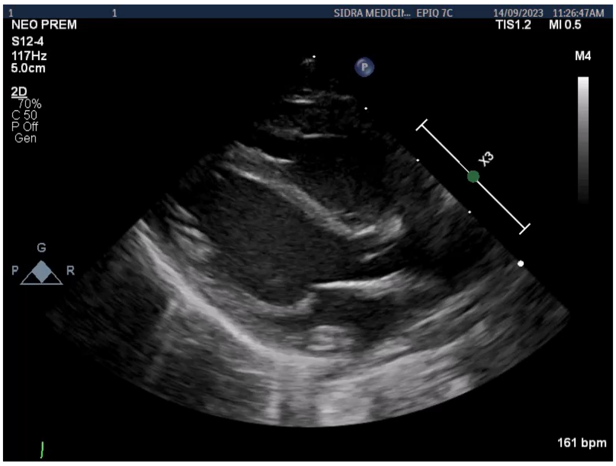
Align the image before you measure



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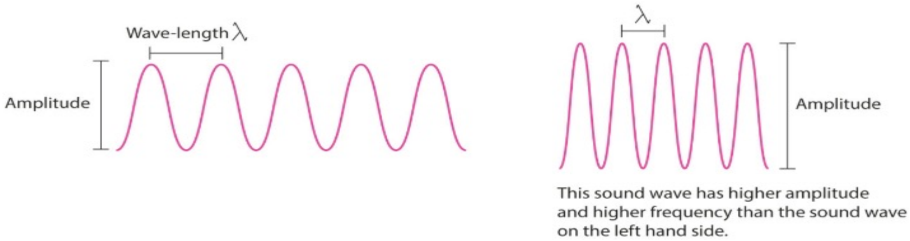
Know Basic Physics of Ultrasound

Sound Wave

- In ultrasound, what we are interested in is the wavelength, amplitude, frequency, speed and direction



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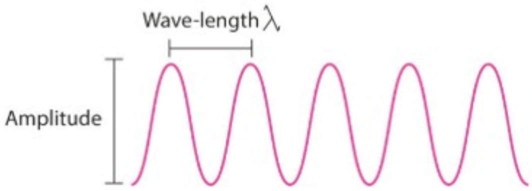
Wave length

Defined as the distance between two points along a sound wave over which one cycle occurs (λ)

Amplitude

Amplitude describes the strength of the sound wave, which corresponds to the maximum displacement or height and measured in decibels (dB)



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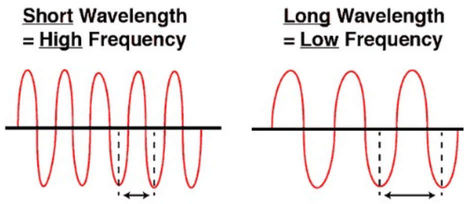
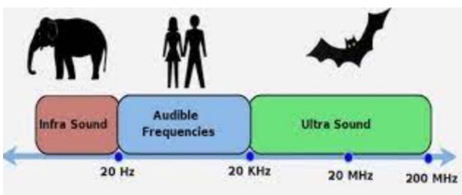
Frequency

- Frequency is the number of wave cycles per second measured in Hertz (Hz)
  = 1,000 Hz = 1 Khz
  = 1,000,000 Hz = 1 MHz
- The human ear can perceive frequencies between 20 Hz and 20,000 Hz (20 KHz)
- Ultrasound for echo has a frequency between 2 and 12 million Hz (2-12 MHz)





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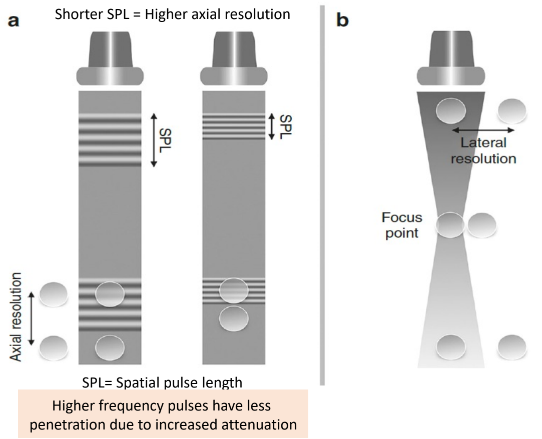

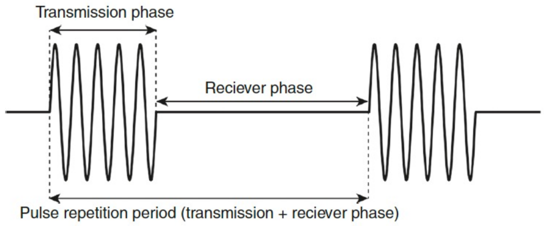

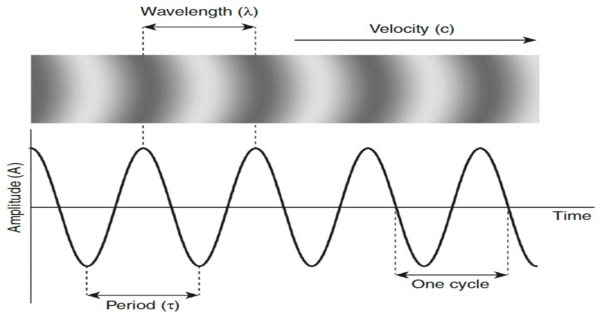

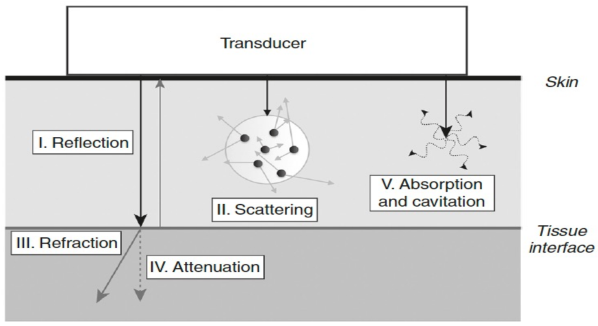

Interaction of ultrasound with tissues

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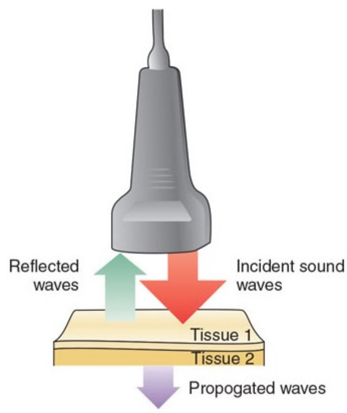
Reflection

- When an ultrasound beam hits a interface between two different tissues, part of the ultrasound is reflected back to the probe while a portion continues deeper.
- The amount of reflection depends on the difference in the acoustic properties of the two tissues, specifically the "acoustic impedance", which is mainly a product of tissue density.
- **Common bright reflectors in echocardiography are the pericardium and diaphragm**



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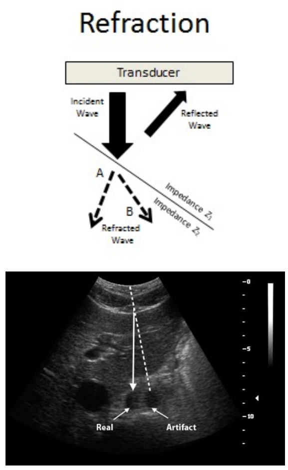
Refraction

- Refraction refers to the bending of the ultrasound beam when it enters a medium.
- The degree of bending depends on the angle between the beam and the surface, and the degree of difference in speeds between tissues.
- **Refraction artifact may cause objects to appear in altered locations.**



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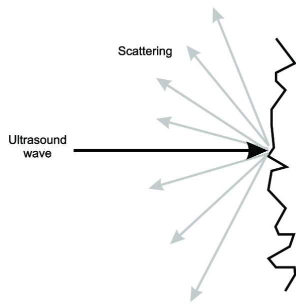
Scattering

- When an ultrasound beam meets a boundary consisting of small and uneven structures, the ultrasound beam is scattered.
- This results in reflection of the beam to all directions and a disorganized returning signal.
- **Much of the signal is lost due to the scattering in multiple directions.**



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Attenuation

- Attenuation is the decrease of the US wave intensity as it travels through tissue layers deeper beneath the surface.
- As ultrasound travels within tissues, part of the energy is lost to absorption and scattering.
- This results in weaker signal intensity travelling to structures that are farther from the probe.
- **The higher the frequency, the greater the attenuation, and therefore the lower the penetration.**

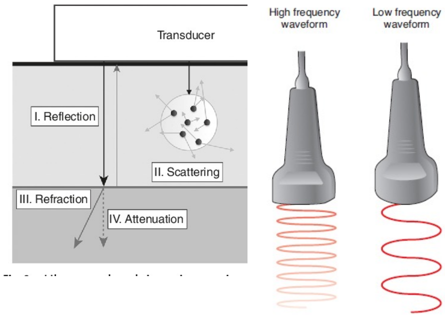

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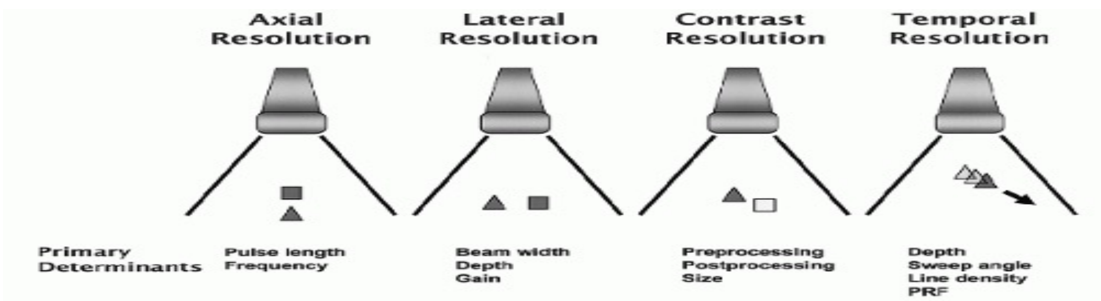
Image Resolution

- Image resolution **determines the clarity of the image.**
- Resolution of any imaging system is its ability to distinguish between two separate points as separate in space



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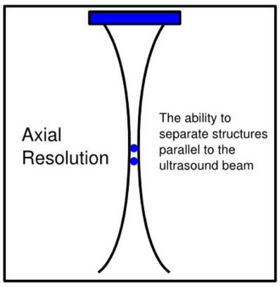
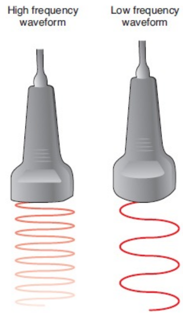
Axial Resolution

- Axial resolution is determined by spatial pulse length (SPL), which is the *product of wavelength and the number of cycles in one pulse*.
- The lower the SPL, the higher the resolution.
- **Increasing the transducer frequency decreases the wavelength and increases number of scan lines, therefore yielding better resolution.**





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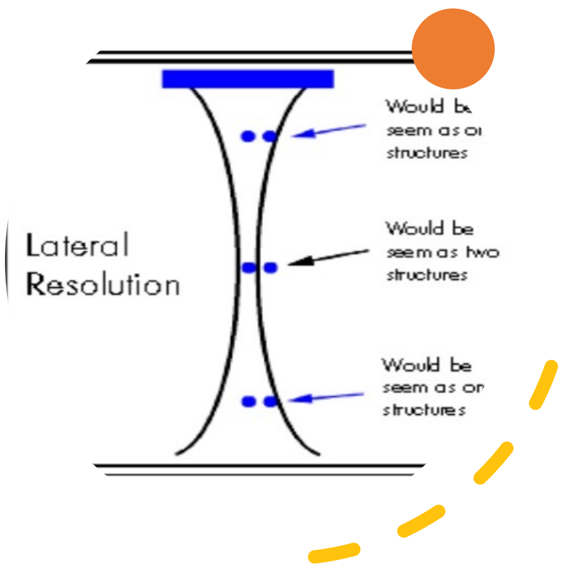
Lateral Resolution

- Lateral resolution is the ability to discriminate objects located in an axis perpendicular to the ultrasound beam
- The major determinant of lateral resolution is beam width.
- **The focus position can be set by the operator and is one of the key steps in image optimization.**
- Lateral resolution is best at shallow depths and narrow beams, and worse with deeper imaging and wide beams.



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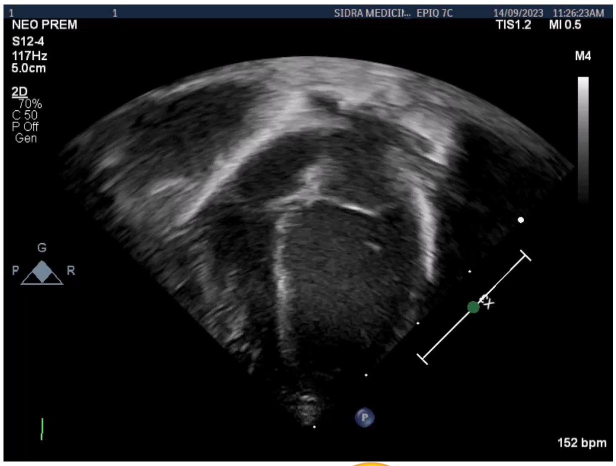
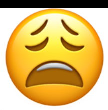
Focus the image to improve Lateral resolution





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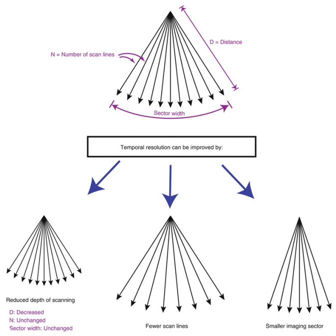
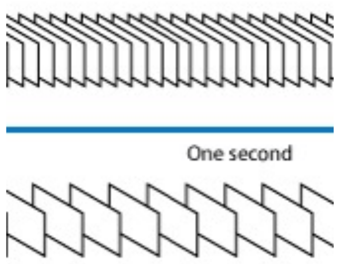
Temporal Resolution





- Temporal resolution is the ability to detect that an object has moved over time
- It is described in terms of frame rate and measured in Hz or frames/s. The frame rate is displayed on the echo machine
- **Frame rate depends on the time taken to create a single image line**, and the number of lines that form each image.
- **Frame rate can be improved by**
  - **decreasing the imaging depth,**
  - **narrowing the image sector width,**
  - **zooming into an area of interest,**
  - **reducing the number of focus points, or**
  - **decreasing the line density of the sector.**

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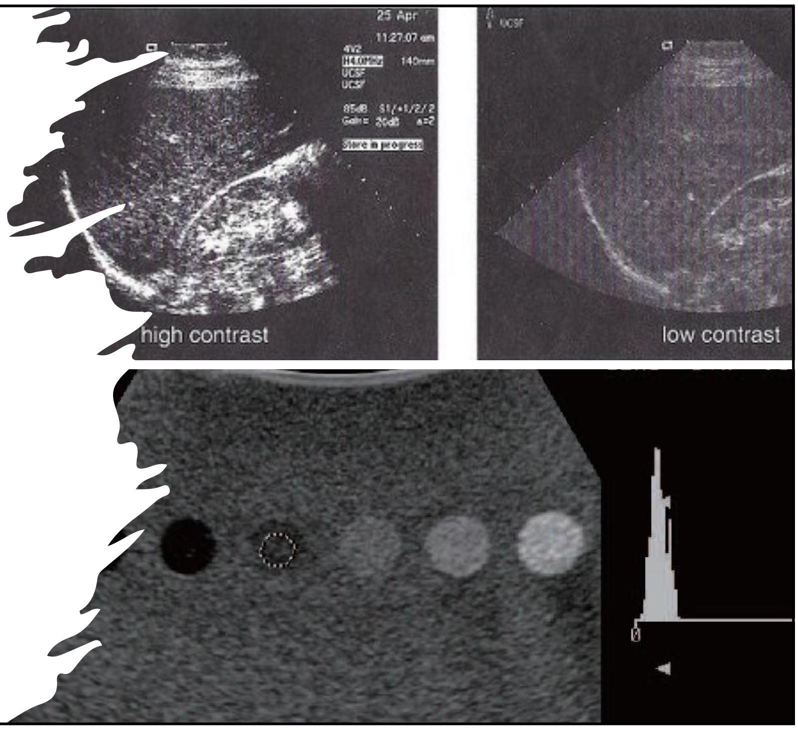
Contrast Resolution

Contrast resolution is the ability to distinguish between differences in intensity in an image.



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Artifacts

- Reverberation
- Side lobe
- Shadowing
- Mirror image
- Beam Width
- Equipment generated artifact

- It's not really important to know each type of artifact.
- The important take home message, is that artifacts occur
- And that we need to understand that artifacts are present in virtually every image we take.
- *When you are unsure whether it is real or an artifact,*
  - *change your acoustic window,*
  - *change the transducer settings, depth ….etc to see if it occurs in every view or just one.*

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Optimizing Echo Images

- The small size of the neonatal heart and its rapid rate of contraction make high spatial and temporal resolutions essential.
- Fortunately, the lack of need for deep tissue penetration in neonatal echocardiography allows use of high-frequency probes and high frame rates.

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TGC (Time gain compensation)

- Compensates for near gain attenuation
- Echoes returning from superficial layers are stronger signals than deeper tissues that return with smaller amplitudes.
- Allows the user to easily make this adjustment.

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Key steps of image optimization in Neonates

1.High frequency transducer
2.Narrowing the sector width
3.Decreasing the image depth
4.Adjusting focal point.
5.Using “zoom”

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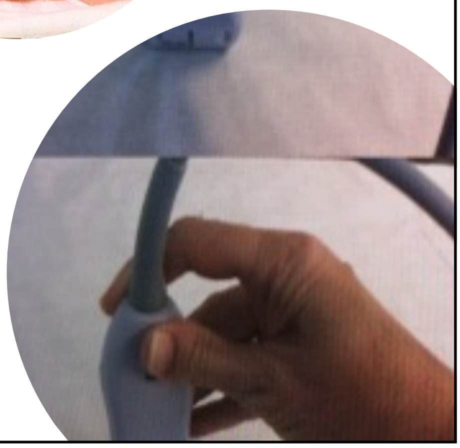
Image optimization

- Holding the probe properly
- Position the patient.
- Ergonomics
- Patient’s breathing
- Adjusting the gain and TGC
- Using iSCAN – *One touch optimization of gain and TGC*
- Adjust dynamic range (compression)
- Be patient.



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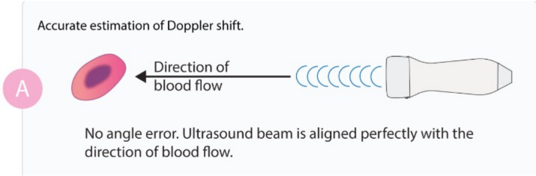
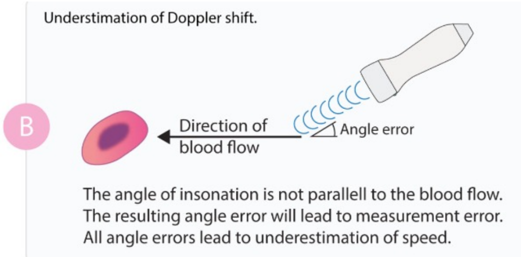
Doppler Angle

- The angle of insonation of the ultrasound beam has a great impact on the extent of the Doppler shift, such that minimization of the angle is a key step in all approaches to Doppler measurement.





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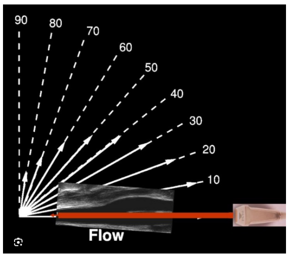
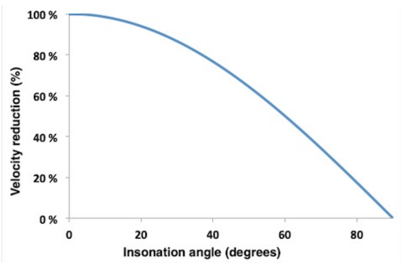
Angle of Insonation

- The curser alignment should be parallel to the flow.
- In clinical practise, it may be difficult to obtain the perfect alignment.
- Small angle errors are not significant.
- In practice, an angle of <20° is considered acceptable since this produces only a 6% reduction in velocity estimation.
- This implies that small angle errors have a negligible impact on calculations





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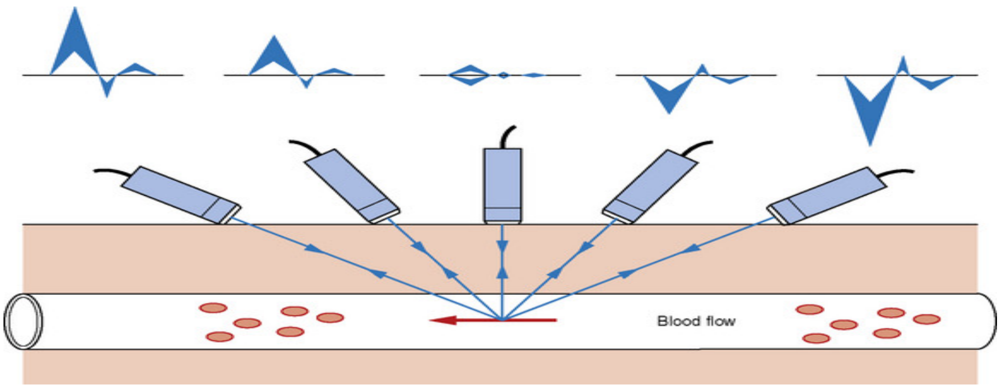
Effect of angle of insonation on Doppler trace



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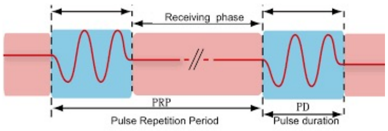
PW – Nyquist Limit

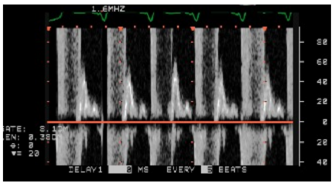
- The Nyquist limit = Pulse Repetition Frequency (PRF) which is tied to the single set of piezoelectric crystals sending and then receiving the signal.
- **Because of this, at any given sampling rate there is a maximum velocity that can be detected, which is called the Nyquist limit.**
- **Above this Nyquist limit, the signal "aliases" (wraps around)** to show an apparent opposite direction of motion

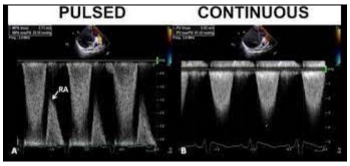
- **Decreasing the imaging depth or decreasing the frequency of the ultrasound beam can be useful to overcome aliasing.**
- **High frequency = good imaging**
- **Low frequency = good Doppler**

TIP:

Changing from a 12 MHz probe to a 8 MHz (or 8 MHz to 5 MHz) probe will increase your Nyquist limit and allow you to sample higher velocity signals







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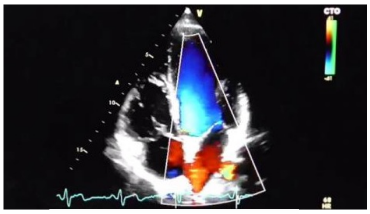
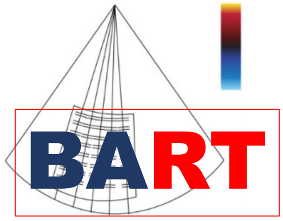
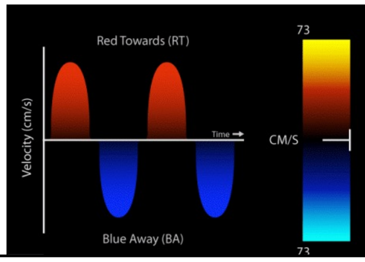
Colour Doppler







- Color Doppler is a technique for visualizing the velocity of blood within an image plane, such that blood flow velocities are superimposed onto the corresponding 2-D image.
- For computing a Color flow map, *PW Doppler technique is employed* using sample volumes placed along multiple Doppler lines
- Velocities are color-coded as red (toward) and blue (away) from the transducer.
- Varying shades of red and blue are used to demonstrated variations in velocity
- High velocity flow (turbulent flow) is encoded by adding yellow or green to the pixels.
- **Like PW, aliasing occurs at the Nyquist limit which represented by Color reversal.**

TIP:

Aliasing can be reduced by

- minimizing depth and sector size of the colour
- changing to a lower frequency probe

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Optimizing Colour Doppler

GAIN SETTING

- The accepted best practice is to increase the colour gain until colour pixels appear, then reducing it back until the noise is suppressed.

FRAME RATE:

- Using the narrowest possible sector
- Use minimal sector depth
- Select most appropriate settings (PRF scale) depending on the type of flow

Tip:

In assessment of PDA (low-velocity signals) it is important to reduce the velocity scale to enable proper visualization.

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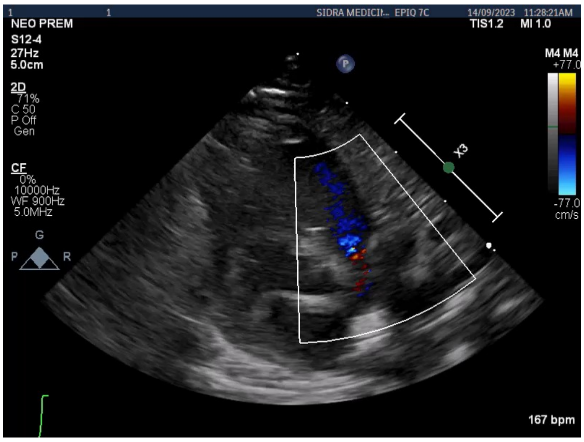
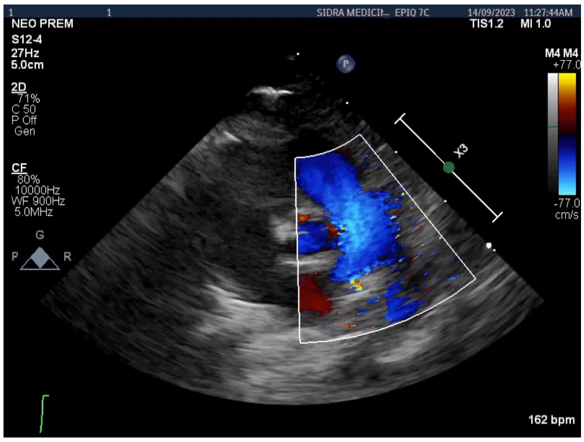
Optimizing Color Gain





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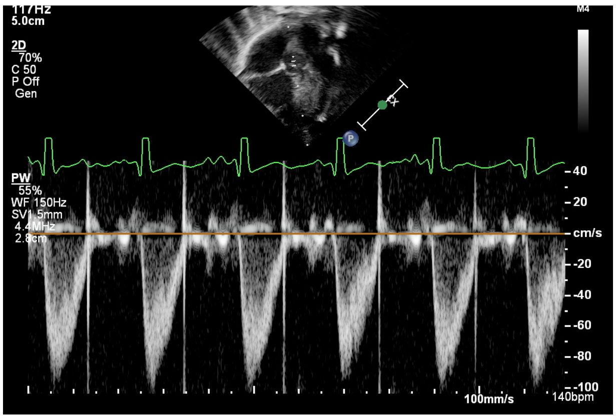
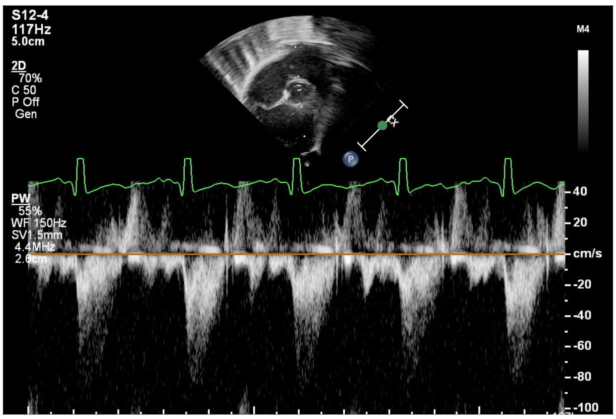
Obtain good Doppler trace before doing measurements





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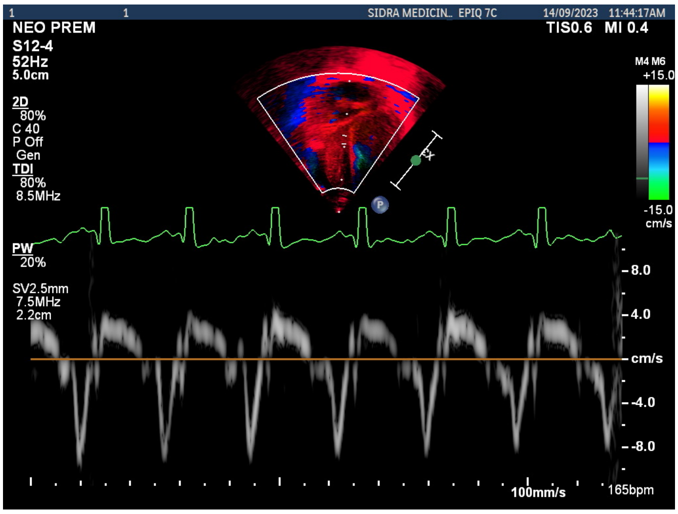
TDI – pulse gate width, gain & sector



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Before you Scan

- Know your patient
- Think why are you performing scan
- Know what are NPE recommendations for assessment
- Remember 3D orientation of heart
- Review, Discuss & Ask
- Don't assume, ONLY report what you see
- Accuracy of measurements to minimize interobserver variability

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Sidra Medicine

Quaternary Childrens Hospital, Qatar

<u>Accredited GME approved Center</u> -
"Perinatal cardiology & Neonatal Hemodynamics Fellowship" program

Questions ?

Samir.gupta@durham.ac.uk
sgupta@sidra.org

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