Session 1

Doppler Ultrasound

Tutor:

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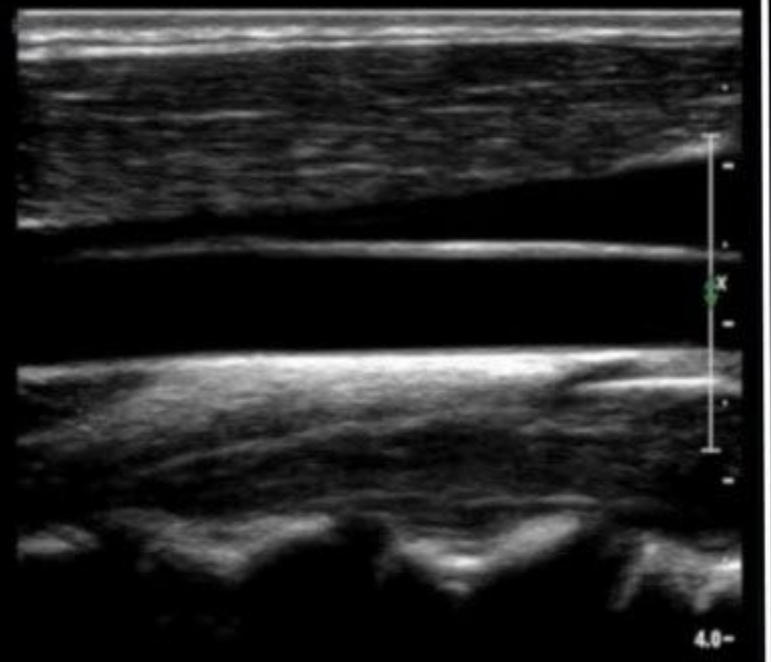
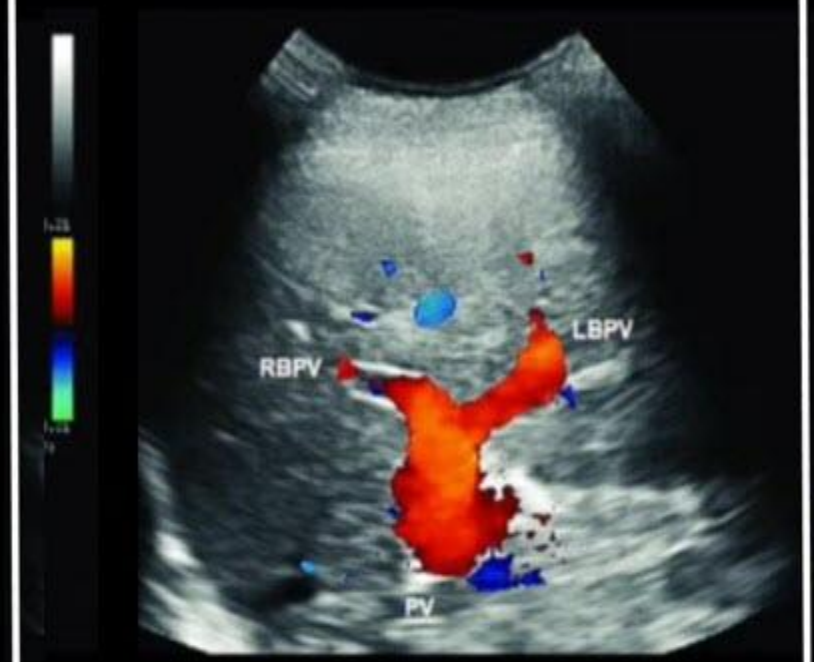
Ultrasound

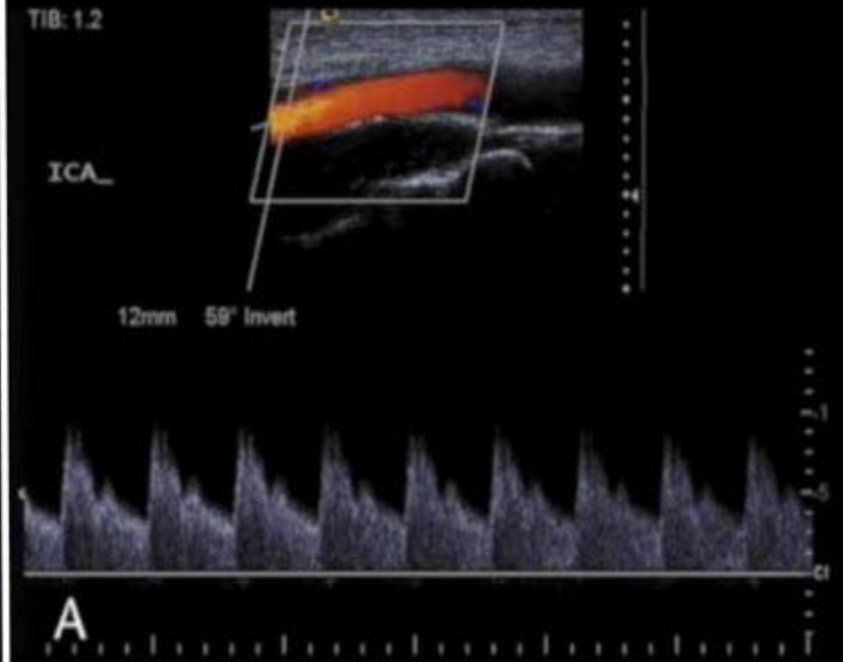
B mode



Color Doppler

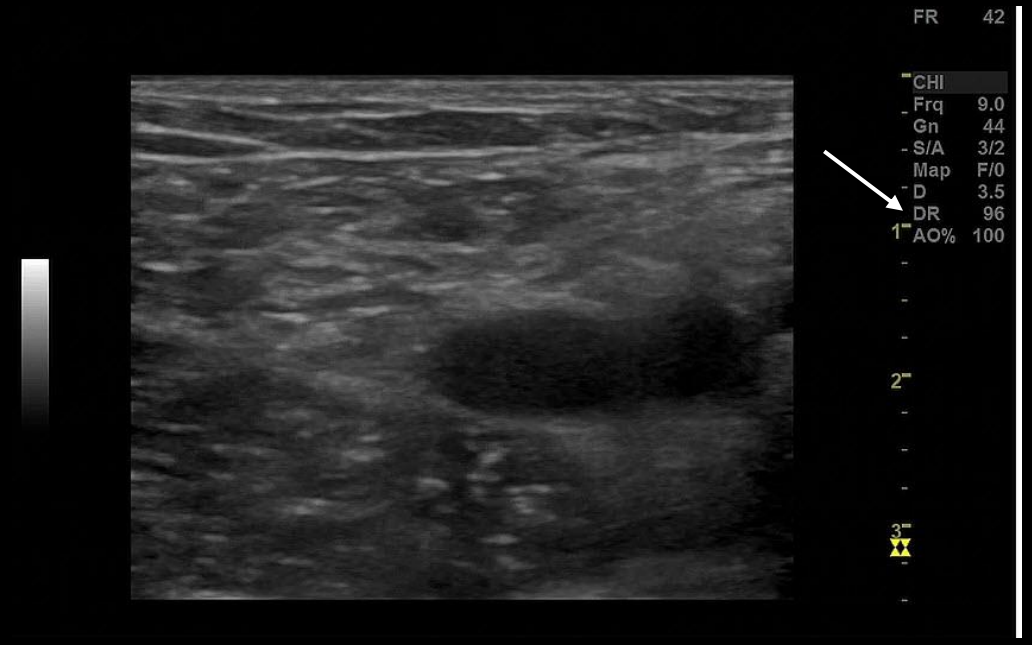


Spectral Doppler

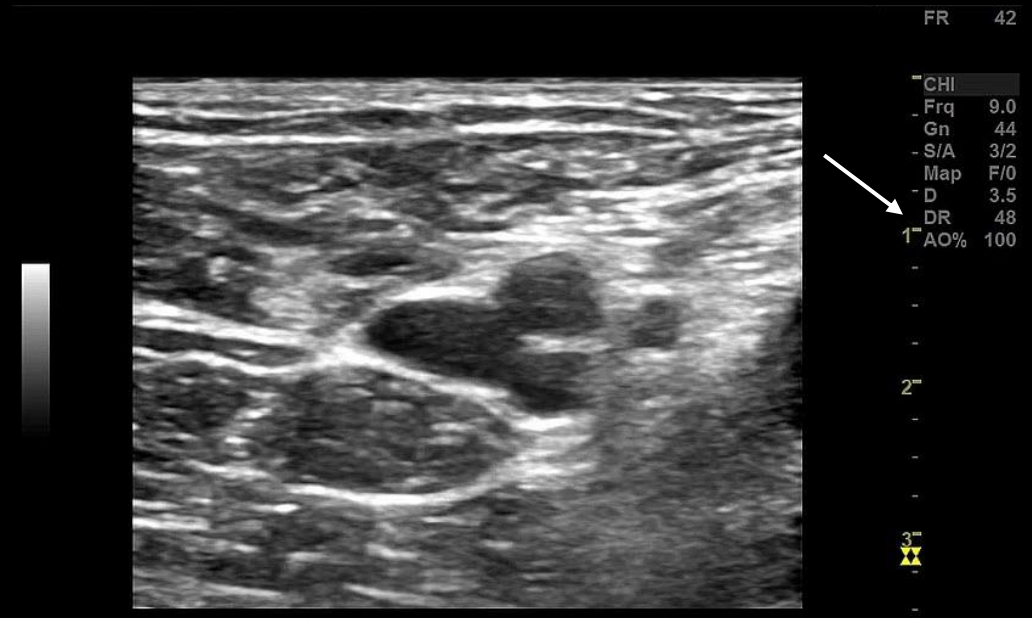


Dynamic Range: (DR) in B-Mode

Control the contrast.
High contrast means more gray shadows. It uses for diagnose any vessel pathology (e.g. thrombus, dissection and others)
While low DR uses to see the adventitia of blood vessels.



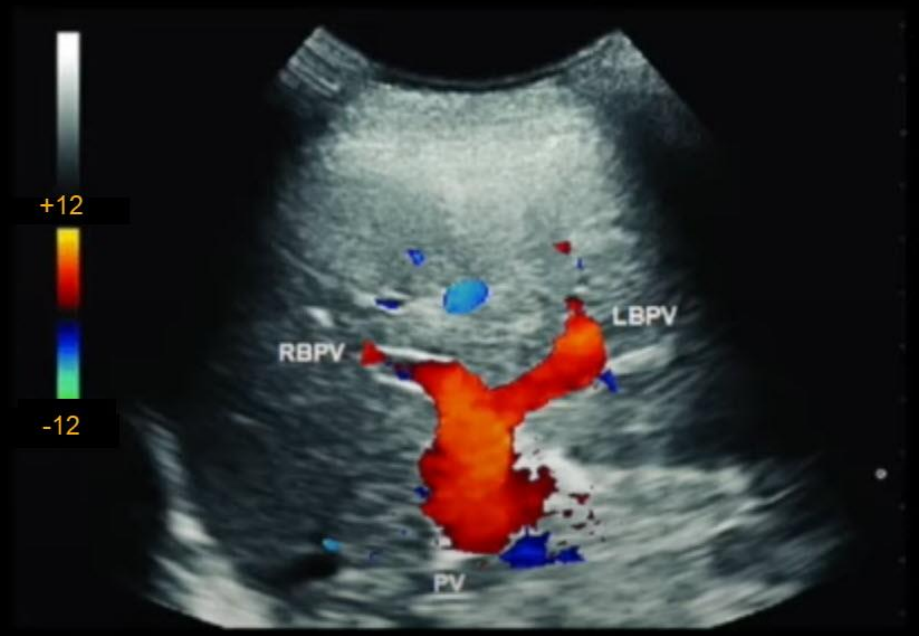
High DR



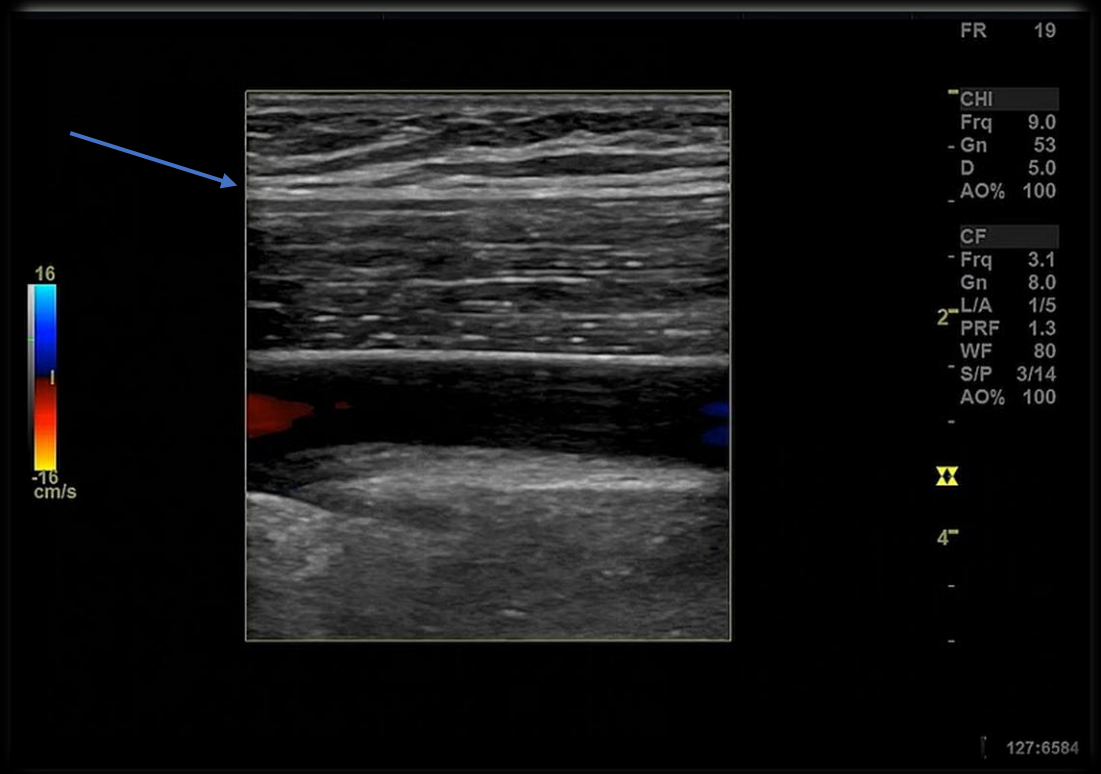
Low DR

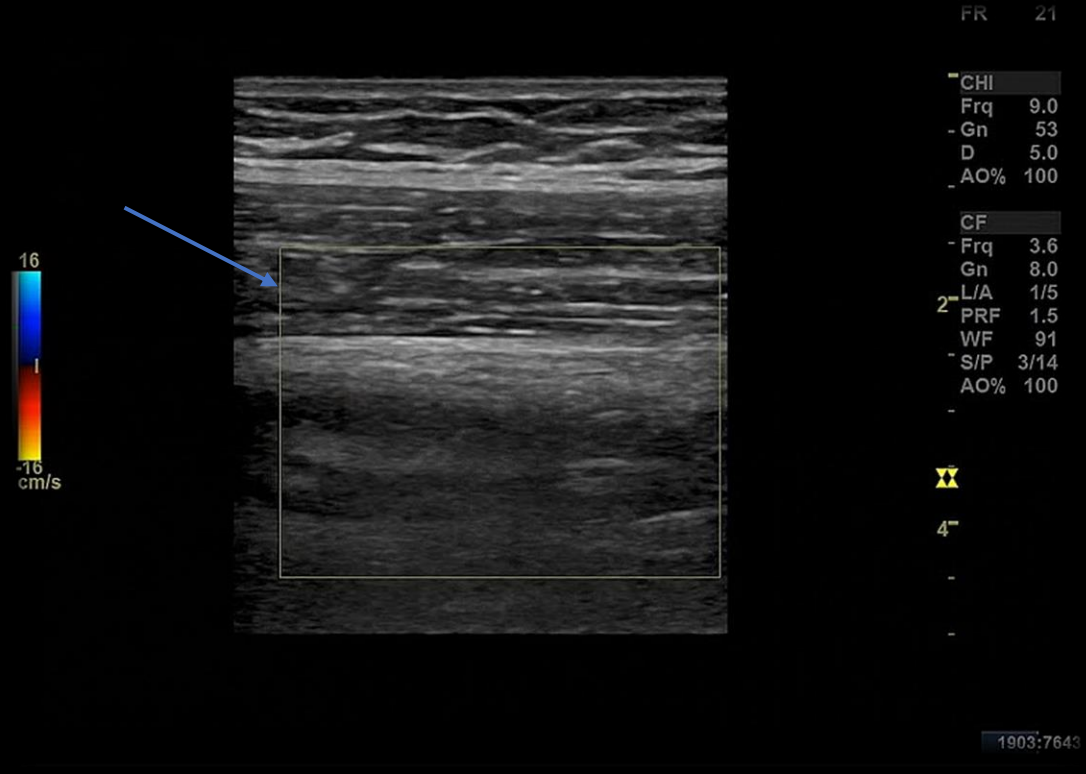
1 Color Doppler

- Samples each pixel and displays doppler shift
- Superimposed color gives **direction**
- **Intensity** relates to flow → Velocity

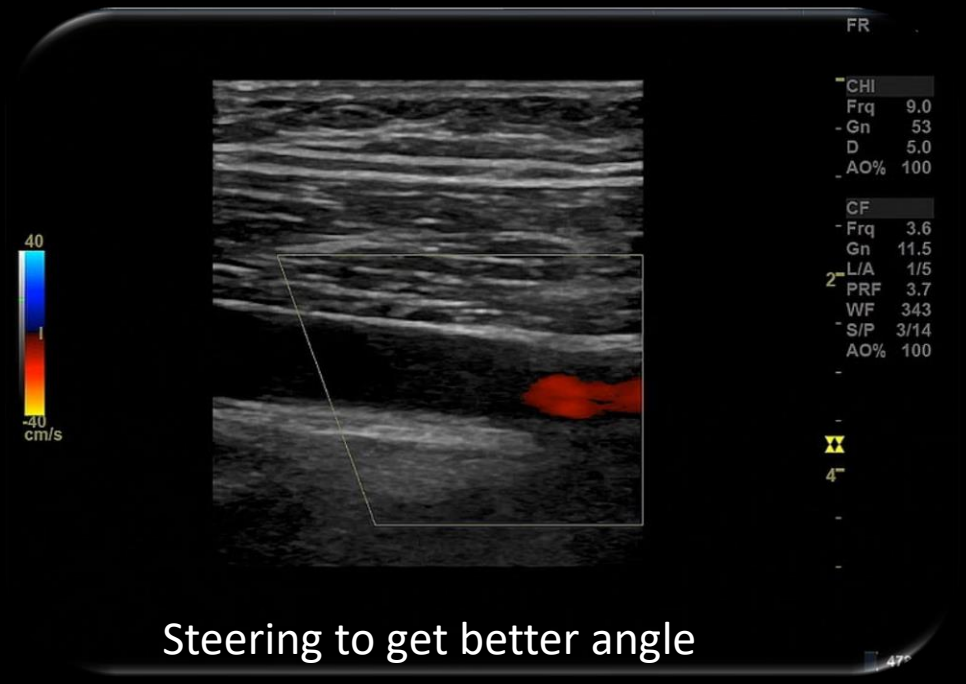


Sample size:

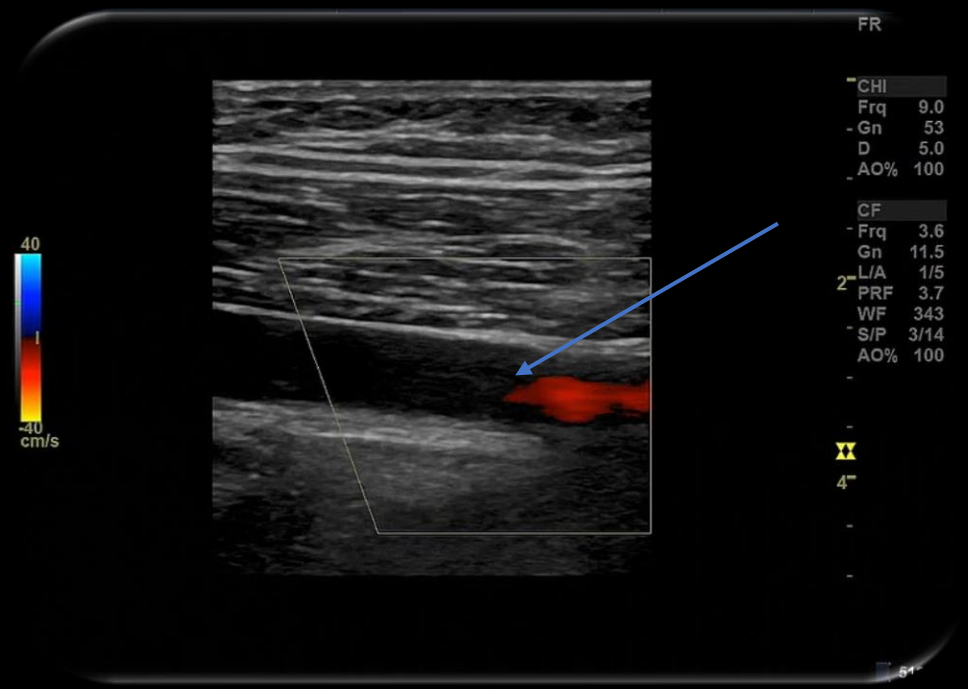




Decrease sample size will increase the frame rate= better image

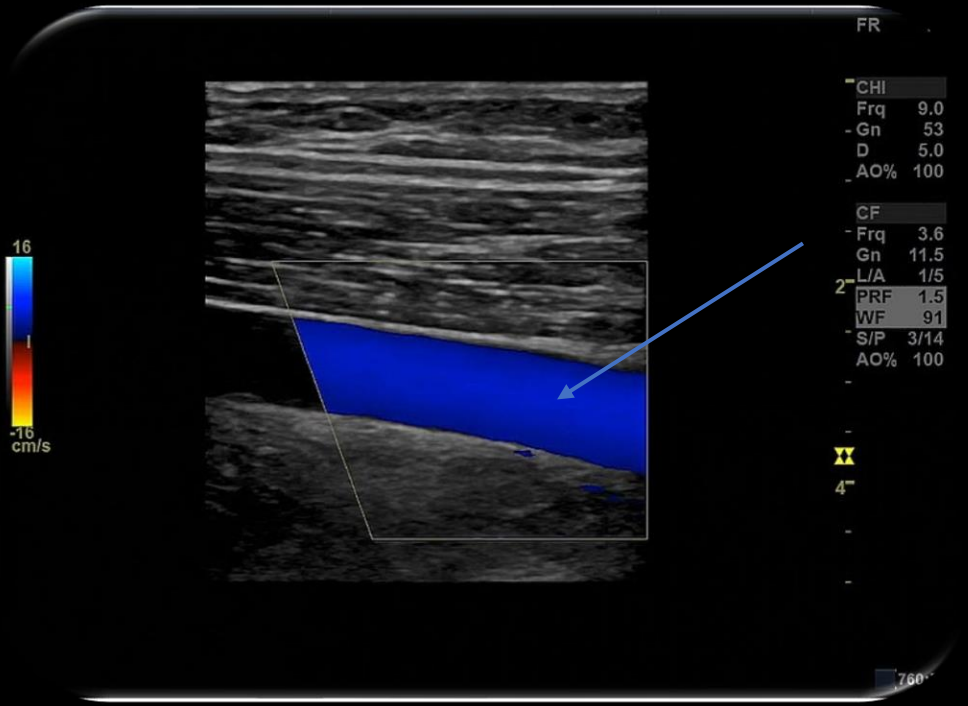


Steering to get better angle



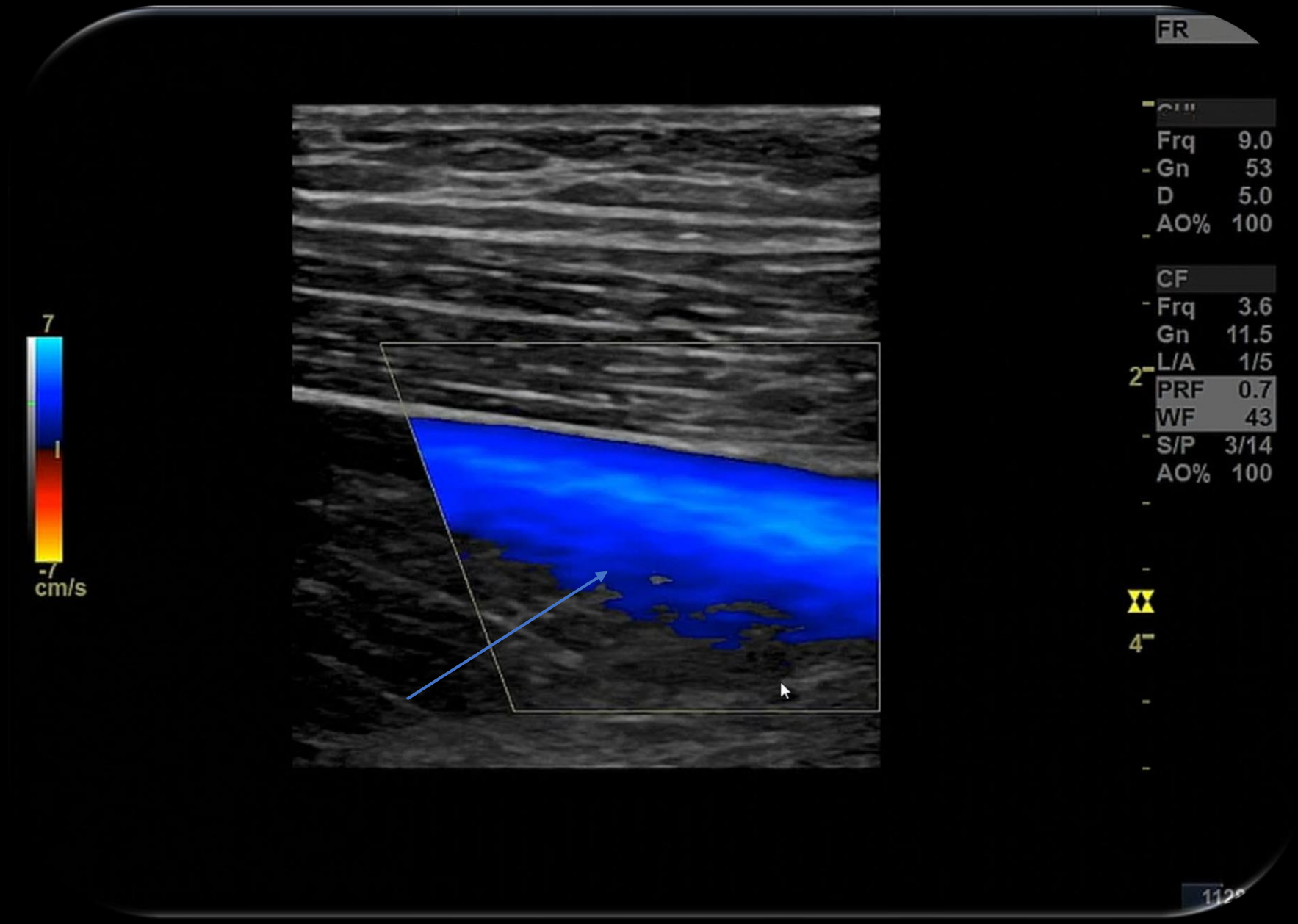
For arteries set the velocity high

Change the highest velocity detection according to the blood vessel under examination

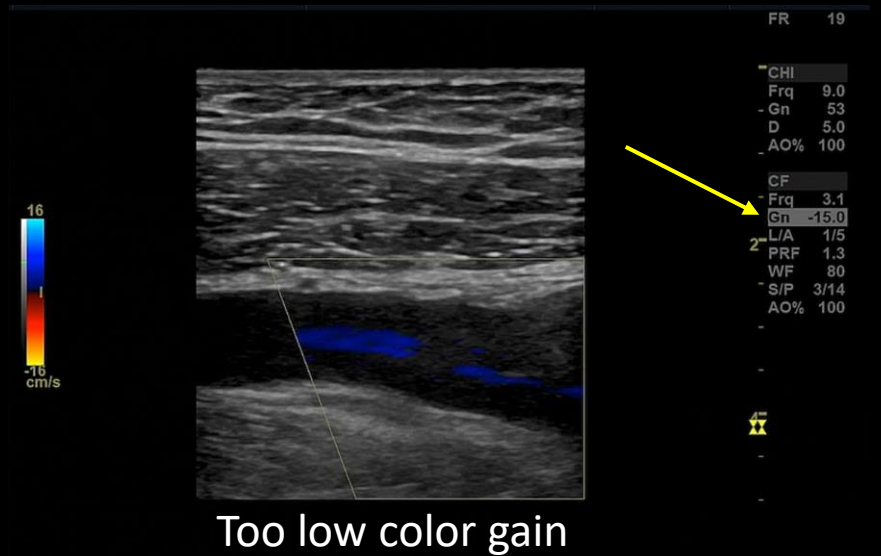


For veins set the velocities low otherwise
The vein will not be detected

Color bleeding outside the vessel if the velocity set too low

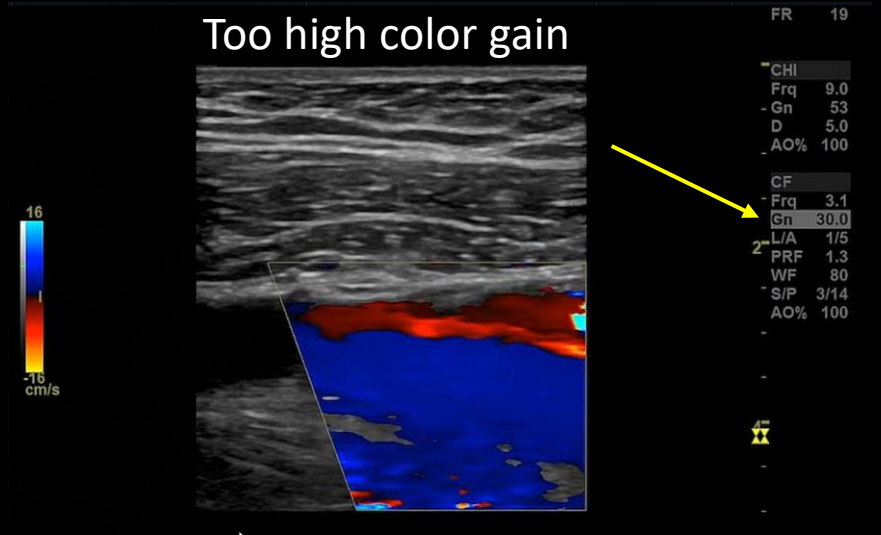


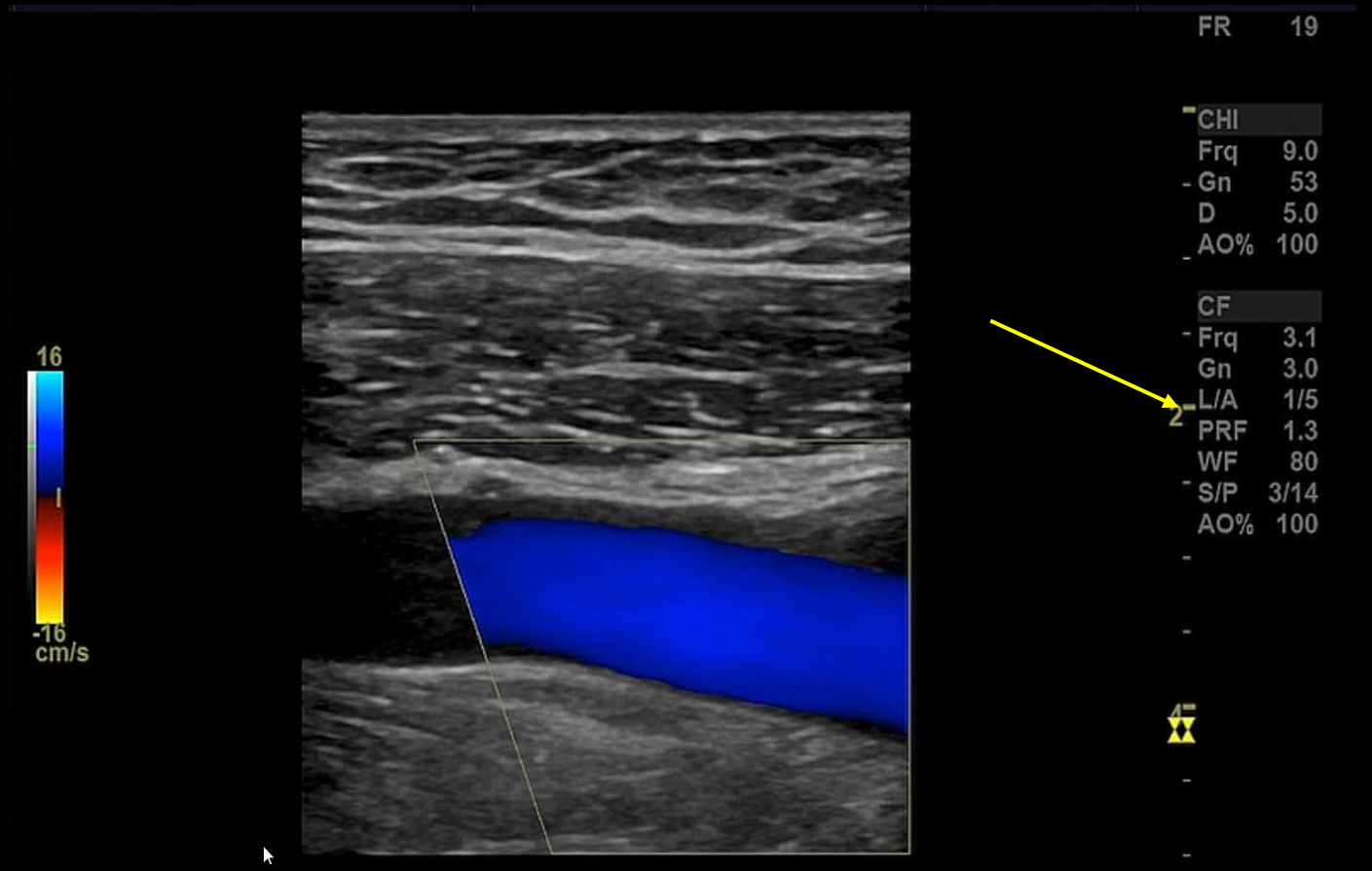
Adjust the color Gain:



Too low color gain

Too high color gain





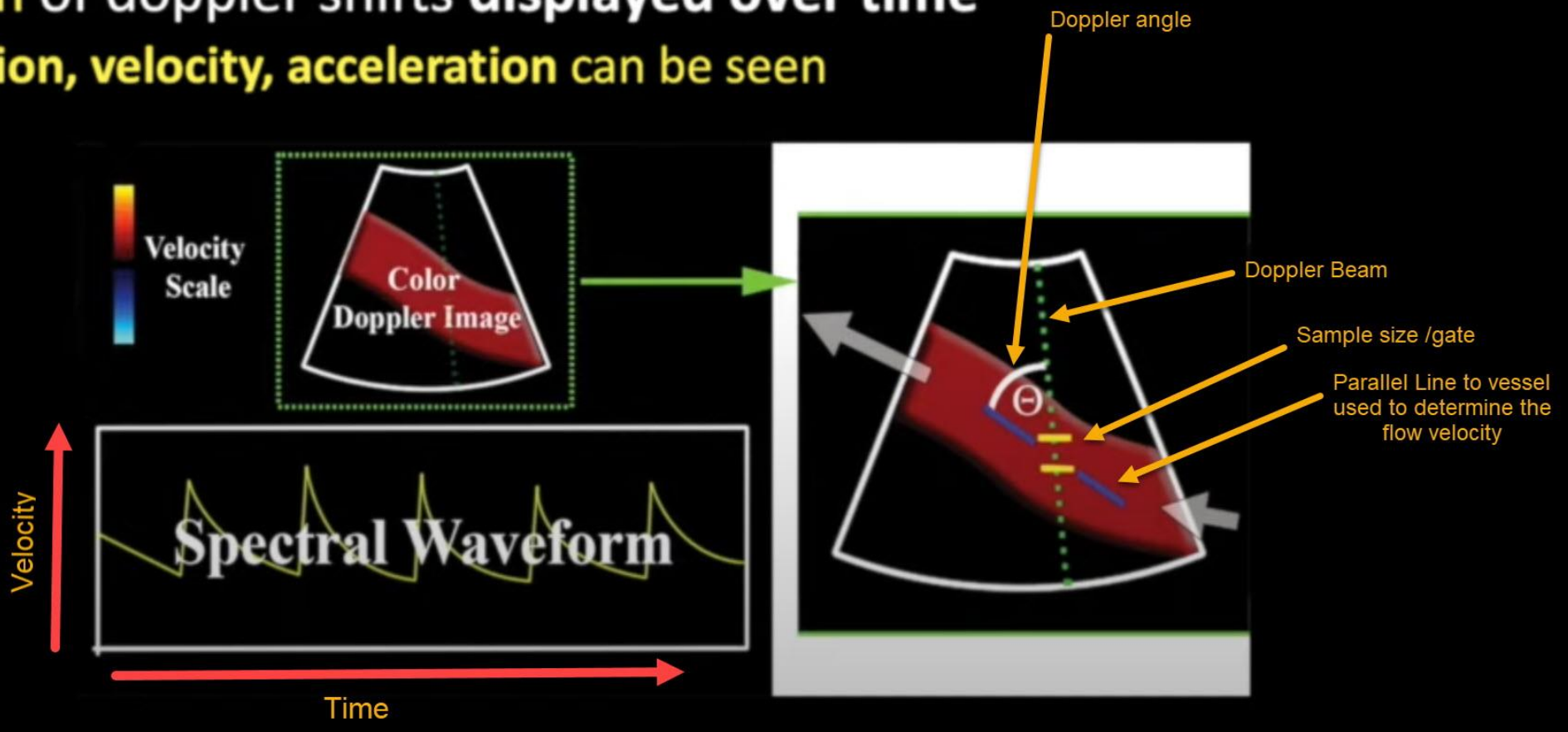
Adjust the amplification of doppler signal by adjusting the Color Gain, to overcome the speckling in the surrounding tissues.

2 Power Doppler

- **Sensitive** for detection of flow, no directional information
- Advantages:
  1. Sensitive
  2. Less dependent on angle
  3. No aliasing

3 Spectral Doppler

- Small sample volume (2-4 mm) in center of vessel
- Spectrum of doppler shifts **displayed over time**
  - **Direction, velocity, acceleration** can be seen

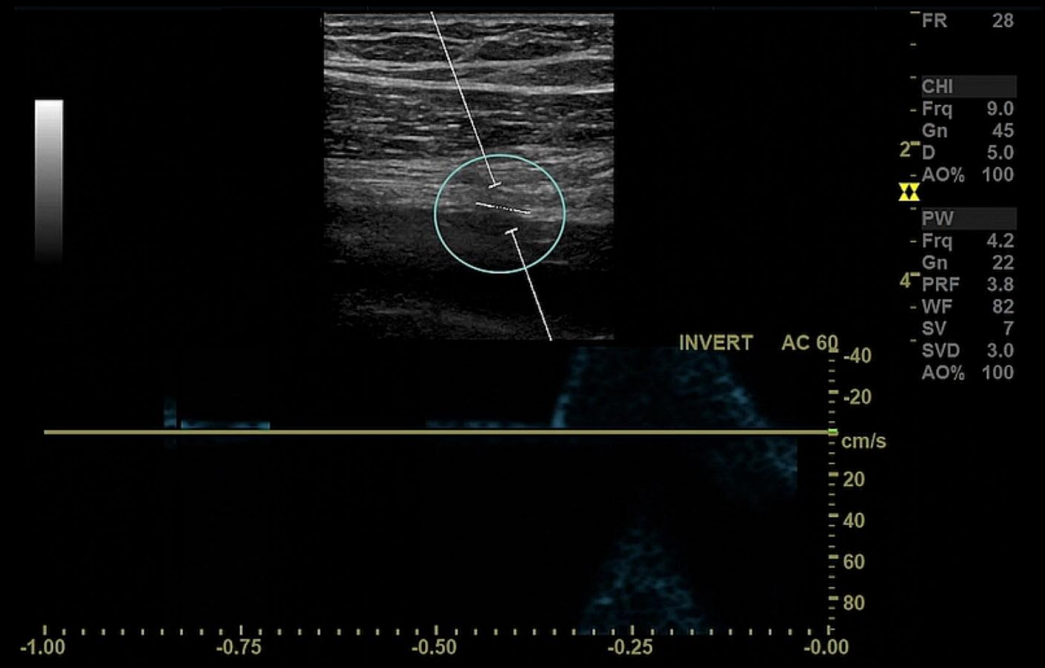


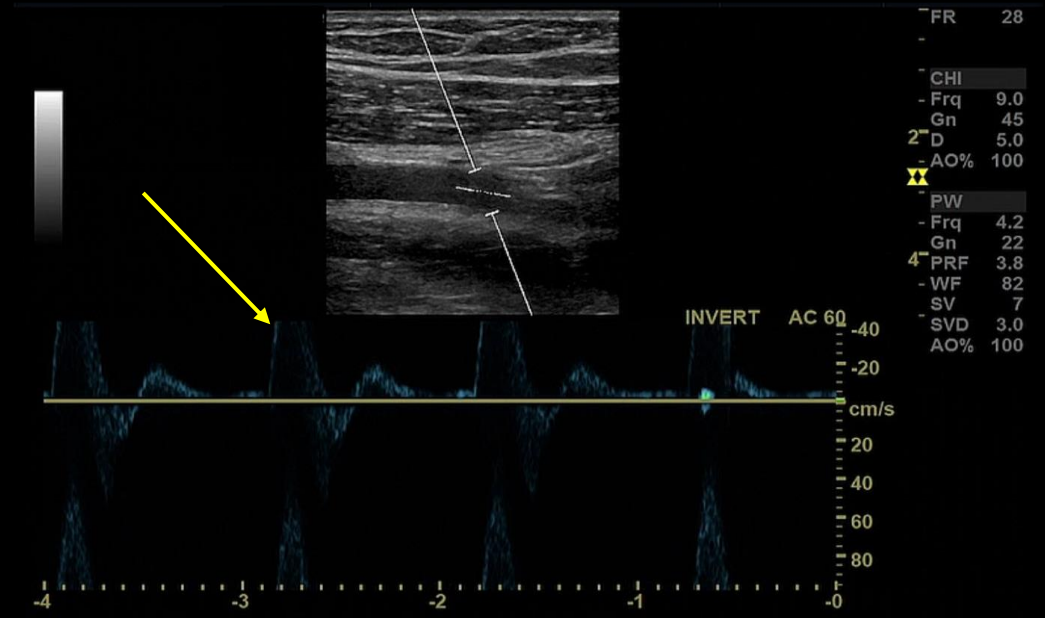
Sample volume size:

The sample volume is the region where the velocities are measured. This region can be adjusted with the help of the trackball and is depicted as an interrupted line (Doppler line). The width of the sample volume can also be adjusted.

Lage sample size will detect the low velocity of surroundings.

Veins usually needs large gate (sample) while arteries usually required a small sample size (gate).

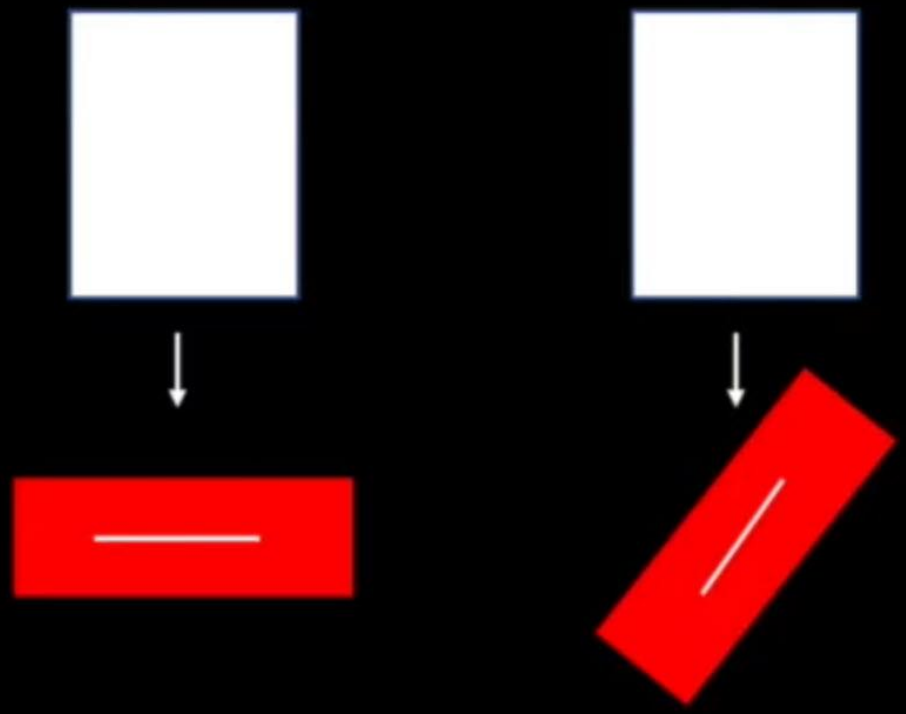




Concept: Doppler Angle

Optimal < 60 degrees

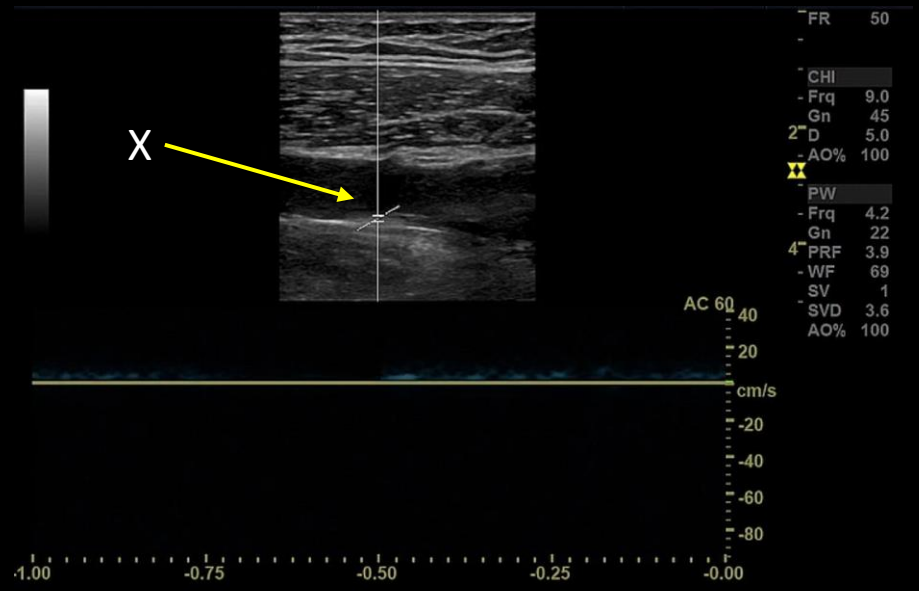
- 90 degrees no signal
- > 60 degrees less accurate velocity (small errors in angle indicator for spectral doppler → inaccuracy)



Spectral Doppler optimization:

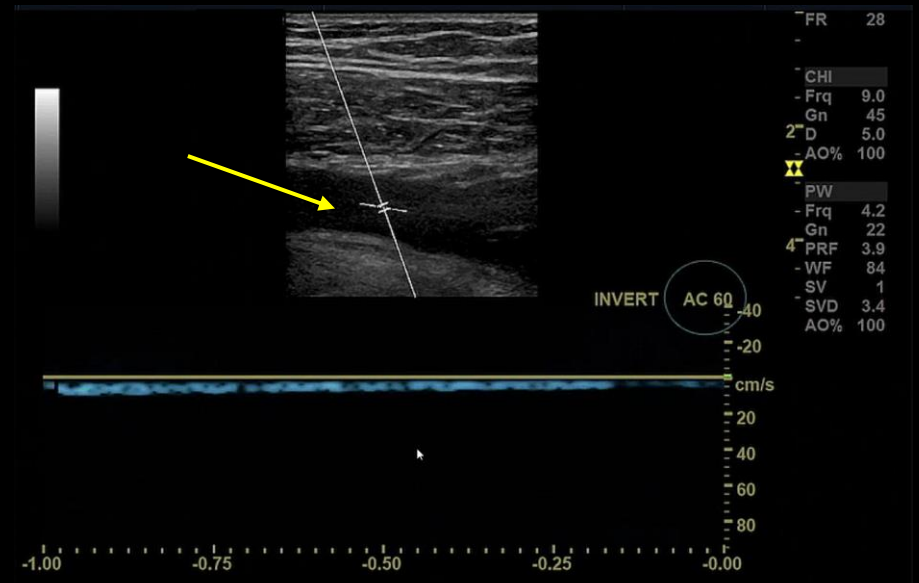
The insonation angle: (beam Steering)

is the angle between the path of the Doppler pulses and the direction of flow in the vessel as indicated by the orientation of the Doppler box. When this angle is 90° (top), there will be no frequency shift because cos(90°) = 0.



Doppler angle correction:

refers to an imaging post-processing method used to adjust for the effects of insonation angle on the Doppler shift.
Measurement of flow velocity with Doppler imaging is dependent on the angle between the ultrasound beam and the target (insonation angle), with the maximum and true velocity achieved at 0 degrees (parallel to the target). In most clinical scenarios, an insonation angle of 0 degrees is impractical and angle correction can still be applied to achieve an accurate velocity measurement . Angle correction is considered accurate for diagnostic purposes at insonation angles less than 60 degrees. At angles above 60 degrees, an error of up to 20-30% in calculated velocities can occur.



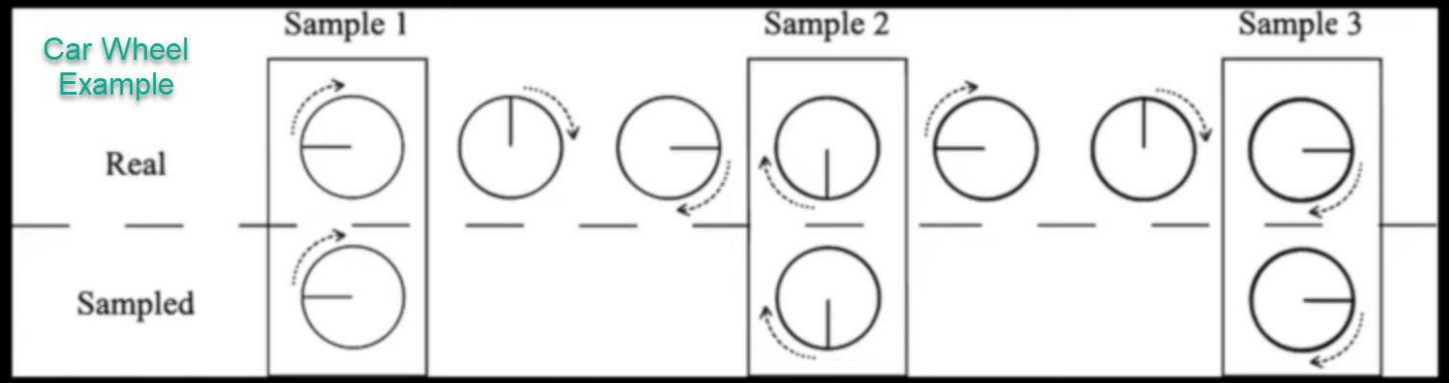
Concept: Scale

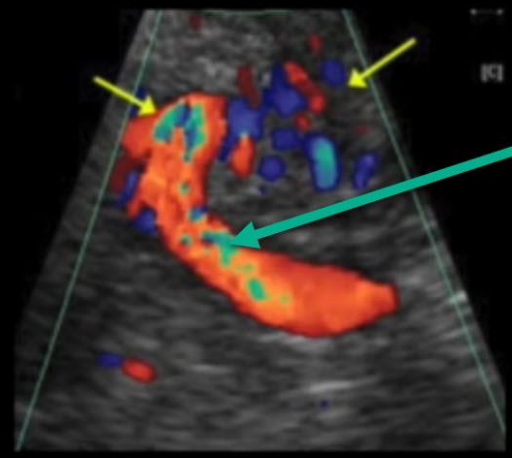
- Spectral: Most of graph visualizes waveform
- Too high: waveform is too small
- Too low: aliasing ('wraparound')

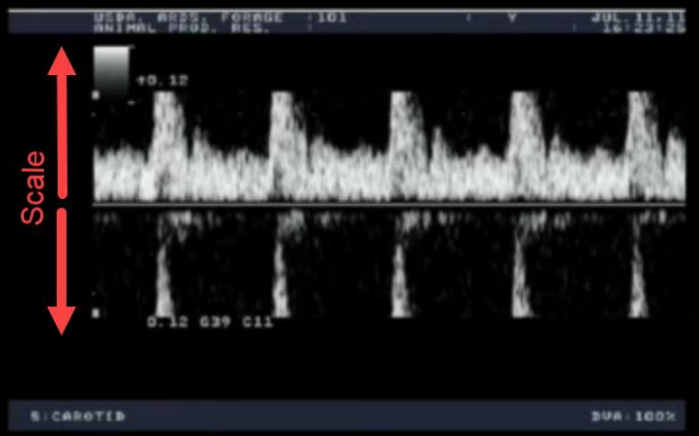
Scale: Aliasing

- High velocities displayed as negative
  - *Occurs when doppler shift f > ½ * PRF (pulse repetition frequency)*

****FREQUENCY SHIFT IS TOO FAST FOR RATE OF SAMPLING****



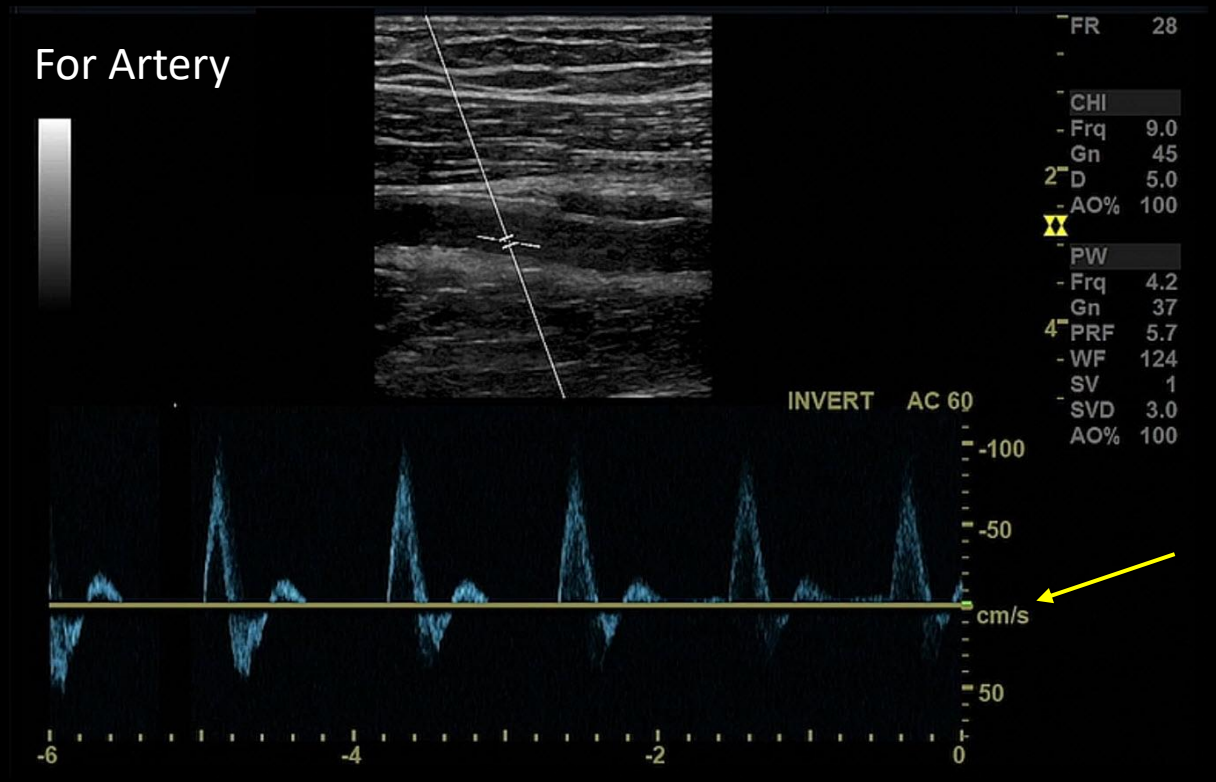




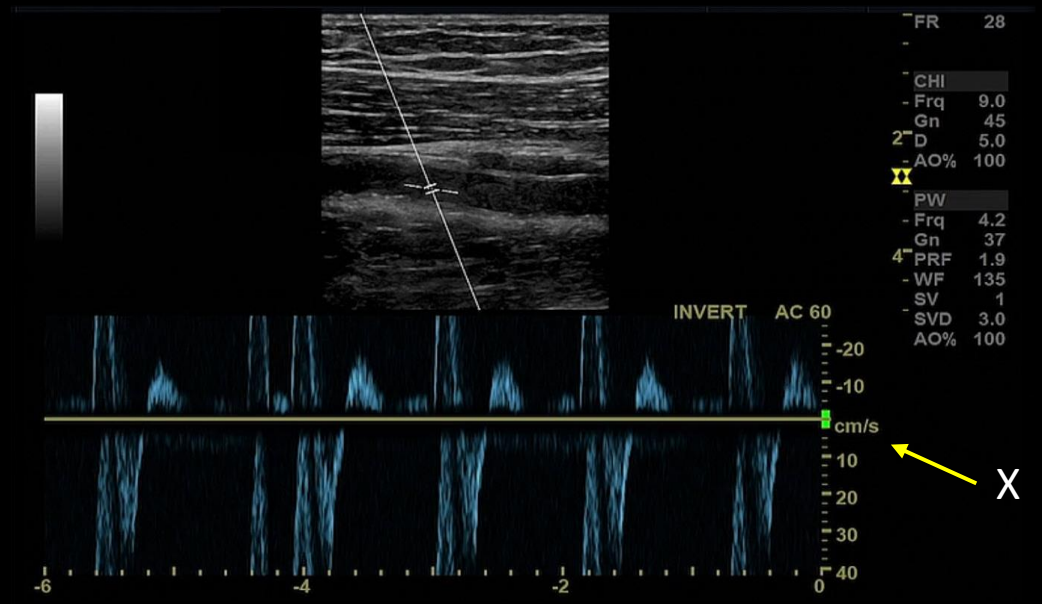
The Base Line and Scale adjustments:

For arteries focus on positive base line and large scale while for veins focus on negative and positive base line with small scale.

For Artery

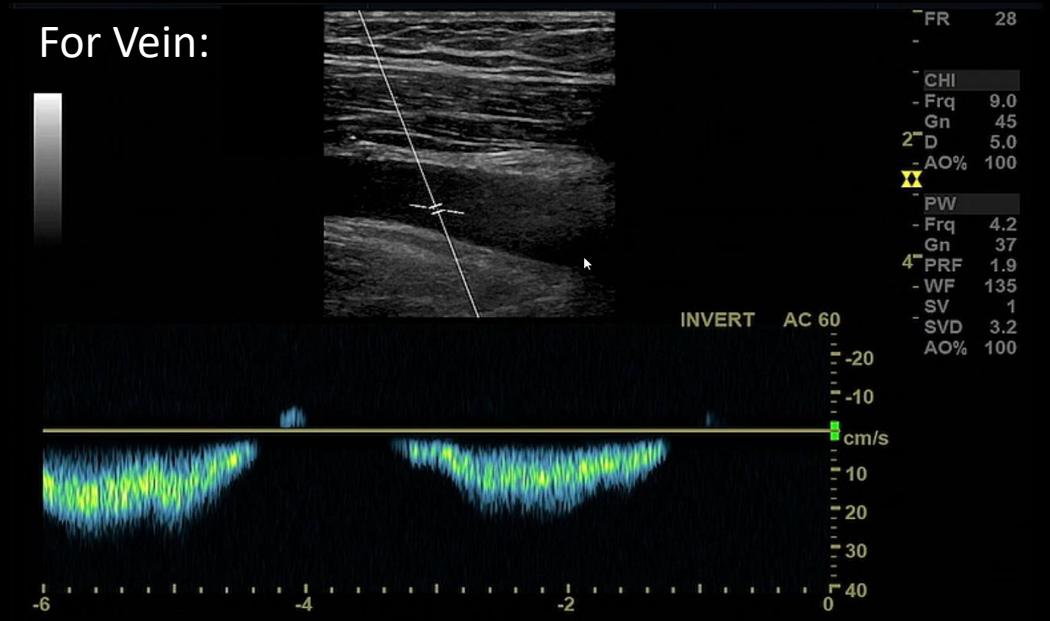


Increased Scale



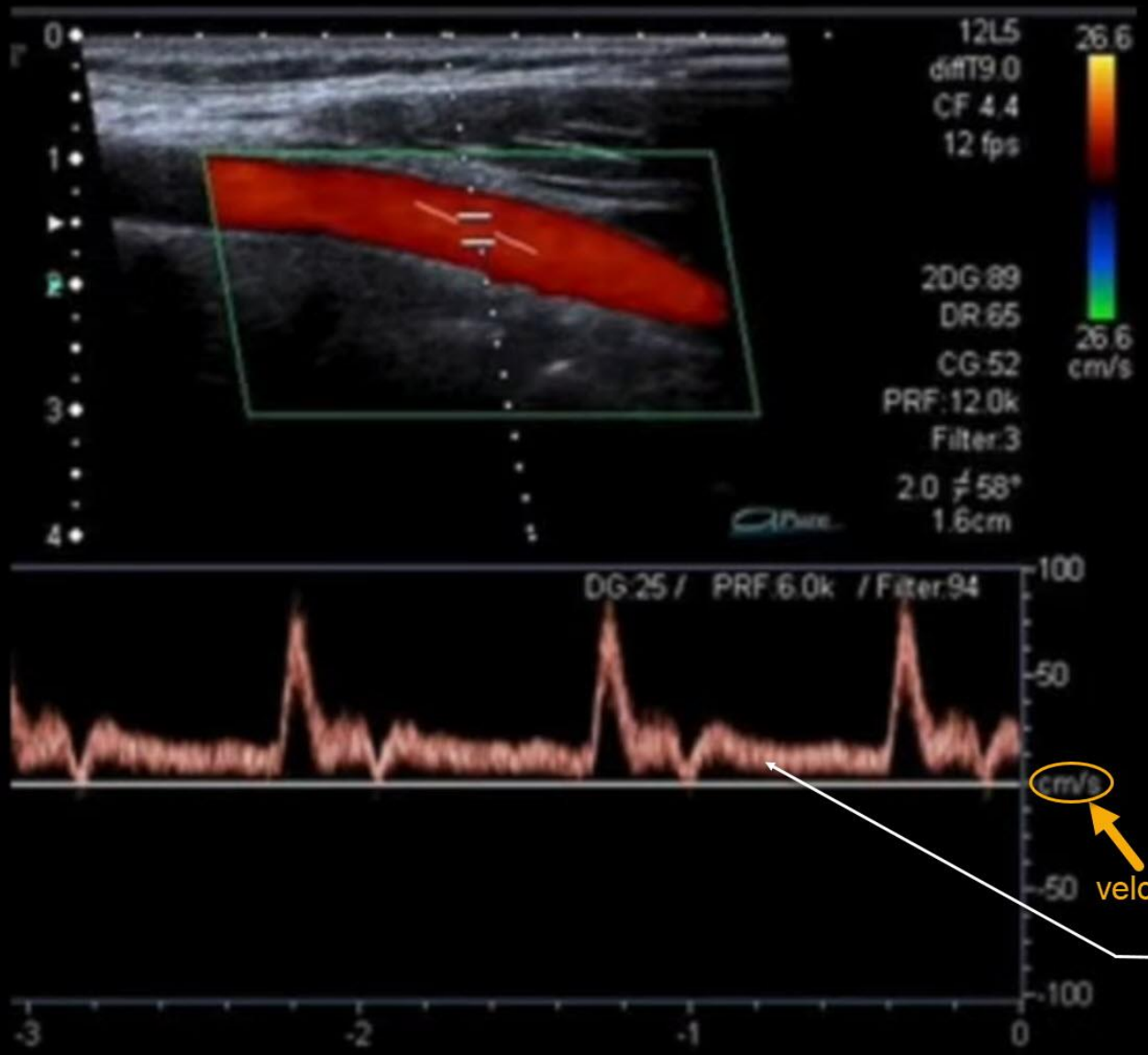
X

For Vein:



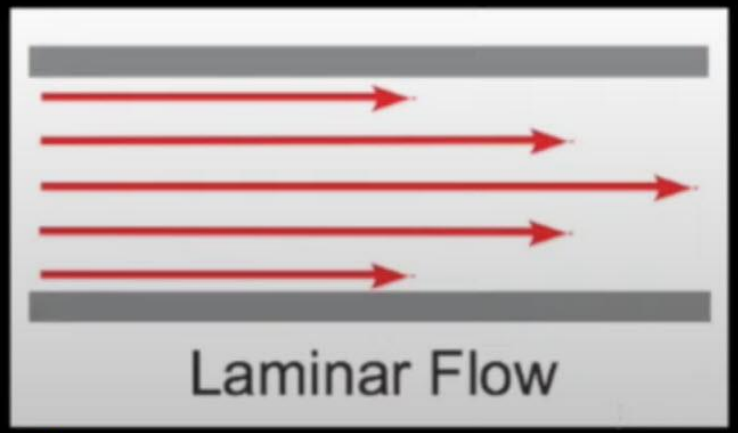
Decreased Scale

Spectral Waveform



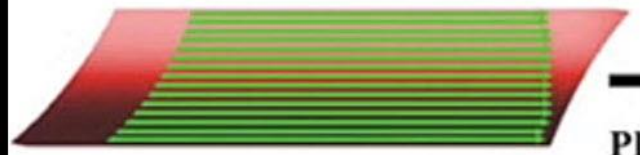
y axis: **range** of frequency shifts/velocities

x axis: time



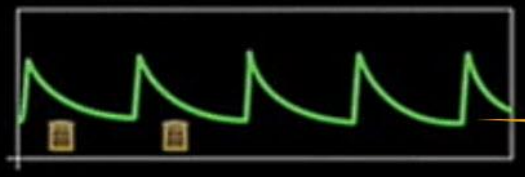
Thickness represents the range of velocities in the gate in blood vessel

aorta



Plug flow

Thin waveform line
Clear window

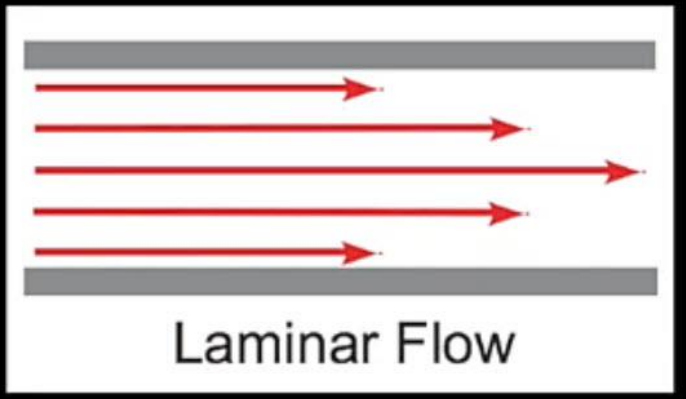


window

Large / medium-sized vessels

Laminar flow

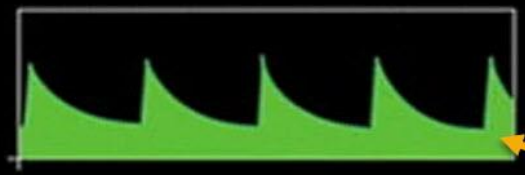
Thick waveform line
Partially clear window

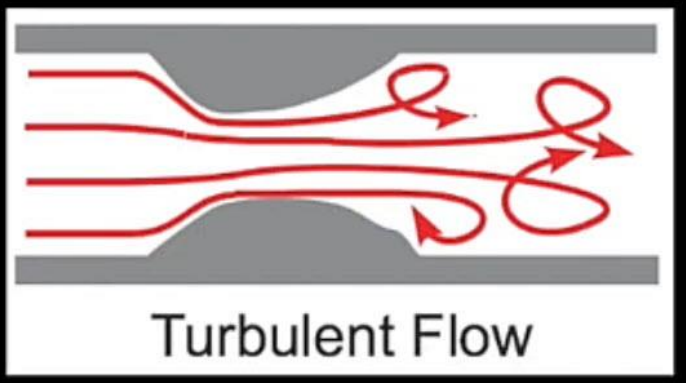


Small or compressed vessels

Laminar flow

Waveform interface only
No window





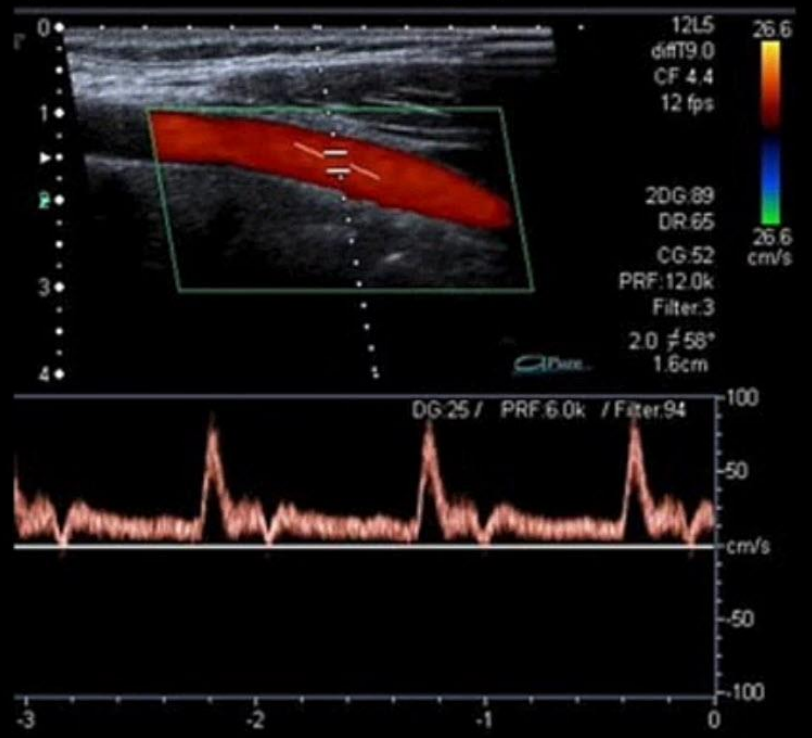
Diseased vessels

Turbulent flow

"SPECTRAL BROADENING"

Spectral Waveform

- **Direction** – above or below the baseline (above towards transducer)
- **Velocity** – how far it is away from the baseline (thickness is range)
- **Acceleration** – slope of the curve



Vessels have characteristic normal waveforms

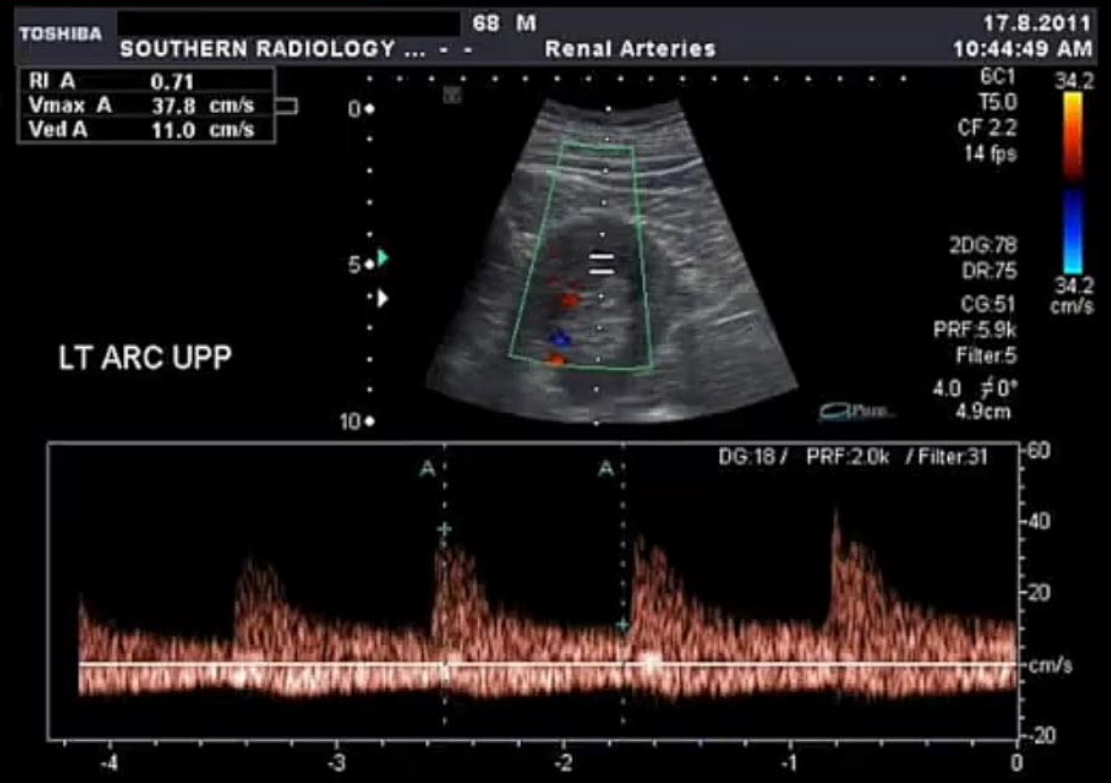
Resistive Index

RI = (S – D) / S

RI < 1 (forward EDF)

RI = 1 (no EDF)

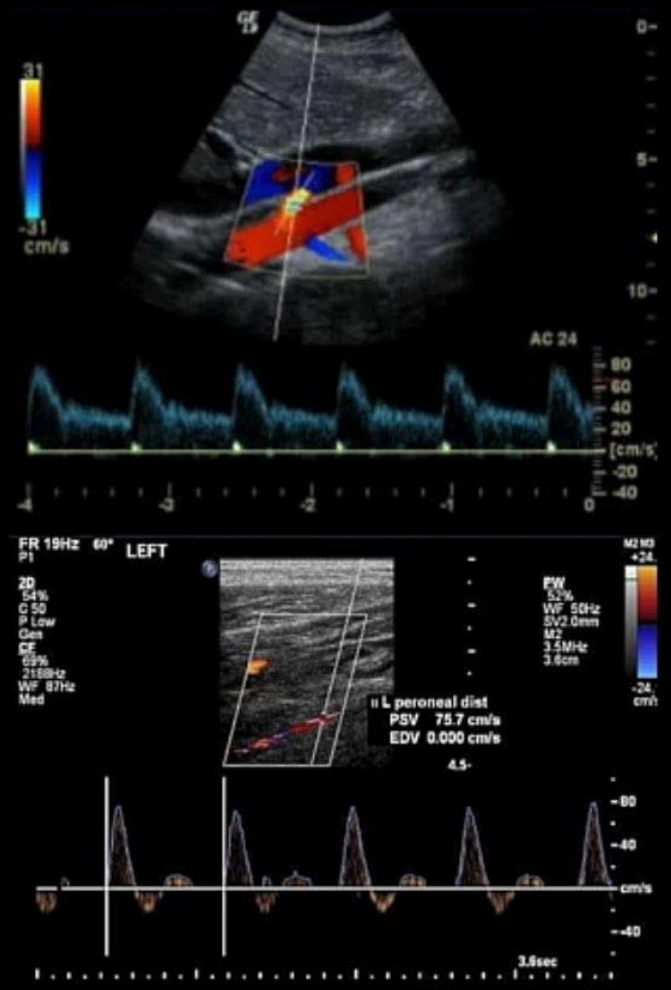
RI > 1 (reversed EDF)



Signifies resistance of vascular bed DISTAL to interrogated vessel

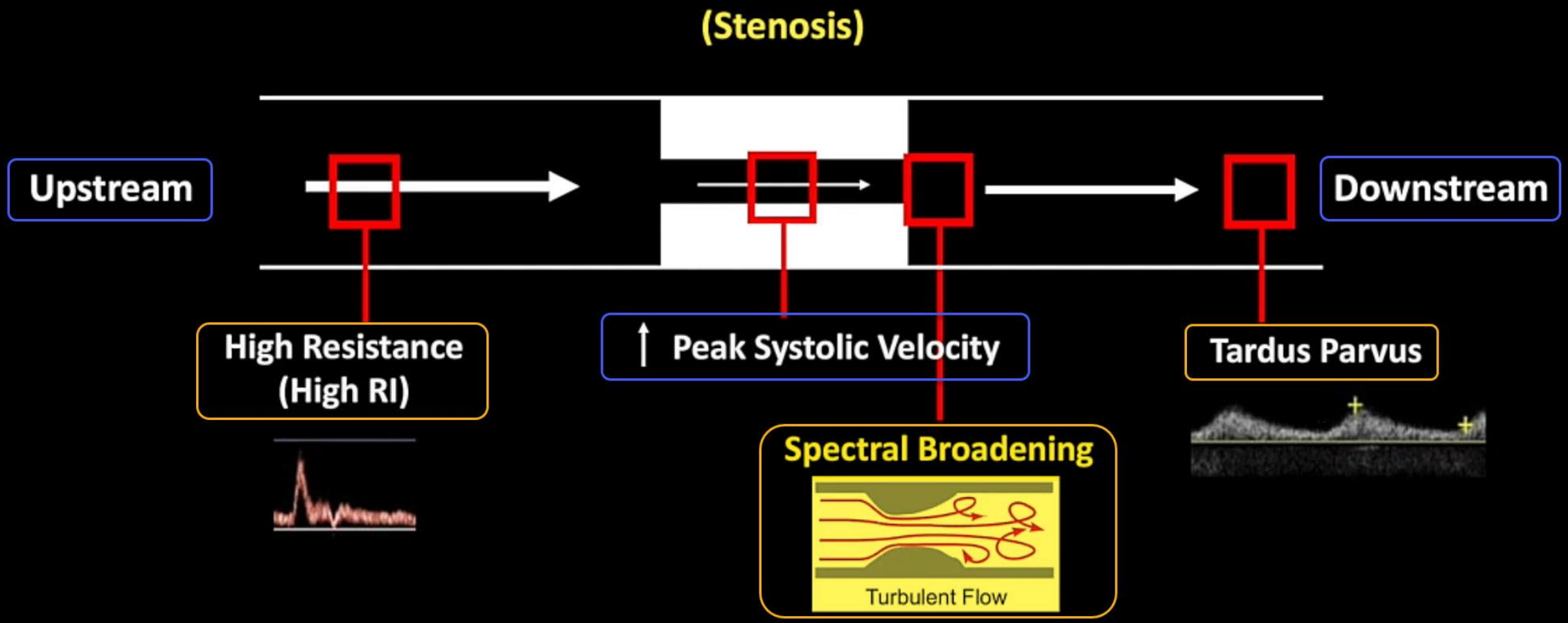
Characteristic Normal Waveforms: RI

- **Low RI**: Arteries supplying organs that need constant perfusion
  - Brain, Liver, Kidneys, Placenta



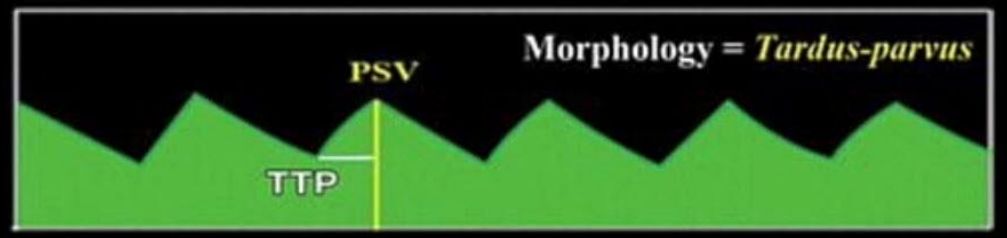
- **High RI**: need intermittent or on-demand blood supply
  - Femoral, facial, SMA

Principle: Stenosis

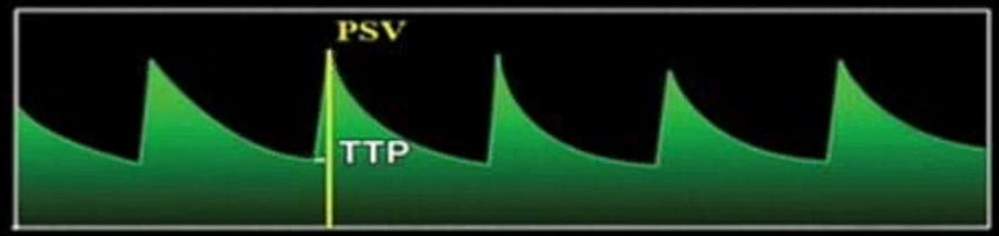


"Tardus Parvus"

- Tardus = slow upstroke
  - Time to peak > 70 ms (TTP)
- Parvus = weak amplitude



Upstream stenosis



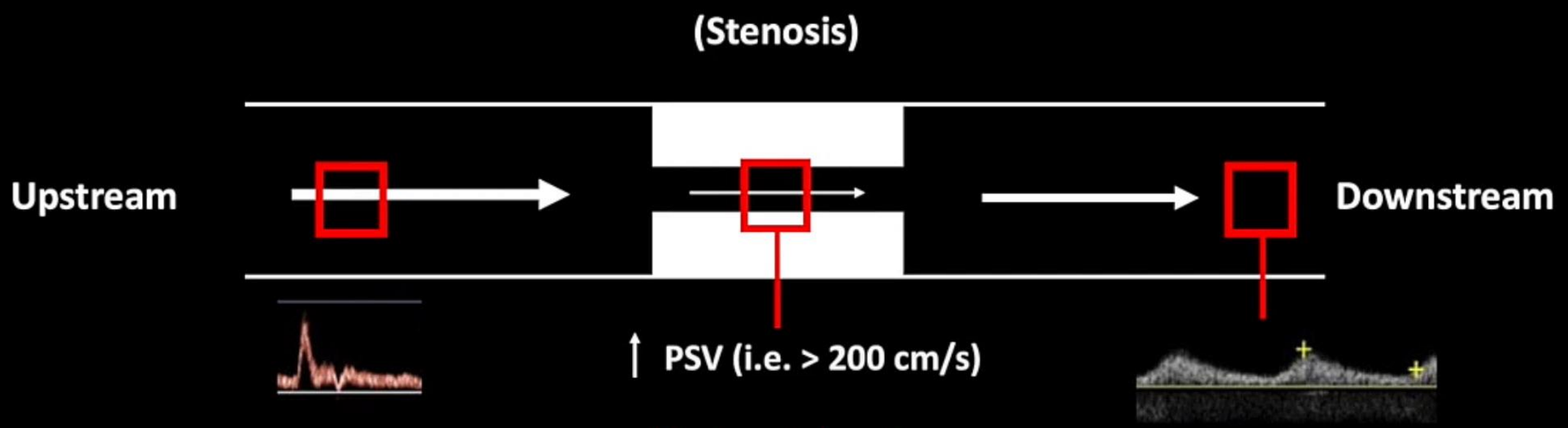
Normal

Subjective:
- **Appearance**

Objective:
1. Time to peak > 70 ms
2. **Low RI** (i.e. < 0.5 for hepatic artery)

Artery distal to stenosis has low RI + dilated blood vessel downstream

Principle: Stenosis



High resistance appearance

High RI (i.e. > 0.7)

Peak systolic volume

"Tardus Parvus"

Low RI (i.e. < 0.5)

Thanks for Listening