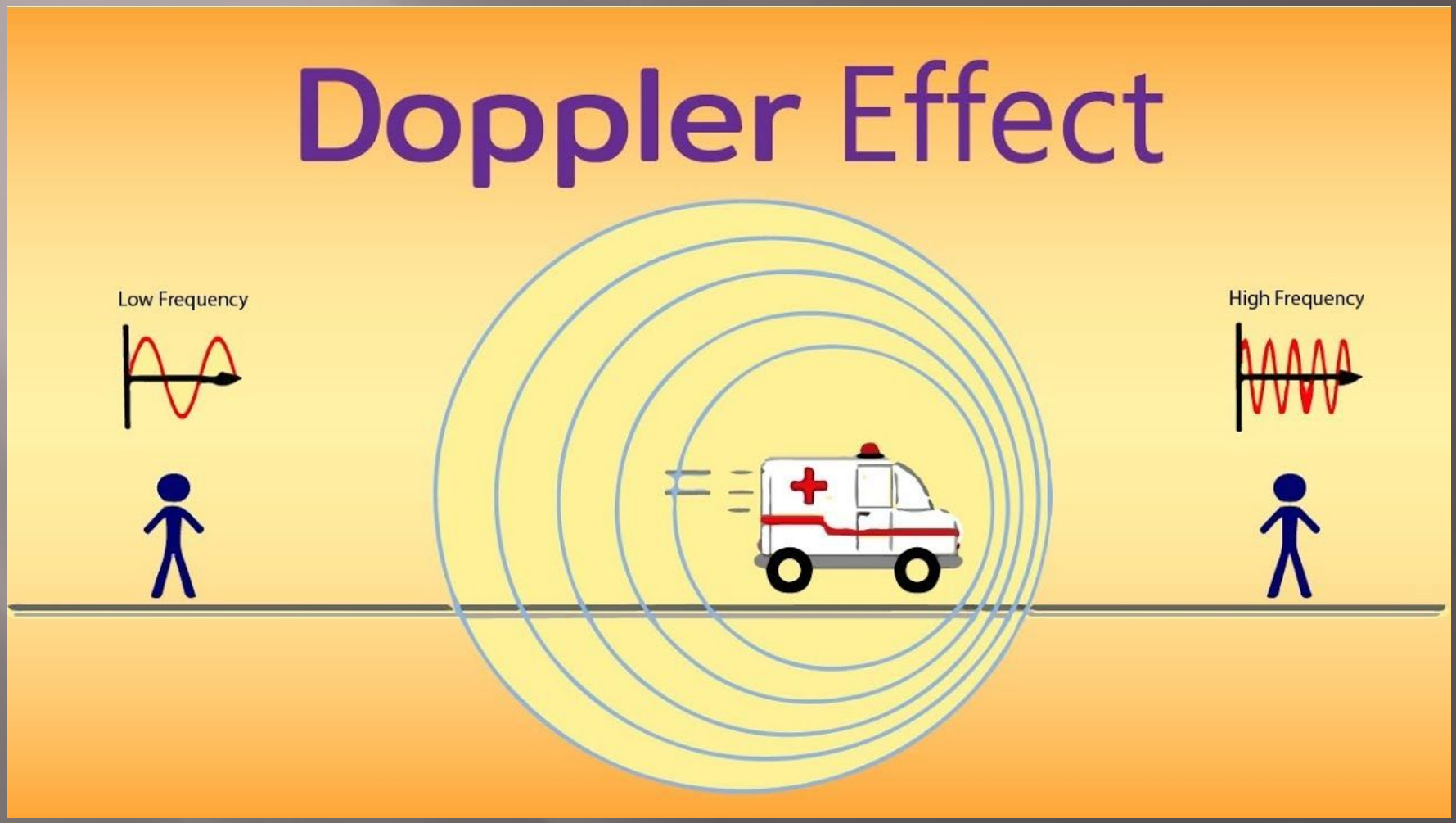
DOPPLER ULTRASOUND

Dr. Badira Al Qudah

Doppler effect

- We are all aware that the pitch of an ambulance siren changes as we stop and listen to it as it drives by.
- The frequency that reaches you is higher as the ambulance approaches and lower as the ambulance passes by.
- This is a consequence of the Doppler effect.


Doppler Effect
Low Frequency
High Frequency

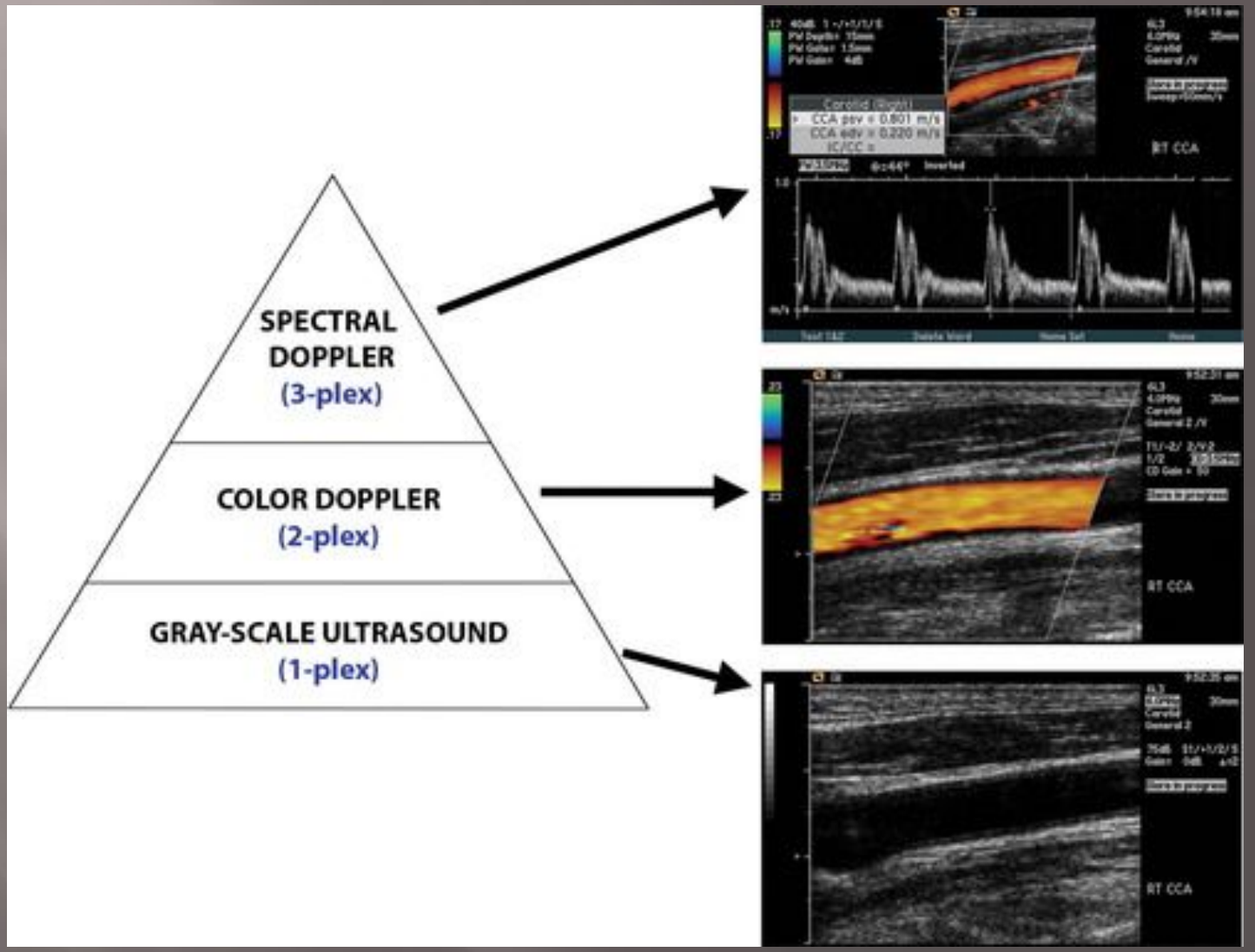
Physics

- Ultrasound images are formed by reflected echoes. These waves have an amplitude (strength) and a frequency, which is equal to the frequency of the emitted wave, if the tissue is static. Tissue movement (e.g. blood) promotes a frequency shift (Doppler shift) in the reflected echoes.

Application of Doppler

Three basic levels of US can be performed, with each level adding information to the preceding level.

- At the first level is the traditional standard brightness mode (B-mode) gray-scale examination, in which no Doppler is used.
- The second level superimposes a color Doppler interrogation region of interest. This level produces an image that shows blood flow in vessels.
- The third level superimposes a small interrogation region, called a sample volume, over a vessel of interest. Targeted interrogation of the vessel produces a spectral Doppler waveform.

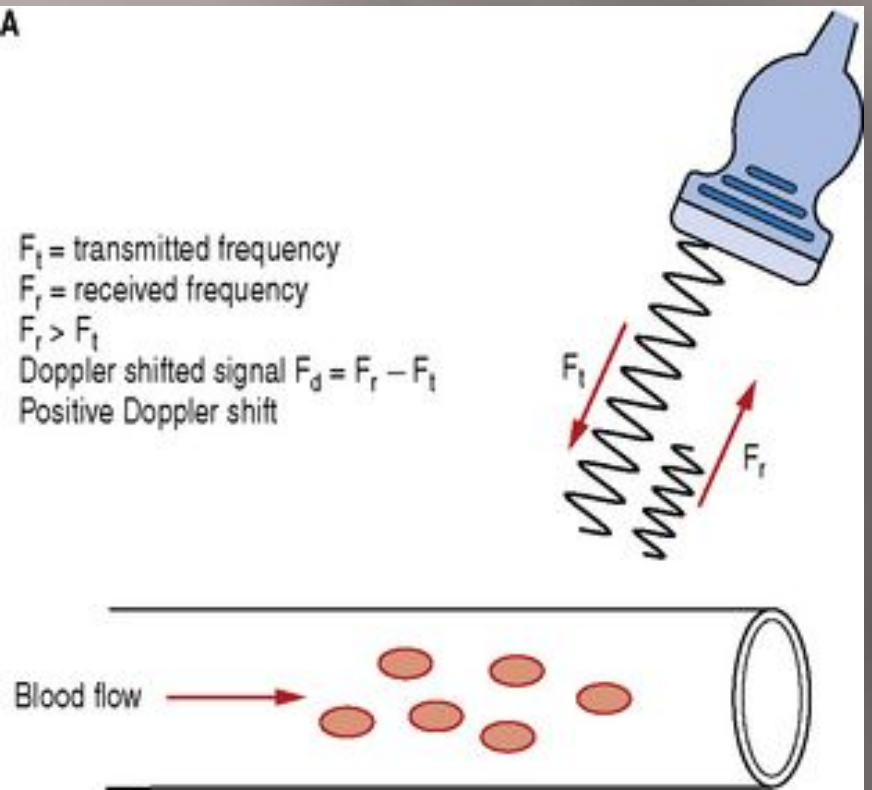

SPECTRAL
DOPPLER
(3-plex)
COLOR DOPPLER
(2-plex)
GRAY-SCALE ULTRASOUND
(1-plex)
Carotid (Right)
CCA psv = 0.801 m/s
CCA edv = 0.220 m/s
RT CCA
RT CCA
RT CCA

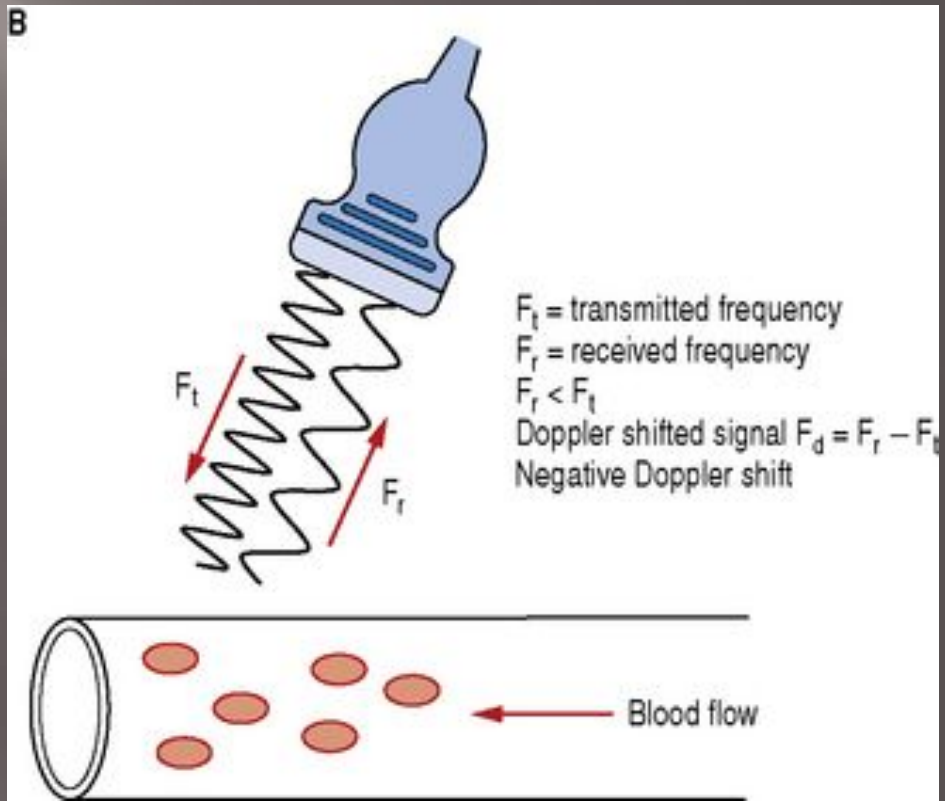
- The Doppler effect in diagnostic imaging can be used to study blood flow, for example, and provides the operator with three pieces of information to determine:

- Presence or absence of flow
- Direction of blood flow
- Velocity of blood flow.

Doppler shift

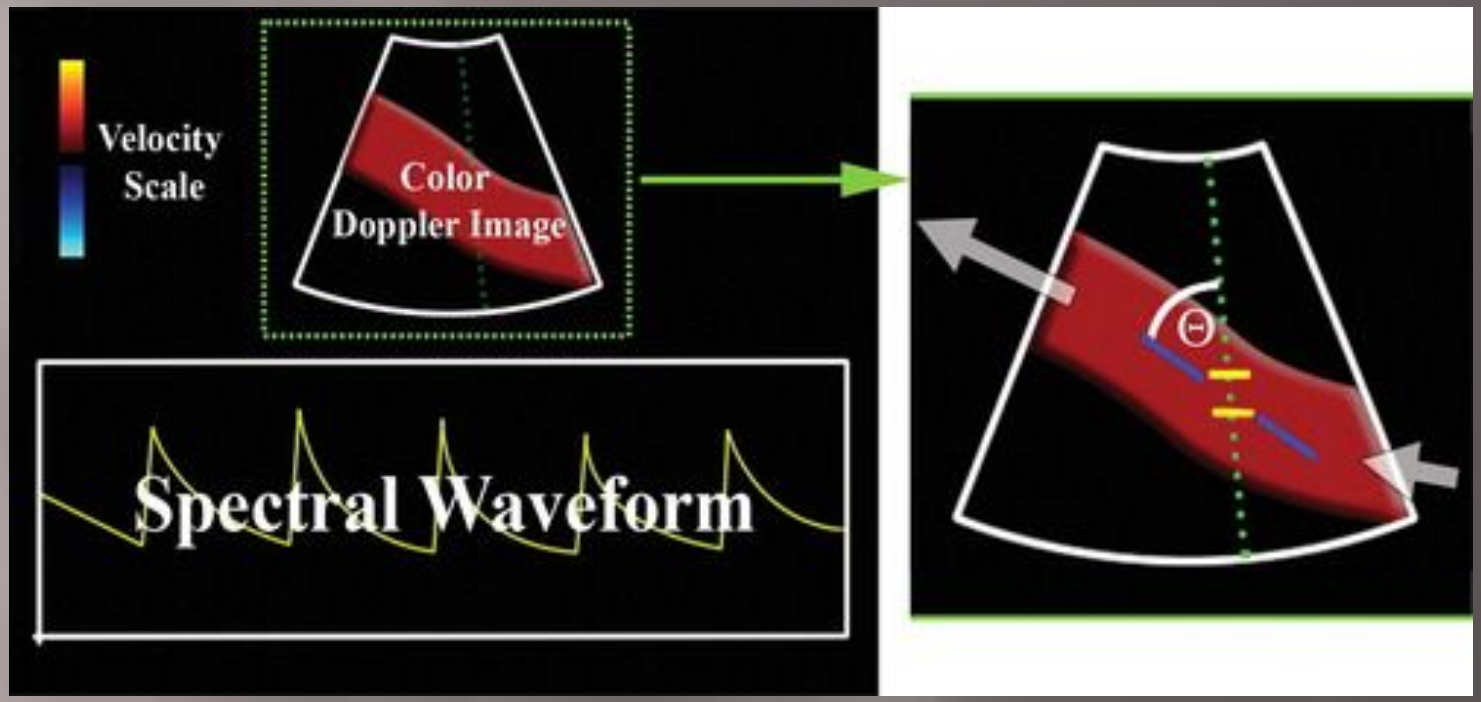
Blood flow moving towards the transducer produces positive Doppler shifted signals and conversely blood flow moving away from the transducer produces negative Doppler shifted signals





Angle of insonation (Doppler angle)

- The angle of insonation is very important.
- The **angle of insonation** is the **angle** between the transducer and the vessel being studied.
- The **angle of insonation** should be between 45° and 60°.
- The velocity measurements become unreliable with angles more than 60°.



- Magnified view (right) of the color Doppler interrogation region shows the components used to acquire the waveform: Doppler beam path (green); angle indicator (blue), which is oriented parallel to the long axis of the vessel; Doppler angle (Θ), which should be less than 60°; and sample volume or "gate" (yellow). Gray arrows = flow direction.

Doppler US

- Doppler US is an application of diagnostic ultrasound used to *detect* moving blood cells or other moving structures and measure their *direction* and *speed* of movement.
- The Doppler effect is used to evaluate movement by measuring changes in frequency of the echoes reflected from moving structures.

- In many instances, Doppler ultrasound has replaced x-ray methods such as angiography, as a method to evaluate blood vessels and blood flow.
- Doppler ultrasound permits real-time viewing of blood flow that cannot be obtained by other methods.
- Doppler ultrasound has proved a helpful in all areas of ultrasound, aiding in the evaluation of the major arteries and veins of the body, the heart, and in obstetrics for fetal monitoring.

Types of Doppler ultrasound include:

- Color Doppler
- Power Doppler
- Spectral Doppler

Color Doppler

- Color Doppler uses a computer to convert the Doppler measurements into an array of colors.
- Colour Doppler imaging colour codes Doppler shift information and superimposes that information over a B-mode image
- Color Doppler displays blood flow toward the transducer as red and blood flow away from the transducer as blue.
- This color visualization when combined with a standard ultrasound picture of a blood vessel shows the speed and direction of blood flow through the vessel.

Color Doppler

Power Doppler

- **Power Doppler** is a technique that uses the amplitude of Doppler signal to detect moving matter.
- It is an ultrasound technique that is used to obtain images that are difficult or impossible to obtain using standard color Doppler and to provide greater detail of blood flow, especially in vessels that are *located inside organs*.
- Power Doppler is more sensitive than color Doppler for the detection and demonstration of blood flow, but provides no information about the direction of flow.
- Color and spectral Doppler both reveal the direction of blood flow which can be valuable information.

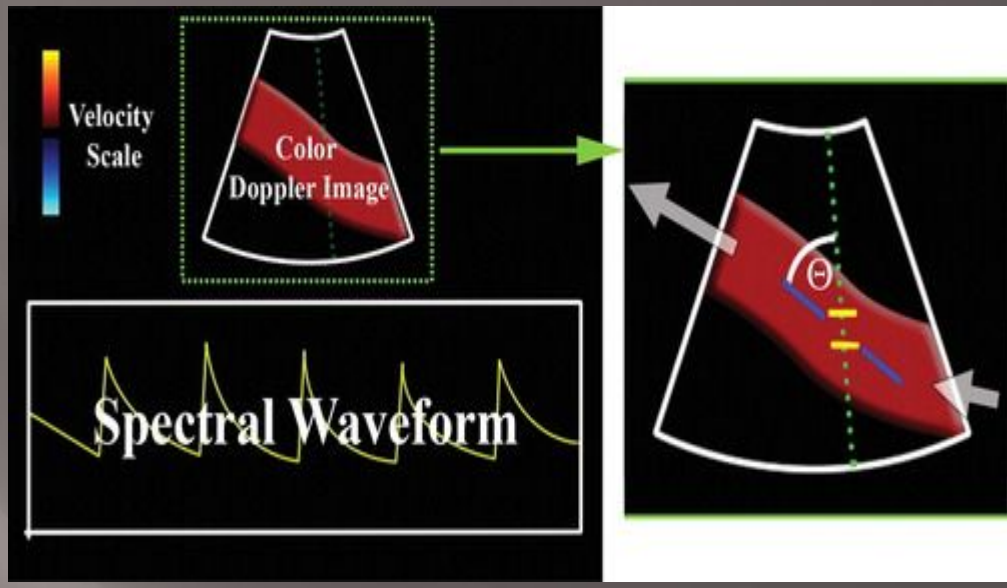
Power Doppler

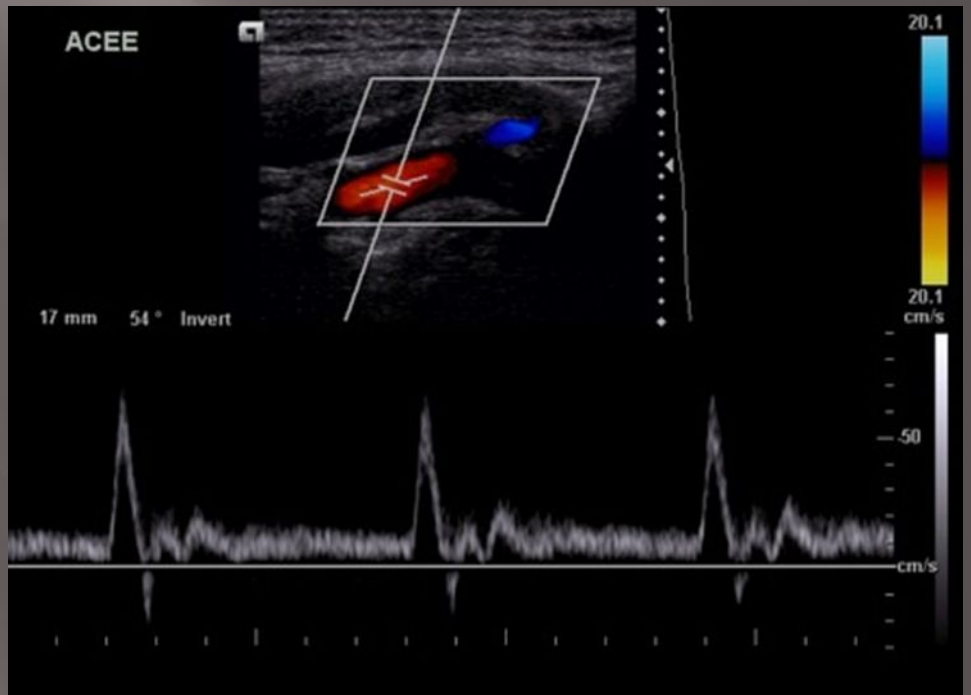
- Power Doppler:
- is independent of velocity and direction of flow.
- is independent of angle, allowing detection of smaller velocities than color Doppler, facilitating examinations in certain technically challenging clinical setting
- has higher sensitivity than color Doppler

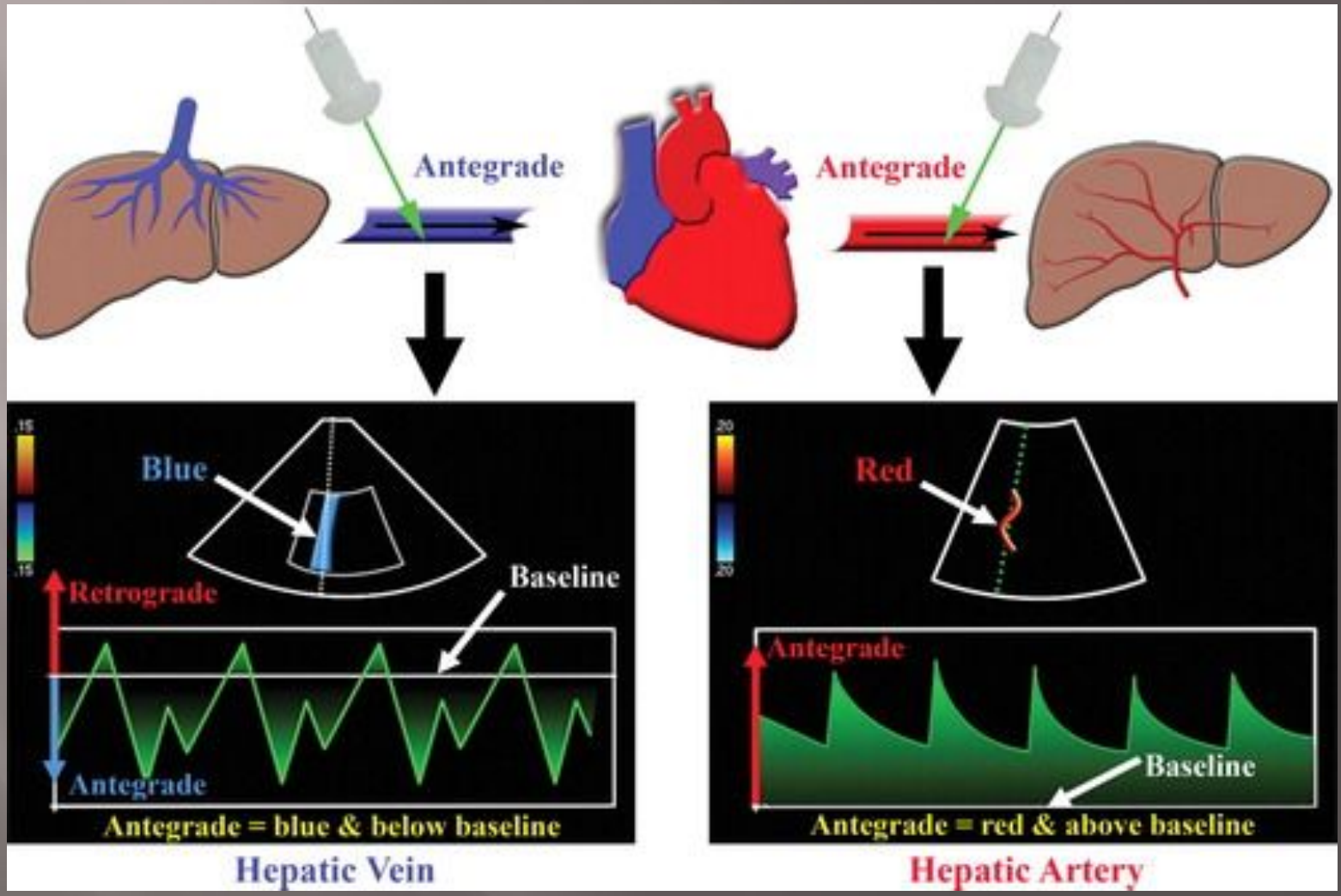
Spectral Doppler

- Instead of displaying Doppler measurements visually as in the color and power Doppler methods, spectral Doppler displays the blood flow measurements graphically, displaying flow velocities recorded over time.
- Spectral analysis of Doppler signal contains both frequency and amplitude information.
- At spectral Doppler, blood flow toward the transducer is displayed above the baseline and blood flow away from the transducer is displayed below the baseline

- Spectral Doppler US findings are displayed with the spectral waveform at the bottom of the screen and a color Doppler image at the top
- Information for the waveform is obtained from a small (usually 2–4-mm) sample volume that is placed in the center of the vessel by the sonographer






Antegrade
Antegrade
Blue
Retrograde
Baseline
Antegrade
Antegrade = blue & below baseline
Hepatic Vein
Red
Antegrade
Baseline
Antegrade = red & above baseline
Hepatic Artery

Introduction to Doppler ultrasound

- https://www.youtube.com/watch?v=tQn8jKtwk6o

References

- https://radiologykey.com/physical-principles-of-doppler-ultrasound
- **Optimizing Doppler and Color Flow US: Application to Hepatic Sonography,** Jonathan B. Kruskal
- **Doppler US of the Liver Made Simple,** Dean Alexander McNaughton, Monzer M. Abu-Yousef, gastrointestinal imaging
- Radiologyinfo.org