HARVARD MEDICAL SCHOOL
TEACHING HOSPITAL

Understanding the Ultrasound Machine

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Outline

- Introduction
- Basic Understanding of ultrasound machines
- Understanding types of transducers, and basic modes
- Understanding common controls across platforms
- Optimizing images and Artifacts explained
- Logistics and Standardization

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Introduction/Concepts

An ultrasound machine uses high and low frequency sound waves to create images of the inside of the body.

Introduction/Concepts Cont'd

Advantages

Disadvantages

Risks

Many types of Machines used by a full-service Vascular Laboratory

- Duplex (all things veins and arteries)
- Pulse Volume Recording (PVR)
- Rapid Inflator System (Reflux Duration Times)

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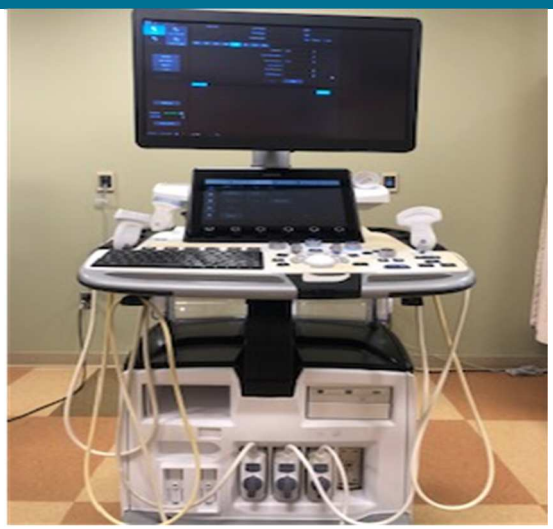
Duplex Ultrasound Machine



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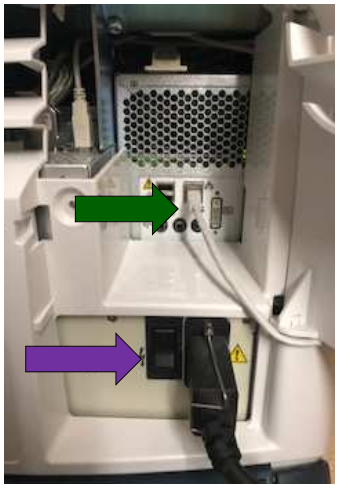
Power supply

- To charge the battery, make sure the power cord Purple Arrow is connected to the bottom housing of the cart and power supply switch is on.
- To pull a worklist of patients or send a completed exam make sure the data cable Green Arrow is plugged in.



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Ultrasound Gel

- This is an example of transducer gel that we are using in the MGH Vascular lab.

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Ultrasound Gel Cont'd

- Ultrasonic gel is applied on the transducer when you are ready to scan the area of interest/concern.

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Ultrasound Frequency and Probe Selection

Ultrasound is high-frequency sound and refers to mechanical vibrations above 20 kHz. Ultrasound Frequencies commonly used for medical diagnosis are between 2 and 15 MHz. Depending on probe application.

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Duplex Ultrasound Transducer/Probes

- This is an example of a High frequency Linear transducer/probe, The flat surface at the top of the probe is where contact is made with the skin.

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Transducer/Probes Cont'd

- This is an example of a Lower frequency Curved transducer/probe.
- The curved surface at the top of the probe is where contact is made with the skin.

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Transducer/Probes Cont'd

- The frequency of the probe will be labeled on the probe.

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Transducer/Probes Cont'd

- This is where the probe is connected into the ultrasound machine, the metallic tab illustrated by the Green Arrow needs to be placed into machine, the grey lever illustrated by the Gray Arrow will need to be turned in order to secure the probe.

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Keyboard

- This is a view of the machine and all the controls that you will need to use.

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Keyboard Cont'd

- The power button is used to turn the machine on and off.
- The button in this picture is Illuminated blue, which means the machine is on.

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Keyboard Cont'd

- The Freeze button is what you press in order to pause an image of what you are investigating.
- This button does not automatically save the picture, it only freezes the image.

Keyboard Cont'd

- The Acquire or P2 button seen here is what you press in order to save a picture that you have taken after you have used the freeze button.

Keyboard Cont'd

- The Green Arrow points to the push button that is used to toggle between Depth and Focus.
- Depth function is lit meaning active and illuminated in blue which means you can increase or decrease the depth of the image.

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Keyboard Cont'd

The Green Arrow points to the Auto Optimize button.

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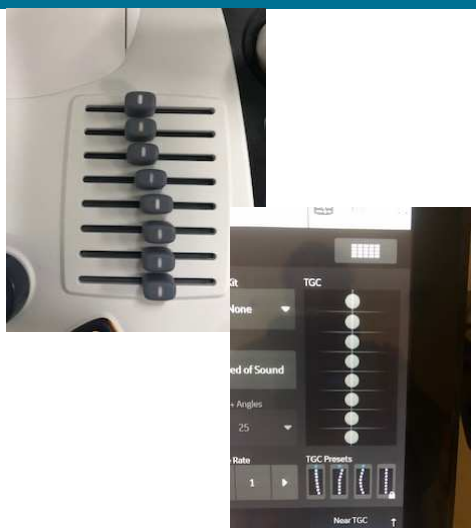
Keyboard Cont'd

- TGC or Time Gain Compensation selectively adjusts the gain at different depths.
- By moving the buttons to the right or left you can adjust the brightness of the image.



Keyboard Cont'd

- Near and Far Overall Gain is used as a simple near or far field adjustment. As the name implies, turning the near field gain dial will adjust the image gain in the top half of the image. Turning the far field gain dial will adjust the image gain in the bottom half of the image.

B-Mode

B Mode or Gray Scale is illustrated by the Green Arrow

- Press B, the button is illuminated in blue which means you are examining the area of interest/concern.

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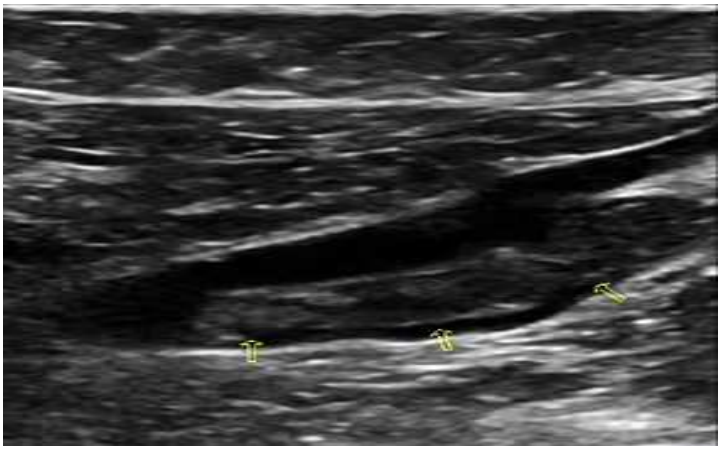
B Mode Cont'd



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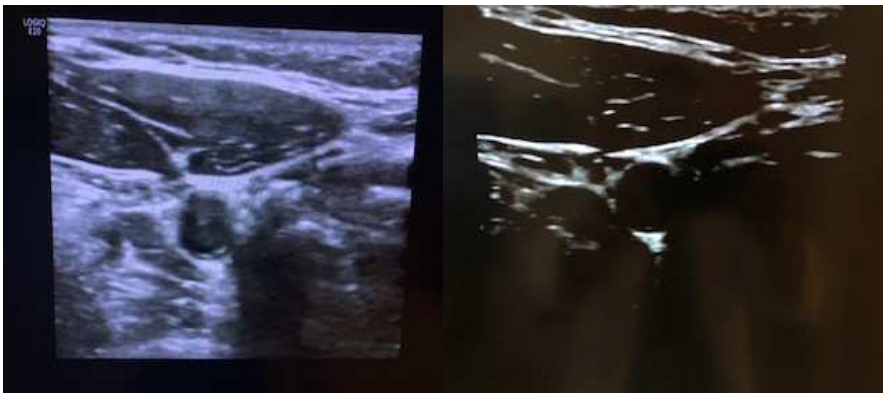
B Mode Cont'd



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Color Mode

Color Mode is illustrated by the Red Arrow

- Press CF, the button is illuminated in blue which means you are examining the area of interest/concern with color.

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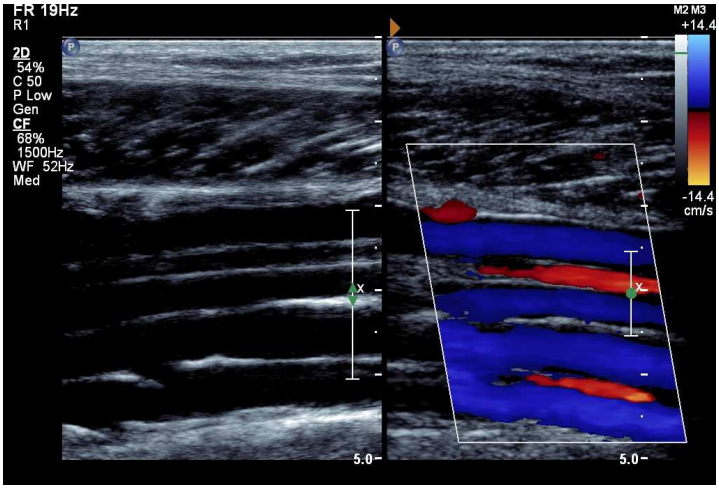
Color Mode Cont'd



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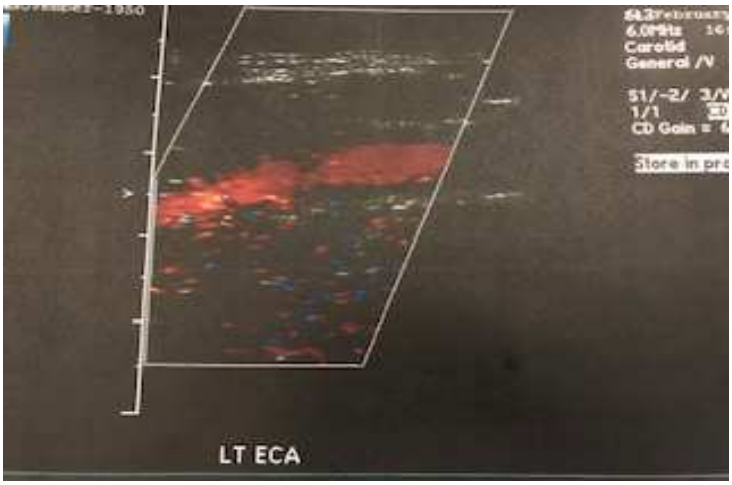
Color Mode Cont'd



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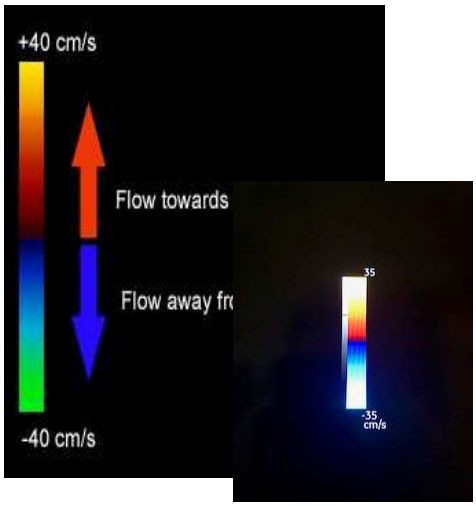
Color Mode Cont'd

The Color Scale provides information on flow direction and velocity.

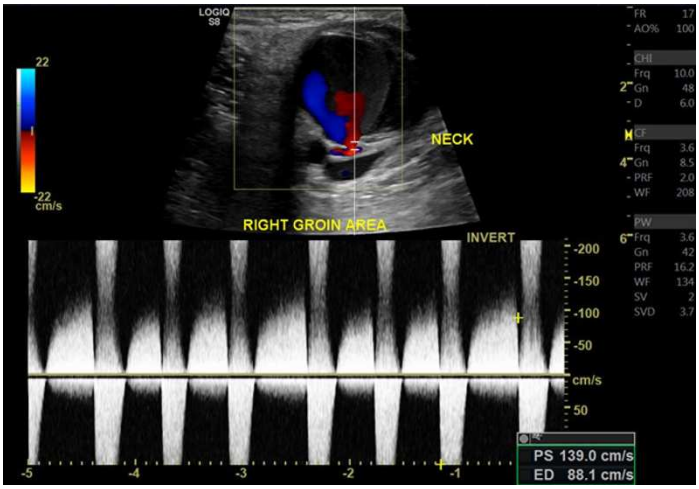


Pulse Wave Mode

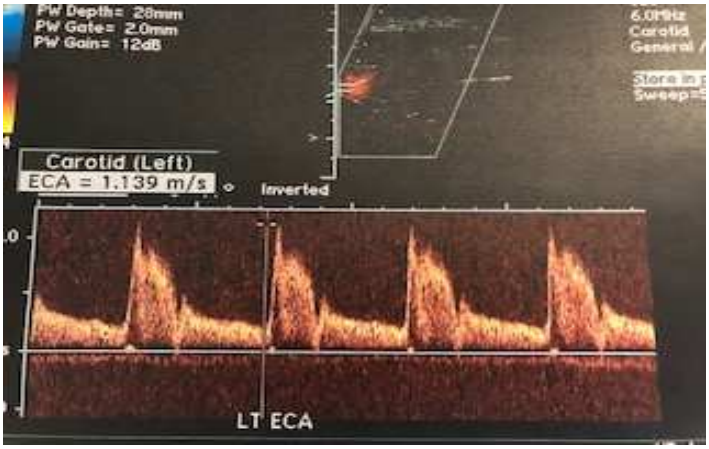
Pulse Wave is illustrated by the Yellow Arrow

- Press PW when you are ready to obtain Doppler measurements in the area of interest/concern.
- Press the PW button again to end Doppler sampling.

Pulse Wave Mode Cont'd

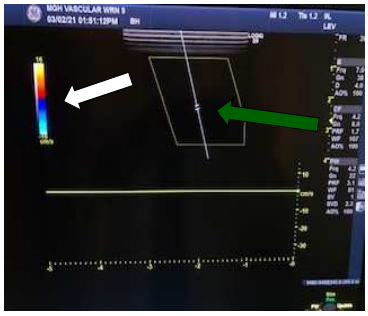


Pulse Wave Mode Cont'd



Pulse Wave Mode Cont'd

- This is an example of an active window with a PW Doppler and Color function on.
- The White Arrow on the left indicates the color or Color Map function is on.
- A Green Arrow in the middle of the screen with angled box around it indicates the PW is on.



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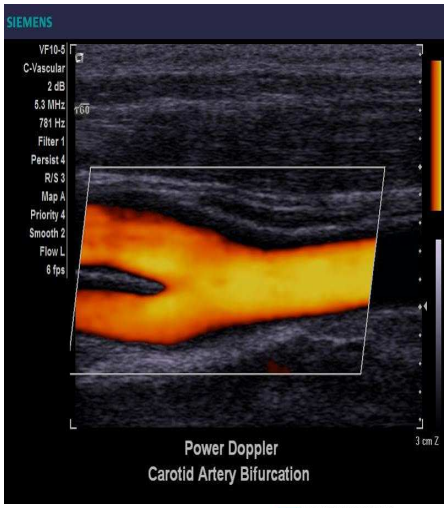
Power Doppler Mode

Power Doppler is Independent of velocity and direction of flow, so there is no possibility of signal aliasing.



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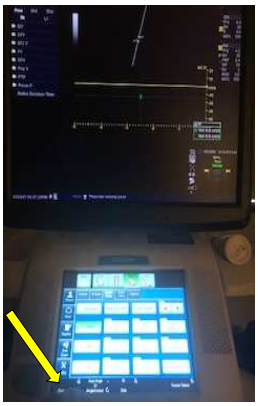
Insonation Angle

Angle Steer/Fine Angle Steer



Square Overlay

- The square overlay on the ultrasound image is letting you know that the color function is active. Anything in the target zone that is moving will be assigned a color.

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2 different images on 1 screen

- Split the screen to allow for two images.
  - Push the button to make the screen accommodate both pictures.

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Optimization

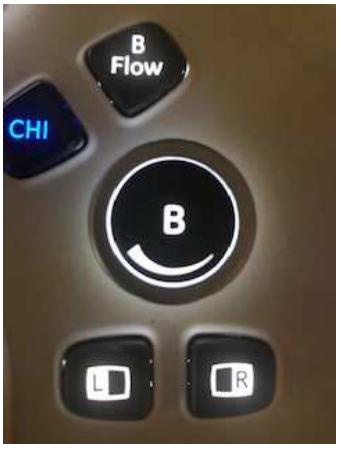
Principles of image optimization.

In order to obtain optimal ultrasound images, it is necessary to adjust several parameters continuously during the examination.

- Gain
- Focus
- Frame Rate

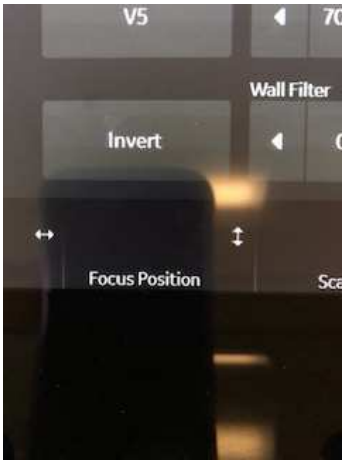
Gain

- The Gain is a measure of the strength of the ultrasound signal, overall gain amplifies all signals by a constant factor regardless of the depth.



Focus

- When the word Focus turns green or pressed, then move the focal indicator points to make your image sharper.



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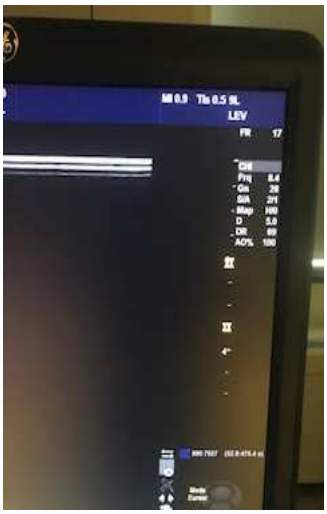
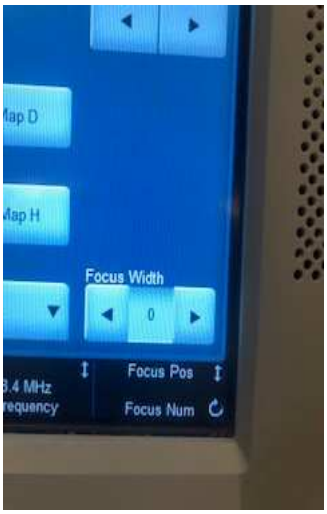
Focus and number of focal zones





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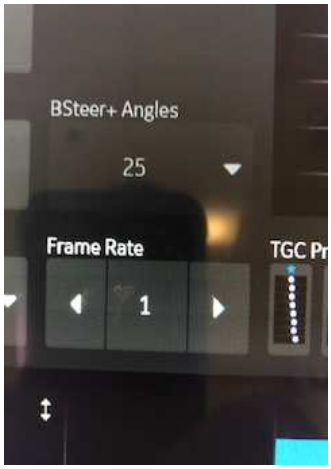
Frame Rate

- Is the rate at which images are updated on the display it is dependent on frequency of the transducer and depth selection.



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To Further define your Image

- Comment:
  - The red arrow points to the “comment” button this will allow you to create text labels directly on your images.

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To Further define your Image Cont'd

- Clear:
  - The green arrow points to the "clear" button this will allow you to erase the text characters.

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To Further define your Image Cont'd

- Arrow:
  - The yellow arrow points to the "arrow" button this will allow you to place arrows on your images.

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To Further define your Image Cont'd

- Measure:
  - The orange arrow points to the "measure" button this will allow you to measure from one border to another.

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Artifacts

- What is an ultrasonic imaging artifact?
  - Any Imaging Error

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Four possible causes of ultrasonic imaging artifacts:

- Violations of certain assumptions about the physics of ultrasound.
- Equipment malfunction or incorrect design.
- Inherent physical limitations of ultrasonic imaging.
- Operator error

Six basic assumptions incorporated into the design of ultrasound systems:

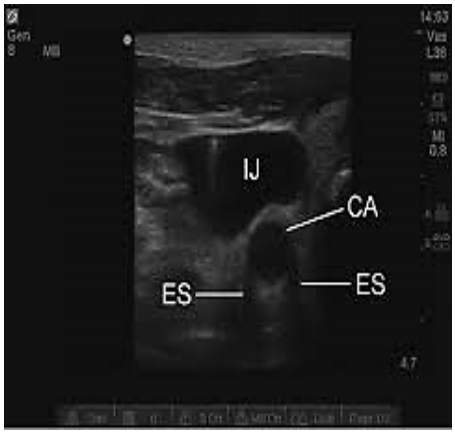
- Ultrasound travels in a straight line.
- Ultrasound reflections are created only from structures along the main axis of the sound beam.
- The strength of a reflection is related to the scattering characteristics of the anatomic structure that produces it.
- The ultrasound imaging plane is extremely thin.
- Ultrasound pulses travel directly to a reflector and then back to the transducer.

Four categories of imaging artifacts:

- Attenuation artifact
- Reverberation artifact
- Refraction artifact
- Reflection artifact

Attenuation Artifact

- When the ultrasound beam encounters any material that attenuates the sound beam to a greater of lesser extent then the surrounding tissue, then the resulting strength of the beam distal to the structure will be either stronger or weaker.



Reverberation Artifact

- Multiple reflections (reverberation) can occur between the transducer and a strong reflector, this results in the display of reflectors that are not real.
- The multiple reflectors are placed beneath the real reflector at separation intervals equal to the separation between the transducer and the real reflector.
- Each subsequent reflector is weaker then the one prior.
- Reverberation artifact can also occur between two anatomic reflecting surfaces.
- This breaks the assumption that an ultrasound pulse travels directly to a reflector and then back to the transducer.

Reverberation artifact: Three types

- Comet tail artifact
- Ring-down artifact
- Mirror image artifact

Comet tail artifact

- A series of closely spaced discrete echoes
- Unable to differentiate individual echoes

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Ring-down artifact

- Appears similar to comet tail artifact but is fundamentally different.
- Discrete echoes cannot be identified, because continuous emission of sound from the origin appears to be occurring.

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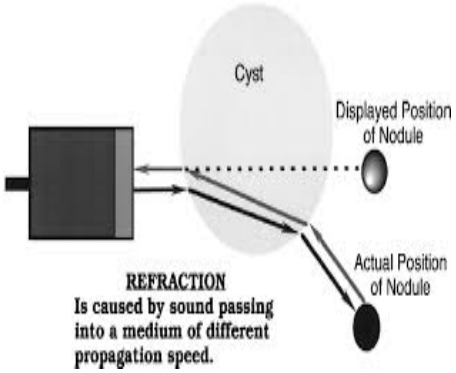
Mirror image artifact

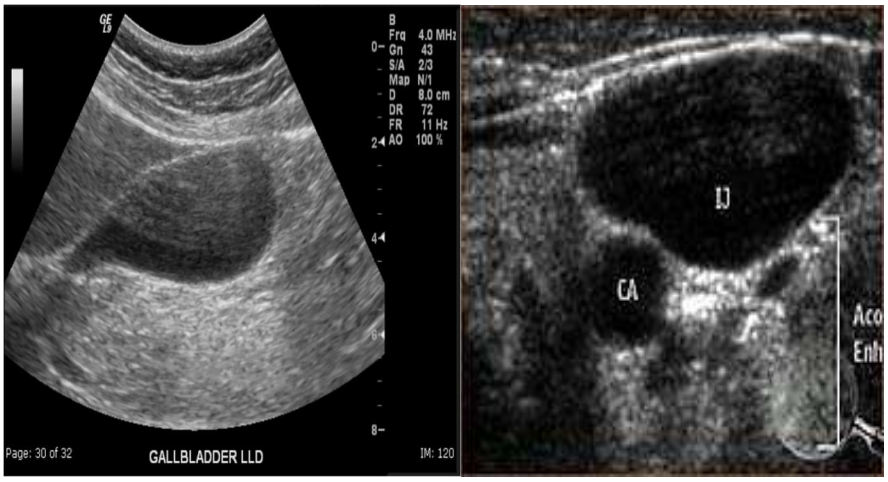
- Displays structures that exist on one side of a strong reflector as being present on the other side as well.
- The display shows a duplicated structure equidistant from the original echo and reflective interface but inferior.
- Also breaks the assumption that an ultrasound pulse travels directly to a reflector and then back to the transducer.

Refraction Artifact



If the propagation velocity is greater in the first medium, refraction occurs towards the center, or perpendicular.

Refraction Artifact Cont'd



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Reflection Artifact

- Shadowing
- Twinkle
- Aliasing

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Shadowing

- Echoes are returning from a weakly attenuating structure or reflector.
- The amplitude of the signal will be greater posterior to the reflector then in the rest of the imaging field this results in false increase in echogenicity posterior to reflector, i.e. through transmission.
- Echoes are returning from a highly attenuating structure thus the signal is diminished.
- The loss of signal is displayed as a hypoechoic or “black” area posterior to the highly attenuation structure. i.e. shadowing.

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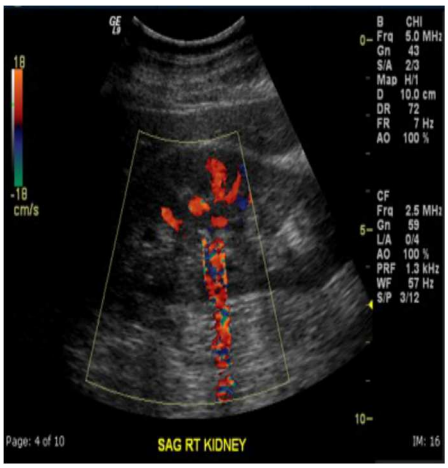
Twinkle Artifact

- Appears as random fluctuating mixtures of Doppler.
- Imitates turbulent flow, but with a flat Doppler spectrum suggestive of “noise”.
- Appears posterior to highly reflective objects.
- Highly dependent on machine settings.



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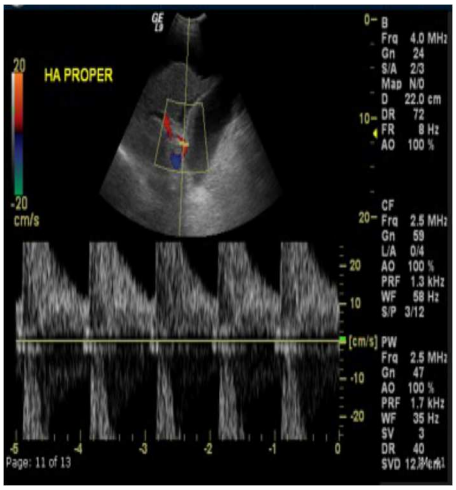
Aliasing

- An imaging artifact in Doppler ultrasound, governed by the Nyquist limit, the maximum frequency shift that can be accurately interpreted in a pulsed Doppler ultrasound unit.



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Exams Performed

EXTRACRANIAL CEREBROVASCULAR

- a. Carotid Duplex
- b. Temporal Artery Duplex

PERIPHERAL VENOUS

- Lower Extremity Veins Duplex
- Lower Extremity Veins Mapping
- Upper Extremity Veins Duplex
- Upper Extremity Veins Mapping

PERIPHERAL ARTERIAL

- Lower Extremity Arteries Duplex including (Pseudoaneurysm, Popliteal Entrapment)
- Upper Extremity Arterial Duplex including (Pseudoaneurysm)
- Hemodialysis Access Duplex

VISCERAL VASCULAR

- Abdomen Arteries and Veins Duplex including (Mesenteric, Median Arcuate Ligament Syndrome)
- Renal Arteries and Veins Duplex
- Aorta Duplex including (EVAR Grafts)
- IVC Iliac Grafts Arteries or Veins Duplex including (Abdominal Veins)

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PVR Ultrasound Machine

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PVR Ultrasound Transducer or Probe

- The frequency of the probe will be labeled on the probe.
- Higher frequency as an example 8mHz probes are for more shallow structures/anatomy.
- Lower frequency as an example 4mHz probes are for deeper structures/anatomy.

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Transducer Cont'd

- Photo Plethysmography or (PPG)

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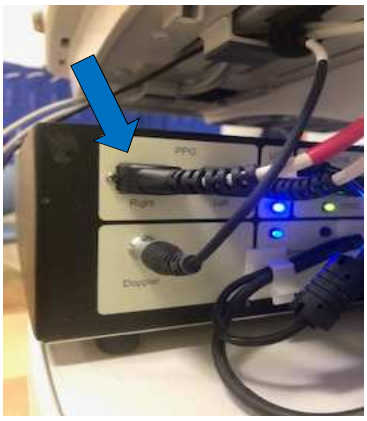
Transducer Cont'd

- The Blue Arrow indicates where the probes are connected into the ultrasound machine.
- Make sure the connections are secured tight for optimal imaging.



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Keyboard

- This is a view of the machine and all the controls that you will need to use.

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Remote

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Rapid Inflator and Tubing

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PVR Rapid Inflator Cuffs

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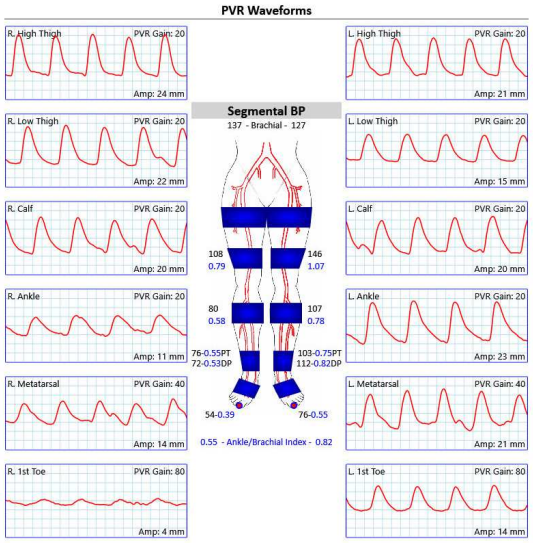
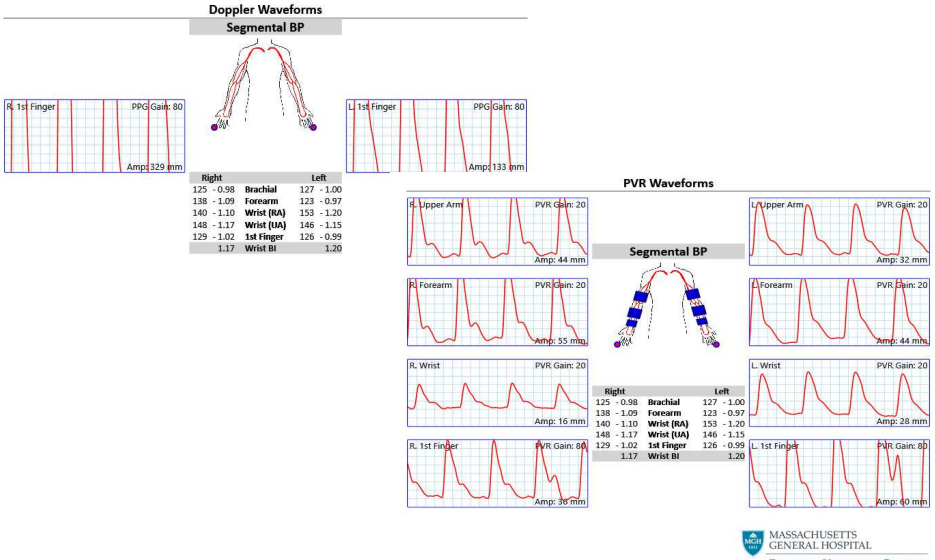
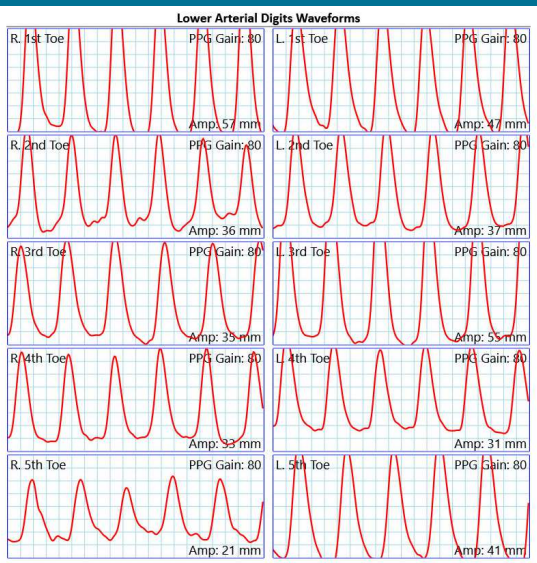
Lower Arterial ABI



Upper Arterial WBI



PPG's Upper and Lower



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Exams Performed

PERIPHERAL ARTERIAL

- Lower Extremity Arteries (ABI) Physio Bilateral including (Temperature Challenge, Popliteal Entrapment)
- Lower Extremity Arteries (ABI) Physio including (at Rest &Treadmill)
- Upper Extremity Arteries (WBI) Physio Bilateral including (Exercise, Thoracic Outlet Syndrome, Temperature Challenge, Allen's Test for CABG, Arterial Venous Fistula Steal)
- Upper Extremity Arteries (Wrist Brachial Index) Physio Limited Bilateral (if WBI only)

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Rapid Cuff Inflation System

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Rapid Cuff Inflation System, Air Source

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Rapid Cuff Inflation System, Cuff Inflator

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Rapid Cuff Inflation System, Timer

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Rapid Cuff Inflation System, Air Hose and Cuff

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Exams Performed

- Lower Extremity Veins Reflux Evaluation for measurement of (Venous Reflux Duration Times) Exam can be performed either bilaterally or unilaterally.

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Preventative Maintenance/Machine Turnover

- Vendor Servicing
  - Service Programs
    - Rapid Onsite Repair
    - Immediate Telephone Response

Preventative Maintenance/Machine Turnover Cont'd

End of Life:

- These notices genuinely mean that the machine can't be supported by the manufacturer, often due to certain key parts that are no longer available. Usually, the machine or equipment has not been made in a few years prior to getting an end-of-life notice.

Preventative Maintenance/Machine Turnover Cont'd

- Software/Securities

There is a point when the software is no longer maintained by the developer because it has been superseded by newer versions. Continuing to use outdated software can present risks.

Preventative Maintenance/Machine Turnover Cont'd

- Probe Inspection
- Cord Inspection
- Cleaning

Perform a visual check of the probe and its connection to the ultrasound machine before each use. Inspect if there are any cracks/cuts on the probe. That's important because ultrasound gel or disinfectant can easily seep into the cracks or cuts and potentially damage the transducer. Furthermore, look for tears in the cable that could indicate broken wires inside the transducer.

Preventative Maintenance/Machine Turnover Cont'd

- Capitol requests
  - Details and Pricing
  - Future Planning

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Logistics

- Standardization of Machines
  - Improved Operational Efficiency
  - More Patient Centered Care
  - Reduce Costs

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Logistics Cont'd

- Standardization of Images
  - Technical Considerations
  - Validation

Logistics Cont'd

Quality Control

As an example, IAC Accreditation:

Extracranial Cerebrovascular

Peripheral Arterial

Peripheral Venous

Visceral

Logistics Cont'd

- Protocols - standard operating procedures
  - Value Based
  - Protocol Variability
  - Proper protocol implementation

Additionally

- Name of Institution - Accreditation purposes
  - IAC
  - ACR
- Technologist Initials – Accountability
  - SM
- Scan Assist – uniform results

In Summary

Don't get overwhelmed by an ultrasound machine. Use the general concepts presented here today. Noninvasive exams such as Ultrasound and the necessary logistics can be a game changer for any practice.

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