Point of Care Ultrasound (POCUS)

Evaluation for Deep Vein Thrombosis

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Overview

Agenda & Learning Objectives

- Venous Anatomy
- Ultrasound Basics & Imaging Modes
  B-mode, Color Doppler, Spectral Doppler
- Thrombus Recognition
  Identifying clots and resolving Doppler issues
- Venous Reflux Assessment

Why Hematology-Focused POCUS?

Point-of-care refers to **diagnostic testing** or **clinical interventions** performed at the **site of patient care**, with **results available immediately** to inform management decisions.

Questions We Can Answer

- Is there a deep vein thrombosis?
  Yes/No
- Is there venous insufficiency (superficial/deep)?
  Yes/No

Clinical Value

- **Rapid Differentiation:** Distinguish DVT from mimics - pain, swelling, erythema and warmth can mimic other conditions.
- **Guides Next Steps:** Immediate decision-making Anticoagulation vs. hemostatic management vs. referral.
- **Complementary Tool:** Supports formal duplex ultrasound when suspicion remains high in clinic or access is limited.

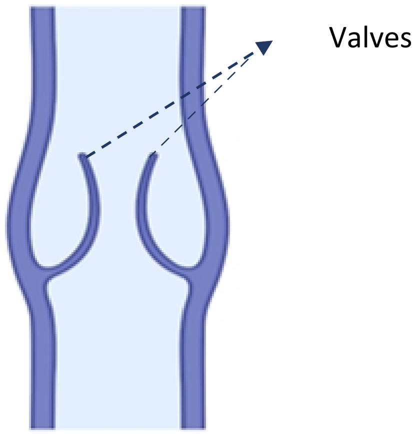
Anatomy & Physiology

Anatomy of the Veins

> Veins are thin-walled, fully compressible structures containing one-way valves. They act as capacitance vessels, accommodating approximately two-thirds of the body's total blood volume.

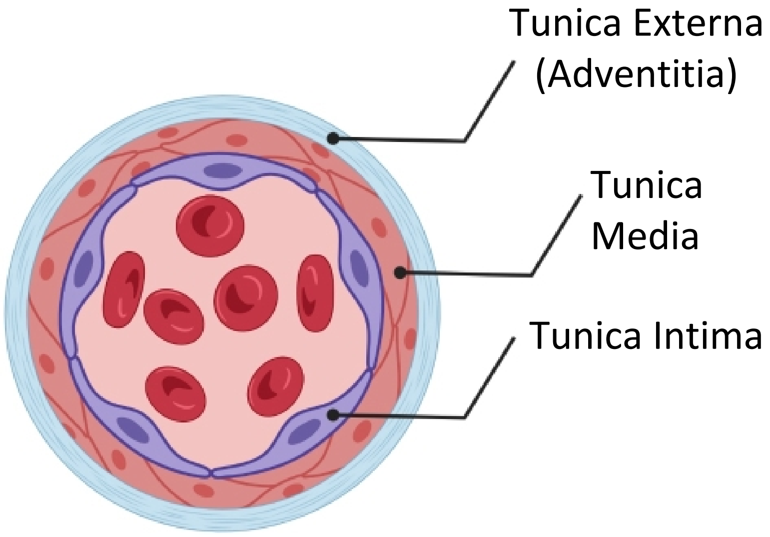
Vessel Wall Layers

1. **Tunica Intima**
   Inner endothelial layer
2. **Tunica Media**
   Middle layer; thin smooth muscle (thinner than arteries)
3. **Tunica Externa (Adventitia)**
   Outer layer; primarily collagen/connective tissue



Venous Return
Deep veins are responsible for >90% of venous return.

One-way Valves
Prevent backflow and support venous return against gravity.



Technical Basics

Probe Selection: Curvilinear vs Linear

Choosing the right transducer for optimal venous imaging

Curvilinear

Low Frequency (2-5 MHz)

Characteristics

- Curved footprint provides a wider view with depth.
- Better **penetration** but lower resolution for details.

Best Use Cases

- Deep veins in obese/edematous patients
- Abdominal, portal, or splenic vein imaging

VS

Linear

High Frequency (8-15 MHz)

Characteristics

- Flat, rectangular footprint
- Better **resolution** but limited penetration depth

Best Use Cases

- Superficial veins and structures
- Standard DVT evaluation in non-obese patients

Clinical Pearl

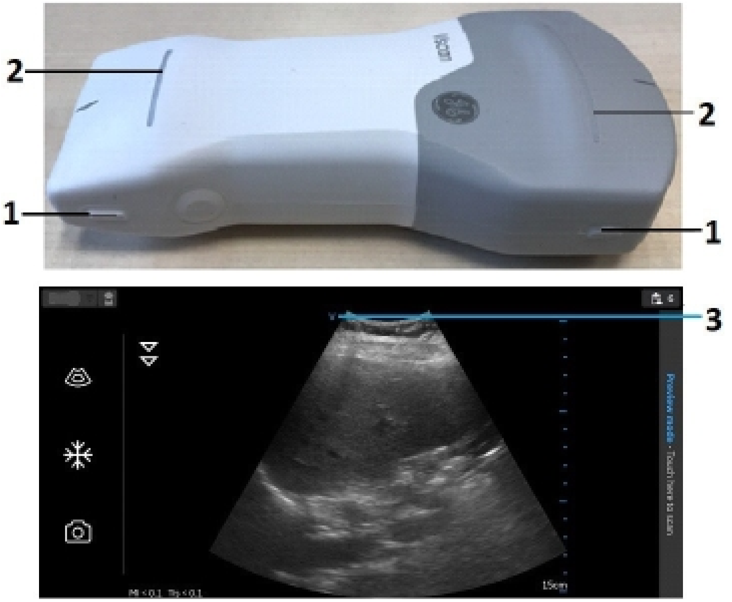
Switch to **curvilinear** if you cannot see the posterior wall clearly with the linear probe.

Probe Positioning & Orientation

Standard Orientation Rules

Transverse Position
Marker towards Patient's RIGHT

Sagittal Position
Marker towards Patient's HEAD

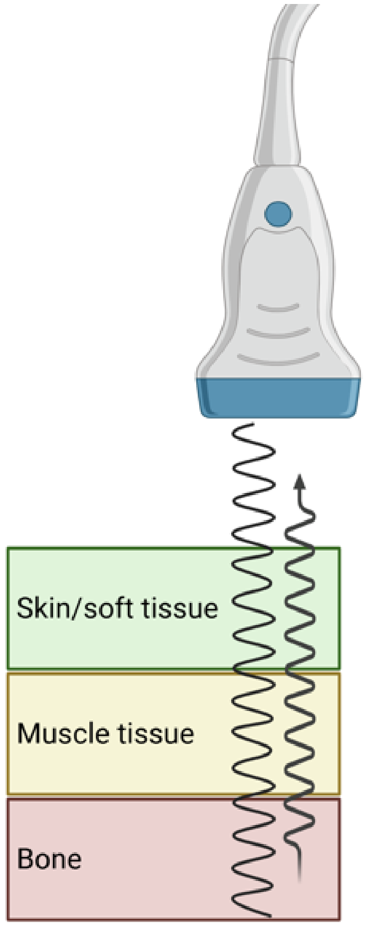


Device Specific

1. Orientation marker
2. LED light
3. Orientation marking on the screen

Make sure that the marker on the probe is correctly positioned to align the screen image with anatomical reality.

Ultrasound Physics



Sound waves leave the transducer, bounce off tissue interfaces, and return to create the image.

Sound Wave Generation

The transducer emits high-frequency sound waves into the body. These waves travel until they encounter a boundary.

Tissue Reflection

Tissues reflect sound back differently based on their **density** and **composition** (acoustic impedance).

B-mode (Brightness) Generation

The machine converts returning echoes into a grayscale image based on amplitude. Brighter pixels represent stronger reflections.

> *Core Concept: Sound waves leave the transducer, bounce off tissue interfaces, and return to create the image.*

Physics & Instrumentation

Acoustic Impedance & Artifacts

Tissue Appearance and Signal Reflection

Tissue Appearance Guide

Simple Fluid (Blood, Bile)

Anechoic (Black) with posterior acoustic enhancement

Soft Tissue (Liver/Spleen)

Mid-level "Gray" echoes

Adipose & Muscle Layers

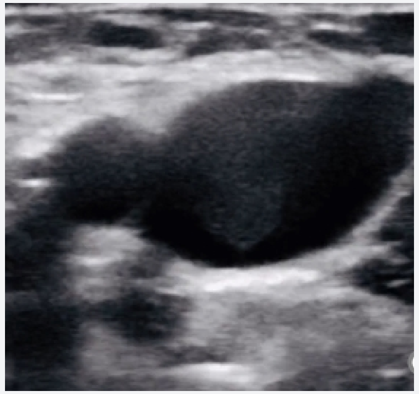
Boundary reflections due to different acoustic impedance → layered appearance

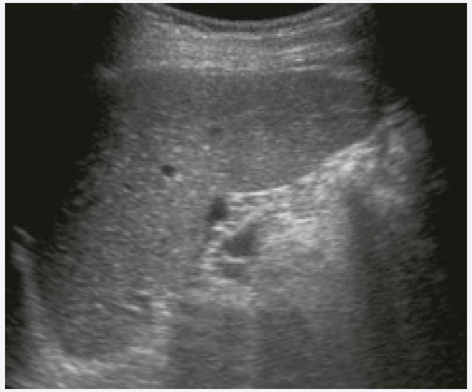
Bone / Calcification

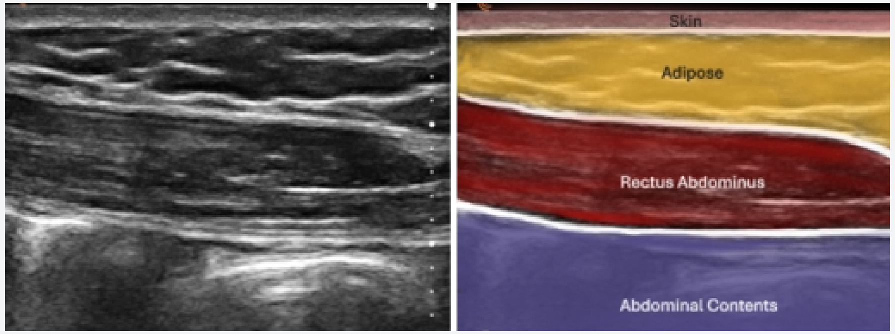
Hyperechoic (Bright) + **Clean Shadowing**

Air / Gas

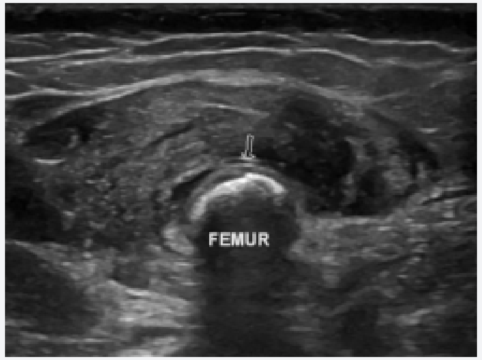
Reverberation + **Dirty Shadowing**


Anechoic blood vessels


Spleen[1]



Adipose & Muscle Layers[2]



Bone[3]

Tip "Dirty shadowing" from air contains low-level echoes (haze), distinguishing it from the "clean" black shadow of a stone.

[1] Image from: [1] https://radiologykey.com/ultrasound-of-the-spleen-and-lymphatic-system/. [2] Diagnostic Musculoskeletal Ultrasound in the Evaluation of the Rectus Abdominis | Published in International Journal of Sports Physical Therapy. [3] Bone Normal And Pathology - Internet Book Of MSK Ultrasound

Physics & Instrumentation

Imaging Modes Overview

Foundations of Venous POCUS Assessment

B-Mode (Brightness)

Visualizes anatomy, vein walls, and surrounding tissues in grayscale based on echo amplitude.

- Allows for **direct visualization** of the vessel lumen.
- Essential for assessing anatomical structure and compressibility.

Core DVT Sign

Incomplete compressibility of the vein in short-axis view.

Doppler Modes

Color Doppler

Maps blood flow direction and velocity over anatomy in real-time using color overlays.

- Useful when compression is limited or veins are deep.

Spectral Doppler

Displays velocity waveforms over time as a quantitative graph.

- Essential for venous hemodynamics / phasicity / augmentation / reflux timing.

Technical Skills B-Mode

B-Mode Essentials

Key Techniques for DVT Evaluation

1 Gain Optimization (Brightness)

Goal: Lumen should look dark (anechoic), vessel walls crisp.

Too Much: "Snowy" lumen mimics clot.

Too Little: Miss subtle thrombus/walls.

2 Probe Positioning

Keep the vein **centered** and **perpendicular** to the beam for optimal resolution.

3 Depth & Focus

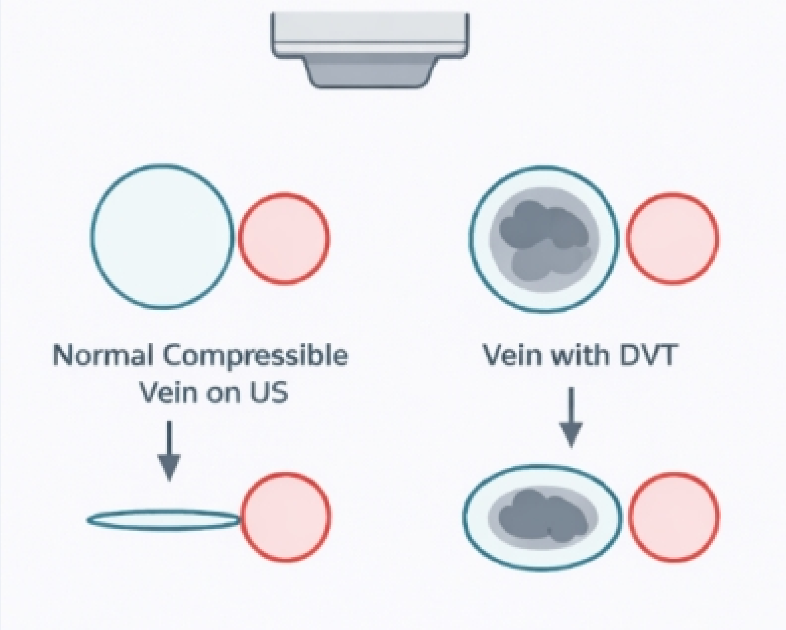
Key: You must visualize the **posterior wall** to confirm compressibility.

Too Shallow: Lose vein during compression.
Too Deep: Vein appears tiny; risk missing partial thrombosis.

4 Systematic Compression Primary Sign

Compress every 1–2 cm in short axis.

Incomplete compressibility is the defining diagnostic criterion for acute DVT.



Ensure perpendicular angle. Vein walls should touch completely ("wink") with gentle pressure.

Differentiation (Artery vs. Vein):
Arteries are pulsatile and difficult to compress due to thicker muscular walls. Veins are thin-walled, easily compressible, and non-pulsatile.

Acute vs. Chronic DVT

Definition

Intraluminal echogenicity refers to how bright or dark the material inside the vein appears on B-mode (brightness mode).

Acute vs. Chronic DVT Characteristics

Acute: Hypoechoic to Anechoic

Thrombus often appears dark (hypoechoic) or even black (anechoic) early on, mimicking fluid.

Acute: Vein Dilation

The thrombosed vein is often dilated, appearing larger in diameter compared to the adjacent artery.

Acute: Non-Compressible (Primary Sign)

Visual appearance is supportive, but the defining criterion remains **incomplete compressibility**.

Chronic: Increased Echogenicity

Thrombus becomes brighter (hyperechoic) and more heterogeneous as it organizes.

Vessel Architecture

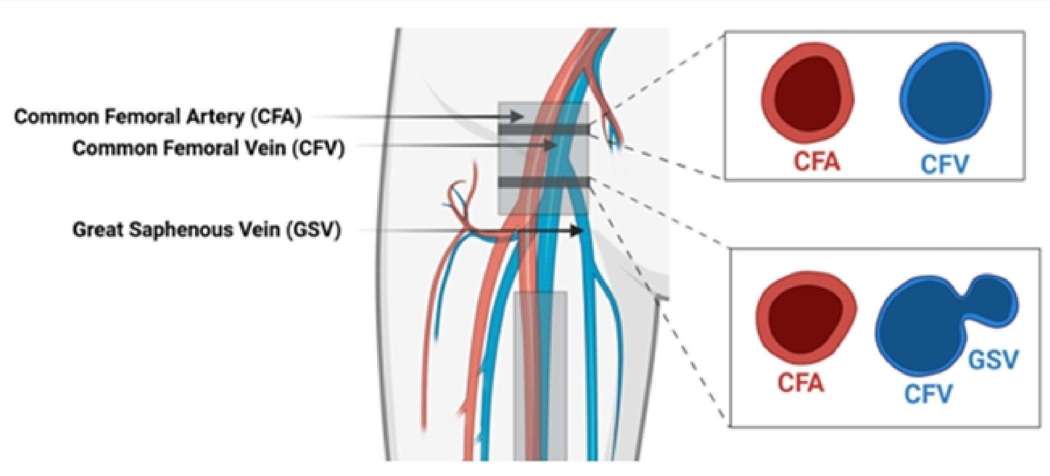
Vein may appear smaller, thick-walled, and irregular compared to acute dilation.

Other Features

Presence of synechiae (webs), linear strands, partial recanalization, or collateral veins.

Unlike acute DVT which is often fully non-compressible, chronic veins might be partially compressible due to recanalization or clot retraction.

Point-of-Care Ultrasound in Action



Physics & Instrumentation

Color Doppler & Probe Positioning

- Color Doppler overlays “flow pixels” on the B-mode image. It is **not** showing clot directly - it shows **moving blood**.
- Use for deep veins, where compression is limited (e.g., subclavian), or to clarify **equivocal B-mode**.
- Lower the pulse repetition frequency (PRF)/Scale to **10–25 cm/s** to detect slow venous flow.

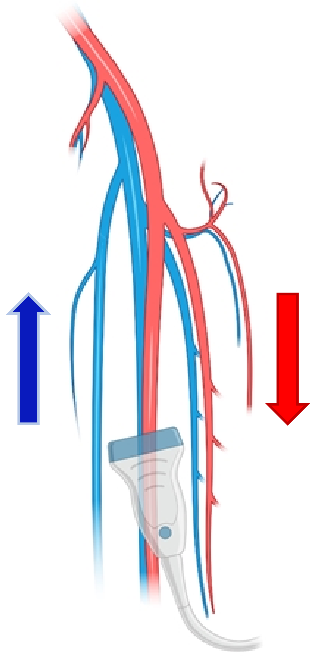
When performing color Doppler analysis:

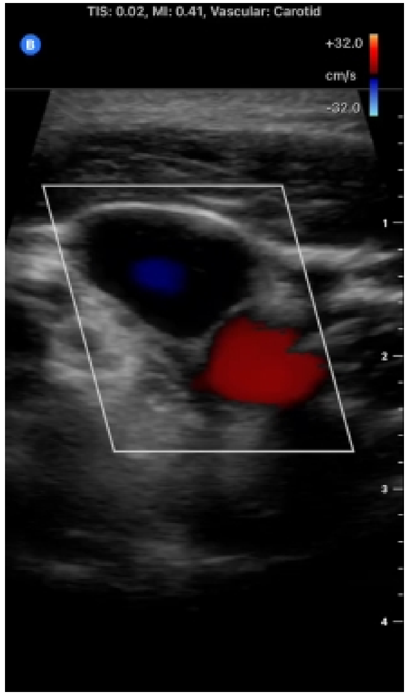
Towards the Probe

Blood Flow is RED

Away from the Probe

Blood Flow is BLUE





Memory Aid

Blue **A**way **R**ed **T**owards

(B.A.R.T.)

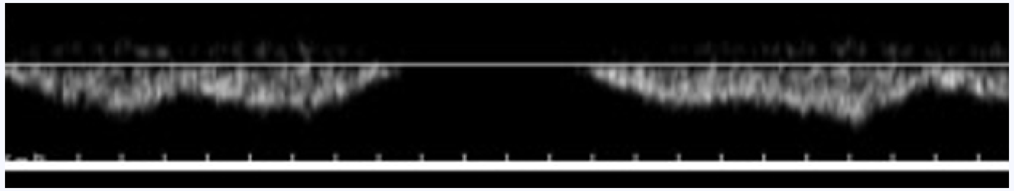
Note: This color coding can be inverted by the operator, but BART is the standard default.

Spectral Doppler Analysis

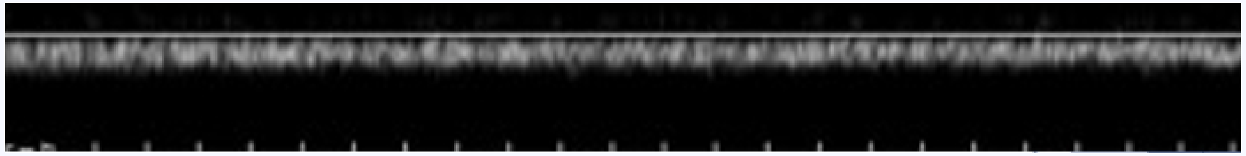
> Spectral Doppler displays the **velocity (cm/s)** of blood flow over **time**. It provides a waveform graph essential for evaluating hemodynamics, phasicity, and reflux.

Phasicity Interpretation

Normal Phasicity
Velocity varies with respiration. Lower extremity proximal veins (e.g., CFV) should show distinct respiratory variation.



Abnormal (Monophasic)
Loss of phasicity (flat, continuous waveform) suggests **proximal obstruction** (e.g., Iliac vein thrombosis or extrinsic compression).



Doppler Hemodynamics

Spectral Doppler Analysis

Augmentation & Venous Reflux Assessment

Venous Valve Dysfunction: Damage to the delicate leaflet structures can lead to venous reflux (reversed flow). This failure of the one-way valve system causes chronic venous hypertension.

Augmentation

Significance: Confirms vessel patency between the squeeze site and the probe.

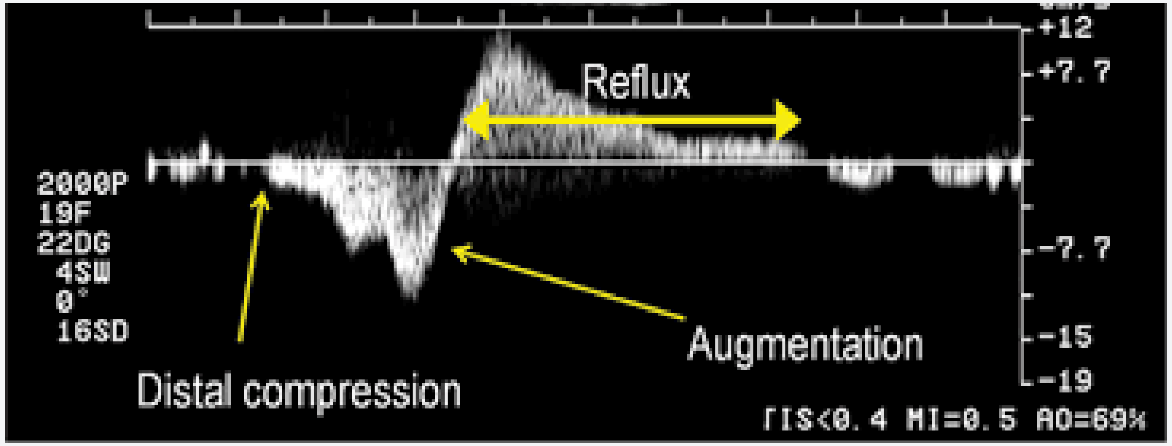
Technique: Distal squeeze causes a brisk velocity spike in the waveform.

Venous Reflux Criteria

Patient Positioning: Standing (preferred) or reverse Trendelenburg to maximize venous pressure.

Diagnostic Thresholds (Duration)

Superficial Truncal Veins	≥ 0.5 s
Deep Veins	≥ 1.0 s



Reference: Broholm R, Kreiner S, Bækgaard N, Panduro Jensen L, Sillesen H. Observer agreement of lower limb venous reflux assessed by duplex ultrasound scanning using manual and pneumatic cuff compression in patients with chronic venous disease and controls. Eur J Vasc Endovasc Surg. 2011 May;41(5):704-10. doi: 10.1016/j.ejvs.2011.01.014.

Thank You!

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