Instructor's Digital Curriculum Resource-

For Techniques in Noninvasive Vascular Diagnosis-4th edition.

by Robert J. Daigle, BA, RVT, RVS, FSVU, FSDMS

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Chapter 6.
Venous Duplex Imaging-Lower Extremities

Techniques In Noninvasive Vascular Diagnosis-4th edition

Deep Venous Thrombosis (DVT) Annual Estimates (USA)

- 500,000 -1 million cases of DVT
- 100,000-300,000 deaths from PE
- 3rd most common causes of death in hospitalized patients

CDC 2015

Definitions for this chapter

- Blood Clot-
  - applies to a clot anywhere, even in a test tube
- Thrombosis-
  - The formation of a blood clot in an artery or vein.
- Thrombus- the actual clot within a vessel
- Stasis- no movement

Definitions for this chapter

- Thromboembolism-
  - A thrombus that breaks free and travels.
- Phlebitis –inflammation of vein wall.
- Thrombophlebitis- thrombus formation associated with phlebitis
- Hypercoagulable- a predisposition to venous thrombosis
- Erythema- redness of the skin

Definitions for this chapter

- **Positive predictive value-** The "accuracy" of a test result in proving that there is disease or a condition present.
- **Sensitivity (of a test)-** The ability to show or prove that disease is truly present.
- **Specificity (of a test)-** The ability to show or prove that disease or a condition is not present.
- **Patent** = open (the artery is "patent")

Definitions for this chapter

- **Thrombophilia-** a blood clotting abnormality that increase the incidence of DVT
- **SX =** symptom or symptoms
- **HX** = history, as in "history of DVT"
- **Coaptation (in venous methods)-** bringing the vein walls together with transducer compression

Definitions for this chapter

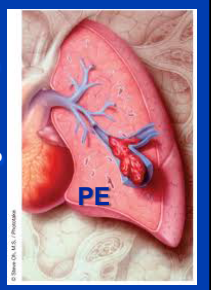
- **Stasis dermatitis-** a discoloration and deterioration of the skin in the foot, ankle and lower calf in the "gaiter" region. A sign of venous insufficiency
- **Reflux**
  - abnormal, reversed flow direction

Definitions for this chapter

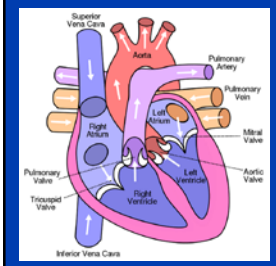
- **Semi-Fowler's position**
  - Pt. supine with upper body elevated up to 30 degrees, bent at waist
- **Reverse Trendelenburg position**
  - Pt. supine with body tilted so head is higher than feet, body is not bent at waist.

Definitions for this chapter

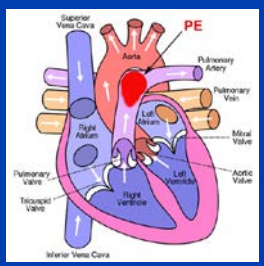
- **Superficial thrombophlebitis**
  - Thrombosis in a superficial vein
- **Pulmonary embolism (PE)**
  - A thrombus that travels to the heart, through the heart and into the lungs



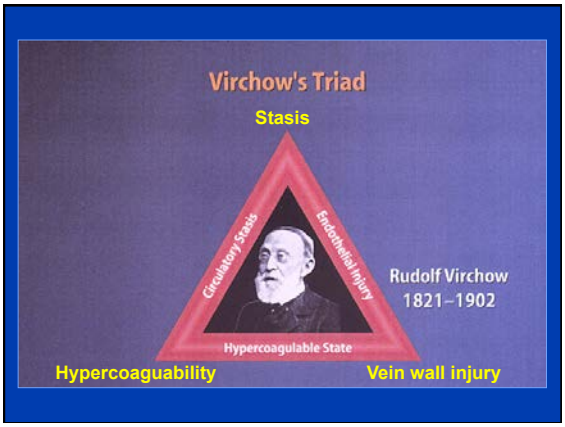
Fatal PE



Normal heart anatomy



PE to "saddle" in pulmonary artery



Risk Factors for DVT

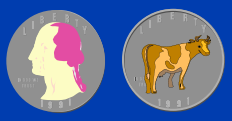
- Post - operative state
- Previous DVT
- Cancer-malignancy
- Thrombophilia
- Trauma
- Pregnancy
- High-dose estrogen
- "Economy class syndrome"

Risk Factors for DVT

- Thrombophilia -
  - ATIII, protein C, protein S, deficiency, APC resistance
  - Antiphospholipid antibody or lupus anticoagulant
- Bed-rest > 4 days
- Lower limb paralysis

Symptoms of Acute DVT

- Persistent leg pain with acute onset
- Persistent leg swelling
- Calf pain/tenderness
- If patients have above symptoms, 50% chance of DVT



Clinical Diagnosis of DVT

- Low sensitivity
  - Many DVTs are clinically asymptomatic
- Low specificity
  - Non-thrombotic disorders can cause the same clinical symptoms as DVT

Symptom with high positive predictive value for DVT:

Phlegmasia Cerulea Dolens

- Massive thigh and calf swelling
- Limb cyanosis
- Ilio - femoral outflow obstruction

Phlegmasia Cerulea Dolens

Extensive swelling and cyanosis of left leg

Symptoms of Superficial Thrombophlebitis

- Erythema / inflammation
- Local tenderness
- Palpable cord or mass
- *Usually more painful that DVT*

Physical Exam
Venous

- Swelling
- Limb discoloration
- Stasis dermatitis, ulceration
- Varicose veins
- Palpable "cords"

Venous (acute) vs.	Arterial
acute onset SX	progressive, chronic SX
persistent pain in calf or thigh	intermittent pain when walking
limb swelling	no swelling
limb cyanosis	limb pallor (whiteness)
limb warmth	limb coolness
local tenderness	rest pain, gangrene, tissue necrosis

Venous Duplex Techniques Overview

1. Visualization of thrombus
2. Compressibility / coaptation of vein
3. Spectral Doppler
4. Color Doppler

Imaging Segment : Common Femoral to Popliteal Vein

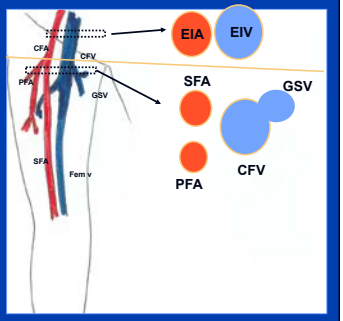
- This is the most important segment, as thrombo-embolus from these veins can be fatal.

Imaging Technique

- Torso elevated 10-20 degrees
- Leg rotated externally
- Start at groin crease , or above, in transverse plane
- Perform a "cursory" scan to familiarize yourself with the anatomy

"Crayon" Venous Anatomy

Variations in anatomy are common

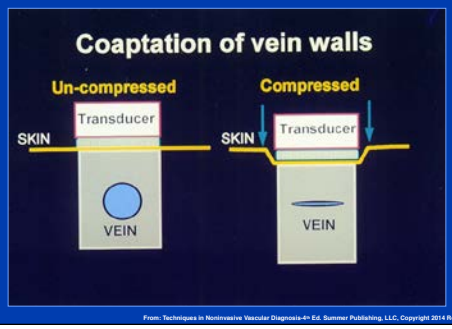


Common Femoral Vein

GOOD! Optimal transducer position for imaging- perpendicular to the vein

NOT SO GOOD !!

Compression Method



Compression

- Look for thrombus in the vein before compressing
- Compress the vein segment with the transducer so that the walls come together, then slowly release pressure and observe the vein reopening.
- Compress the CFV and the GSV at the sapheno-fem. junction

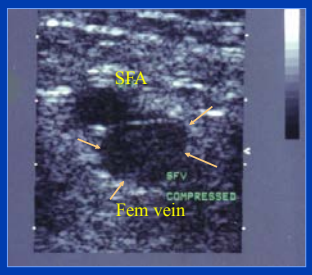
Normal CFV Compression

When in PowerPoint Show. click on link below for video demo on youtube.

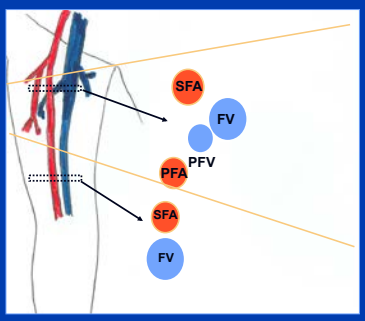
http://youtu.be/C1rYkrAb7uE

Movie: CFV compression demo-4

Femoral Vein with DVT, Compressed

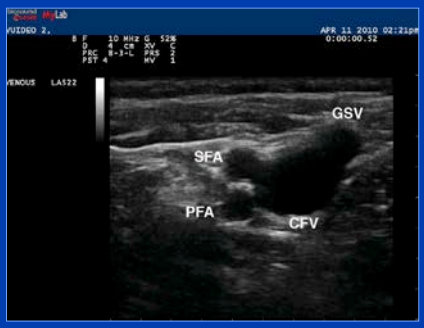


Crayon Venous Anatomy



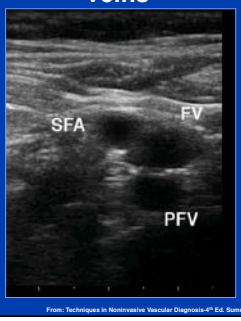
At groin crease - CFA-CFV

Sapheno-Femoral Junction, Rt. Leg

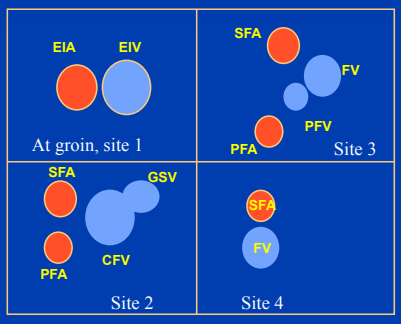


Slightly distal to Sapheno-femoral Junction

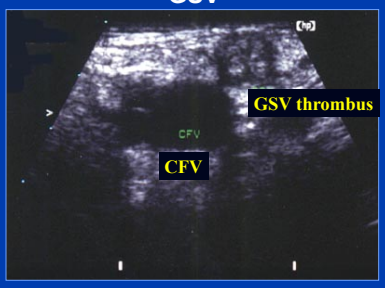
FV and PFV bifurcation, actually, it's the "confluence" of the 2 veins



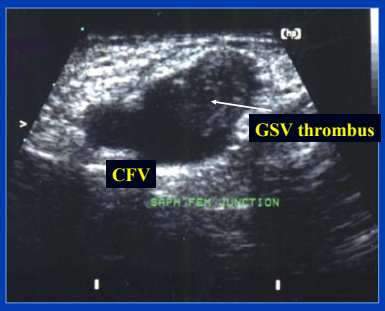
Transverse – Inguinal Region



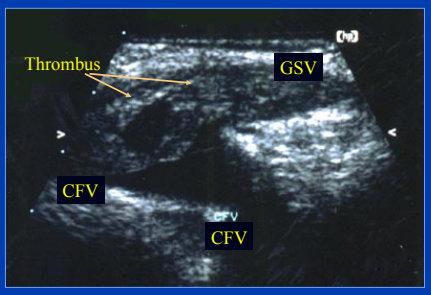
Carefully evaluate the sapheno-femoral junction for thrombus in the GSV



Sapheno-femoral Junction

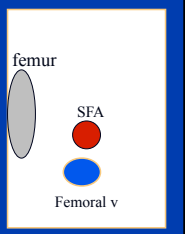


GSV Thrombosis

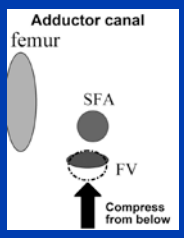


Longitudinal plane

Continue to distal thigh along deep veins



At adductor canal, compress from underneath with other hand



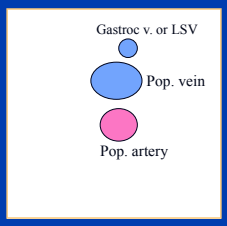
The vein will not compress with transducer pressure if the vein segment is below the femur, so press from posterior with your free hand.

Anterior Approach at Adductor Canal

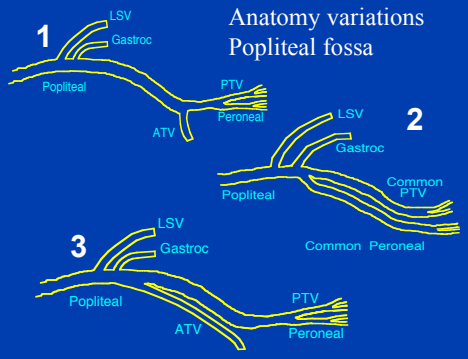
On many patients, this approach provides an excellent acoustic window to the FV and SFA in the adductor canal. However, you must compress from the posterior thigh.

Popliteal Vein

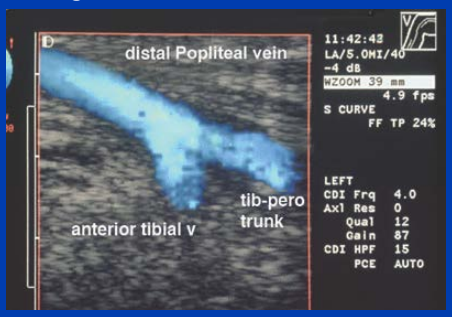
Rotate the knee externally and place the transducer behind the knee. Compress vein with transducer. Other *hand on the knee-cap helps!*



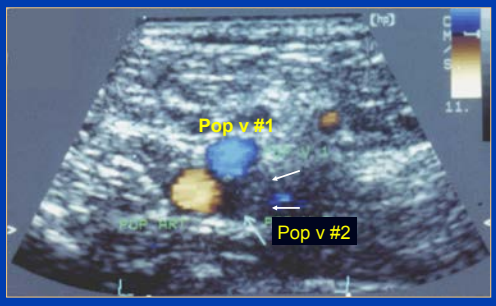
Anatomy variations Popliteal fossa



Always Scan to the Distal Popliteal Segment- longitudinal color works well here.



Bifid Popliteal vein or high entry ATV ?, one is thrombosed.

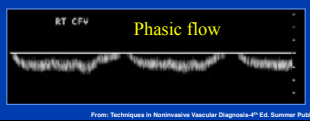


Doppler Methods - Comments

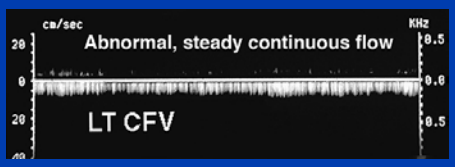
- Color Doppler is useful in the distal popliteal, the calf veins, and to document absence of filling.
- Spectral Doppler is more important than Color for proximal veins
- If the vein compressions are normal, color Doppler does not have to be performed on the proximal veins-It's too time consuming.

The following flow characteristics are assessed with spectral Doppler in longitudinal plane.

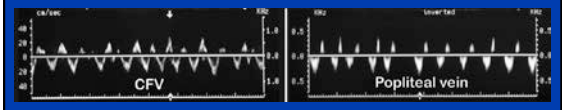
- **Spontaneous flow ?**
- **Phasic with respiration ?**
- **Augments with distal limb compression ?**
- **Reflux ?**



Continuous venous flow, without respiratory phasicity, is abnormal and suggests more proximal disease

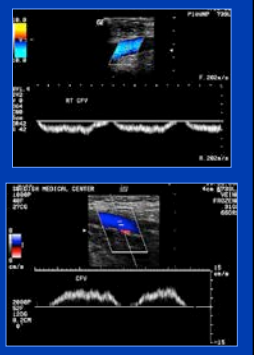


Pulsatile flow in the common femoral vein and ipsilateral popliteal vein in a patient with congestive heart failure (CHF)



Flow direction display

- **Traditionally, the Doppler waveform has been displayed below baseline; a carry-over from the days of continuous-wave Doppler with a "pencil" probe, and before duplex ultrasound imaging**
- **This is not necessary with duplex ultrasound systems**



Respiratory phasicity may <u>not</u> be present due to:

- Shallow breathers, (patients with pulmonary embolus-PE).
- Patients who are lying supine.
- Patients who have their arms raised and hands behind their head.
- Spinal cord injured patients due to reduced abdominal muscle tone.
- Proximal DVT or extrinsic venous compression.

Doppler Sample Sites

- **Common femoral veins - <u>bilaterally</u>**
- **Proximal and distal femoral veins**
- **Distal popliteal vein**
- **Posterior tibial veins (color)**
- **Peroneal veins (color)**

When in PowerPoint Show. click on link below for video demo on youtube.

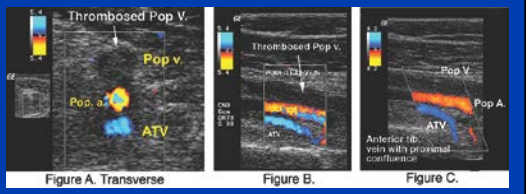
http://youtu.be/c-Ylbxmzbvc

David-ven-dubbed.sm.mov.

Potential Pitfalls

- Some normal veins may not compress:
  - CFV when the patient's reflex increases venous intraluminal pressure (ala Valsalva)
  - Popliteal vein if the transducer is pressed against the tendons in the posterior knee region
  - Calf veins if the transducer is pressing on the tibia
- Misidentifying a collateral vein when a deep vein is thrombosed.

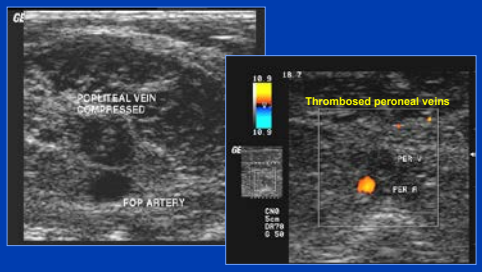
Pitfall- Thrombosed pop. vein with patent high-confluence of anterior tibial vein



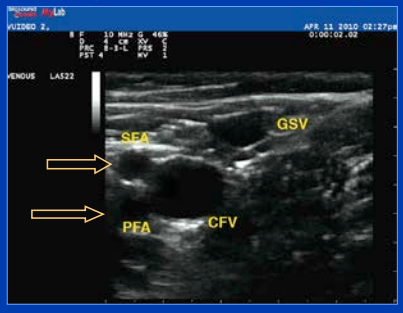
A thorough knowledge of the anatomy should help you avoid this pitfall

Patient #3

Acute DVT pop v, peroneal veins and 1 of 2 PTVs

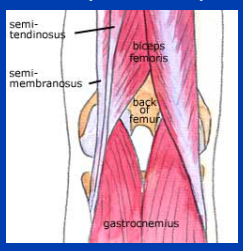


CFV here is "guarded" 2 by arteries and may be difficult to compress.



Popliteal Fossa- Pitfall?

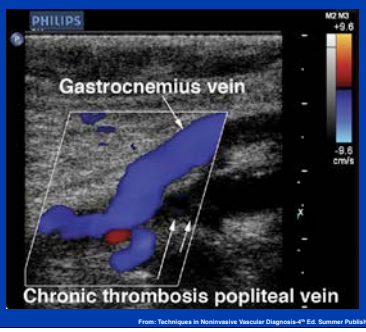
Two tendons behind the knee
Semi-tendinosis and semi-membranosus can prevent compression.



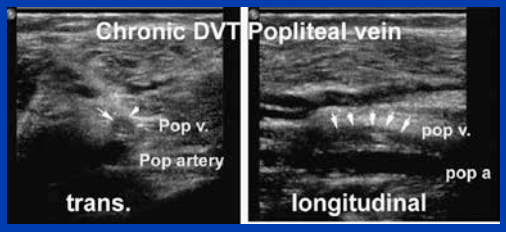
Potential Pitfall

- In the presence of a thrombosed deep vein, collateral veins can become large and carry a lot of outflow.
- In this case the distal popliteal vein is chronically thrombosed. The gastrocnemius vein is large and carrying outflow from the calf.
- The gastrocnemius vein was misidentified as a patent popliteal vein.

Chronic Popliteal DVT with large gastrocnemius collateral

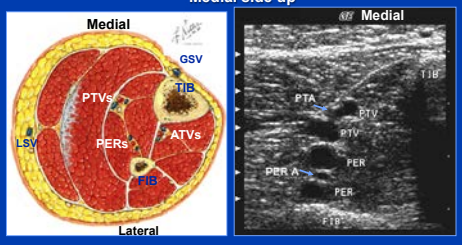


Chronic Popliteal DVT with large gastrocnemius collateral

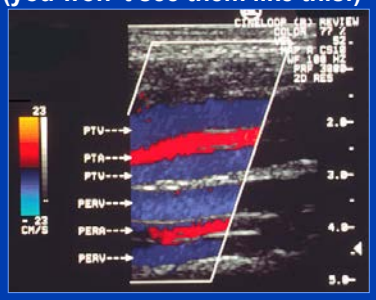


Calf Vein Imaging
Transverse calf

Medial side up



Calf Veins
(you won't see them like this!)



Calf Imaging- start at ankle in transverse

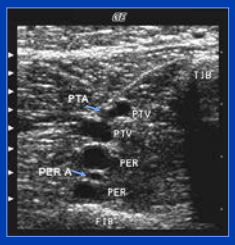
- Start at ankle, then move proximally.
- Identify the PTVs first and follow as proximally as possible using compression methods
- Keep transducer perpendicular to optimize image quality

Calf Imaging

- Move transducer across the calf to optimize the acoustic "window"
- You may use color Doppler in transverse plane, but it's not as good as in long view

Next, evaluate the peroneal veins (per)

- Start in transverse plane just below mid calf from the medial aspect.
- Adjust field of view for greater depth
- Identify the fibula, and look for peroneals
- Follow veins distally, then proximally to popliteal confluence (difficult to image).



Easy Veins

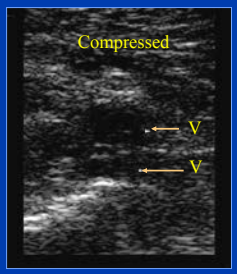
- start at distal PTVs, scan proximally in transverse- compress
- proceed to tib-peroneal trunk
- next, identify peroneals in mid calf - compress
- confirm with color Doppler with augmentation

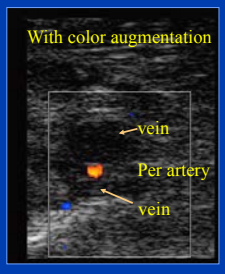
Use longitudinal scan with distal augmentation to demonstrate flow.

Tough Calf Veins - Deep and Small

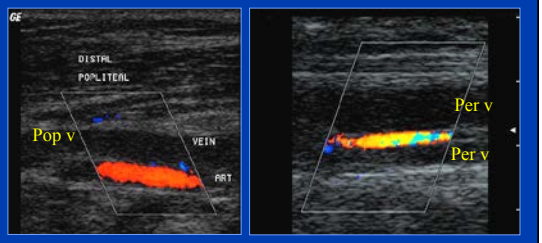
- use longitudinal color
- use augmentation
- try different leg positions
- If calf is swollen due to venous obstruction, the popliteal vein will be involved.

Thrombosed Peroneal Veins





Thrombosed Popliteal and Per v.

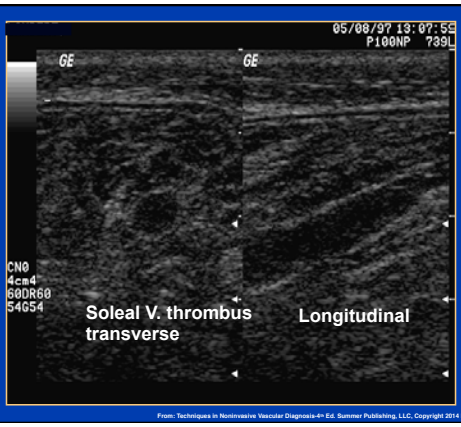


Anterior Tibial Veins?

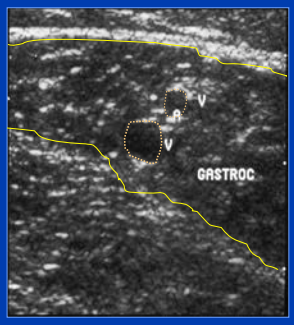
- Don't bother !
- Too tedious
- Too small
- They're rarely involved unless there is extensive DVT in other vessels

Calf Muscle Veins

- Gastrocnemius veins
- Soleal veins
- Local tenderness, and pain when walking
- Ask patient to indicate "where it hurts", and look there.



Gastroc muscle with artery and veins



Gastroc Vein Thrombosis

- May be clinically important if thrombus extends to popliteal vein.
- So, determine the extent of thrombus proximally

Calf Vein Caveats

- Flow in calf veins is usually not spontaneous, you often must augment flow by squeezing the calf or ankle.
- If the patient is symptomatic (tenderness), look for muscular vein thrombosis
- If you find calf, SSV, or gastroc vein thrombosis, look carefully for extension into the popliteal vein.
- If you miss a calf vein thrombus, it won't kill the patient! But don't miss thrombus in the popliteal and above.

Perspective: thrombus anywhere from the popliteal to the iliac veins is life threatening.

Calf vein DVT may cause PE but thrombus is too small to be fatal.

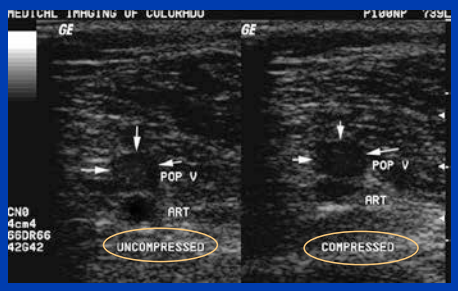
Criteria for Patency: All Veins

- Complete coaptation of vein walls with transducer pressure
- Absence of visible intramural thrombus
- Normal venous Doppler signals of spontaneity and phasicity.
  - Exception: spontaneous flow may not be present in calf veins
- Visualization of blood flow throughout the lumen with color Doppler

Criteria for Venous Thrombosis

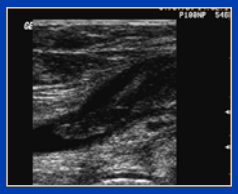
- Visualization of thrombus
- Absence of vein compressibility
- Vein distention
- Abnormal Doppler signals
- Reduced / absent augmentation
- Reduced / absent color filling

Popliteal Vein DVT



Acute DVT

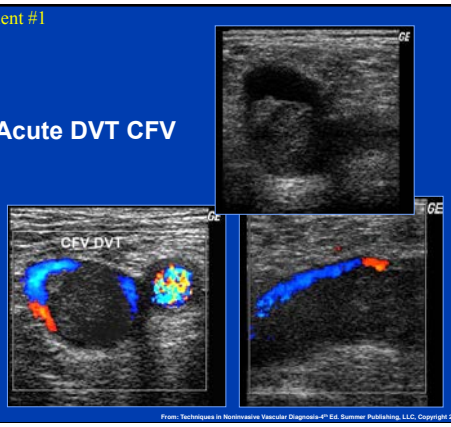
- Vein may be distended
- Somewhat hypo-echoic
- No collaterals
- Maybe free floating (scary!) Don't scrunch it and send it flying!



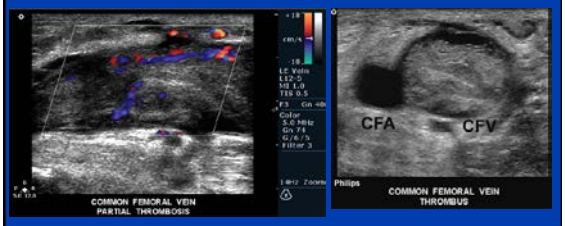
Partially attached, free-floating popliteal thrombus

Patient #1

Acute DVT CFV

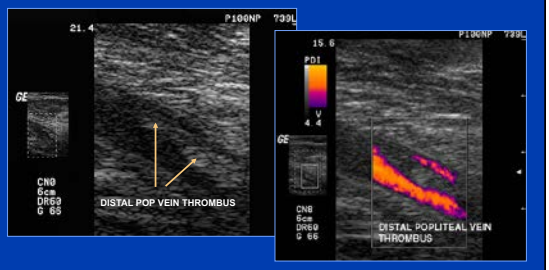


Acute DVT CFV



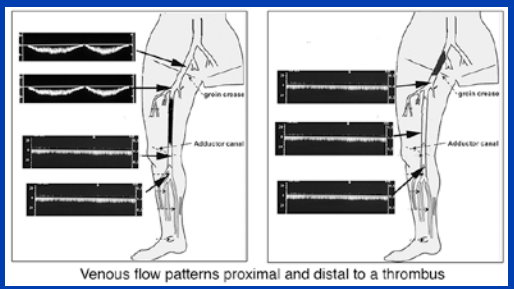
Patient #2

If PTV or peroneal vein thrombus is detected, you must look carefully in the distal pop vein for propagation. It's a difficult region to image.



Whether or not you're successful in imaging calf veins, you must thoroughly assess distal popliteal vein

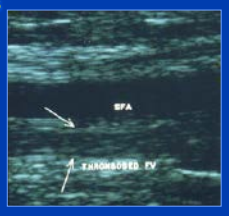
Flow proximal to thrombus may have respiratory changes.
Flow distal to thrombus is abnormal



Venous flow patterns proximal and distal to a thrombus

Chronic DVT

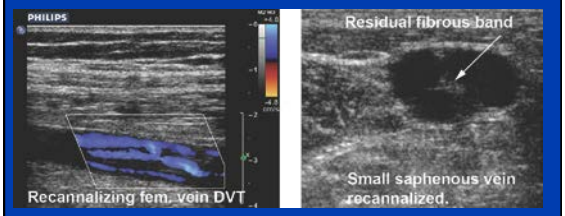
- Echogenic thrombus
- Vein smaller than artery
- Presence of collaterals
- Recannalization



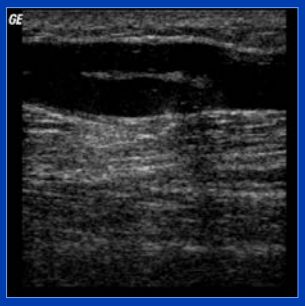
Contracted femoral vein

Chronic DVT- other signs:

- Recannalization
- Residual fibrous bands



Residual fibrous band in recannalized GSV



Sub - acute vs. Acute DVT

- Thrombus absent : no problem
- Thrombus present: difficult judgement call based on current symptoms, state of anticoagulation, etc.
- D-dimer test?

Venous Imaging

"Practical stuff"

Perspective:

Thrombus anywhere from the popliteal to the iliac veins is life threatening.

Calf vein DVT may cause PE but thrombus is too small to be fatal.

Ditto for great saphenous thrombosis

Patient with Large Legs

There are published investigations that indicate the following:

If the CFV and proximal FV are patent, and the popliteal vein is OK, there is a very high probability the study is normal (calf veins excluded).

Detection of deep venous thrombosis by real time B-Mode Ultrasonography . N Engl. J Med, 1989: 320: 342-345

- A. Lansing et. Al.
- 220 venograms comparing duplex ultrasound
- Evaluation of CFV and POP v with compression only
- FV not imaged
- Sensitivity 100%, Specificity 99%

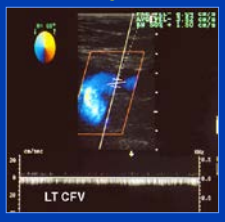
Limited Study Summary

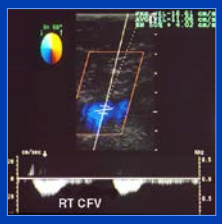
- If the exam is limited by obesity, a limited exam can rule out proximal acute DVT.
  - If CFV, proximal fem vein and popliteal veins compress, and..
  - Normal respiratory variation occurs in the CFV and popliteal veins, there is no acute DVT in the deep veins above the knee.
  - There is a negative predictive value.
- The limited exam does not rule out calf vein thrombosis.

Compare bilateral CFV waveforms to rule out Iliac obstruction

Steady, continuous flow suggests proximal DVT or extrinsic compression.

Normal ipsilateral flow with respiratory variation

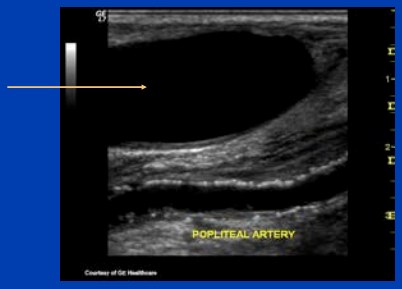




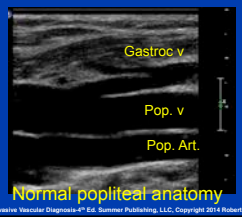
Differential Diagnoses: Leg Pain and Swelling

- Popliteal cyst / dissected cyst
- Popliteal artery aneurysm
- Muscle tear
- Hematoma
- Lymphedema
- Cellulitis

Is this a dilated popliteal vein or a Baker's cyst? How can you determine?



- The popliteal vein lies adjacent to the popliteal artery. The structure in the above image does not.
- It's a Baker's cyst.



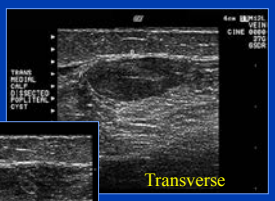
Normal popliteal anatomy

Baker's Cyst

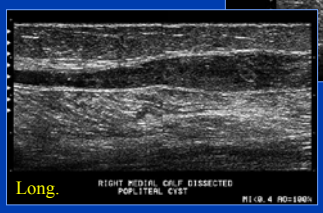
- aka Synovial cyst
- Synovial lining and fluid bulge into the popliteal space.
- May dissect into calf muscles or along intermuscular septums
- Rule out calf hematoma by demonstrating communication with joint space

Longitudinal Baker's Cyst

Dissected Popliteal cyst with hemorrhage



Transverse

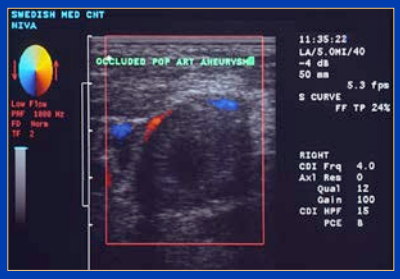


Long.

Calf Hematoma

- Notice how the hematoma lies within the muscle fibers.
- Hematomas usually do not extend up into the popliteal joint space

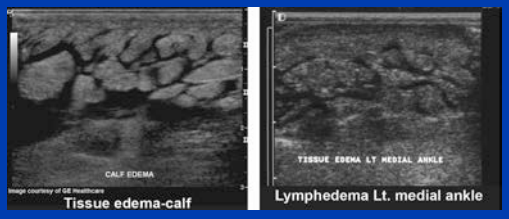
Incidental finding:
Popliteal artery Aneurysm



Lymphedema

"Ant farm" appearance

Lymphedema

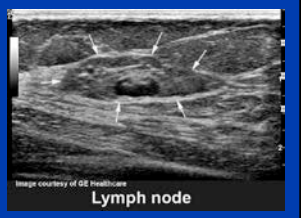


Tissue edema-calf

Lymphedema Lt. medial ankle

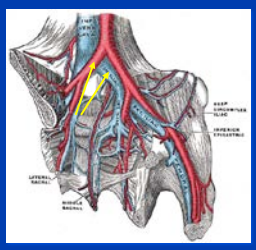
Lymph Nodes

- Commonly seen in the groin region.
- Kidney-shaped and can be swollen in the presence of systemic infection, malignancy, etc.
- Should be measured in three dimensions and reported.



Compression Syndromes

- **May Thurner Syndrome**
- **Compression/ thrombosis of left iliac vein by overlying right iliac artery**



Other Differential Diagnoses

- Tumors: often have increased arterial flow noted with color Doppler.
- Abscess: look for swirling debris within.
- Arterio-venous fistulas: high venous flow and low arterial resistance (high velocity,low resistance flow).

Pitfalls and "Pearls" Summary

- A "heavy hand" on the transducer will compress veins inadvertently; if you cannot see the veins, Ease up.
- If any vein segment does not compress, make sure the transducer is not pressing against aa adjacent bone or tendon
- The distal popliteal vein is difficult to image. Examine this segment carefully in longitudinal plane all the way to the anterior tibial vein confluence.

Pitfalls and "Pearls" Summary

- Beware of bifid/duplicated femoral and popliteal veins; they're common. One may be patent and the other thrombosed.
- Popliteal or Baker's cyst may contain hemorrhage and look like a popliteal DVT. Pay attention to anatomy to avoid this error

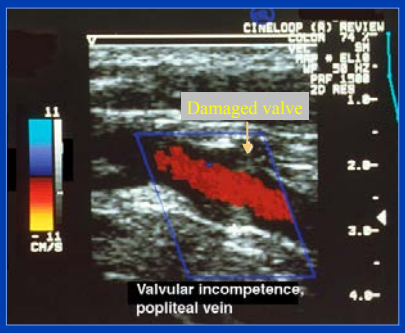
Pitfalls and "Pearls" Summary

- In longitudinal plane, color Doppler may obscure partially occlusive thrombus due to the" slice thickness" of the color Doppler beam.
- Some patients may not exhibit respiratory phasicity in the proximal veins. You must determine if this is a systemic phenomenon by evaluating the other leg.
  - If this is a unilateral phenomenon and no DVT is detected in that leg, iliac vein thrombus or extrinsic compression of the iliac vein should be suspected.

Venous Insufficiency
Venous Incompetence

- **Primary**
  - Congenital absence or malfunction of valves
- **Secondary**
  - Post-phlebitic - damage to valves secondary to thrombosis and/or venous outflow obstruction

Valve damage following thrombosis and recannalization



Symptoms of Venous Insufficiency

- **Recurrent calf, ankle, or foot swelling.**
- **Varicosities.**
- **Venous claudication.**
- **Stasis dermatitis.**
- **Ulceration.**
- **Chronic limb swelling.**

Note that these symptoms are distinctly different from those of acute venous thrombosis.

Comparison of Symptoms

Symptoms of Acute DVT	Symptoms of Insufficiency
• Acute, persistent limb swelling	• Recurrent limb swelling
• Recent onset, persistent pain: calf, thigh	• Varicose veins
• Local tenderness	• Chronic leg heaviness, discomfort
• Limb warmth	• Stasis dermatitis
• Shortness of breath (? PE)	• Ankle/foot Ulceration

The Current Venous Ultrasound Examination

May include evaluation for:

- **DVT**
- **Superficial thrombophlebitis**
- **Deep venous insufficiency**
- **Superficial vein incompetence**

Plus

Evaluation for:

- **Perforator vein incompetence**
- **Pre-ablation information- mapping**
- **Differential diagnoses: Baker's cyst, etc**
- **Optional - Pre-operative vein suitability for arterial bypass**

Unilateral or Bilateral Evaluation?

Most common sonographer complaint…..

" If I do all I'm supposed to do, the exam takes 2 hours!"

Stressful ??

Recommended Venous Protocols

Protocols based on "logic" and symptoms

1. **Rule out acute DVT**
2. **Evaluation for Venous insufficiency**
   a. **Deep veins**
   b. **GSV, SSV**
   c. **Perforators**
3. **Pre-ablation protocol (includes #2)**
4. **Vein mapping for arterial bypass**

Venous Protocol #1: Rule out Deep Vein Thrombosis

- Use methods as described in this chapter. Scan for superficial thrombophlebitis if symptomatic.
- Perform this protocol for patients with acute symptoms (SX within 2 weeks).
- Don't evaluate for insufficiency or valvular incompetence: these are chronic symptoms.

Venous Protocol #2: Evaluation for Insufficiency.

- Perform this exam for patients with non-acute symptoms of insufficiency.
- Rule out DVT and chronic outflow obstruction (quickly) by scanning the CFV and popliteal veins only; use compression and Doppler methods.
- Evaluate CFV, proximal femoral and popliteal veins for reflux.

Venous Protocol #2: Evaluation for Insufficiency (cont).

- Evaluate GSV for flow reflux, evaluate the small saphenous vein if large.
- Identify incompetent perforating veins and where they connect to deep veins.
- Don't scan calf veins except for perforator connection.
- See Chapter 7 for methods and detail.

Venous Protocol #3: Pre-ablation protocol

- Perform protocol # 2, and add the following procedures
  - Evaluate GSV for flow reflux, identify the highest level of incompetence.
  - Mark (map) the course of the GSV with an indelible marker (establish beforehand if this is needed)
  - "Mark" incompetent perforating veins (establish beforehand if this is needed). Ignore competent perforators.

Venous Protocol #3:
Pre-ablation protocol (cont.)

- Perform protocol # 2, and add the following procedures
  - Measure and record the GSV diameter at its widest spot.
  - Measure the depth of the GSV at its shallowest position.
  - Identify the source vein of large varicosities.

Venous Protocol #4:
Vein Mapping for Arterial Bypass

- Rule out femoral vein thrombosis
- Determine suitability of the great saphenous vein
  - Is it continuous to the ankle?
  - Does it have residual thrombus?
  - Is it a duplicated system?
  - Any areas of abnormal narrowing or dilation (aneurysm)?

Venous Protocol #4:
Vein Mapping for Arterial Bypass (cont.)

- Measure the diameter in the proximal, mid, distal thigh, and mid & distal calf.
- More detail will be found in the chapter on bypass grafts.