Focused ultrasound exam for the detection of DVT

Philips tutorial

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Contents

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1 Introduction

Deep venous thrombosis (DVT) is a significant problem in our modern society and carries a high morbidity and mortality burden.

The responsibility of diagnosing a DVT falls squarely onto the shoulders of the clinician evaluating the patient. In the emergency department a swollen or tender lower extremity is the most common presentation. However, in many cases, the patient may present with what appears to be an unrelated complaint. This is all the more complicated by the variety of symptoms that actually may herald DVT formation.

Ultrasound performed by radiology or vascular laboratories is considered the testing modality of choice for evaluation of lower extremity DVT. Ultrasound evaluation itself displaced venography by the early 1990s as most ultrasound systems began to offer images of adequate resolution to closely match the high sensitivity and specificity of venography. Unlike venography, however, ultrasound does not require any intravenous contrast load, does not deliver ionizing radiation, and does not require cannulating small veins in the foot.

The DVT exam protocol performed by radiology and vascular laboratories is comprehensive and can take up to an hour. Services from these traditional imaging providers are often limited or lacking after-hours and on weekends. In addition, due to their high cost and the effect of shrinking institutional budgets, service from traditional ultrasound departments is becoming less and less available in some institutions. Thus, it did not take long for clinicians to discover that they can greatly increase diagnostic efficiency by performing a point-of-care ultrasound exam themselves while at the patient's bedside. When point-of-care ultrasound is employed, there is the potential to reduce the time-to-diagnosis, decrease lengths of stay, and lower costs.

The use of a focused ultrasound exam to rule out DVT is now routinely taught in Emergency Medicine residency programs, fellowships and clinical courses.

2 Indications

Any patient suspected of having a DVT or of being at risk for having a DVT is a good candidate for the exam.

The most common presentation is a patient with a tender or swollen lower extremity.

The focused DVT ultrasound examination can be performed in virtually any setting. This allows the treating clinician to perform a study on any patient in whom a DVT is suspected regardless of time of day.

The focused DVT ultrasound evaluation typically involves scanning the extremity for **proximal DVT** only. The reason for this approach is that the embolization rate of **distal DVTs** is thought to be extremely low. The detection of a distal clot can be extremely time-consuming and inaccurate. While there is some debate whether or not distal clots should be treated with anticoagulation, many clinicians do not treat distal thrombi but rather rescan the patient to check for thrombus propagation.

A typical strategy for the detection of proximal propagation of a thrombus is to repeat the focused ultrasound exam five to seven days after the initial evaluation unless there is a change in symptoms or signs that warrant a repeat evaluation sooner.

It is important to note that the clinician should not be deterred from scanning farther down the leg when scanning for a proximal DVT, especially if the patient can point to a focal area of discomfort. The decision to treat or continue to observe a distal clot is dependent on the individual clinician and the local practice preferences.

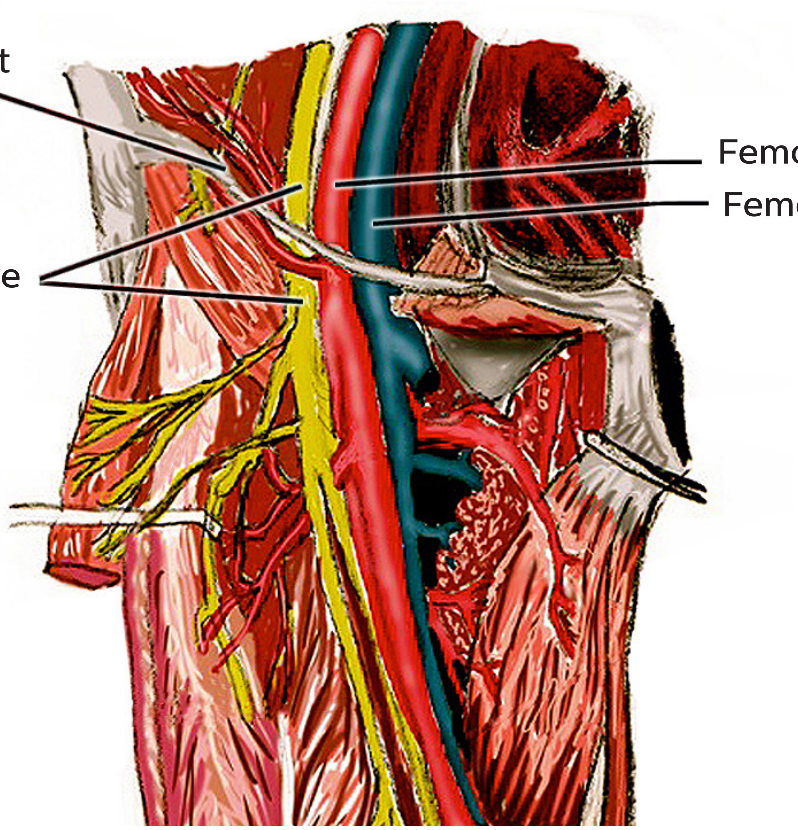
3 Clinical anatomy

Although venous flow is from distal-to-proximal, it is helpful to discuss the anatomy, as well as the examination, in proximal-to-distal orientation.

The common femoral vein (CFV) begins at the inguinal ligament **(Figure 1)**. As the CFV descends into the proximal thigh, it runs adjacent to the common femoral artery (CFA). The CFV bifurcates into the deep femoral vein (DFV) and superficial femoral vein (SFV), sometimes known simply as the femoral vein (FV).

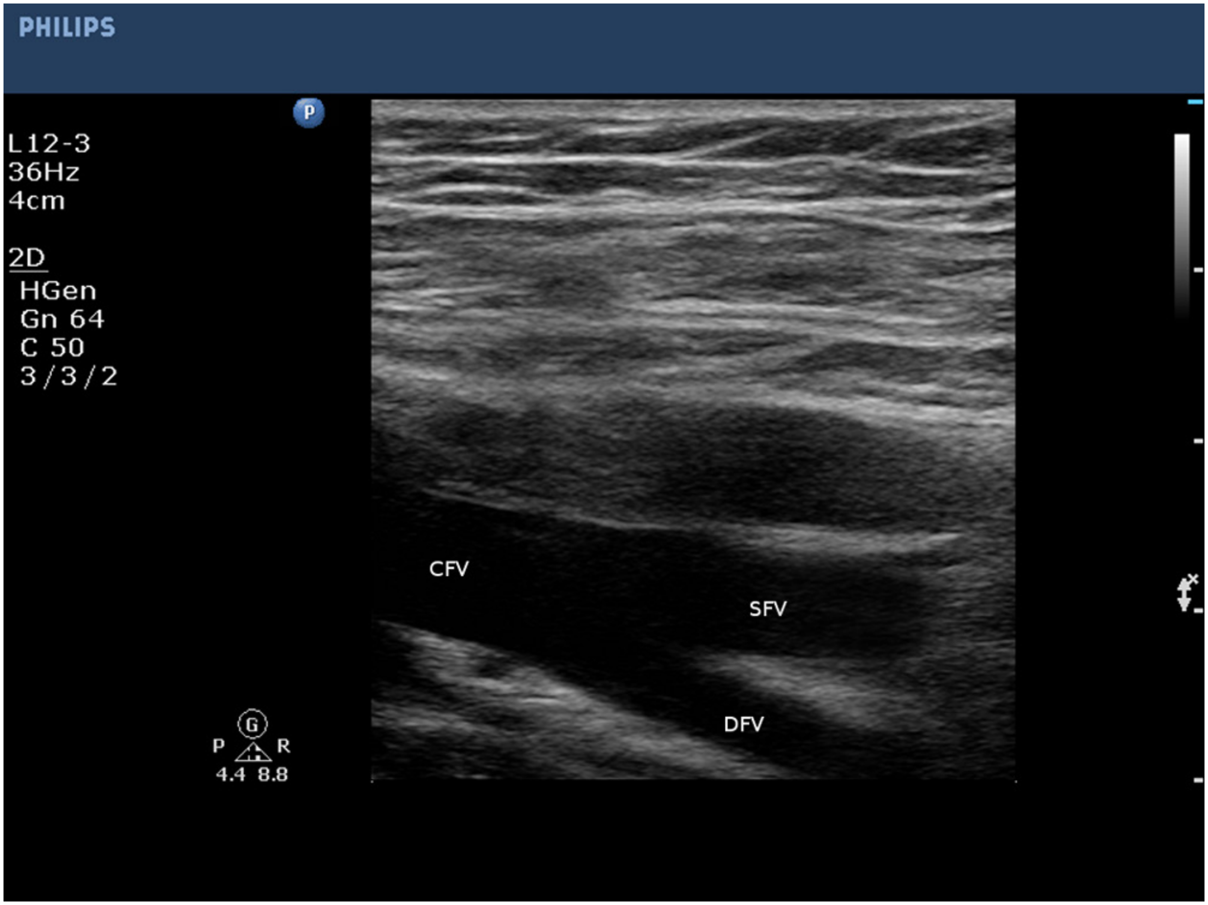
The CFA typically bifurcates into the deep and superficial femoral arteries, one or two centimeters more proximal than the CFV bifurcation.

The DFV, sometimes called the profunda, frequently dives deep into the thigh **(Figure 2)**. While it is not uncommon to see the CFV sitting directly underneath the CFA at the level of the inguinal ligament, in general, after bifurcation the artery and vein do not overlap significantly.



[Figure 1] Anatomical illustration demonstrating the femoral vein, femoral artery and femoral nerve at the level of the inguinal ligament.

This illustration was borrowed from the *"Ultrasound-guided femoral nerve block"* tutorial by Dr. Francis Salinas with his gracious permission (www.philips.com/RAPMeducation).



[Figure 2] **Ultrasound image demonstrating bifurcation of the CFV into the DFV and the SFV. Cephalad is to the left on the screen, caudal is to the right on the screen.**

As the SFV progresses distally, it dives through the obturator canal proximal to the knee and reappears proximal to the popliteal fossa. In this orientation, the popliteal vein (PV) and popliteal artery (PA) frequently overlap to some degree. As the PV progresses distally to the bottom of the popliteal fossa, it trifurcates into the veins of the calf: the peroneal, the anterior tibial, and the posterior tibial.

The greater saphenous vein, which is a superficial vein, eventually drains into the CFV just inferior to its bifurcation into the DFV and SFV. Evaluating this area is especially important as any thrombus seen here is likely to seed the CFV directly and develop a proximal DVT.

4 Ultrasound anatomy and technique

Transducer selection

The optimal transducer is generally a high frequency linear transducer in the 3-12 MHz range. A lower frequency curved array transducer may be needed for larger patients.

[Figure 3] Linear transducer.

The size of the transducer may be a consideration. Although a shorter transducer may be easier to position behind the knee and in the inguinal crease, a shorter transducer may be more difficult to stabilize over the vessel during compression. A longer transducer may facilitate performing compressions; however, due to its size it may be difficult to position behind the knee or in the inguinal crease **(Figure 3)**.

Patient positioning

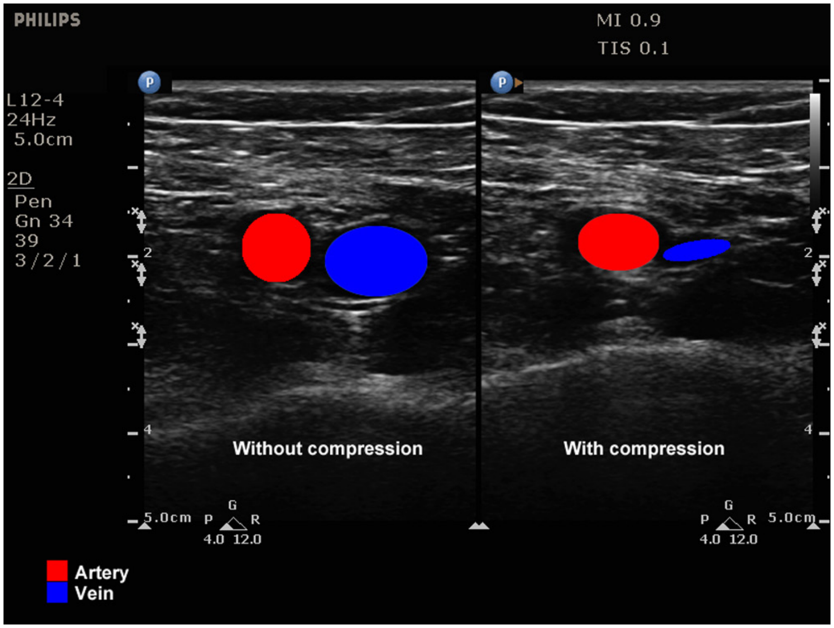
Ideally the patient is in the supine position with the head of the bed elevated to about 30–45 degrees. This allows the lower extremity veins to be adequately distended to facilitate good visualization using ultrasound **(Figure 4)**. External rotation of the leg may be helpful. The traditional imaging literature frequently shows patients sitting on the edge of a bed or a chair with a technician scanning the bent leg. This is neither possible nor practical in many clinical settings and thus will not be discussed here.

[Figure 4] The patient's bed is inclined at 35 to 45 degrees and the transducer is positioned transversely in the inguinal area as proximal as possible. The leg is externally rotated.

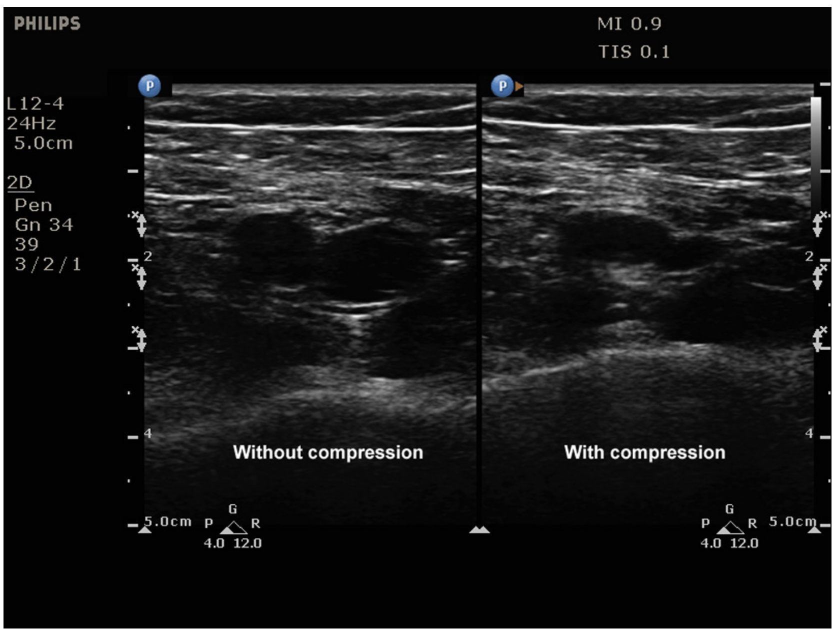
Technique

The ultrasound exam is performed by compressing the vein with the transducer. A normal vein will compress with pressure applied from the transducer – complete apposition of the vein walls is the goal. Compression of the vein is observed in real time. If complete compression of the vein is not obtained by using enough pressure to deform the artery, a DVT should be suspected **(Figure 5 and Video 1)**.

It is critical to begin scanning above the inflow of the greater saphenous vein. Begin the scan as proximally as possible to the inguinal canal. Be sure to use adequate gel. The transducer is held transverse to the long axis of the leg **(Figure 4)**. The vessels are typically somewhat medial on either extremity. Starting in the mid-line of the anterior proximal thigh will ensure that the vessels are not missed. Move the transducer medially until the vessels are located. Identify both the vein and artery. After some experience, the vessels are nearly always visualized on the first attempt in most patients. This is especially true for those clinicians familiar with placing femoral central lines or performing femoral arterial blood gas sampling. Compress firmly with the transducer to see the vein collapse (Video 1). The common femoral artery may deform, but typically will not collapse completely. Compression should be applied systematically down the leg **(Video 2)**.



[Figure 5a] Color overlay on the ultrasound image of femoral artery and vein demonstrating images without compression and with compression.



[Figure 5b] Ultrasound image of femoral artery and vein demonstrating images without compression and with compression. Note the compression of the femoral vein when pressure is applied with the transducer.

[Video 1]

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Video demonstrating compression of the femoral vein. Note the artery is pulsatile and does not collapse with pressure from the transducer. Femoral artery = red circle, femoral vein = blue circle.

[Video 2]

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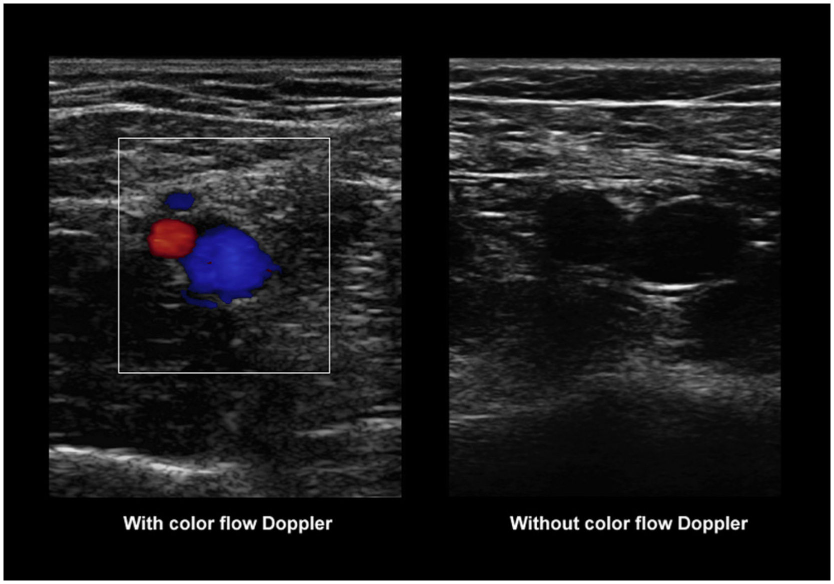
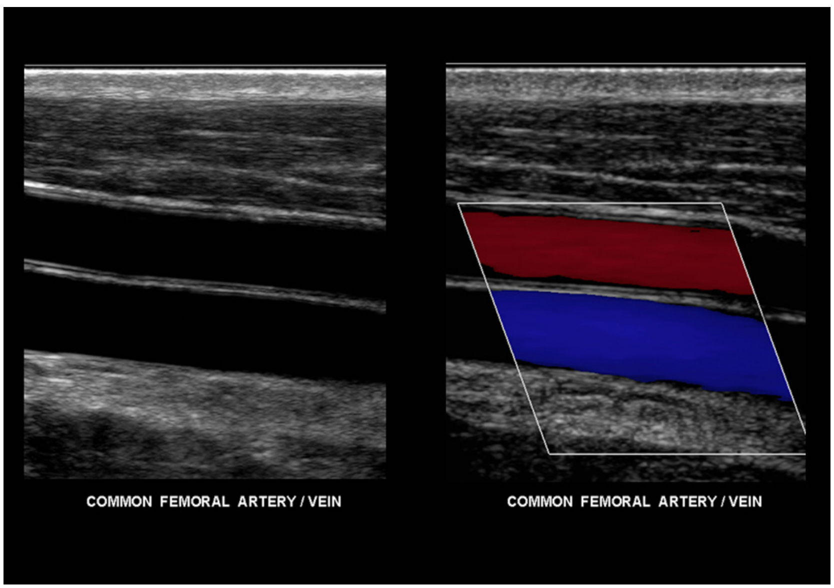
Video demonstrating transducer placed transversely in the inguinal area. Note the skin and underlying tissue are being compressed with the transducer.

If there is any confusion about vessel identity, use color flow Doppler or pulsed wave (PW) Doppler to confirm which vessel is the artery and which vessel is the vein **(Figure 6a and 6b)**.

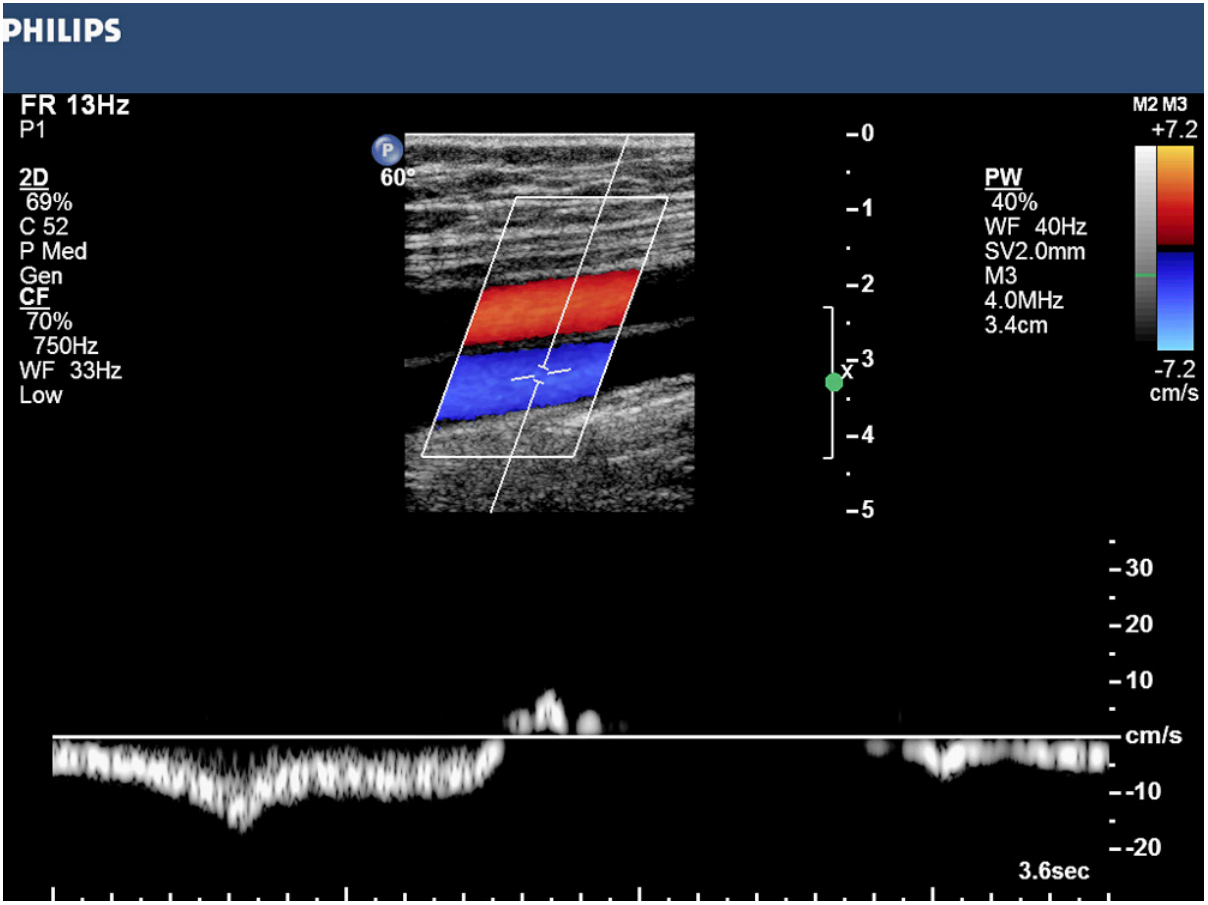


[Figure 6a] Transverse view of the femoral artery and vein. Color flow Doppler is applied to the image on the left to help identify the vein and artery.



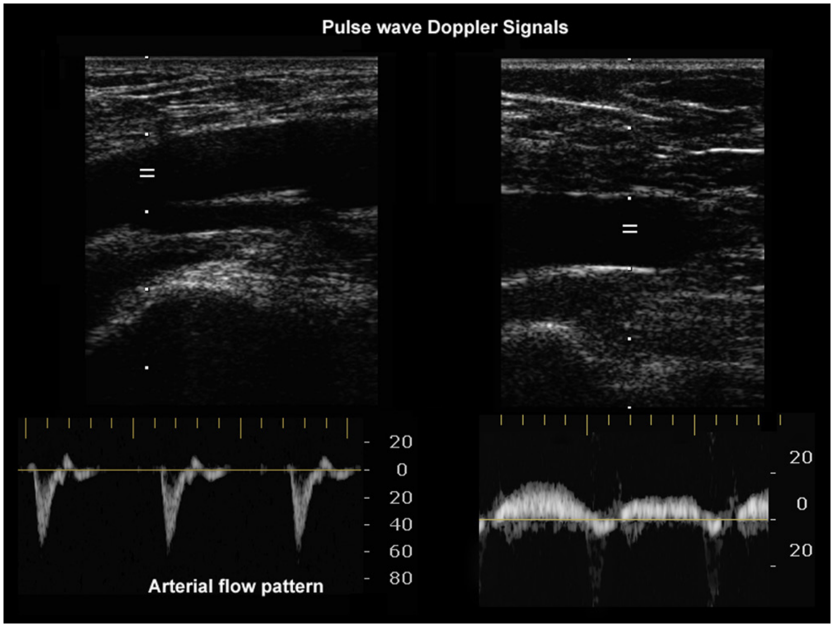
[Figure 6b] Long-axis image of the common femoral artery and vein. Color flow Doppler is applied to the image on the right to help identify the vein and artery.

Pulse wave Doppler is the most sensitive and accurate way to distinguish between artery and vein **(Figure 7)**. A long-axis view is needed for the best PW Doppler signal. Using a long-axis view (obtained by turning the transducer 90° from the transverse view), center the image over the vessels in question, one at a time. Place the Doppler sample volume inside the vessel. Obtain a pulse wave Doppler tracing over the CFA and CFV.

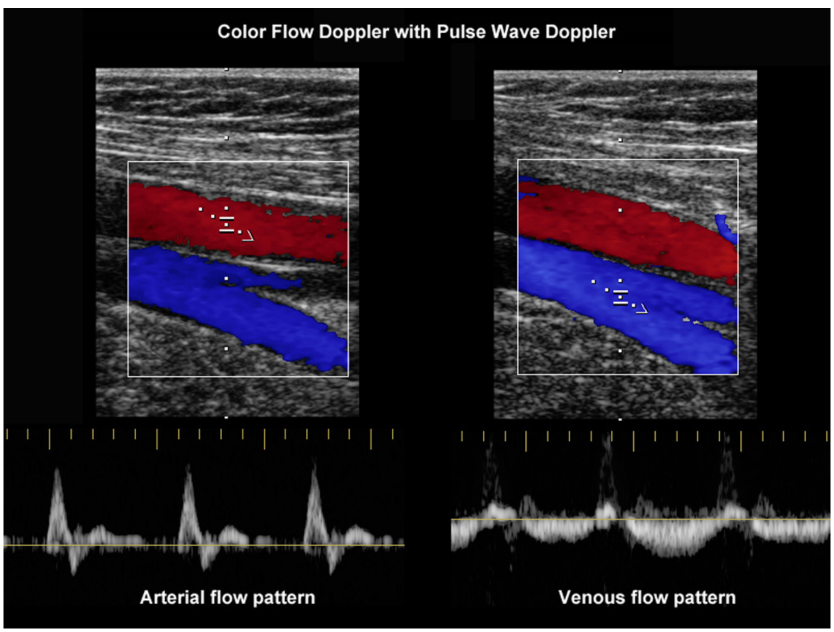


[Figure 7] The Doppler sample volume is placed in the vein. A normal venous signal with respiratory variation and lack of significant pulsations is noted.

If there is difficulty identifying vasculature from background soft tissue, the use of color Doppler should help identify the femoral artery if not the femoral vein as well **(Figures 8a and 8b, and Video 3)**.



[Figure 8a] Left image: Doppler sample volume is placed in the artery. The normal triphasic arterial signal is seen. Right image: The Doppler sample volume is placed in the vein. A normal venous signal is noted.



[Figure 8b] Color flow Doppler with pulsed wave Doppler demonstrating flow in the common femoral artery and vein.

[Video 3]

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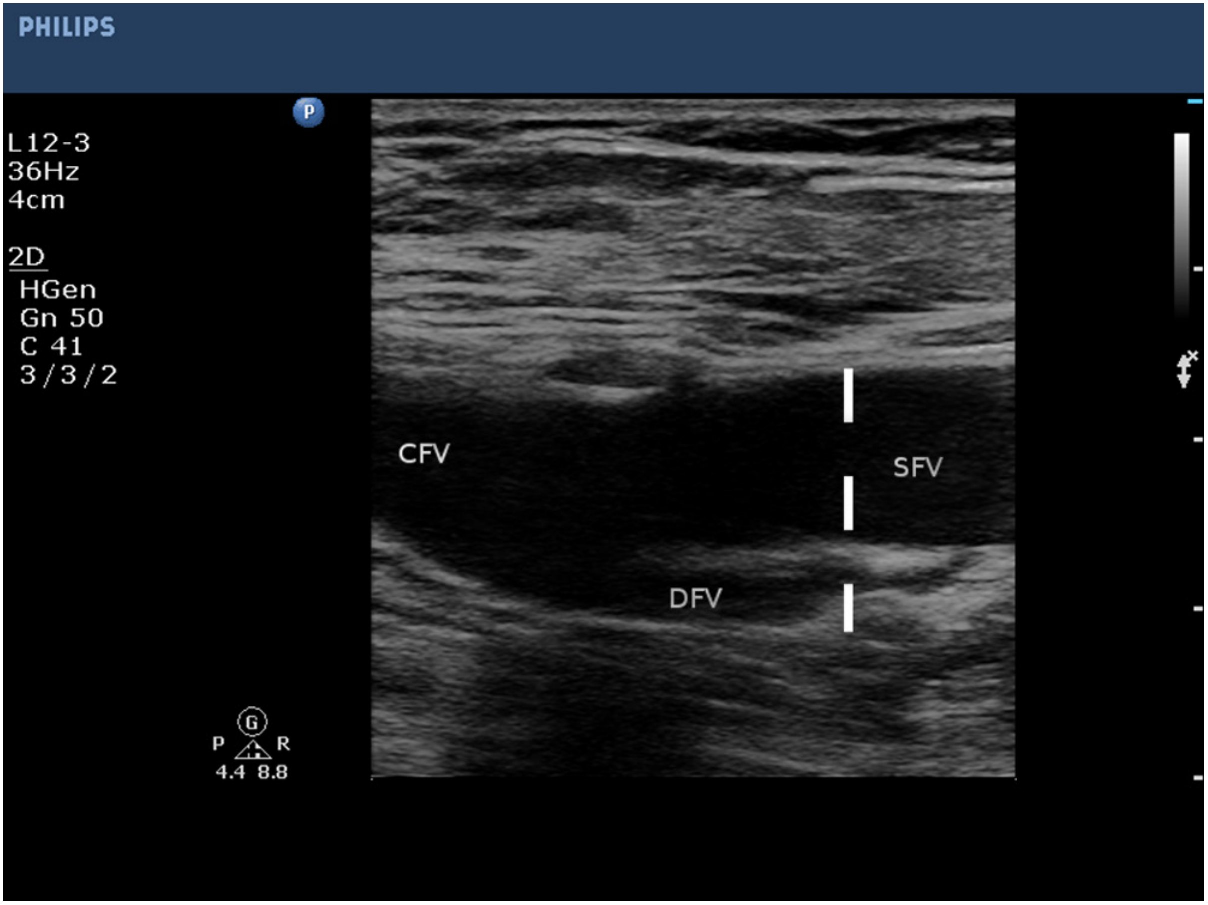
Transverse image of the femoral artery and vein with color flow Doppler. Note the red pulsatile signal in the artery and the blue non-pulsatile signal in the vein.

Continue to compress the CFV through the junction of the greater saphenous vein (SFV) past the bifurcation of the CFV into the DFV and SFV. It is important to continue distally another 2 cm to make sure there is no thrombus in the DFV or proximal SFV **(Figure 9 and Video 4)**. Occasionally, a DFV thrombus will be seen in the vein's proximal portion as it is about to propagate into the CFV. This is not common, but the additional compressions to evaluate it will be well worth the effort when such a thrombus is encountered. The total length of the segment compressed in the proximal thigh is typically 4 to 5 cm.



[Figure 9] **This ultrasound image demonstrates the common femoral vein splitting into the deep femoral vein and the superficial femoral vein. The hashed line indicates how far distally compression should occur in the focused ultrasound examination.**

[Video 4]

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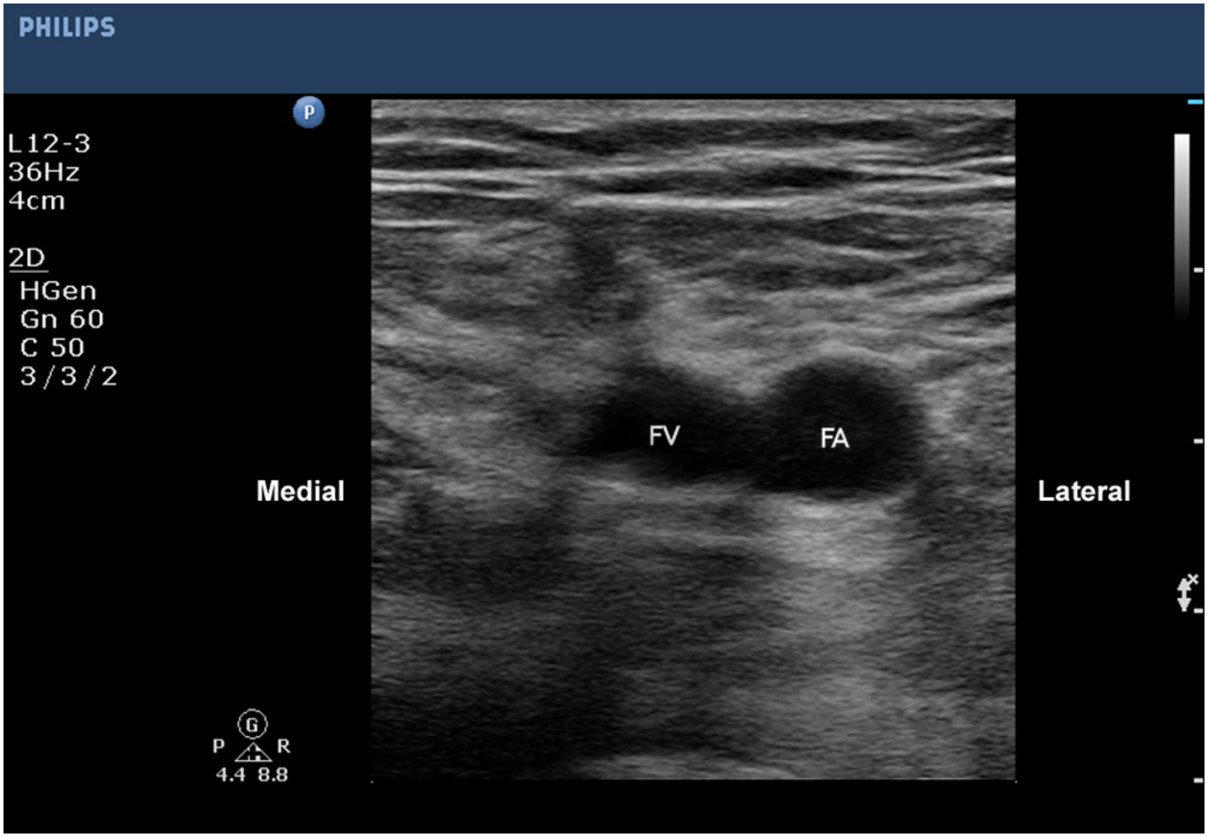
Long-axis image of the femoral vein at the saphenous-femoral junction.

Any lack of complete collapse of the venous lumen raises the possibility of DVT **(Figure 10)**. Scarring from a previous DVT or from chronic DVT may result in incomplete collapse, but these abnormalities are usually recognized by their higher echogenicity when compared to acute thrombi and because of their general appearance as they hug the vessel walls.



[Figure 10] **In this still frame ultrasound image, compression is being applied over the femoral artery and vein. The femoral vein (FV) has collapsed only partially and was later found to contain a thrombus.**

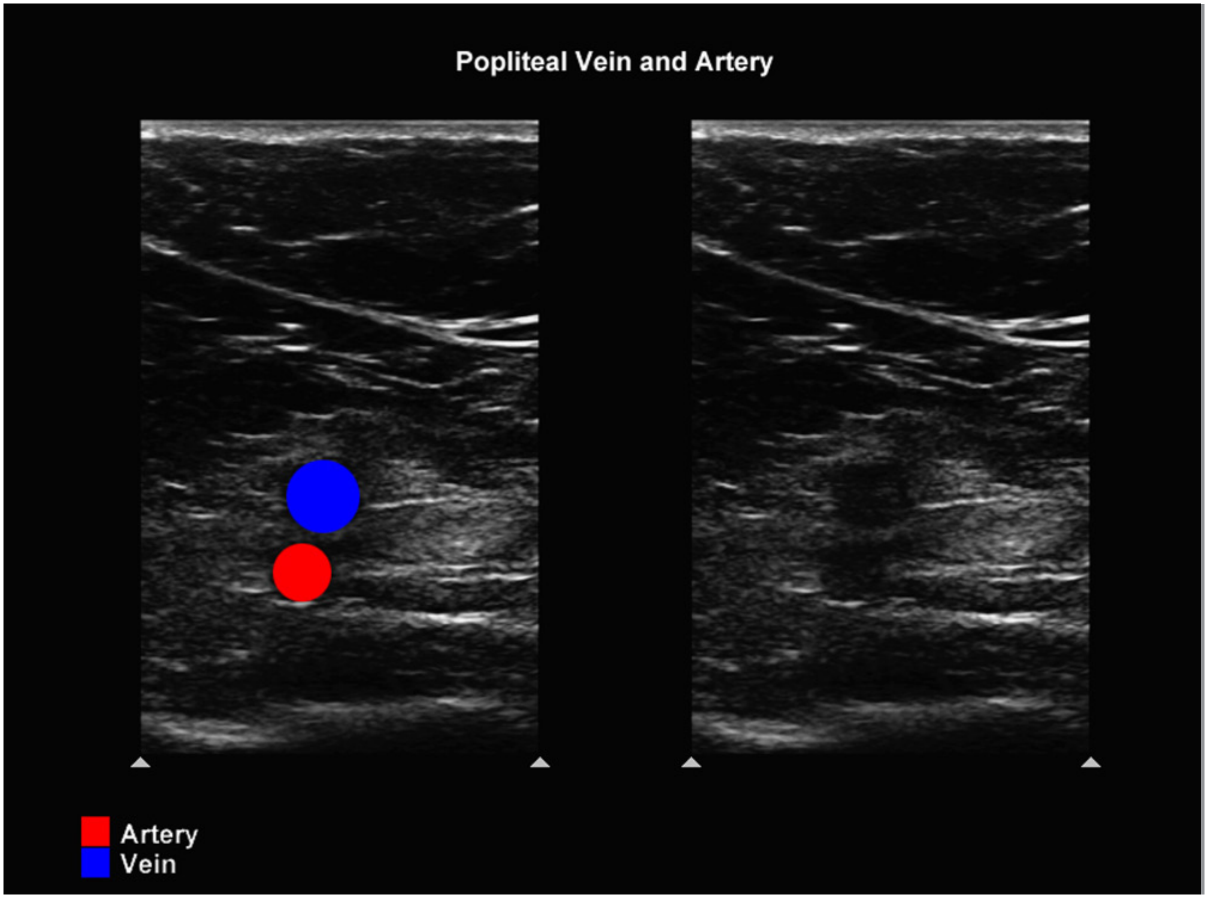
Comparing transverse and long-axis images may highlight the scar-like appearance of a chronic DVT. (Inexperienced users encountering the abnormality for the first time may wish to obtain help from a more experienced colleague.)

The examination then moves down to the popliteal fossa **(Figure 11)**. Here the ultrasound anatomical relationships appear to change. The popliteal vein (PV) is now near-field to the popliteal artery (PA). This is not an anatomical anomaly, but rather the ultrasound transducer is being placed in the back of the leg.

Start compressions high in the popliteal fossa, proximal to any split from the PV **(Video 5 and 6)**. Typically, moving two to three centimeters distal or making three to four compressions should take you to the proximal aspect of the PV trifurcation.

Calf vein DVTs that are just about to seed the PV may occasionally be encountered. These thrombi have high potential for seeding the PV due to their proximity. They would be treated differently or, at least, observed more closely than if they were completely isolated to the calf.

[Figure 11] In the popliteal fossa the transducer is held behind the knee.



[Figure 12] Ultrasound image of the popliteal artery and vein. Image on the left has a color overlay on the artery and vein. This image is obtained with the transducer on the back of the leg, hence, the popliteal vein is near-field to the popliteal artery.

[Video 5]

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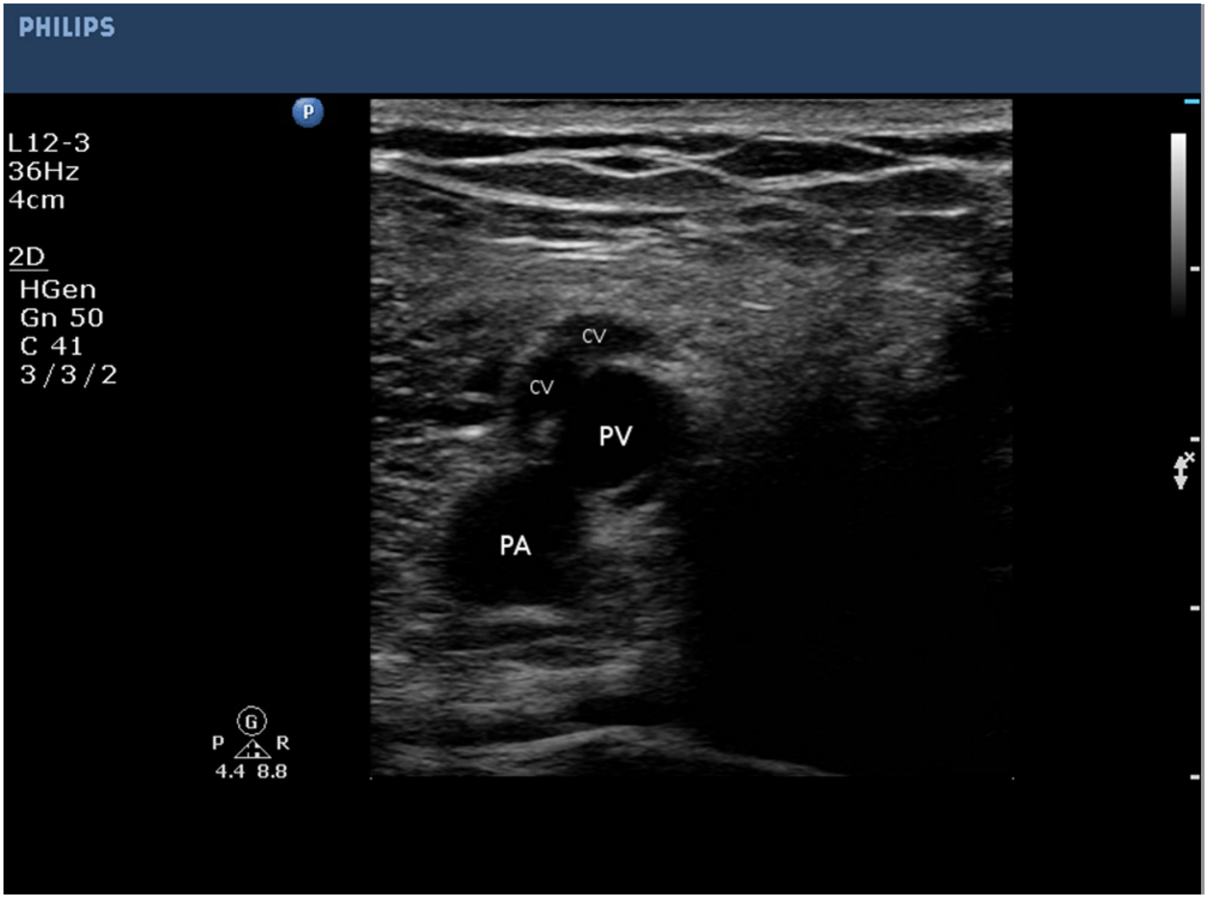
The video demonstrates transducer compression in the popliteal region as the scan progresses from proximal to distal.

[Video 6]

Click here to view this video in the online tutorial, or go to www.philips.com/CCEMeducation

Video demonstrating ultrasound image of the popliteal vein and artery.



[Figure 13] **Ultrasound image demonstrating calf veins (CV), popliteal vein (PV) and popliteal artery (PA).**

[Figure 14] Ultrasound image demonstrating the posterior tibial veins.

It is important to note that nothing precludes the clinician from scanning other portions of the leg. In fact, it is often helpful to scan the entire SFV in certain cases. One common scenario occurs when the CFV, DFV and very proximal SFV are thrombus-free but the entire PV appears to be thrombosed. Evaluating the mid and distal thigh can help identify the proximal end of the DVT in the SFV. This allows the clinician or his colleagues to re-evaluate the status or change in status of the DVT at a later time should symptoms worsen.

5 Clinical pearls and tips

- Many patients do not have the classic anatomical relationship between the vein and artery. Use color flow and pulsed wave Doppler for confirmation.
- A lower frequency curved array transducer may be needed for obese patients.
- Comparison with the opposite leg may be helpful in some cases.
- Patients with bandages or a cast can present considerable challenges. If necessary, bandages or casts should be removed partially or totally in order to perform the examination.
- It is often helpful to use color Doppler to help identify the vessels. It also can be helpful to “squeeze” the calf. This is known as augmentation and is used routinely in the traditional DVT exam. Augmentation may help identify veins that are difficult to see otherwise. As the blood is squeezed out of the calf, the color or power Doppler signal will be enhanced, “lighting up” the vessel. It may take several attempts of sampling in different areas to find the vessels. Once the vessels are located you can work on distinguishing them from the surrounding tissue. It is often helpful to compress the area several times and look for “winking” of the vessel. The “winking” vessel will usually stand out from the surrounding tissue. This technique can help identify the vessel more clearly as well as confirm the absence of thrombosis.

DVT appearance – DVTs can appear differently depending on the age of the thrombus, the ultrasound appearance of the surrounding soft tissue and the amount of clot within the vessel. In some patients the thrombus is obvious during initial visualization, however, in others, compression is required to denote the clot. Sometimes the compression is repeated several times before the thrombus can be clearly distinguished from the surrounding tissue and background noise.

Chronic DVT – These entities can challenge even experienced practitioners. An easy approach for the complete novice is to simply assume a positive examination any time complete collapse of the venous lumen cannot be achieved. However, it is best to avoid anticoagulation when it is not needed. A coagulopathy work-up or referral for further evaluation should be considered when the history of prior DVT is uncovered.

Pelvic veins – In a small percentage of patients, typically rather thin patients, the pelvic veins can be imaged well and DVT ruled out or perhaps identified. It is worth the effort to try tracing the CFV proximally in any patient in whom a pelvic vein DVT is suspected. The clinician, however, often has to resort to other imaging options such as contrast venography or, more typically in North America, an abdominal and pelvic CT with IV contrast.

Difficult to visualize vasculature – Morbidly obese patients are frequently technically difficult to image and may present a significant challenge. These patients should be scanned regardless as some patients that appear to be ultrasound "immune" actually image surprisingly well. This depends on whether the patient has anhydrous fat (this type of fat degrades ultrasound waves significantly).

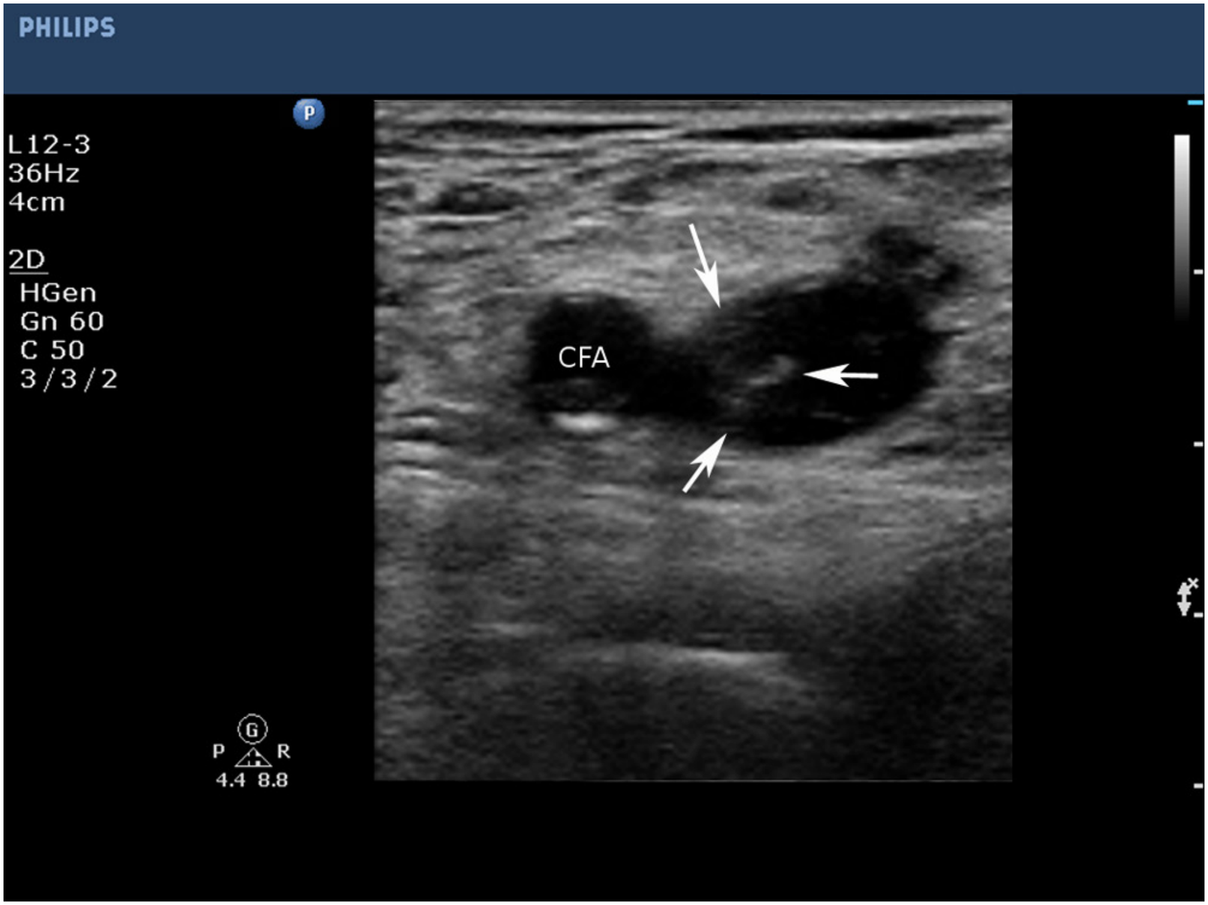
Isolated thrombus plug – While this concept has received considerable attention in the traditional imaging literature, there are no good data to support the occurrence of small isolated plugs of thrombus. In fact, there is an abundance of literature to suggest that these are very rare occurrences. However, if the patient can point to the exact area of pain, place the ultrasound transducer there and scan the area.

Superficial vein thrombosis – Although not treated like a DVT, identification of superficial vein thrombosis may be of help by simply providing an answer for the symptoms with which the patient presents. If extensive thrombosis is noted it should be followed to make sure deep veins are not about to be seeded.

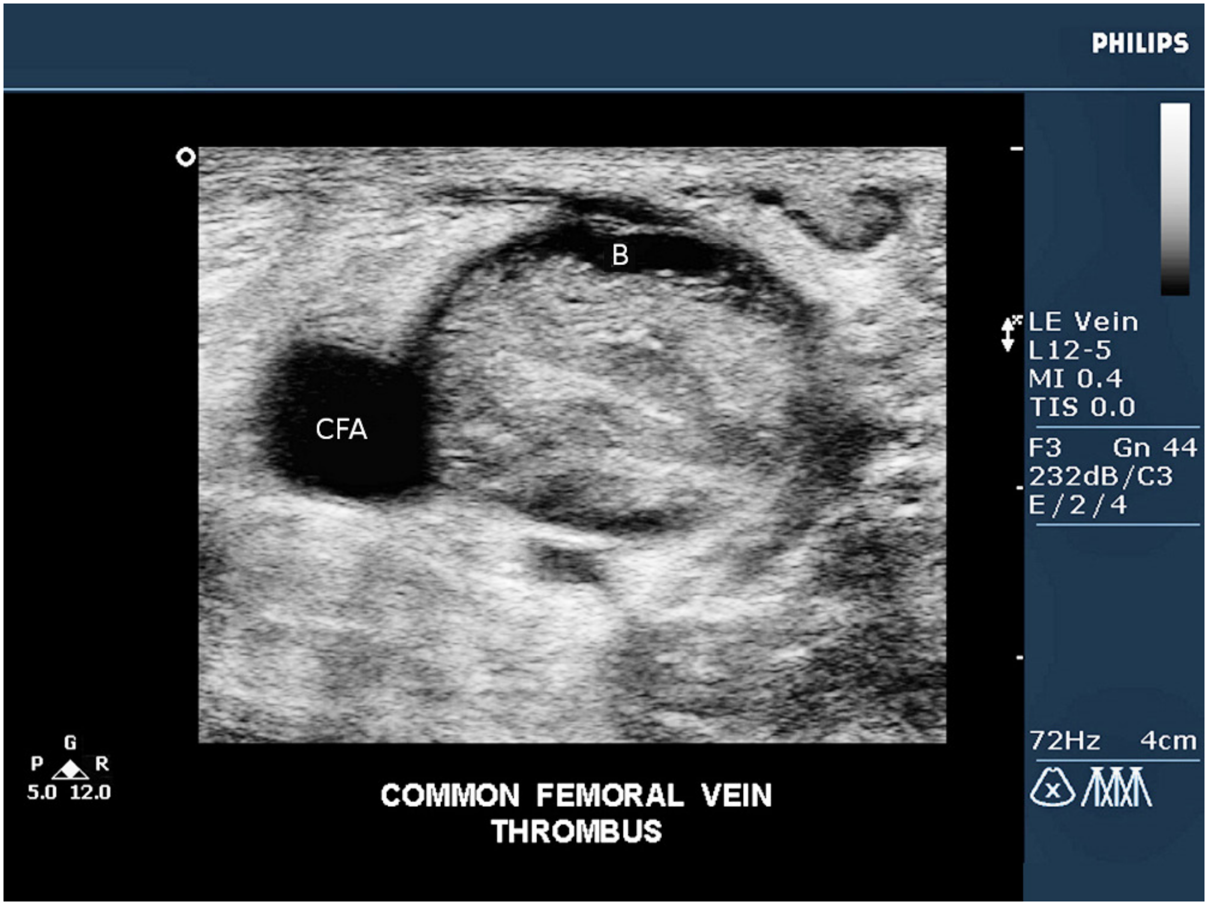
Common mimics of DVT pain – There are several common mimics of DVT-type pain. One of most common is a popliteal or Baker's cyst. This is typically a cystic structure located posterior to the knee. A Baker's cyst can rupture causing significant and sudden pain. Even without rupturing, the cyst may cause significant discomfort as it enlarges. Ultrasound will reveal a cystic structure that is often somewhat irregular in shape . A stalk may be seen extending to the knee joint in the far-field, but this may be very difficult to visualize. Typically the cyst is anechoic, but bleeding into the cyst or infection of the cyst may create an echogenic appearance.

Upper extremity DVT evaluation – This tutorial describes the focused lower extremity DVT evaluation using ultrasound, but the same principles can be applied to evaluating the upper extremity as well. Upper extremity clots are becoming more common in settings where indwelling catheters are frequently utilized, especially PICC lines. The upper extremity DVT evaluation is similar in all respects to the lower extremity evaluation with the exception that one small portion of the subclavian vein cannot be directly visualized. In addition, much of the subclavian vein cannot be adequately compressed. Color Doppler, as well as pulse wave Doppler, is utilized to evaluate for normal flow.

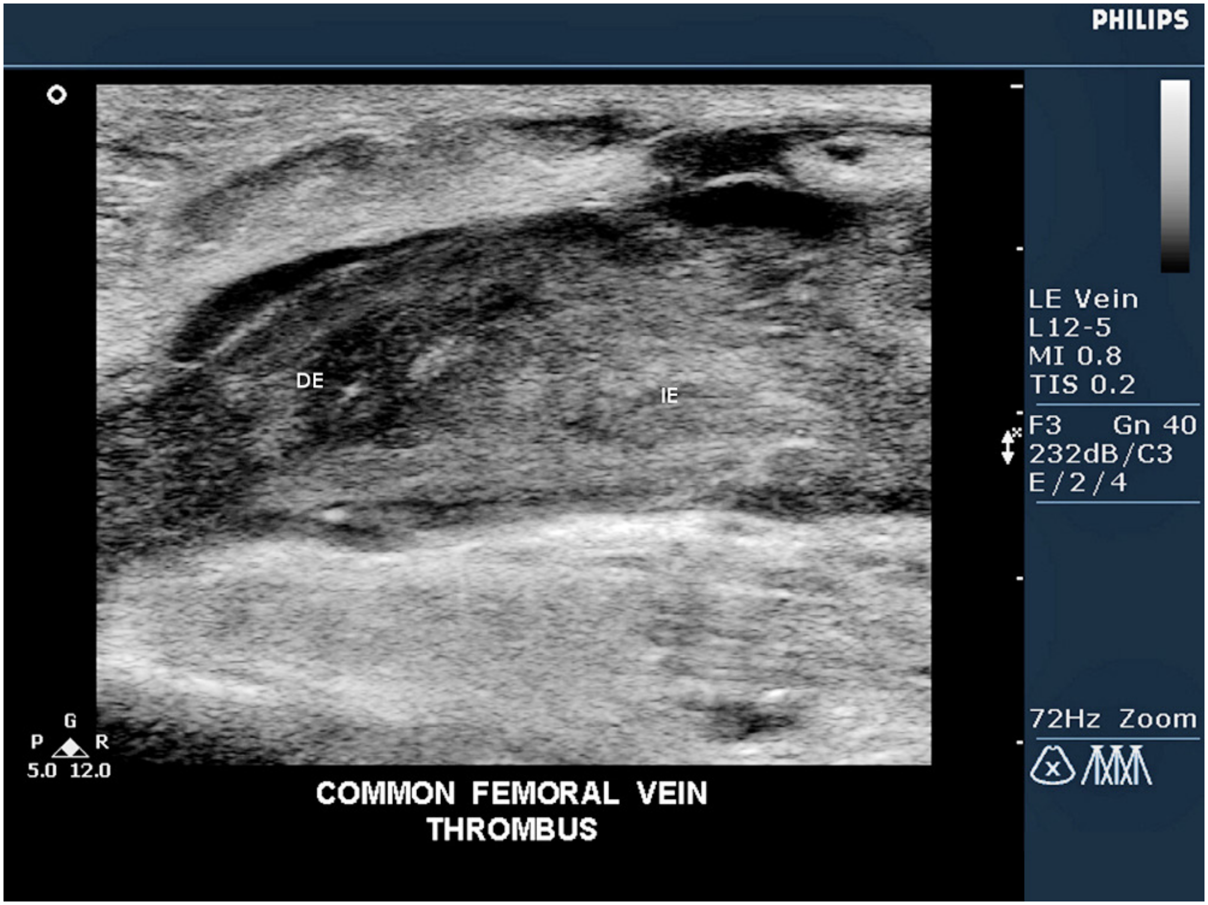
6 DVT images and video cases



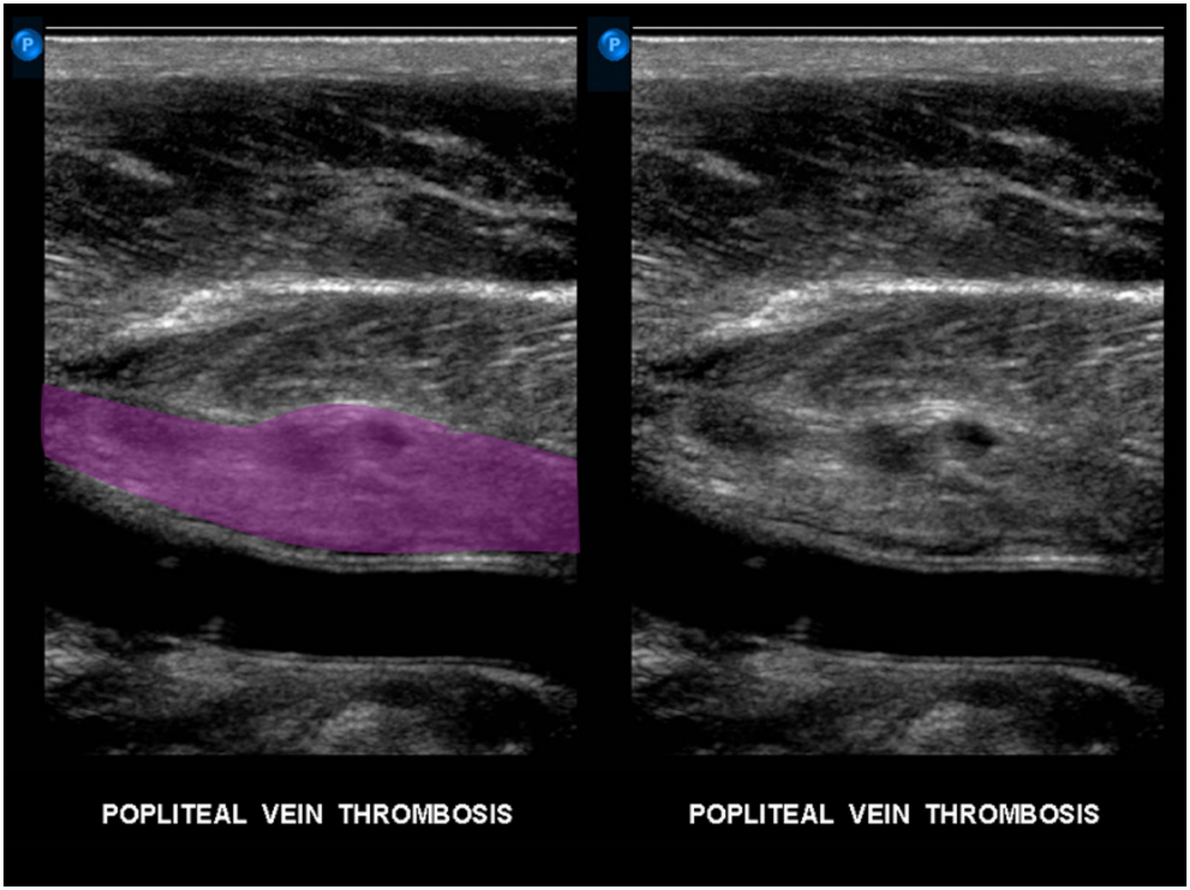
[Figure 15] **Example of a thrombus (arrow) in the common femoral vein. CFA – common femoral artery.**



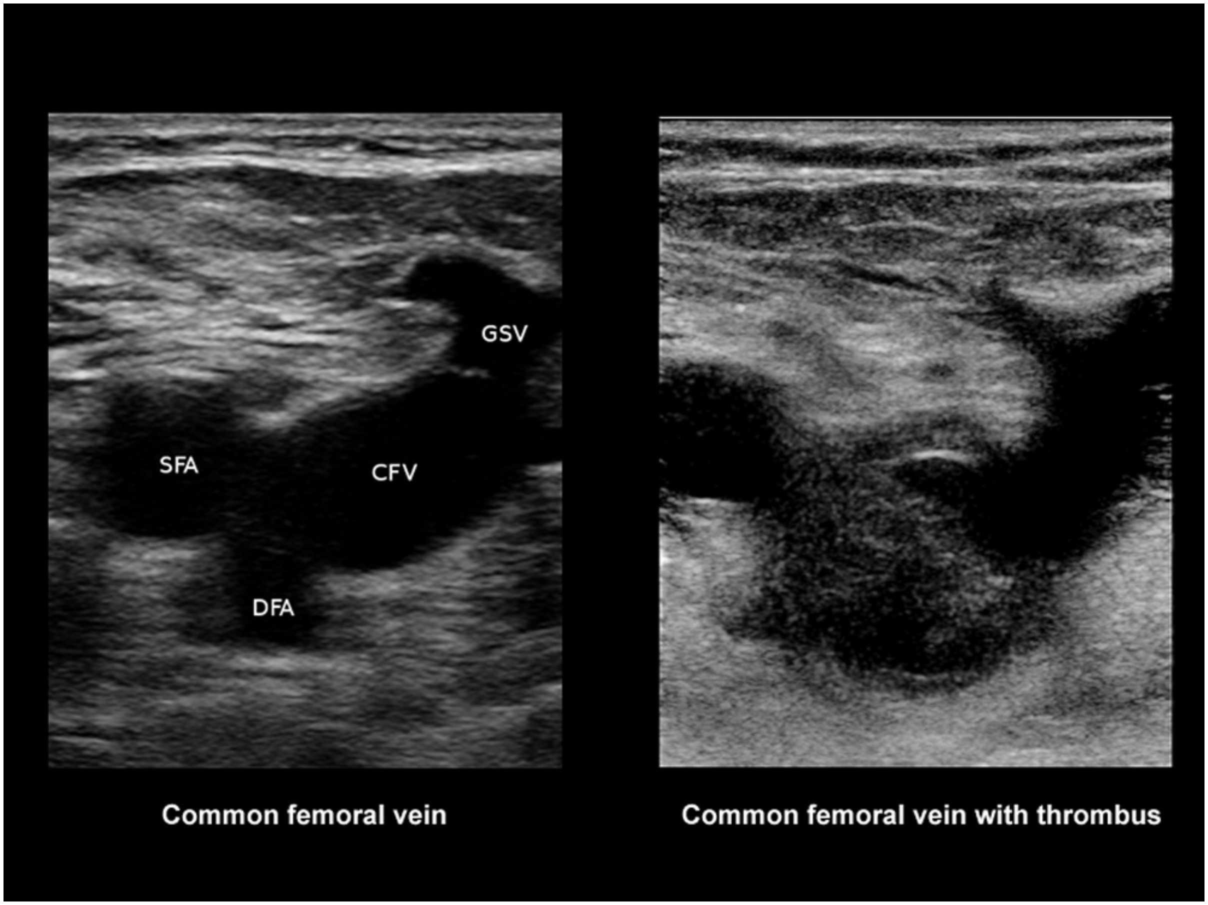
[Figure 16] Example of a large thrombus. There is some blood seen above the thrombus (B = blood). The thrombus itself is heterogeneous with some areas that are more echogenic and some areas that are less echogenic.



[Figure 17] Example of a large thrombus with areas of increased (IE) and decreased (DE) echogenicity. Differentiating old thrombus from fresh thrombus can be difficult. This image shows a combination of fresh thrombus that has decreased echogenicity and chronic thrombus that has increased echogenicity. The patient had been scanned several times previously and on this visit had developed new thrombus on top of the chronic DVT.

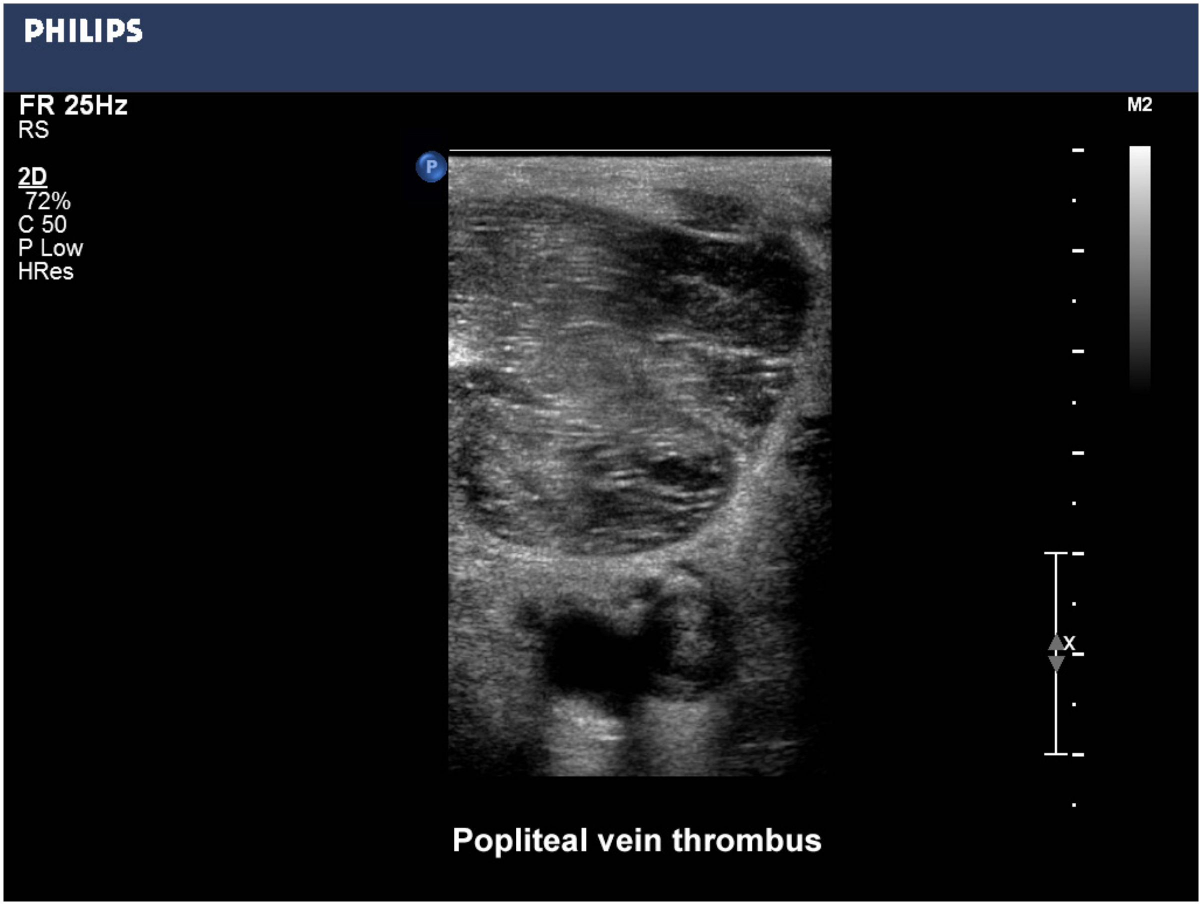


[Figure 18] Long-axis image of a popliteal vein thrombus. The image on the left has a cover transparency demonstrating the thrombus. Note the popliteal artery below the vein.



[Figure 19] Image on the left is a normal image at the level of the greater saphenous vein. Image on the right demonstrates a thrombus in the common femoral vein at the level of the greater saphenous vein.

[Figure 20] Long-axis image demonstrating a distal superficial femoral vein with thrombus.



[Figure 21] Ultrasound image demonstrating a thrombus in the popliteal vein.

[Video case 1]

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Video demonstrating a right superficial femoral vein with thrombus. Note the vein does not collapse with compression.

[Video case 2]

▶

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Left common femoral vein in transverse orientation confirming the presence of a thrombus. Note there is only slight compression.

[Video case 3]

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Video demonstrating a popliteal vein thrombus. Note the pulsatile popliteal artery lateral to the popliteal vein.

[Video case 4]

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Transverse view demonstrating a thrombus in the CFV. Using color flow Doppler, a pulsatile color signal is seen in the artery. Note the lack of a color flow Doppler signal in the vein.

[Video case 5]

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Longitudinal sweep of the common femoral vein demonstrates a large thrombus extending the length of the vein.

[Video case 6]

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Longitudinal image of a thrombus in the common femoral vein.

[Video case 7]

▶

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Video demonstrating an echogenic thrombus in the left deep femoral vein (profunda) at the junction of the deep and superficial femoral veins. Note the spontaneous contrast visible at the junction.

[Video case 8]

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Long-axis image of the left superficial femoral vein with intraluminal thrombus. The thick-walled superficial femoral artery is seen above the vein.

[Video case 9]

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Longitudinal sweep demonstrating an extensive thrombus within the left superficial femoral vein.

[Video case 10]

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Color Doppler ultrasound of the right superficial femoral vein demonstrates a thrombus in the vein with partial obstruction of blood flow. Note the thin color flow Doppler signal posterior to the thrombus. The artery is superior to the vein and demonstrates a red/blue mosaic, pulsatile color flow Doppler signal.

7 References

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