Colour Doppler Ultrasound for Calf Vein Deep Venous Thrombosis: What Radiologists Need to Know

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Authors: C. H. Lee¹, G. Tan¹, R. Vikram², C. H. Tan¹; ¹Singapore/SG, ²Houston, TX/US
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Learning objectives

We aim to:

1. Highlight current controversies surrounding the need for colour doppler ultrasound (CDUS) for suspected deep venous thrombosis (DVT) involving the calf veins

2. Demonstrate the techniques of interrogating the deep veins of the calf

3. Review the anatomical variants of the deep calf veins.
**Background**

Up to one-third of lower limb DVT occurs in the calves, and the risks of progression / embolism are not insignificant.

However, evaluation of calf vein DVT is debatable due to unproven clinical value and risks of anticoagulation. Calf veins are also difficult to interrogate with ultrasound due to their small size and anatomical variations.

With the lack of prospective studies directly comparing outcomes of calf DVT with and without treatment, there are thus, no fixed recommendations as to whether the deep calf veins should be routinely evaluated when screening for lower limb DVT.
OVERVIEW

Isolated DVT of the calf is not uncommon. Up to one-third of lower limb DVT occur in the calves, and isolated DVT of the calf is asymptomatic in up to 53% of cases (Fig. 1).

Yet, review of the literature suggests that there is no consensus regarding the need to evaluate the deep calf veins when screening for lower limb DVT with CDUS.

Several studies have suggested that routine evaluation of the deep calf veins may not be necessary.

Gottlieb et al observed only 1.1% adverse events in patients with a negative CDUS of the thigh, without interrogating the deep calf veins. Adverse endpoints were taken as proximal progression to the deep veins of the thigh, and pulmonary embolism.


In a separate prospective study, the same author evaluated 261 patients for lower limb DVT. CDUS of the calf was only performed in the presence of specific calf symptoms. Overall, only 2 patients were found to have adverse outcome.


A meta-analysis by Righini et al, found that routine CDUS of the deep calf veins potentially doubled the anticoagulation rates without significant differences in the 3mth thromboembolic rate, compared to untreated patients with a negative thigh CDUS (0.6 vs 0.4%).

However, other studies have noted up to 5% risk of pulmonary embolism and 20-30% risk of proximal progression, thus recommend that calf DVT be sought for and treated.


Schellong concluded that diagnosing calf DVT allows signs and symptoms to be ascribed to a definitive diagnosis which in itself is benefit for patient care. It is subsequent treatment that the risk-benefits should be carefully weighed.


With the lack of prospective studies directly comparing outcomes of calf DVT with and without treatment, there are no fixed recommendations as to whether the deep calf veins should be evaluated when screening for lower limb DVT.

The American College of Radiology does not recommend routine evaluation of the calf veins. The American Institute of US Medicine recommends routine evaluation.

A reasonable compromise would be to limit the DVT study to the thigh, and to evaluate the calf veins if symptoms and signs persist (if the initial above-knee evaluation is negative). However as more than 50% of isolated calf DVT may be asymptomatic, particularly in high-risk (such as ICU) patients, screening in these select group of patients may also be necessary.

At our institution, routine evaluation of the deep calf veins is performed, unless DVT is already detected in the thigh.

**RELEVANT ANATOMY OF THE DEEP CALF VEINS**

The deep veins of the calf include the anterior tibial, posterior tibial, and peroneal veins (Fig. 2).
The posterior tibial (PTV) and peroneal veins (pero v) course posterior to the interosseous membrane where they join in the proximal calf to form the tibioperoneal trunk. The peroneal vein runs more laterally close to the fibula.

The anterior tibial vein (ATV) courses anterior to the interosseous membrane and crosses its superior edge to join the tibioperoneal trunk and form the popliteal vein.

Quinlan et al observed several anatomical variants:

- paired (68-76%)
- single (6-13%)
- 3 or more peroneal veins (8%)
- Pero v draining into trifurcation (59%)
- Pero v draining into PTV (32%)
- Pero v draining into ATV (8%)

Various levels of the confluence of the ATV and tibioperoneal trunk are also noted (Fig. 3):

(A) 6% at, (B) 65% below, and (C) 29% above the knee.

**CROSS-SECTIONAL ANATOMY AND POSITIONING THE ULTRASOUND PROBE**

Cross-sectional relationship between the deep calf veins at the level of the mid-lower leg is shown in Fig. 4.

Suggested protocol for evaluating the deep calf veins:

1. ATV: Traced along the lateral aspect of the proximal calf as it crosses over the interosseous membrane.

2. PTV and peroneal vein: Traced from the level just above the medial malleolus. They can be interrogated in the same plane as shown.

3. Every 1-2 cm intervals.
4. Colour and spectral doppler is used. Evaluation of patent deep veins in the longitudinal axis is sufficient.

**METHODS OF EVALUATING THE DEEP CALF VEINS WITH CDUS**

Fig. 5: Compression

Fig. 6 and 7: Colour Doppler

Fig. 8: Spectral analysis and augmentation

A potential pitfall in augmentation, is that if performed above the level of the short saphenous vein, the augmentation can be falsely positive (even if all calf veins are occluded, augmented flow can still be demonstrated from the short saphenous vein)

**FEATURES OF CALF DVT ON ULTRASOUND**

Fig. 9 and 10: Acute thrombus.

Fig. 11: Corresponding spectral analysis.

Fig. 12: Chronic thrombus in the popliteal vein.

**MIMICS OF CALF DVT**

Fig. 13: Thrombosis of the muscular veins (eg. soleal vein).

The soleal and gastrocnemius veins are intramuscular veins that run within their respective calf muscles. The deep calf veins can be differentiated by their typical paired nature accompanying the artery in between, and their location in the intermuscular plane.

Fig. 14: Complicated Baker's cyst.
Fig. 15: Muscle tear and hematoma.
**Fig. 0:** Isolated calf DVT is asymptomatic in up to 53% of patients.

**Fig. 0:** The deep calf veins include the anterior tibial, posterior tibial, and peroneal veins.

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**Fig. 0:** Various levels of the confluence of the ATV and tibioperoneal trunk: (A) 6% at, (B) 65% below, and (C) 29% above the knee.

Fig. 0: Relationship of the deep calf veins at the level of the mid-lower leg. The PTV and peroneal veins can be interrogated in the same plan as shown.

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**Fig. 0:** Transverse grey-scale image of the distal popliteal vein (PV) at the knee level. Compression is done in the cross-sectional plane. Complete collapse on compression is the most reliable marker of vein patency. However, it is usually not performed on the calf veins due to their small diameter.

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**Fig. 0:** Colour doppler indicating good flow. This is usually performed along the longitudinal axis. The paired nature of the deep calf veins, the relationship between the PTV and peroneal veins are demonstrated. The accompanying artery can be visualised in between the veins.

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**Fig. 0:** The proximal ATV as it joins the tibioperoneal trunk (A). The PTV and peroneal vein run parallel to each other in most parts of the calf (B).

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Fig. 0: Spectral analysis allows evaluation of flow pattern in relation to respiration. During normal inspiration, increased intra-abdominal pressure leads to decreased velocity of blood flow in the veins of the lower extremity. Unobstructed venous flow typically varies cyclically with respiration. Augmentation (aug) involves squeezing the calf veins to increase venous return, enhancing visualisation of flow. Spectral analysis allows evaluation even if colour doppler is unable to detect slow flow.

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**Fig. 0**: Thrombus in the peroneal and posterior tibial veins. Acute thrombus is of varying echogenicity and fills the lumen resulting in non-compressibility. The thrombus expands the veins, enabling demonstration of non-compressibility in the axial plane (A). Corresponding colour doppler in the longitudinal plane showing reduced and absent flow in the PTV and peroneal veins respectively (B).

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Fig. 0: Peroneal vein (longitudinal and transverse sections) distended with echogenic thrombus (A). Non-compressible PTV on transverse section suggestive of thrombus (B). ATV thrombosis with patchy colour doppler signal (C). The signal does not reach the vein walls.

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Fig. 0: Spectral doppler shows loss of phasicity with respiration (PTV) or even complete loss of signal (peroneal vein).

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**Fig. 0:** Chronic thrombus in the popliteal vein. The thrombus demonstrates increased echogenicity and the wall of the vein is thickened. Recanalisation (not shown) can occur.

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Fig. 0: Thrombosis of the soleal vein. The intramuscular location of the thrombosed vein is apparent. Echogenic material within the vein and noncompressibility is again shown in axial section (A). Colour doppler shows flow in a more proximal segment leading away from the vein (B).

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Fig. 0: Baker's cyst. Echogenic strands within suggest hemorrhage or rupture.

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**Fig. 0:** Tear of the medial head of the gastrocnemius (A) with an associated hematoma (B).

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Conclusion

1. Calf DVT is not totally benign. However CDUS of the deep calf veins is challenging due to their small size and anatomical variations that makes it difficult to evaluate every deep vein in certain circumstances.

2. Presence of intramuscular calf veins (soleal and gastrocnemius) makes it necessary to differentiate them from the deep calf veins.

3. Conditions such as tumours, muscle tears and ruptured cysts should also be borne in mind.

4. Even if the treatment of calf vein DVT remains debatable, its diagnosis allows a definitive diagnosis that itself is a benefit for patient care.
References


