Bedside Ultrasound for Detection of Deep Vein Thrombosis: the Two-Point Compression Method

Tom Ashar MD RDMS[a], Krishnaraj Jayarama DO, Raymond Yun MD

Department of Emergency Medicine, Newark Beth Israel Medical Center, Newark NJ, USA

Abstract

This article reviews physician-performed bedside ultrasound for the evaluation of lower extremity deep vein thrombosis (DVT). Unlike traditional vascular studies which image the entire lower extremity venous system, this focused exam focuses on demonstrating venous compression in the femoral and popliteal areas. Accurate and efficient, this is an invaluable tool in treating the patient with potential DVT.

MeSH Words: Deep vein thrombosis, Ultrasound, Emergency

The emergency department (ED) patient with suspected lower extremity deep vein thrombosis (DVT) is a dilemma faced daily by ED physicians. With a combination of non-specific clinical findings, a confusion of d-dimer assays, the limited availability of vascular ultrasound technicians off-hours and an ingrained fear of sending home a 'potential PE' versus unnecessary anticoagulation, it should be a relief that the advancement of physician-performed bedside ultrasound has developed to include the evaluation of the lower extremity venous system.

The lower extremity ultrasound exam as performed by imaging specialists is often involved and time consuming – the symptomatic leg is evaluated throughout the entire venous system, often utilizing color flow ('duplex' ultrasound). Furthermore, it is routine in many centers to evaluate the contralateral leg as well.

The focused exam discussed in this article limits the exam to 2 points – the common femoral vein and the popliteal vein – and utilizes compression only to assess for venous thrombus. This article will discuss how to perform this focused exam: findings, pitfalls, and some of the relevant supporting literature.

Key Sonographic Finding: Venous Compression

The key ultrasonographic finding in excluding venous clot is the *complete compressibility* of the vein with downward pressure of the ultrasound probe (image 1). Normally, veins easily compress under external force, as opposed to the arteries which have more muscular walls and are higher-pressure systems. However, with thrombosis and lumen obstruction, downward probe pressure will fail to compress the vein (image 2 and 3).

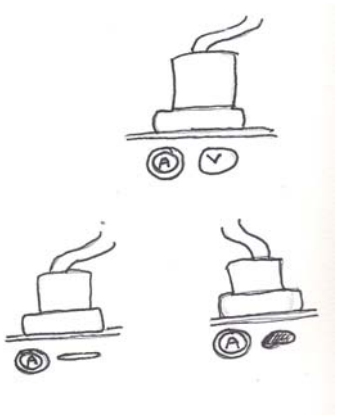

Image 1: Diagram of Vein Compressibility. *The top image shows appearance of an artery (A) next to a vein (V) without probe pressure. With probe pressure, the bottom left image shows the collapse of a patent vein while the image on the right shows lack of compression due to the presence of thrombus.*

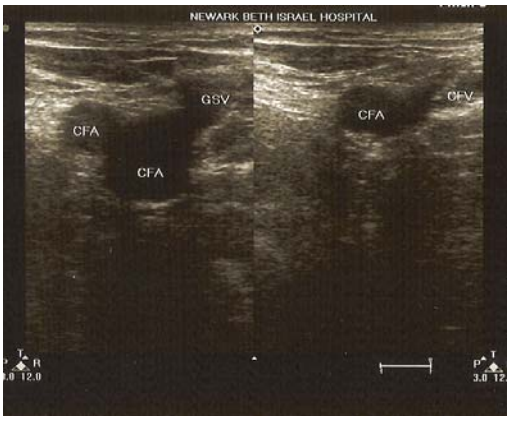

Image 2: *Common Femoral Vein (CFV) and Greater Saphenous Vein (GSV) compress with probe pressure in the image on the right while the Common Femoral Artery (CFA) does not compress. The image on the left is all 3 patent vessels without probe compression.*

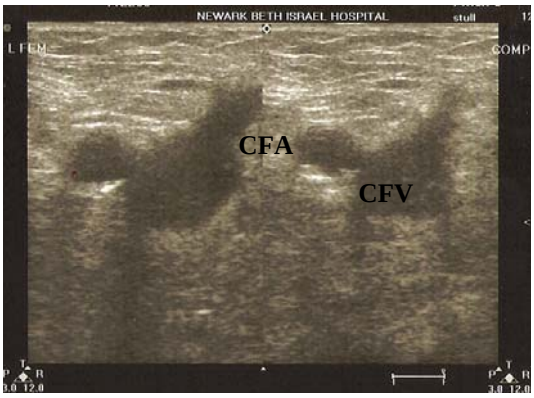

Image 3: *In this image of the femoral anatomy, probe compression in the image on the left shows lack of compression of the Common Femoral Vein. Note that although there is lack of compression, echogenic clot within the lumen is not seen*

How much downward probe pressure is enough?

When sufficient pressure to deform the artery is applied, the vein should completely collapse. Although normally patent veins easily collapse, if there is failure to collapse the vein with enough pressure to deform the artery this is considered a positive finding for venous occlusion. Incomplete or partial collapse is also considered an abnormal finding, in that clot obstructing part of the vessel lumen could result in partial vessel collapse.

Will I be able to visualize the clot?

Oftentimes the clot itself may be visualized as echogenic ('gray') echoes within the vessel lumen, but not always (image 4 and 5). The amount of echogenicity may depend on clot size and chronicity – the larger, older and more fibrinated the clot, the more visible it may be on ultrasound. Image quality may also depend on the quality of the ultrasound machine and probe. Again, it is lack of compressibility that is the key finding.

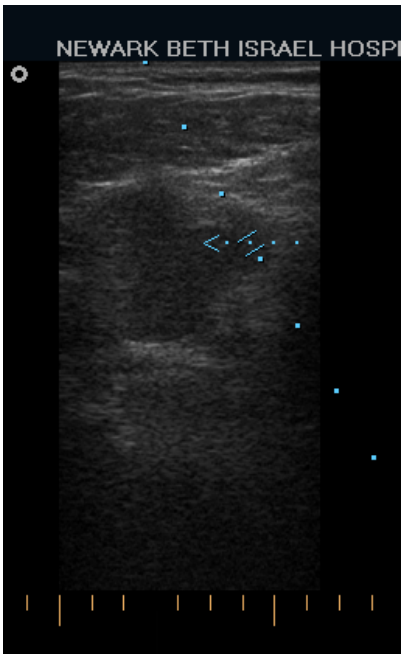

Image 4, 5*: Echogenic clot in the Common Femoral Vein (CFV) and in the Poplieal Vein (PV). Note Common Femoral Artery (CFA) and Popliteal Artery (PA).*

What about color flow imaging?

Traditionally, vascular studies have utilized color flow ultrasound to evaluate for venous occlusion as well (image 6). However, a number of studies have shown that 'B-mode' ultrasound, simple gray-scale imaging without color flow, is sufficiently accurate to detect deep vein thrombosis [1,2,3]. This reinforces the idea that lack of compression, and not alterations in blood flow as visualized via color doppler, is the key finding in detecting DVTs.

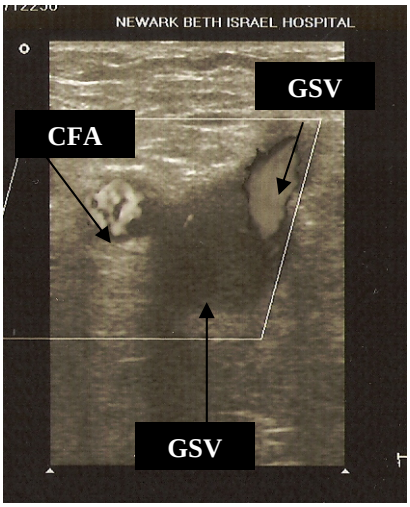

Image 6*: Color flow doppler image of Common Femoral Vein (CFV) showing lack of blood flow secondary to thrombus. Note the presence of color flow in the Common Femoral Artery (CFA) and the Greater Saphenous Vein (GSV).*

What about Pulse Doppler?

Pulse doppler, which evaluates blood flow in a specific area of the imaging field, is a good way to differentiate vascular from non-vascular structures and to differentiate artery from vein if it is not apparent based on appearance. There are distinct differences in the pulse doppler patterns of arteries versus veins: arteries display a distinct pulsatile flow pattern while veins demonstrate a more phasic flow pattern (image 7 and 8). Although not necessarily relevant to identify the presence or absence of a DVT, pulse doppler may be a useful adjunct to differentiate artery, vein and non-vascular structures.

2-Point Compression U/S: Common Femoral and Popliteal Veins

Is it necessary to image the entire venous system of the leg?

As time constrained emergency physicians, it comes as welcoming news that a 'limited' ultrasound focusing on the common femoral vein in the groin and the popliteal vein is sufficient.

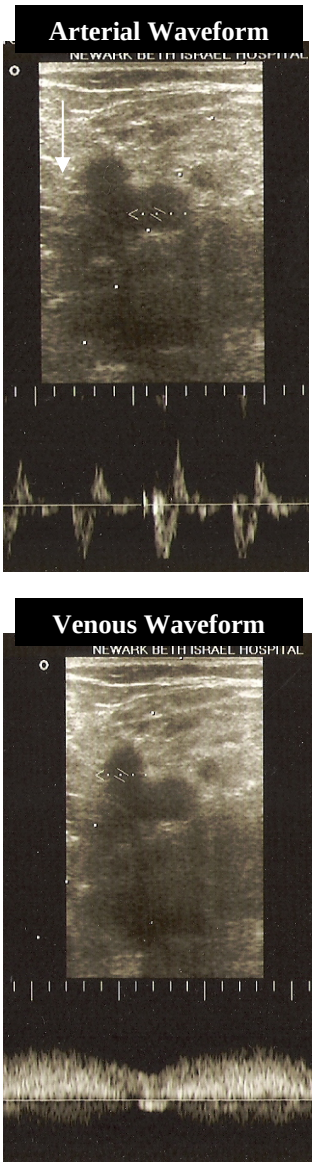

Image 7,8: *Pulse doppler appearance of an artery shows a distinct pulsatile pattern, while venous flow is a more phasic, less pulsatile pattern. Arrows point to area sampled by doppler.*

Multiple studies, including Poppiti et al. [4] (72 patients) and Pezzullo et al. [5] (155 patients) have shown that ultrasound exams limited to the femoral and popliteal areas did not miss any 'segmental' thrombus that involved only the mid-thigh and did not include either the popliteal or common femoral veins. Furthermore, an analysis by Cogo et al. [6] of 542 venograms supports the use of the '…relatively simple, inexpensive, and rapid compression ultrasound method that limits the examination of the proximal veins to the common femoral and popliteal veins.'

Is it necessary to scan the contralateral leg?

Although ultrasound exams as performed by imaging specialists often include scanning the opposite leg as well, studies by Sheiman et al. [7] (206 patients) and Strothman et al. [8] (1694 patients) have shown that only the symptomatic leg should be imaged - the likelihood of thrombus in the asymptomatic leg if the symptomatic one has a negative study is negligible.

Equipment – which probe, which setting?

Which ultrasound probe should I use?

A high-frequency linear array transducer is the preferred probe (Image 9). The high frequency (usually 7-9 MHz) allows for good image quality but compromises on tissue penetration. However, the venous system is a relatively superficial network of veins and great tissue penetration is usually not necessary. The leg should be scanned in a transverse plane, with the probe marker to the patient's right. If a linear transducer is unavailable, use of other ultrasound probes (mid-range abdominal probe or a high-frequency endocavitary probe) may also be used.

Image 9: *High frequency (7-9 MHz) linear transducer used for vascular ultrasound studies*

Any specific depth and gain settings?

Depth and gain ('brightness') settings should maximize the image in the center of the screen.

Anatomy of lower extremity venous system

What is the relevant anatomy of the lower extremity venous system?

The venous system of the lower extremities is composed of deep and superficial veins (Image 10). The deep system begins in the abdomen at the inferior vena cava (IVC) and common iliac veins. The external iliac vein becomes the common femoral vein (CFV) just below the inguinal ligament. The CFV becomes the superficial femoral vein and deep femoral (or profunda) vein. The femoral vessels lie deep to the corresponding arteries. The SFV continues down the thigh and passes through the adductor canal. At this point, it becomes the popliteal vein. The popliteal vein runs along the medial aspect of the thigh to the back of the knee. It lies superficial to the popliteal artery. The popliteal divides just below the knee into three deep-paired vessels of the calf – the anterior tibial, posterior tibial and peroneal veins.

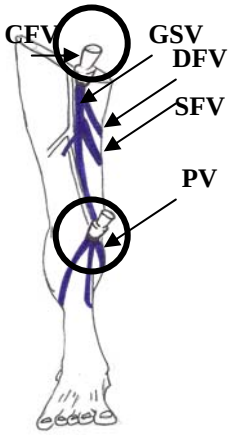

Image 10: *Relevant veins of the lower extremity. Note the ultrasound probe at the femoral and popliteal locations. CFV = common femoral vein, SFV = superficial femoral vein, GSV = greater saphenous vein, PV = popliteal vein, DFV = deep femoral vein*

Performing the Exam

Where and how do I hold the probe to begin my exam?

The patient should have their leg externally rotated and slightly bent at the knee. The probe should be placed in the in the transverse plane in the groin slightly below the inguinal ligament (Image 11) and the common femoral artery and vein should be identified. The greater saphenous vein may be seen entering the common femoral vein (Image 2). Downward probe pressure should completely collapse the vein if it is patent.

Image 11*: Image the Common Femoral Artery and Vein by holding the probe in the transverse plane in the femoral region. Note leg should be externally rotated*

If time permits and there is good venous visualization, continue following the venous system distally down the leg, compressing the vein every few centimeters until it cannot be visualized. The vein lies deep to the artery and is not collapsible. In thin patients, the femoral vein may be visualized as it courses thru the entire thigh until it enters the adductor canal. However, in difficult patients with a large body habitus the vein may be hard to follow distal to the groin. Remember – this is a focused exam and visualizing the entire venous system is unnecessary!

How do I evaluate the Popliteal Vein?

To evaluate the popliteal vein, hold the probe in the transverse position behind the knee in the popliteal fossa and identify the vein *superficial* to the artery (Image 12 and 13). The vessels course on the lateral aspect of the popliteal fossa. It may be easier to have the patient hang their leg over the side of the stretcher to further engorge the venous system and make for easier visualization.

Image 12:*Tto visualize the popliteal vein, hold the probe in transverse plane in the lateral aspect of the popliteal fossa.*

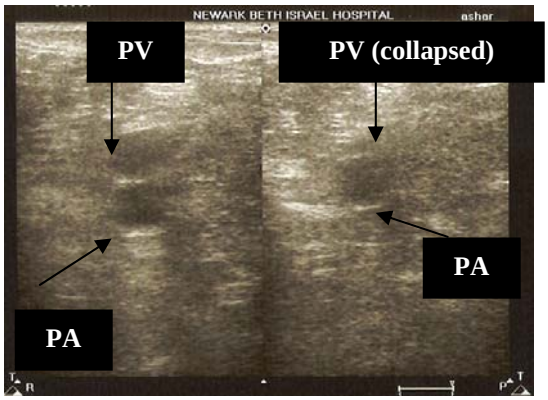

Image 13: *Normal Popliteal Artery (PA) and vein (PV) on the left. With compression, the popliteal vein collapses entirely.*

Accuracy and Efficiency of ED physician performed EVT ultrasound

Are we accurate as compared formal imaging?

In a 2001 study by Frazee et al. [9] EP's with previous ultrasound experience underwent a 2-hour training session in limited 2-point compression ultrasound to evaluate for DVTs in the common femoral and popliteal veins. In a subsequent convenience sample of 75 symptomatic patients, the negative predictive value of EP performed U/S was 96% as compared to the complete duplex exam as performed by the department of radiology. A 2004 study by Jang et al. [10] trained 8 residents with limited previous ultrasound experience in the 2-point compression method in a 1 hour didactic session followed by a brief hands-on session. In 72 subsequent patients, sensitivity was 100% and specificity 92% in comparison to formal radiology duplex ultrasound. The authors conclude that the patient with a positive study may need formal confirmation, but a negative study is sufficiently accurate.

Are we saving time?

In a study by Blaivas et al. [11], physicians with 5 hours of training in limited 2-point compression ultrasound performed 112 studies on symptomatic patients. Average time of exam was 3 minutes, with 98% agreement with formal studies performed by the department of radiology. In a follow-up study in 2004 by Theodoro et al. [12], time from triage to final disposition in 156 patients with suspected DVT was compared. Patients undergoing EP-performed ultrasounds had a mean time of 95 minutes from triage to final disposition, as compared to 220 minutes in patients sent for formal studies (agreement in ultrasound findings between the ED and radiology (kappa) was 0.9).

Pitfalls and False Positives

What are some pitfalls in bedside ultrasound evaluation for DVT?

As is true in all of bedside ultrasound, the first and most common difficulty involves obtaining the correct images. Although the femoral vessels are large and relatively easy to locate, the popliteal artery and vein are smaller, deeper and thus harder to image. The only real solution is to practice and compare your findings to confirmatory exams. Although color flow and pulse Doppler may help identify vessels, only through practice comes comfort with the sonographic anatomy and appearance of normal and abnormal findings.

Another potential pitfall is failure to consider *distal* calf DVT. Although your bedside ultrasound may rule-out the presence of thrombus proximal to the popliteal vein, there is still the very real possibility of thrombus present in the smaller calf veins with eventual propagation into the proximal venous system. A repeat study in 7-10 days should be peformed if there is a high likelihood of venous thrombosis despite a negative proximal venous evaluation. In a 2006 study by McIlrath et al. [13] of 159 high risk patients with initially negative ED-performed DVT studies, only 28% had a repeat ultrasound when followed up at 3 months, and 29% of patients who did not have a repeat ultrasound were told by their physician that it

was unnecessary. If the ED ultrasound is negative and the possibility of thrombus likely, tell the patient that a repeat ultrasound in a week should be performed.

What may give a false positive DVT exam?

Other soft tissue structures may give the appearance of a non-compressible vein:

- Lymph nodes in the femoral region. Lymph nodes, especially in inflammatory states, may appear as round hyperechoic structures. Scanning in both a transverse and longitudinal plane, as well as using flow Doppler, may help differentiate an artery/vein versus a lymph node (Image 14).
- Baker's Cyst in the popliteal fossa. The presence and/or rupture of a Baker's cyst can cause calf pain and swelling. On ultrasound, a superficial fluid collection in the popliteal fossa should be distinct from the deeper, pulsatile vascular structures.
- Other fluid collections: abscess, calf hematoma (Image 15) and other fluid collections may give the clinical impression of a DVT. However, ultrasound should easily differentiate these findings from DVT's.

(Image 14A)

(Image 14B)

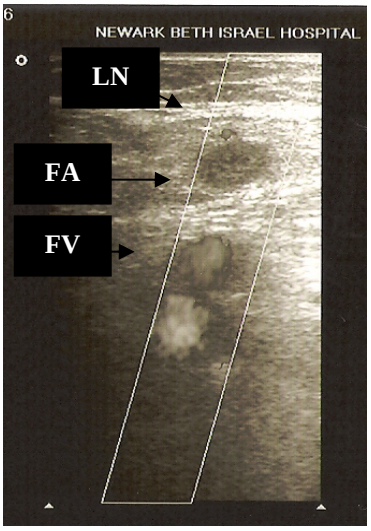

Image 14: *False positive finding: Lymph node. Image A shows the typical appearance of an inflamed lymph node with hyperechoic center and hypoechoic cortex. Image B shows color flow in the femoral vein (FV) and femoral artery (FA) but absence of flow in the lymph node.*

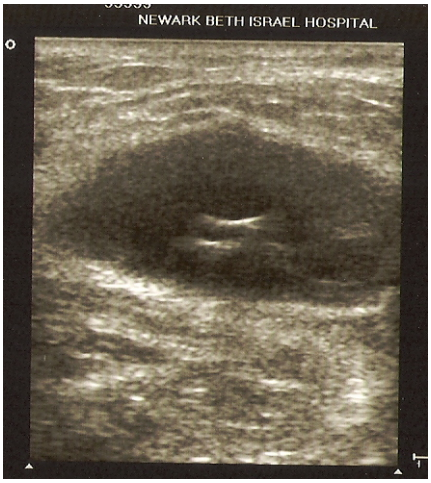

Image 15: *Calf hematoma in a patient with calf swelling and pain.*

To avoid false positive findings:

- Imaging the structure in both a longitudinal and transverse plane. While a vein appears circular in the transverse plane and tubular in the longitudinal plane, lymph nodes will appear circular in both.

- Color Flow and Pulse Doppler are useful adjuncts if there is a question whether it is a vascular structure or not.

Conclusion

Two-point compression ultrasound is a rapid and accurate method to evaluate the ED patient with suspected DVT. This abbreviated exam, which examines the common femoral and popliteal veins for complete collapse with probe pressure,

is as reliable as more comprehensive duplex ultrasounds currently considered as the gold standard. This exam, which can be learned with minimal training (2-5 hours) and quickly performed (3 minutes) is an invaluable tool in the approach to the patient with suspected proximal lower extremity DVT.

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Correspondance:

Tom Ashar, MD RDMS
Department of Emergency Medicine
Newark Beth Israel Medical Center
201 Lyons Ave
Newark, New Jersey 07112
USA