

**American College of Radiology  
ACR Appropriateness Criteria®**

**Clinical Condition:**                      **Suspected Lower Extremity Deep Vein Thrombosis**

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
US lower extremity with Doppler with compression	9		None
INV venography pelvis	6	When other studies equivocal or an intervention is planned.	IP
MRI venography lower extremity	6	Demonstrated to be useful, but insufficient supporting data so far.	None
CT pelvis with contrast	6	As an adjunct to CTPA done for suspected PE.	Med
INV venography lower extremity	5	When other studies equivocal or an intervention is planned.	Med
CT venography lower extremity (following arm injection)	5	As an adjunct to CTPA done for suspected PE.	Med
NUC venography lower extremity	3		Med
X-ray lower extremity	2		Min
US continuous wave Doppler (nonimaging) lower extremity	1		None
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

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## SUSPECTED LOWER EXTREMITY DEEP VEIN THROMBOSIS

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### **Summary of Literature Review**

The patient with symptomatic acute deep vein thrombosis (DVT) in a leg vein presents either with local pain and tenderness or with edema and swelling of the lower extremity, although patients with extensive DVT may be completely asymptomatic. Accuracy of the clinical diagnosis DVT is no better than 50%. Some of the pathological entities that mimic the signs and symptoms of acute DVT are Baker's cyst, cellulitis, lymphedema, chronic venous disease, and varied musculoskeletal disorders. The importance of diagnosing acute DVT lies mostly in its relationship to acute pulmonary embolism. Without treatment, pulmonary embolism is likely to occur in up to 50% of patients who have DVT of the lower extremity. Up to 30% of the episodes of pulmonary embolism can have death as an outcome. This can be significantly reduced—by a factor of 10—when the patient is treated with anticoagulation. The site of DVT is important since involvement of the popliteal and above-the-knee veins is strongly associated with the risk of pulmonary embolism. DVT involving only the calf veins is not associated with a high risk for pulmonary embolism. Symptomatic DVT isolated to the calf veins is also less common than DVT of the femoropopliteal system.

Various tests that are available for evaluating the patient include contrast venography, Doppler ultrasound (US), various radionuclide approaches, a plasma D-dimer test, magnetic resonance venography, and contrast computed tomographic venography. Diagnostic tests that have been discarded include nonimaging Doppler waveform analysis, thermography, and various iterations of plethysmography: impedance, strain and photo-plethysmography.

Imaging is a key component of diagnostic strategies used

to determine the presence of lower extremity DVT. Lower extremity contrast venography is now rarely used in clinical practice, although it is still considered to be the “gold standard” examination. Noninvasive tests, with the exception of plasma D-dimer (due to high sensitivity but limited specificity for DVT), are used with the following consideration: a patient with a positive result on a noninvasive test is considered to have DVT and is treated. If the test gives a negative result, then the clinical suspicion of DVT is used to determine whether another test or the same test should be used to serially monitor the patient. If the repeated test becomes positive, the patient is treated. If the noninvasive test remains negative, it or another test may be repeated. The type of test, the number of repeat examinations, and the duration of serial monitoring vary. For example, patients who have only above-the-knee venous US studies may still have below-the-knee (calf) deep vein thrombi. A repeat US examination at 5 to 7 days has been proven to reliably diagnose patients with calf vein thrombi that extend into the above-the-knee veins. If this occurs, the patient is treated. If the test remains negative, the patient is considered not to have lower extremity DVT.

### **Contrast Venography**

Contrast venography is the “gold-standard” examination. An iodine-containing contrast agent is injected into a foot vein. DVT is present if a distinct filling defect is present in a deep vein of the calf or thigh. Other findings, such as an abrupt cut-off, absence of filling or presence of collaterals, are less specific and may be related to technical factors or to chronic venous thrombosis. Although this examination serves as the “gold standard,” it may not give reliable results in 5%-10% of patients. It also carries some risks: contrast reaction, local irritation or skin loss due to extravasation, renal failure, and chemically induced thrombophlebitis.

### **Ultrasound Imaging**

US is now recognized as the most effective alternative to contrast venography for the detection of symptomatic venous thrombosis of the leg. During real-time imaging, the main diagnostic criterion is failure to compress the vein walls while pressure is applied to the skin. This approach has a very high sensitivity (95%) and a high specificity (98%) for the above-the-knee veins. The accuracy for detecting isolated calf vein thrombosis is not as well studied. Sensitivity is at least 90% for specificity above 90% if isolated calf vein thrombi are sought. Doppler waveform analysis is integrated with imaging US as either duplex US or color flow US. Color Doppler imaging may also help characterize the type of DVT as obstructive or partly obstructive. Although continuous-wave Doppler can be used without imaging, this requires

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considerable skill. This non-imaging approach has been supplanted by duplex and color flow imaging techniques. The real-time US examination is easy to perform, can be done at the bedside, and can be used for serial studies. It has a low technical failure rate. It is less consistent in diagnostic performance above the inguinal canal.

### **Tests of Limited Utility**

Plethysmography was for a time considered the main approach to the noninvasive detection of DVT. It evaluates the filling and emptying characteristics of blood in the lower extremity veins under resting conditions and simple physiologic maneuvers (PRG) or during a standardized protocol (impedance plethysmography). Measurements of blood volume changes are made with pressure cuffs, strain-gauge meters, or electrical impedance metering. Its accuracy is not as high as that of compression US, and it must be performed with meticulous technique. Also, it does not detect most cases of calf vein thrombosis (sensitivity of 20%-30%). Consequently, plethysmography-based techniques are now rarely used.

Light rheography (photoplethysmography) is a technique that gives a signal proportional to the blood volume in the subcutaneous tissues. It uses infrared detectors. It performs poorly for the detection of DVT but can be used to confirm the presence of venous insufficiency.

Thermography relies on the detection of temperature changes in the limb to diagnose DVT. It may work well for active superficial thrombophlebitis, but it has limited utility for most cases of DVT. It is unlikely that it will identify most patients with nonobstructive DVT.

### **Radionuclide Imaging**

There are two approaches to the use of radioactive compounds: imaging of the vein lumen, and use of radiopharmaceutical complexes that target thrombi. The vein lumen can be visualized by labeling the blood pool (ie, erythrocytes) with Technetium-99m. Acute DVT replaces labeled blood and causes a loss of blood pool radioactivity. This causes a defect on the image. This test has an accuracy of close to 90% when large obstructive venous thrombi are present in the femoropopliteal veins. A radionuclide venogram can also be performed during the injection of Tc-99m labeled macroaggregated albumin, typically as part of a pulmonary perfusion scintigram. Nonvisualization of the vein is then used as a diagnostic criterion.

There are many approaches to the use of active uptake of a radiolabeled compound by forming thrombi. Diagnostic tests that rely on this approach include labeled fibrinogen, platelets, fibrin, and plasmin. They perform best for DVT located below the knee or in the lower thigh. Iodine-labeled fibrinogen has long served as a “gold standard” with sensitivity above 80%-90%, but it is no longer

available. Labeled platelets can also be used. Their sensitivity is low for detecting thrombi above the knee: this is due to the small amount of radioactivity that accumulates in the forming thrombus with respect to the amount of background radioactivity. This can be improved by delayed (24-hour) imaging. Uptake is also decreased by concurrent anticoagulation. Labeled antifibrin antibody also suffers from a low signal-to-noise problem that decreases the sensitivity for detecting thrombi above the mid-thigh. Labeled plasmin, as reported in the literature, is very sensitive. Its specificity, however, is poor; the highest reported values for specificity vary between 60%-70%.

### **Magnetic Resonance Imaging**

Magnetic resonance venography (MRV) has principally been used for evaluating the pelvic veins. Thrombus shows up either as a venous segment without flow or as a discrete filling defect in the vein lumen with a flow-based approach such as time-of-flight or gradient-focused rapid imaging. The accuracy is high for the pelvic veins, and it is also reported to be above 90% in the few series studying its application to the femoro-popliteal system and the calf veins. Contrast enhanced magnetic resonance imaging (MRI) following the intravenous injection of a gadolinium based complex is also principally used in evaluating pelvic veins and is rarely used for the lower extremities. An alternative imaging approach is to use MRI to directly image thrombus while it is forming. Selective pulse sequences that highlight the signal in forming thrombi have shown good diagnostic performance, but diagnostic experience to date has been limited to one group of investigators. Patients with pacemakers or claustrophobia cannot tolerate the procedure. MRV is likely to be used when venous thrombi are located above the inguinal ligament or when extrinsic compression on the iliac veins mimics the signs and symptoms of DVT.

### **Computed Tomographic Venography**

Computed tomography (CT) can be used to diagnose leg vein DVT. This approach was originally used for imaging of the iliac veins. It is superior to iliac vein venography because it can identify sources of extrinsic compression of the iliac vein as well as diagnose DVT. The technique does not, however, give the fine anatomic detail of the vein lumen and may not show evidence of scarring due to previous episodes of DVT. CT venography in conjunction with CT pulmonary angiography has recently been investigated for its ability to image the thigh and calf veins. Delayed (3 minute) imaging shows good diagnostic performance when compared to contrast venography and US imaging. One advantage of the approach is the ability to screen for both DVT and pulmonary embolism during a single CT examination. The accuracy and cost-efficacy of this approach have yet to be fully defined.

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## Plasma D-Dimer Levels

Various blood tests are able to detect elevated levels of plasma D-dimer. This plasma constituent is present when the fibrin from active thrombus is released. Although very sensitive (above 95%), this test is very nonspecific (less than 50%), since it indicates that thrombus is forming, but not where. It has clinical utility since it has a high sensitivity and the negative predictive value of the test is very high. It is often used as an initial screening test and in conjunction with US imaging and CT pulmonary angiography when findings of these studies are negative despite high clinical suspicion for thromboembolic disease.

## Patients with Suspected Pulmonary Embolism

The strong linkage between lower extremity DVT and pulmonary embolism has sometimes lead to an investigation of the lower extremity veins in patients suspected of having a pulmonary embolism. The diagnostic yield of a positive venous US is low, typically less than 10%, in such patients. More recent data also indicate that the use of follow-up US in patients with negative CT angiography is low.

## Summary

The current approach to the evaluation of a symptomatic patient with suspected acute DVT favors venous US. Other imaging approaches are either more invasive (contrast venography), less accurate or less cost-effective for suspected DVT of the femoral or popliteal veins. Suspected involvement of the iliac veins can be investigated with venography or CT. Delayed CT venography following an arm vein injection has shown good reliability as compared to US and venography. MRV is reliable for the pelvic and thigh veins but has yet to be evaluated in any large clinical series for evaluating calf veins. Plasma D-dimer levels are excellent as a screening test in high-risk patients or in the presence of high clinical suspicion, but a positive result must be confirmed by other studies, such as CT or US.

Users of these guidelines must take into consideration the recent recommendation that symptomatic calf vein DVT needs to be treated with systemic anticoagulation.

## Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Additional information regarding radiation dose assessment for imaging examinations can

be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.

Relative Radiation Level Designations	
Relative Radiation Level*	Effective Dose Estimate Range
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

\*RRL assignments are not included for some examinations. The RRL assignments for the IP (in progress) exams will be available in future releases.

## References

1. Kelemouridis V, Eckstein MR, Dembner AG, et al. The normal leg venogram: significance in suspected vein thrombosis. *Int Angiol* 1985; 4(3):369-371.
2. Lensing AW, Buller HR, Prandoni P, et al. Contrast venography, the gold standard for the diagnosis of deep-vein thrombosis: improvement in observer agreement. *Thromb Haemost* 1992; 67(1):8-12.
3. Pedersen LM, Lerche A, Jorgensen M, et al. Follow-up study of patients with clinically suspected deep venous thrombosis and a normal venogram. *J Intern Med* 1993; 234(5):457-460.
4. Appelman PT, De Jong TE, Lampmann LE. Deep venous thrombosis of the leg: US findings. *Radiology* 1987; 163(3):743-746.
5. Chance JF, Abbitt PL, Tegtmeier CJ, Powers RD. Real-time ultrasound for the detection of deep venous thrombosis. *Ann Emerg Med* 1991; 20(5):494-496.
6. Cronan JJ, Dorfman GS, Scola FH, et al. Deep venous thrombosis: US assessment using vein compression. *Radiology* 1987; 162(1 Pt 1):191-194.
7. Elias A, Le Corff G, Bouvier JL, et al. Value of real time B mode ultrasound imaging in the diagnosis of deep vein thrombosis of the lower limbs. *Int Angiol* 1987; 6(2):175-182.
8. Lensing AW, Prandoni P, Brandjes D, et al. Detection of deep vein thrombosis by real-time B-mode ultrasonography. *N Engl J Med* 1989; 320(6):342-345.
9. Mattos MA, Londrey GL, Leutz DW, et al. Color-flow duplex scanning for the surveillance and diagnosis of acute deep venous thrombosis. *J Vasc Surg* 1992; 15(2):366-376.
10. Anderson DR, Lensing AW, Wells PS, et al. Limitations of impedance plethysmography in the diagnosis of clinically suspected deep-vein thrombosis. *Ann Intern Med* 1993; 118(1):25-30.
11. Heijboer H, Buller HR, Lensing AW, et al. A comparison of real-time compression ultrasonography with impedance plethysmography for the diagnosis of deep-vein thrombosis in symptomatic outpatients. *N Engl J Med* 1993; 329(19):1365-1369.
12. Huisman MV, Buller HR, ten Cate JW, et al. Management of clinically suspected acute venous thrombosis in outpatients with serial impedance plethysmography in a community hospital setting. *Arch Intern Med* 1989; 149(3):511-513.
13. Prandoni P, Lensing AW, Buller HR, et al. Failure of computerized impedance plethysmography in the diagnostic management of patients with clinically suspected deep-vein thrombosis. *Thromb Haemost* 1991; 65(3):233-236.
14. Carpenter JP, Holland GA, Baum RA, et al. Magnetic resonance venography for the detection of deep venous thrombosis; comparison with contrast venography and duplex Doppler ultrasonography. *J Vasc Surg* 1993; 18(5):734-741.
15. Evans AJ, Sostman HD, Knelson MH, et al. 1992 ARRS Executive Council Award. Detection of deep venous thrombosis: prospective

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- comparison of MR imaging with contrast venography. *AJR* 1993; 161(1):131-139.
16. Zerhouni EZ, Barth KH, Siegelman SS. Demonstration of venous thrombosis by computed tomography. *AJR* 1980; 134(4):753-758.
  17. Bendick PJ, Glover JL, Holden RW, Dilley RS. Pitfalls of the Doppler examination for venous thrombosis. *Am Surg* 1983; 49(6):320-323.
  18. Hanel KC, Abbott WM, Reidy NC, et al. The role of two noninvasive tests in deep venous thrombosis. *Ann Surg* 1981; 194(6):725-730.
  19. Ouriel K, Walter M, Whitehouse J, Zarins CK. Combined use of Doppler ultrasound and phlebography in suspected deep venous thrombosis. *Surg Gynecol Obstet* 1984; 159(3):242-246.
  20. Schroeder PJ, Dunn E. Mechanical plethysmography and Doppler ultrasound: diagnosis of deep-venous thrombosis. *Arch Surg* 1982; 117(3):300-303.
  21. Farlow DC, Ezekowitz MD, Rao SR, et al. Early image acquisition after administration of Indium-111 platelets in clinically suspected deep venous thrombosis. *Am J Cardiol* 1989; 64(5):363-368.
  22. Jung M, Kletter K, Duczak R, et al. Deep vein thrombosis: Scintigraphic diagnosis with In-111-labeled monoclonal antifibrin antibodies. *Radiology* 1989; 173(2):469-475.
  23. Kilpatrick TK, Lichtenstein M, Andrews J, et al. A comparative study of radionuclide venography and contrast venography in the diagnosis of deep venous thrombosis. *Aust N Z J Med* 1993; 23(6):641-645.
  24. Mangkharak J, Chaiyasoot W, Permpikul C, Sripraporn W. Radionuclide venography in the diagnosis of deep vein thrombosis of the lower extremities: A comparison to contrast venography. *J Med Assoc Thai* 1998; 81(6):432-441.
  25. Catalano C, Pavone P, Laghi A, et al. Role of MR venography in the evaluation of deep venous thrombosis. *Acta Radiol* 1997; 38(5):907-912.
  26. Laissy JP, Cinqualbre A, Loshkajian A, et al. Assessment of deep venous thrombosis in the lower limbs and pelvis: MR venography versus duplex doppler sonography. *AJR* 1996; 167(4):971-975.
  27. Baldt MM, Zontsich T, Stumpflen A, et al. Deep venous thrombosis of the lower extremity: Efficacy of spiral CT venography compared with conventional venography in diagnosis. *Radiology* 1996; 200(2):423-428.
  28. Birdwell BG, Raskob GE, Whitsett TL, et al. The clinical validity of normal compression ultrasonography in outpatients suspected of having deep venous thrombosis. *Ann Intern Med* 1998; 128(1):1-7.
  29. Cornuz J, Pearson SD, Polak JF. Deep venous thrombosis: complete lower extremity venous US evaluation in patients without known risk factors – outcome study. *Radiology* 1999; 211(3):637-641.
  30. Bernardi E, Prandoni P, Lensing AW, et al. D-dimer testing as an adjunct to ultrasonography in patients with clinically suspected deep vein thrombosis: prospective cohort study. The Multicentre Italian D-dimer Ultrasound Study Investigators Group. *BMJ* 1998; 317(7165):1037-1040.
  31. Lee AY, Julian JA, Levine MN, et al. Clinical utility of a rapid whole-blood D-dimer assay in patients with cancer who present with suspected acute deep venous thrombosis. *Ann Intern Med* 1999; 131(6):417-423.
  32. Lennox AF, Delis KT, Serunkuma S, et al. Combination of a clinical risk assessment score and rapid whole blood D-dimer testing in the diagnosis of deep vein thrombosis in symptomatic patients. *J Vasc Surg* 1999; 30(5):794-803.
  33. Yoshida S, Akiba H, Tamakawa M, et al. Spiral CT venography of the lower extremities by injection via an arm vein in patients with leg swelling. *Br J Radiol* 2001; 74(887):1013-1016.
  34. Becker D, Gunter E, Strauss R, et al. Color Doppler imaging versus phlebography in the diagnosis of deep leg and pelvic vein thrombosis. *J Ultrasound Med* 1997; 16(1):31-37.
  35. Evans AJ, Sostman HD, Witty LA, et al. Detection of deep venous thrombosis: prospective comparison of MR imaging and sonography. *J Magn Reson Imaging*. 1996; 6(1):44-51.
  36. Fraser DG, Moody AR, Morgan PS, et al. Diagnosis of lower-limb deep venous thrombosis: a prospective blinded study of magnetic resonance direct thrombus imaging. *Ann Intern Med* 2002; 136(2):89-98.
  37. Garg K, Kemp JL, Wojcik D, et al. Thromboembolic disease: comparison of combined CT pulmonary angiography and venography with bilateral leg sonography in 70 patients. *AJR* 2000; 175(4):997-1001.
  38. Miller N, Satin R, Tousignant L, Sheiner NM. prospective study comparing duplex scan and venography for diagnosis of lower-extremity deep vein thrombosis. *Cardiovasc Surg* 1996; 4(4):505-508.
  39. Elias A, Mallard L, Elias M, et al. A single complete ultrasound investigation of the venous network for the diagnostic management of patients with a clinically suspected first episode of deep venous thrombosis of the lower limbs. *Thromb Haemost* 2003; 89(2):221-227.
  40. Loud PA, Katz DS, Klippenstein DL, et al. Combined CT venography and pulmonary angiography in suspected thromboembolic disease: diagnostic accuracy for deep venous evaluation. *AJR* 2000; 174(1):61-65.
  41. Schellong SM, Schwarz T, Halbritter K, et al. Complete compression ultrasonography of the leg veins as a single test for the diagnosis of deep vein thrombosis. *Thromb Haemost* 2003; 89(2):228-234.
  42. Bendick PJ, Glover JL, Brown OW, Ranval TJ. Serial duplex ultrasound examinations for deep vein thrombosis in patients with suspected pulmonary embolism. *J Vasc Surg* 1996; 24(5):732-737.
  43. Rosen MP, Sheiman RG, Weintraub J, McArdle C. Compression sonography in patients with indeterminate or low-probability lung scans: lack of usefulness in the absence of both symptoms of deep-vein thrombosis and thromboembolic risk factors. *AJR* 1996; 166(2):285-289.
  44. Perrier A, Roy PM, Sanchez O, et al. Multidetector-row computed tomography in suspected pulmonary embolism. *N Engl J Med* 2005; 352(17):1760-1768.

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