

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

Clinical Condition: Suspected Lower-Extremity Deep Vein Thrombosis

Radiologic Procedure	Rating	Comments	RRL*
US lower extremity with Doppler	9	The use of this procedure is limited to between the inguinal ligament and knee.	O
MR venography lower extremity and pelvis without and with IV contrast	7	This is the primary modality for pelvic or thigh DVT if US is nondiagnostic.	O
MR venography lower extremity and pelvis without IV contrast	7	This procedure can be performed when contrast is contraindicated.	O
CT venography lower extremity and pelvis with IV contrast	7	This procedure can be performed when MRV is not available or contraindicated.	☼☼☼
X-ray venography pelvis	6	This procedure is reserved for inconclusive, noninvasive studies or when thrombolysis is planned.	☼☼
X-ray venography lower extremity	4	This procedure is reserved for inconclusive, noninvasive studies or when thrombolysis is planned.	☼☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

SUSPECTED LOWER-EXTREMITY DEEP VEIN THROMBOSIS

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Summary of Literature Review

Introduction/Background

Lower-extremity deep venous thrombosis (DVT) has an estimated annual incidence of approximately 5 per 10,000 in the general population, with the incidence increasing with advancing age [1]. DVT typically starts distally below the knee but can extend proximally above the knee and potentially result in life-threatening pulmonary embolism. Pulmonary embolism can occur in 50%–60% of patients with untreated DVT, with an associated mortality rate of 25%–30% [2,3]. Mortality associated with venous thromboembolism is more commonly seen in patients who present with pulmonary embolism or have advanced age, cancer, or underlying cardiovascular disease [4].

It is clinically important to determine the location and extent of DVT [3,5]. DVT that is limited to the infrapopliteal calf veins (ie, below-the-knee or distal DVT) often resolves spontaneously and is rarely associated with pulmonary embolism or other adverse outcomes [3,6,7]. Above-the-knee or proximal DVT, on the other hand, is strongly associated with the risk of pulmonary embolism. The treatment of choice for DVT is anticoagulation to reduce the risk for DVT extension and pulmonary embolism and reduce the likelihood of recurrent DVT and post-thrombotic syndrome. It is generally accepted that the benefits of anticoagulation therapy in patients with proximal DVT outweigh its risks [3,5]. Because below-the-knee DVT rarely results in pulmonary embolism, the role of anticoagulation therapy in patients with distal DVT remains controversial [3,5,8]. However, because one-sixth of patients with distal DVT will experience extension of the thrombus proximally above the knee, serial imaging assessment to exclude proximal DVT extension is recommended at 1 week, if anticoagulation therapy is not initiated at presentation [3,5]. This issue is complicated by the variability in evaluation for below-the-knee DVT as part of a routine examination. Because DVT and pulmonary embolism are part of the same disease, a proximal DVT is sufficient enough for diagnosing and treating stable patients who have a clinically suspected pulmonary embolus [9].

Classically, a patient with symptomatic lower-extremity DVT presents with either local pain or tenderness or with edema and swelling of the lower extremity. However, approximately one-third of patients with DVT do not have any symptoms [10]. Often, symptoms are not apparent until there is involvement above the knee [3]. The clinical diagnosis of DVT using clinical risk-stratification scores (eg, Wells score) alone has, therefore, been less than ideal [10]. Wells et al [11,12] suggested using a clinical DVT-prediction score (a.k.a. Wells score) in combination with a blood evaluation for plasma D-dimer, a degradation product of cross-linked fibrin that is elevated during thromboembolic events. DVT is unlikely if the clinical-prediction score is low and the D-dimer levels are normal [3,5,10-12]. However, the highly variable nature of DVT presentation, numerous potential pathologic mimics for DVT, and variations in D-dimer assay performance in certain populations limit the reliability of diagnosis solely on the clinical DVT-prediction score and D-dimer testing. Imaging is frequently required to definitively exclude DVT and properly document the extent of venous thrombosis, which is critical for proper therapeutic management of DVT. Moreover, the clinical-prediction score and D-dimer level are often unreliable for diagnosing recurrent DVT and are not useful for diagnosing alternative conditions, such as an intact or ruptured Baker's cyst, cellulitis, lymph edema, chronic venous disease, and various musculoskeletal disorders that can clinically mimic DVT.

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Imaging remains critical for the proper diagnosis and management of DVT. Lower-extremity contrast x-ray venography has been the traditional gold standard for diagnosing DVT but is now rarely used in routine DVT assessment, except in complex cases, eg, to exclude acute DVT in a patient with a prior history of DVT. In most cases, contrast x-ray venography has been replaced by less invasive techniques, especially ultrasound (US), but also magnetic resonance venography (MRV) and CT venography (CTV). For patients diagnosed with DVT, follow-up imaging can be helpful in guiding management, such as determining whether to continue anticoagulation or when to remove an inferior vena cava filter [13,14].

Imaging Options

Contrast X-ray Venography

Contrast x-ray venography is the historic and *de facto* “gold standard” for diagnosing DVT [3,5,10,11]. With this technique, proximal compression tourniquets are applied, and a series of overlapping radiographs are obtained following an iodine-containing contrast medium injected into a dorsal vein in the foot. DVT is present if a distinct filling defect is present in a deep vein, typically in the calf or thigh, but it can often extend to or involve more proximal veins, such as those in the pelvis. Less specific findings for DVT include an abrupt contrast cut-off, the absence of contrast filling, or the presence of collateral venous vessels. Contrast x-ray venography is particularly helpful for assessing recurrent acute DVT in patients with a prior history of DVT in whom venous anatomy is often complex and difficult to evaluate using other methods.

Ultrasound

US is widely recognized as the most cost-effective and preferred imaging modality for diagnosing proximal DVT [2,3,5-7,10-12]. Real-time duplex US is noninvasive, is easily performed (eg, at the patient’s bedside), and can be reliably used for serial evaluation. It is, however, less consistent in diagnostic performance above the inguinal canal and below the knee. The major sonographic criterion is to identify the failure of complete compression of imaged vein walls when pressure is applied to the skin during real-time imaging. US evaluation for DVT is often combined with real-time Doppler imaging, such as duplex, continuous-wave, and color-flow Doppler imaging. Color-flow Doppler imaging can assist in characterizing a clot as obstructive or partially obstructive. Using duplex US for the augmentation of venous flow rarely provides additional information when diagnosing DVT, but it can be useful as a secondary diagnostic tool [15]. A recent meta-analysis found US to have high sensitivity (range, 93.2%–95.0%; pooled sensitivity, 94.2%) and high specificity (range, 93.1%–94.4%; pooled specificity, 93.8%) for diagnosing proximal DVT [5]. In the same study, US was found to have a much lower sensitivity (range, 59.8%–67.0%; pooled sensitivity, 63.5%) for diagnosing distal DVT, which confirmed a widely known diagnostic limitation for this technique [5]. Although there are suggestive US findings, using imaging alone to distinguish acute from chronic DVT can be difficult [16]. Lower-extremity US has also been included in an algorithm for the workup of patients who have a fever of unknown origin after more common causes have been excluded [17,18].

Magnetic Resonance Venography

MRV is another noninvasive alternative to contrast x-ray venography that shares many of the clinical advantages of US, such as not exposing the patient to ionizing radiation or iodinated contrast media [19-23]. However, US remains the preferred first choice for DVT imaging because of its relatively lower cost, wider availability, and portability that facilitates evaluation of critical patients at bedside. MRV does have inherent advantages over US, especially in its ability to delineate extravascular anatomy. MRV can help identify potential sources of extrinsic venous compression that can be an underlying cause for DVT or suggest alternative diagnoses that mimic DVT.

MRV has been shown to successfully diagnose DVT using any variety of pulse sequences or techniques [19-23]. Patency or DVT can typically be determined without contrast media by using a variety of MRI techniques, such as spin echo, fast-spin echo, time-of-flight, phase contrast, steady-state free precession, or flow-independent imaging. Cardiac-gated cine bright blood MRI can be used to differentiate transient flow artifacts from true filling defects that persist over the cardiac cycle, but it requires real-time review and expertise. Contrast media-enhanced MRV, however, is more reproducible and less susceptible to artifacts. Despite the wide variety of techniques, however, a recent meta-analysis found MRV to have both high sensitivity (range, 87.5%–94.5%; pooled sensitivity, 92%) and specificity (range, 92.6%–96.5%; pooled sensitivity, 95%) [22]. When evaluating for proximal DVT, MRV is as sensitive and specific as US or contrast x-ray venography. MRV has the advantage over US in evaluating veins above the inguinal ligament, as 20% of DVTs are isolated to the pelvic veins [24]. As such, MRV has been used for evaluating patients with cryptogenic stroke [25]. MRV does, however, have contraindications and is not recommended for certain patients, such as those with MRI-unsafe devices.

Computed Tomography Venography

CTV can also be used to diagnose DVT [5,23,26]. However, there are the same clinical concerns about its use as there are with contrast x-ray venography, namely, patient exposure to ionizing radiation and iodinated contrast media. CTV can be performed either as direct CTV, using a venous injection of iodinated contrast media in a pedal vein similar to that in contrast x-ray venography, or, more commonly, as an indirect CTV using an antecubital vein for a contrast media injection and a delayed-imaging acquisition suitable for deep-venous opacification. CTV, like MRV, has the inherent advantages of cross-sectional imaging for identifying extravascular sources of extrinsic compression that could be underlying causes for DVT. In patients who have a suspected pulmonary embolism, a recent meta-analysis found CTV to have high sensitivity (range, 71%–100%; pooled sensitivity, 95.9%) and high specificity (range, 93%–100%; pooled specificity, 95.2%) comparable to that of US for diagnosing proximal DVT [23]. CTV can also be incorporated into a comprehensive examination that includes pulmonary CT angiography for evaluating both pulmonary embolism and proximal DVT [26], but it should not be performed routinely in all patients who are being evaluated for pulmonary embolism [27]. There is little evidence to support the use of CTV to diagnose DVT other than as a workup for pulmonary embolism. However, based on the published experience with pulmonary embolism, CTV may be considered a reasonable alternative to MRV for pelvic DVT or when US is nondiagnostic.

Summary

- The initial screening for possible DVT should be performed using a combination of clinical risk-stratification score (ie, Wells score) and plasma D-dimer assessment.
- DVT typically begins in the distal calf veins and often extends above the knee. DVT can result in a variety of complications, notably pulmonary embolism, which can be fatal. Although the likelihood for pulmonary embolism is sufficiently high for proximal DVT to merit initiation of anticoagulation therapy, the treatment for distal DVT remains controversial.
- Both clinical risk-stratification scoring and D-dimer assessment have limitations, and imaging is typically required for the confirmation of DVT and proper treatment planning.
- Noninvasive imaging for DVT is most cost-effective when using US. Although it is highly sensitive and specific for evaluating proximal DVT, US is far less sensitive for evaluating distal DVT; repeat US at 1 week is recommended to exclude a proximal extension of thrombus. US can also be used to tailor the duration of anticoagulant therapy [14].
- MRV and CTV are viable imaging options, especially in patients who are unable to undergo US (eg, a patient in a cast), are highly suspected of having pelvic DVT, or have nondiagnostic US examinations.
- MRV and CTV have a distinct advantage over US for demonstrating overall venous clot burden, especially within the inferior vena cava and pelvic veins. MRV and CTV can be used to evaluate extravascular anatomy, which can be particularly useful for diagnosing external sources of venous compression or alternative diagnoses.
- Contrast x-ray venography is the time-honored gold standard that is helpful for evaluating more complex cases, such as acute DVT in patients with chronic DVT.

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. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). 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*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
⊕	<0.1 mSv	<0.03 mSv
⊕⊕	0.1-1 mSv	0.03-0.3 mSv
⊕⊕⊕	1-10 mSv	0.3-3 mSv
⊕⊕⊕⊕	10-30 mSv	3-10 mSv
⊕⊕⊕⊕⊕	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies”.

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.