# American College of Radiology
## ACR Appropriateness Criteria®

### Clinical Condition:
Sudden Onset of Cold, Painful Leg

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arteriography lower extremity</td>
<td>8</td>
<td></td>
<td>☢☢☢</td>
</tr>
<tr>
<td>CTA lower extremity with contrast</td>
<td>7</td>
<td>Distal abdominal aorta should be included.</td>
<td>☢☢☢</td>
</tr>
<tr>
<td>MRA lower extremity without and with contrast</td>
<td>7</td>
<td>Distal abdominal aorta should be included. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>Segmental Doppler pressures and pulse volume recordings</td>
<td>6</td>
<td>Not required in the acute setting but may provide important physiologic information not obtained on imaging studies to help direct care.</td>
<td>O</td>
</tr>
<tr>
<td>MRA lower extremity without contrast</td>
<td>5</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>US lower extremity with Doppler</td>
<td>5</td>
<td>Limitations include heavily calcified vessels and operator dependency. May be helpful for problem solving.</td>
<td>O</td>
</tr>
<tr>
<td>US echocardiography transthoracic resting</td>
<td>4</td>
<td>Generally not part of the initial workup. May be useful to look for source of emboli.</td>
<td>O</td>
</tr>
<tr>
<td>US echocardiography transesophageal</td>
<td>3</td>
<td>Generally not part of the initial workup. May be useful to look for source of emboli. More invasive and time-consuming than TTE but affords better visualization of the left atrium.</td>
<td>O</td>
</tr>
<tr>
<td>MRI heart function and morphology without contrast</td>
<td>2</td>
<td>Generally not part of the initial workup. May be useful to look for source of emboli. Less accurate in the presence of atrial fibrillation and other irregular heart rhythms.</td>
<td>O</td>
</tr>
<tr>
<td>MRI heart function and morphology without and with contrast</td>
<td>2</td>
<td>Generally not part of the initial workup. May be useful to look for source of emboli. Less accurate in the presence of atrial fibrillation and other irregular heart rhythms.</td>
<td>O</td>
</tr>
<tr>
<td>CT heart function and morphology with contrast</td>
<td>2</td>
<td>Generally not part of the initial workup. May be useful to look for source of emboli. Less accurate in the presence of atrial fibrillation and other irregular heart rhythms.</td>
<td>☢☢☢☢</td>
</tr>
</tbody>
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**Rating Scale:** 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*Relative Radiation Level*
SUDDEN ONSET OF COLD, PAINFUL LEG

Expert Panel on Vascular Imaging: Clifford Weiss, MD1; Ezana Azene, MD2; Frank J. Rybicki, MD, PhD3; Hyun S. Kim, MD4; Benoit Desjardins, MD, PhD5; Chieh-Min Fan, MD6; Scott D. Flamm, MD7; Christopher J. Francois, MD8; Marie D. Gerhard-Herman, MD9; Sanjeeva P. Kalva, MD10; M. Ashraf Mansour, MD11; Emile R. Mohler III, MD12; Isabel B. Oliva, MD13; Matthew P. Schenker, MD.14

Summary of Literature Review

Introduction/Background
Acute onset of a cold painful leg, although not directly a significant cause of mortality, contributes significantly to morbidity. The etiologies are limited, the most common being arterial occlusion. Total venous outflow occlusion is another but much less common cause. It often results in what is known clinically as “phlegmasia cerulea dolens” (precursor to venous gangrene) with lower-extremity swelling, pain, and a dusky color. It is differentiated from arterial occlusion by the presence of distal arterial pulses. Other causes, such as prolonged exposure to cold and trauma, are rare and usually clinically obvious.

This condition generally requires urgent treatment, regardless of the etiology. Once the etiology is clinically defined, directing appropriate care of the patient requires assessing the source (ie, embolic vs thrombotic occlusion) and extent of the underlying arterial obstruction. The available alternatives include noninvasive testing: duplex ultrasound (US), magnetic resonance angiography (MRA), computed tomography angiography (CTA), and catheter angiography.

Catheter Angiography
Digital subtraction angiography (DSA) remains the diagnostic gold standard for detecting peripheral vascular occlusive disease, but new and less invasive modalities are gradually replacing it [1-7]. The ability to diagnose and treat disease in a single procedure is a major benefit of DSA that remains unmatched in the treatment of acute ischemic vascular disease. There has been extensive debate regarding the cost-benefit ratios when comparing DSA and MRA. Because of the invasive character of DSA, there is a recovery period typically lasting 4 hours or more. In some countries, patients remain in the hospital overnight [8-10]. If complications from DSA occur, additional intervention and prolongation of the hospital stay may add cost as well as morbidity or even mortality. To be truly cost-effective, any noninvasive method would have to supplant DSA, not just precede or supplement it.

The reported incidence of complications with DSA varies greatly. There are also risks associated with iodinated contrast agents. Most worrisome are the rare fatal systemic reactions and contrast-induced nephropathy (CIN). The nephrotoxic effects are important to consider, as many patients who present with the sudden onset of a cold, painful leg are elderly, diabetic, and have impaired renal function [8]. Also, many patients will have repeated catheter angiography over the course of their disease, and minimizing patient radiation exposure should always be considered. Angiography has also been criticized for its imperfect evaluation of outflow vessels, specifically for limited visualization of pedal vasculature and patent distal vessels beyond significant obstructive lesions [1,6,11].

Magnetic Resonance Angiography
MRA has high sensitivity and specificity for detecting arterial occlusive disease, using DSA as a gold standard [3,4,6,9,12-15]. Early sequences required protocols with 30 minutes of gradient time or more. However, modern technology — 3 Tesla main fields, parallel imaging, multi-channel coils, sequences such as time-resolved MRA, and enhanced acquisition speed — enables rapid assessment of acute limb ischemia [3,11,16-19]. In addition to decreased total examination times, faster acquisition reduces motion artifact and venous contamination. Motion artifact can also be corrected with automated image registration protocols [20]. Improved spatial resolution

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translates to thinner slices and clearer depiction of small vessels [3,11,17]. Most information needed for the interventionalist or vascular surgeon is routinely illustrated with MRA, such as a general road map of arterial anatomy, including runoff vessels and collaterals, as well as the location and extent of significant stenoses and occlusions.

Limitations include less accurate evaluation of smaller arteries, which means that more time-consuming sequences are required to get better results. Also, limited information can currently be obtained on a routine basis regarding the character of vessel walls and detailed flow dynamics, although time-resolved contrast-enhanced MRA techniques are beginning to provide qualitative flow information [11,16,18,19]. Overestimation of stenosis has been reported in native arteries and in patients with vascular stents secondary to artifacts [14,21]. Overestimation in native arteries varies among sequences [21] and may or may not be a clinical problem in specific cases. This uncertainty highlights the poor consensus on optimal protocols. In part, this is a function of the continuing evolution of technology, both software and hardware.

Another concern with MRA is that most techniques have required the administration of a gadolinium-based contrast agent. Although MRA has few associated complications, with the realization of the risk of nephrogenic systemic fibrosis (NSF) in patients with underlying renal dysfunction [22] who receive these contrast agents (see Anticipated Exceptions), there has been increased interest in using other modalities or limiting the use of gadolinium-based contrast agent in such patients. Significantly lower contrast doses can be used at 3 Tesla compared to 1.5 Tesla without compromising image quality [23]. Noncontrast MRA may prove useful [22,24-26], although there is only anecdotal experience in patients with critical limb ischemia (CLI). Further improvements will be required, particularly in techniques for assessing pedal circulation [26,27]. Finally, blood-pool gadolinium-chelate contrast agents have prolonged retention in the intravascular space and allow for steady-state imaging [21,28-31] that, in turn, can enable high spatial resolution acquisitions. Additional studies will be needed to confirm potential clinical benefits and cost-effectiveness of such agents.

**Computed Tomography Angiography**

Multi-detector-row technology has dramatically shortened CT acquisition times, improved spatial resolution, and improved vascular image quality depicted with CT. Multidetector CT (MDCT) scanners can image from the diaphragm to the ankles in <30 seconds using a single-contrast bolus [10,32]. The use of 64-row or greater MDCT significantly increases the accuracy of stenosis detection, particularly in smaller vessels [7,33,34]. Dynamic, time-resolved, “4D” CTA may improve accuracy even further [33]. However additional studies are needed before this can be confirmed.

Sophisticated postprocessing tools enable multiplanar visualization in all three orthogonal axes as well as in any oblique axis. In addition to multiplanar reconstructions, both volume rendering and maximum-intensity projections can be used, each with advantages and disadvantages. Maximum-intensity projections are very accurate for larger vessels (as distal as the infrapopliteal region) but less accurate for smaller vessels [35,36]. Volume rendering, including endoluminal reconstruction, is good for evaluating embolic or vascular endothelial injury. It is also valuable in evaluating heavily calcified vessels. However, interpretation from volume-rendered images or maximum-intensity projections alone is insufficient to characterize vascular lesions [36] and should always be accompanied by an assessment of the raw axial dataset and multiplanar reformatted images.

CTA has proven comparably accurate to MRA in evaluating peripheral arterial diseases [5,7,36]. The advantages of CTA over MRA are its excellent spatial resolution, widespread availability, cost-effectiveness, and usability in patients who have contraindications to MRI, such as those who have pacemakers or defibrillators [37,38]. The literature focused on patients with CLI is limited, although one study showed that CTA can help ensure correct treatment recommendations [10].

One disadvantage of CTA is its limited ability to depict the lumen in heavily calcified arteries. Calcium-induced artifact causes an overestimation of stenosis [36,39]. In theory, dual-energy CTA can provide data from two kV settings which can then be used to distinguish between vascular calcium and iodinated contrast agent [40]. Initial studies have shown improved accuracy of stenosis detection and grading with dual-energy CTA compared to conventional CTA [41]. However, early studies also suggest dual-energy CTA may still overestimate high-grade vessel stenosis as occlusion [42]. Dual-energy CTA may also correlate less well with DSA in calcified calf and pedal arteries [43]. Expanded clinical use of dual-energy CTA will require further validation and assessment of relative radiation doses.

Complications related to iodinated contrast are similar to those in catheter-based angiography and have been discussed above. Cumulative radiation dose is also a concern; CTA has been increasingly used for both
preprocedural planning and postprocedural surveillance. Recent advances in hardware and software, however, have achieved lower radiation dosages for a single CTA examination [35]. Also, techniques tailored to the evaluation of lower-limb vasculature have been published that allow reduced patient radiation by decreasing kVp while preserving the ability to evaluate the smaller lower-limb vessels [37,44,45]. Decreasing kVp also has the added advantage of allowing lower doses of iodinated contrast as kVp approaches the iodine K-edge [45].

**Other Imaging Examinations**

In this patient population, Duplex US is limited by the need for operator expertise, by poor accessibility of vessels, by heavy calcification, and often by poor overall accuracy if multilevel disease is present [4,46,47]. Its advantages are that it can provide useful physiologic as well as anatomic information. Further, it is noninvasive, widely available, and relatively inexpensive.

Transthoracic echocardiography (TTE) or the more specific and invasive transesophageal echocardiography (TEE) may be useful if patient symptoms could be from cardiac embolization, particularly in patients with known atrial fibrillation. In the acute setting, however, this knowledge is unlikely to influence the immediate evaluation. Similarly, cardiac CT or MRI may identify or exclude cardiac thrombus or areas of cardiac dysfunction that might be the source of emboli, but this knowledge is not likely to have clinical impact in the acute setting.

**Noninvasive Physiologic Testing**

Noninvasive physiologic testing includes measurement of ankle-brachial index (ABI), segmental blood pressures and pulse-volume recordings, transcutaneous oxygen pressure measurement (TcPO2), and exercise treadmill testing. ABI measurement is simple and reliable and serves both as confirmation of arterial occlusion as the etiology of sudden onset of cold leg and as a baseline to guide further intervention [48]. Useful physiologic information may also be obtained. In this clinical setting, other noninvasive tests generally are not helpful, as they do not provide specific information that will alter or guide therapy [49].

**Summary**

- DSA remains the gold standard for diagnosing peripheral vascular disease and continues to be the only modality that allows diagnosis and simultaneous treatment of pathology. This advantage alone will ensure that it continues to be a valuable tool.
- Noninvasive imaging with MRA or CTA before catheter angiography or surgery is accepted and common. Both MRA and CTA can be used for diagnosis and can positively influence management into percutaneous or surgical.
- Other imaging and noninvasive physiologic testing may prove important for longer-term management but are less recommended in the acute setting.
- Peripheral vascular disease is a significant and growing problem, and continued research and development of current and emerging technologies will ultimately shape the standard of care.

**Anticipated Exceptions**

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m²), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m². For more information, please see the ACR Manual on Contrast Media [50].

**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

<table>
<thead>
<tr>
<th>Relative Radiation Level*</th>
<th>Adult Effective Dose Estimate Range</th>
<th>Pediatric Effective Dose Estimate Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>0 mSv</td>
<td>0 mSv</td>
</tr>
<tr>
<td>☢</td>
<td>&lt;0.1 mSv</td>
<td>&lt;0.03 mSv</td>
</tr>
<tr>
<td>☢☢</td>
<td>0.1-1 mSv</td>
<td>0.03-0.3 mSv</td>
</tr>
<tr>
<td>☢☢☢</td>
<td>1-10 mSv</td>
<td>0.3-3 mSv</td>
</tr>
<tr>
<td>☢☢☢☢</td>
<td>10-30 mSv</td>
<td>3-10 mSv</td>
</tr>
<tr>
<td>☢☢☢☢☢</td>
<td>30-100 mSv</td>
<td>10-30 mSv</td>
</tr>
</tbody>
</table>

*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
- ACR Appropriateness Criteria® Overview
- Procedure Information
- Evidence Table

References
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   bad name? Current accuracy and morbidity of diagnostic contrast arteriography for aortoiliac and lower
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   arteries with gadobenate dimeglumine, a contrast agent with increased relaxivity, and comparison with
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