

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

Clinical Condition: Recurrent Symptoms Following Lower Extremity Angioplasty

Variant 1: Claudication.

Radiologic Procedure	Rating	Comments	RRL*
US segmental Doppler pressures and pulse volume recordings	9	Usual first tests.	None
MRA lower extremity	8	Able to triage between catheter and surgical management and thus may substitute for other noninvasive studies. See comments regarding contrast in text under "Anticipated Exceptions."	None
US lower extremity with Doppler	8	May be useful to identify focal lesions amenable to percutaneous intervention.	None
INV arteriography lower extremity	7	Used for a lesion amenable to percutaneous intervention (eg, restenosis).	Low
CTA lower extremity	7	Can be an alternative to MRA. Heavy calcification, especially in calf arteries, can limit evaluation of outflow disease.	Med
US lower extremity intravascular	1	May be indicated as part of an interventional procedure but not for diagnostic use.	None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: Threatened limb.

Radiologic Procedure	Rating	Comments	RRL*
INV arteriography lower extremity	9	Allows most timely diagnosis and treatment.	Low
US segmental Doppler pressures and pulse volume recordings	8		None
MRA lower extremity	5	Useful if angiography is not performed (ie, surgical treatment is necessary). See comments regarding contrast in text under "Anticipated Exceptions."	None
CTA lower extremity	5	Useful if angiography is not performed with limitations as described above.	Med
US lower extremity with Doppler	4	May be useful to identify focal lesions amenable to percutaneous intervention.	None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

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RECURRENT SYMPTOMS FOLLOWING LOWER EXTREMITY ANGIOPLASTY

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Summary of Literature Review

Endovascular interventions for lower extremity arterial obstructive disease, both for lifestyle-limiting claudication and for critical ischemia with threatened limb, have become accepted treatment modalities. The availability of these techniques has reduced the numbers of surgical reconstructive procedures. But in spite of their very high initial technical success rates, restenosis after angioplasty with recurrent symptoms is frequent, especially with infrainguinal lesions [1,2].

The use of nitinol stents appears to decrease restenosis in the peripheral arteries. The long-term results—of drug-eluting stents in decreasing restenosis are still under investigation [3]. The literature has not clarified the importance of the follow-up of patients after lower extremity intervention. Recurrent symptoms usually precede the onset of limb- or life-threatening events, in contrast to coronary artery disease. Close surveillance of these patients, therefore, is often not routine; follow-up has often been driven by recurrence of symptoms.

Clinical examination with evaluation of the peripheral pulses and determination of the ankle-brachial indices (ABIs) is a low-cost and well-accepted first step in evaluation. However, restenosis is not always clinically discernible, since the natural progression of the patient's disease process is often characterized by development of new lesions at different sites. Thus definitive diagnosis is important for therapeutic planning, whether for repeat endovascular intervention, for reconstructive vascular surgery, or for medical management.

Noninvasive Hemodynamic Studies

Segmental Doppler pressures (SDP) and pulse volume recordings (PVR) (commonly referred to as lower extremity noninvasives or LENIs) are the most commonly performed noninvasive techniques for evaluating

peripheral vascular disease. Deterioration of SDP from previous levels by 15% or more has been accepted as indicative of restenosis [4-6]. However, this measurement does not clearly specify the site or length of the lesion beyond general terms, such as “femoropopliteal” or “inflow” disease, and it is of little value in patients with noncompressible arteries, as often occurs in diabetics and patients with renal insufficiency. Similarly, segmental PVR, a useful adjunct in calcified arteries, are not accurate with regard to location or length of lesions nor do they provide specific enough information for treatment decision-making in patients with symptomatic recurrent peripheral vascular disease [7]. In conjunction with ABIs, however, they do provide a useful guide to the overall clinical severity of the obstructive disease.

Ultrasound Imaging

Duplex color Doppler ultrasound (US) imaging is the lowest cost cross-sectional imaging modality and has widespread usage and acceptance in this patient population. US is recommended for routine surveillance and in the setting of recurrent symptoms following surgical or percutaneous intervention. It has the ability to localize lesion sites and assess their hemodynamic significance.

One limitation of US is its operator dependence. With meticulous technique (by either a technologist or a physician), there is a high, although not perfect, correlation with catheter angiography, especially for infrainguinal disease. A second limitation is that US alone is unable to triage patients between catheter and surgical management. As discussed below, contrast-enhanced magnetic resonance angiography (CE-MRA) is more sensitive and specific for peripheral arterial disease [8].

Catheter Angiography

Although the acceptance of MRA, computed tomography angiography (CTA), and US have decreased the role of catheter angiography with digital subtraction, it is still considered the “gold standard” for peripheral arterial imaging and allows for intervention at the time of diagnosis. This can prove invaluable in patients with a threatened limb [9]. Contrast-based catheter angiography can localize and quantify obstructive lesions with an accuracy exceeded only by intravascular US. Moreover, it allows physiological evaluation by determining pressure gradients. In addition to its diagnostic capabilities, it permits immediate intervention in many circumstances. In high-acuity settings, such as a thrombosed bypass graft, where immediate catheter-based intervention is likely to be indicated, direct referral to catheter angiography is the preferred option. However, catheter angiography is an invasive technique with a small but definite risk in every patient and a variable higher risk in patients with severe widespread vascular disease, diabetes, renal insufficiency,

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or other contraindications to the use of iodinated contrast media. CO₂-negative contrast angiography may be of value in these patients. In light of the risk of nephrogenic systemic fibrosis (NSF) in patients with severe renal disease, there is no role for gadolinium chelates as X-ray contrast agents.

Computed Tomography Angiography

Early multidetector CT (MDCT) had insufficient spatial resolution, temporal resolution, and volume coverage per gantry rotation to adequately evaluate the lower extremity arterial system. With improvements in technology, CTA is rapidly evolving in the imaging of peripheral vascular obstructive disease [10,11]. It now has the advantage of allowing very rapid, noninvasive evaluation of a large portion of the arterial tree (for example, from the level of the renal arteries to the foot vessels). Although particularly useful for evaluating a defined vascular segment, CTA is still somewhat limited in the ability to grade the severity of stenotic lesions accurately when the presence of calcium is significant with respect to the vessel diameter [12]. CTA can be used to study segmented arterial components and is particularly good for evaluating aortoiliac disease, especially with its ability to view the image in coronal and sagittal views in addition to the conventional axial projection [13]. Large calcified plaques currently remain a significant problem in quantifying the degree of stenosis [14,15], and thus CT can be limited in surgical planning of touch-down in the calf. Although it is relatively noninvasive compared with catheter angiography, it has similar disadvantages with respect to iodinated contrast medium.

Magnetic Resonance Angiography

MRA has become a widespread method of imaging arterial obstructive disease, particularly with gadolinium enhancement [16,17]. This modality has the benefit of being noninvasive with minimal risk. It can image the entire vascular system, including difficult-to-visualize tibial and pedal arteries. With specialized techniques it also may be able to assess hemodynamic significance. With newer time-resolved MRA sequences, MRA correlates more accurately with catheter angiography, especially in the calf vessels [3,18,19]. Moreover, in a patient with total occlusion, MRA more reliably defines the reconstituted vessels. Metallic stents, especially stainless steel, cause signal intensity dropout, which can be indistinguishable from an occlusion. This is less of a problem with nitinol stents. MRA is now widely available, and its use, especially in conjunction with duplex vascular US, allows reliable determination of appropriate intervention when symptoms occur after angioplasty [20-30]. It takes longer to acquire images with MRA when compared to CTA. It is, however, similarly noninvasive and has the advantages of not requiring iodinated contrast agents and not using ionizing radiation. However, recent associations with gadolinium administration and the development of NSF in patients

with chronic renal insufficiency has the potential to reduce its use in this patient population [31-33] (see anticipated exceptions).

Summary

A complete vascular physical examination, including measurement of the ABIs, is always the first step in assessing a patient with recurrent symptoms after an initially successful endovascular intervention. With this knowledge the clinician/angiographer can decide on appropriate imaging studies. If it is clear that reintervention is necessary, as is often the case with a threatened limb, proceeding directly to catheter angiography is timely and appropriate. Preliminary US imaging in less urgent cases may be helpful to define the problem by confirming a recurrence at the previously treated site or suggesting progression elsewhere.

Both MRA and CTA continue to develop and thus are likely to assume a greater role in patient evaluation within the next few years. Some of the development is evolutionary, such as the use of time-resolved sequences in CE-MRA to evaluate calf vessels when venous contamination using more traditional methods can be problematic. Another example is noncontrast MRA. Meticulously performed time-of-flight MRA, while time-consuming, has proven efficacy in infrapopliteal disease [34,35]. In patients at high risk for NSF, these noncontrast techniques, after clinical testing, may prove useful to direct patient management [32].

Another fundamental development with respect to imaging science is the potential to perform CTA with two keV settings (dual-energy CT), in theory allowing separation between calcium and iodinated contrast material in small, calcified vessels. As with the new techniques above, at present there is only anecdotal experience, and thus while extremely promising, use of these advanced strategies in MR and CT must ultimately be supported by scientific evidence. Current MR and CT protocols are quite robust, but they are somewhat limited in practice by the lack in distribution of high-end MR and MDCT equipment and the limited number of trained professionals. However, where this equipment and expertise are available, the improved accuracy, comprehensiveness, and reproducibility of MR and CT make them appropriate first exams after clinical examination. The choice of modality is usually related to the expertise of the imager. Considering the technology alone, MRA has the advantage of more easily visualizing lesions obscured by overlying bone cortex in the calf, in particular the anterior tibial artery. In properly screened patients or in patients who are at risk for significant reactions to iodinated contrast medium, MRA is the procedure of choice.

Anticipated Exceptions

Patients presenting with critical recurrent ischemia with motor and sensory deficit occurring shortly after a

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percutaneous intervention (<7-10 days), and in whom the anatomy is well understood, should proceed directly to surgical revascularization by bypass or mechanical thrombectomy.

Nephrogenic systemic fibrosis (NSF), also known as nephrogenic fibrosing dermopathy) was first identified in 1997 and has recently generated substantial concern among radiologists, referring doctors and lay people. Until the last few years, gadolinium-based MR contrast agents were widely believed to be almost universally well tolerated, extremely safe and non-nephrotoxic, even when used in patients with impaired renal function. All available experience suggests that these agents remain generally very safe, but recently some patients with renal failure who have been exposed to gadolinium contrast agents (the percentage is unclear) have developed NSF [31,33,36], a syndrome that can be fatal. Further studies are necessary to determine what the exact relationships are between gadolinium-containing contrast agents, their specific components and stoichiometry, patient renal function and NSF. Current theory links the development of NSF to the administration of relatively high doses (eg, >0.2mM/kg) and to agents in which the gadolinium is least strongly chelated. The FDA has recently issued a “black box” warning concerning these contrast agents (http://www.fda.gov/cder/drug/InfoSheets/HCP/gcca_200705HCP.pdf).

This warning recommends that, until further information is available, gadolinium contrast agents should not be administered to patients with either acute or significant chronic kidney disease (estimated GFR <30 mL/min/1.73m²), recent liver or kidney transplant or hepato-renal syndrome, unless a risk-benefit assessment suggests that the benefit of administration in the particular patient clearly outweighs the potential risk(s) [36].

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

References

1. Capek P, McLean GK, Berkowitz HD. Femoropopliteal angioplasty. Factors influencing long-term success. *Circulation* 1991; 83(2 Suppl):I70-80.
2. Johnston KW. Femoral and popliteal arteries: reanalysis of results of balloon angioplasty. *Radiology* 1992; 183(3):767-771.
3. Sabeti S, Schillinger M, Amighi J, et al. Primary patency of femoropopliteal arteries treated with nitinol versus stainless steel self-expanding stents: propensity score-adjusted analysis. *Radiology* 2004; 232(2):516-521.
4. Ahn SS, Rutherford RB, Becker GJ, et al. Reporting standards for lower extremity arterial endovascular procedures. Society for Vascular Surgery/International Society for Cardiovascular Surgery. *J Vasc Surg* 1993; 17(6):1103-1107.
5. Decrinis M, Doder S, Stark G, Pilger E. A prospective evaluation of sensitivity and specificity of the ankle/brachial index in the follow-up of superficial femoral artery occlusions treated by angioplasty. *Clin Investig* 1994; 72(8):592-597.
6. Hartmann A, Gehring A, Vallbracht C, et al. Noninvasive methods in the early detection of restenosis after percutaneous transluminal angioplasty in peripheral arteries. *Cardiology* 1994; 84(1):25-32.
7. Masi PJ, Manninen HI. Impact of different patency criteria on long-term results of femoropopliteal angioplasty: analysis of 106 consecutive patients with claudication. *J Vasc Interv Radiol* 1995; 6(2):159-163.
8. Leiner T, Kessels AG, Nelemans PJ, et al. Peripheral arterial disease: comparison of color duplex US and contrast-enhanced MR angiography for diagnosis. *Radiology* 2005; 235(2):699-708.
9. Minar E, Ahmadi A, Koppensteiner R, et al. Comparison of effects of high-dose and low-dose aspirin on restenosis after femoropopliteal percutaneous transluminal angioplasty. *Circulation* 1995; 91(8):2167-2173.
10. Adriaensen ME, Kock MC, Stijnen T, et al. Peripheral arterial disease: therapeutic confidence of CT versus digital subtraction angiography and effects on additional imaging recommendations. *Radiology* 2004; 233(2):385-391.
11. Martin ML, Tay KH, Flak B, et al. Multidetector CT angiography of the aortoiliac system and lower extremities: a prospective comparison with digital subtraction angiography. *AJR* 2003; 180(4):1085-1091.
12. Rieker O, Duber C, Schmiedt W, von Zitzewitz H, Schweden F, Thelen M. Prospective comparison of CT angiography of the legs with intraarterial digital subtraction angiography. *AJR* 1996; 166(2):269-276.
13. Willmann JK, Baumert B, Schertler T, et al. Aortoiliac and lower extremity arteries assessed with 16-detector row CT angiography: prospective comparison with digital subtraction angiography. *Radiology* 2005; 236(3):1083-1093.
14. Ofer A, Nitecki SS, Linn S, et al. Multidetector CT angiography of peripheral vascular disease: a prospective comparison with intraarterial digital subtraction angiography. *AJR* 2003; 180(3):719-724.
15. Ouwendijk R, Kock MC, van Dijk LC, van Sambeek MR, Stijnen T, Hunink MG. Vessel wall calcifications at multi-detector row CT angiography in patients with peripheral arterial disease: effect on clinical utility and clinical predictors. *Radiology* 2006; 241(2):603-608.
16. Ho VB, Corse WR. MR angiography of the abdominal aorta and peripheral vessels. *Radiol Clin North Am* 2003; 41(1):115-144.

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17. Tatli S, Lipton MJ, Davison BD, Skorstad RB, Yucel EK. From the RSNA refresher courses: MR imaging of aortic and peripheral vascular disease. *Radiographics* 2003; 23 Spec No:S59-78.
18. Andreisek G, Pfammatter T, Goepfert K, et al. Peripheral arteries in diabetic patients: standard bolus-chase and time-resolved MR angiography. *Radiology* 2007; 242(2):610-620.
19. Elsmann BH, Legemate DA, van der Heijden FH, de Vos HJ, Mali WP, Eikelboom BC. Impact of ultrasonographic duplex scanning on therapeutic decision making in lower-limb arterial disease. *Br J Surg* 1995; 82(5):630-633.
20. Baum RA, Rutter CM, Sunshine JH, et al. Multicenter trial to evaluate vascular magnetic resonance angiography of the lower extremity. American College of Radiology Rapid Technology Assessment Group. *JAMA* 1995; 274(11):875-880.
21. Davis CP, Schopke WD, Seifert B, Schneider E, Pfammatter T, Debatin JF. MR angiography of patients with peripheral arterial disease before and after transluminal angioplasty. *AJR* 1997; 168(4):1027-1034.
22. Link J, Steffens JC, Brossmann J, Graessner J, Hackethal S, Heller M. Iliofemoral arterial occlusive disease: contrast-enhanced MR angiography for preinterventional evaluation and follow-up after stent placement. *Radiology* 1999; 212(2):371-377.
23. Lundin P, Svensson A, Henriksen E, et al. Imaging of aortoiliac arterial disease. Duplex ultrasound and MR angiography versus digital subtraction angiography. *Acta Radiol* 2000; 41(2):125-132.
24. Meaney JF, Ridgway JP, Chakraverty S, et al. Stepping-table gadolinium-enhanced digital subtraction MR angiography of the aorta and lower extremity arteries: preliminary experience. *Radiology* 1999; 211(1):59-67.
25. Mitsuzaki K, Yamashita Y, Sakaguchi T, Ogata I, Takahashi M, Hiai Y. Abdomen, pelvis, and extremities: diagnostic accuracy of dynamic contrast-enhanced turbo MR angiography compared with conventional angiography-initial experience. *Radiology* 2000; 216(3):909-915.
26. Nelemans PJ, Leiner T, de Vet HC, van Engelshoven JM. Peripheral arterial disease: meta-analysis of the diagnostic performance of MR angiography. *Radiology* 2000; 217(1):105-114.
27. Sueyoshi E, Sakamoto I, Matsuoka Y, et al. Aortoiliac and lower extremity arteries: comparison of three-dimensional dynamic contrast-enhanced subtraction MR angiography and conventional angiography. *Radiology* 1999; 210(3):683-688.
28. Visser K, Hunink MG. Peripheral arterial disease: gadolinium-enhanced MR angiography versus color-guided duplex US--a meta-analysis. *Radiology* 2000; 216(1):67-77.
29. Winchester PA, Lee HM, Khilnani NM, et al. Comparison of two-dimensional MR digital subtraction angiography of the lower extremity with x-ray angiography. *J Vasc Interv Radiol* 1998; 9(6):891-899; discussion 900.
30. Yucel EK, Kaufman JA, Geller SC, Waltman AC. Atherosclerotic occlusive disease of the lower extremity: prospective evaluation with two-dimensional time-of-flight MR angiography. *Radiology* 1993; 187(3):637-641.
31. Broome DR, Girguis MS, Baron PW, Cottrell AC, Kjellin I, Kirk GA. Gadodiamide-associated nephrogenic systemic fibrosis: why radiologists should be concerned. *AJR* 2007; 188(2):586-592.
32. Ersoy H, Rybicki FJ. Biochemical safety profiles of gadolinium-based extracellular contrast agents and nephrogenic systemic fibrosis. *J Magn Reson Imaging* 2007; In Press.
33. Sadowski EA, Bennett LK, Chan MR, et al. Nephrogenic systemic fibrosis: risk factors and incidence estimation. *Radiology* 2007; 243(1):148-157.
34. Miyazaki M, Sugiura S, Tateishi F, Wada H, Kassai Y, Abe H. Non-contrast-enhanced MR angiography using 3D ECG-synchronized half-Fourier fast spin echo. *J Magn Reson Imaging* 2000; 12(5):776-783.
35. Miyazaki M, Takai H, Sugiura S, Wada H, Kuwahara R, Urata J. Peripheral MR angiography: separation of arteries from veins with flow-spoiled gradient pulses in electrocardiography-triggered three-dimensional half-Fourier fast spin-echo imaging. *Radiology* 2003; 227(3):890-896.
36. Kanal E, Barkovich AJ, Bell C, et al. ACR guidance document for safe MR practices: 2007. *AJR* 2007; 188(6):1447-1474.

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