

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

Clinical Condition: Follow-up of Lower-Extremity Arterial Bypass Surgery

Variant 1: Infrainguinal vein graft. Asymptomatic patient. Surveillance.

Radiologic Procedure	Rating	Comments	RRL*
Ankle brachial index and single level pulse volume recording	9		O
US lower extremity with Doppler	8		O
MRA lower extremity without and with contrast	3		O
MRA lower extremity without contrast	2		O
CTA lower extremity with contrast	2		☼☼☼
Arteriography lower extremity	1		☼☼☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2: Infrainguinal vein graft. Pain and/or swelling and/or ischemia and/or abnormal ankle brachial index (ABI).

Radiologic Procedure	Rating	Comments	RRL*
Ankle brachial index and single level pulse volume recording	9		O
Arteriography lower extremity	9		☼☼☼
US lower extremity with Doppler	8		O
MRA lower extremity without and with contrast	8	See statement regarding contrast in text under "Anticipated Exceptions."	O
CTA lower extremity with contrast	8		☼☼☼
MRA lower extremity without contrast	5		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

FOLLOW-UP OF LOWER-EXTREMITY ARTERIAL BYPASS SURGERY

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Summary of Literature Review

Introduction/Background

Peripheral arterial occlusive disease (PAOD) affects nearly 8 million patients in the United States and up to 20% of patients in the primary care setting. Increased prevalence among older patients, diabetics, and those with end-stage renal disease is well established. This disease progresses from an asymptomatic process to claudication and then to critical limb ischemia [1]. Over the past few decades, the increasing variety of pharmacological agents and the improving efficacy of endovascular interventions for PAOD have led to fewer lower-extremity arterial bypass procedures, according to national trend studies, with comparable quality-of-life and amputation-free survival outcomes. Lower-extremity arterial bypass procedures are also used in patients who are technically unsuitable candidates for aggressive medical management or endovascular revascularization [2-5].

A lower-extremity arterial bypass is categorized by the anastomoses of the created conduit and use of autogenous vein, prosthetic graft, or biologic graft. Historically, autogenous, greater saphenous venous grafts are preferred over prosthetic or biologic grafts, particularly for below-the-knee bypass. Prosthetic grafts are the mainstay when the greater saphenous vein has been previously harvested or is currently unsuitable; biologic graft use is limited to infected fields. Studies comparing primary patency, secondary patency, and limb-salvage rates of graft materials further support the preference for autogenous bypass graft [6-9].

Bypass failure stems from the development of stenoses within or adjacent to the graft and, ultimately, thrombosis, if left uncorrected [10,11]. Although early bypass failures reflect technical errors in placement, later failures are usually due to intimal hyperplasia or the progression of underlying disease at anastomotic sites. During the first postoperative year, up to 30% of venous grafts develop stenoses [12]. There is evidence suggesting that repair of these stenoses, by either surgical or endovascular means, extends the patency of venous bypass grafts [13-18]. Moreover, patency following revision of a thrombosed vein graft is inferior to patency following revision of a stenotic graft prior to thrombosis [19].

There is strong evidence that using intraoperative, duplex ultrasound (US) during the graft reduces early graft failures [12,20]. In fact, the most sensitive predictor of subsequent graft stenosis formation is an abnormal duplex US during initial surgery [17].

Previously, postsurgical surveillance was limited to clinical observation of recurring symptoms, ABI measurement, and segmental volume recordings [21,22]. Over the past 2 decades, use of routine duplex US for asymptomatic patients following infrainguinal bypass has gained acceptance. Further imaging may be warranted for anatomic mapping prior to open surgical or endovascular intervention for dysfunctional grafts as identified by clinical symptoms or duplex US.

Digital subtraction angiography (DSA) remains the standard imaging modality reference for precise evaluation of the severity, location, and character of graft stenoses as well as evaluation of the quality of native vessels proximal and distal to the graft prior to reintervention. More recently, magnetic resonance angiography (MRA) and computer tomography angiography (CTA) have become more accepted as noninvasive imaging substitutes for DSA. These studies may be warranted prior to urgent intervention even in cases of an acutely threatened limb after bypass graft failure.

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Ultrasound

Vein graft surveillance is most commonly performed using duplex US, which has been a method of vein graft surveillance for more than 20 years [23-25].

In clinical practice, duplex US of the bypass conduit is routinely performed at the time of implantation and at regular intervals for surveillance. The technique involves the sequential study of a graft from the proximal to distal anastomosis, with measurement of peak systolic flow velocity (PSFV) and peak systolic flow velocity ratio (PSFVR), which is the ratio of peak systolic velocity to the systolic velocity in the adjacent normal segment. There is evidence to suggest that PSFVR is the most sensitive indicator of a graft stenosis [26-28]. A PSFVR of >2.0 – 2.5 is often considered representative of a significant stenosis, although some reports suggest a higher value of 3.0 – 3.5 is a more appropriate threshold for intervention. Other values that can signify a graft stenosis are a PSFV >200 cm/sec at any point in the graft or a midgraft PSFV <45 cm/sec, which may indicate high outflow resistance (suggesting progressive atherosclerosis in the runoff vessels). However, low PSFV can also be present in normal large-caliber vein grafts. Additionally, phase-sensitive US speckle tracking is being studied as a potential means for assessing local wall strain to detect neointimal hyperplasia [29].

No large, randomized, controlled trials support the use of duplex US for either autologous or prosthetic graft surveillance. Moreover, several studies have reached different conclusions. Separate publications by Ferris, Hobbs, Mofidi, and Wilson [30-33] reported that intraoperative, predischARGE, and early surveillance duplex US can detect technical problems in grafts at higher risk for future stenoses or occlusions. The Lundell et al [34] study of 165 grafts showed a significant benefit in assisted primary and secondary patency for autologous grafts at 3 years but no benefit in patency for the surveillance of prosthetic grafts. Additionally, a large, nonrandomized study of 615 bypasses found significant improvement in secondary patency and limb salvage for grafts followed by duplex US and ABI when compared with clinical surveillance alone [35].

However, other trials comparing duplex US surveillance versus clinical follow-up of lower-extremity bypass grafts have reached contrary conclusions. A multicenter prospective trial of 594 patients was randomized into a clinical or duplex US follow-up group for 18 months [36]. The primary, primary assisted, and secondary patency rates were nearly identical for both groups (69%, 76%, 80% versus 67%, 76%, 79%, respectively), but the diagnostic costs were significantly higher for the US group. The investigators concluded that using US for routine lower-extremity bypass graft surveillance showed no additional health benefit, but it incurred greater cost. Additionally, multiple authors have reported that duplex US does not enhance lower-extremity arterial bypass graft patency, particularly for prosthetic grafts [37-40].

Digital Subtracted Angiography

Although DSA remains the gold standard for diagnosing PAOD prior to reintervention, it generally plays no role in surveillance of otherwise well-functioning grafts [41,42]. Access-site hematoma, arterial dissection, and thrombosis are known local complications that result from the procedure and occur in up to 8% of patients. Serious systemic complications are also possible. These occur less frequently with increasing operator experience [43,44].

Magnetic Resonance Angiography

Contrast-enhanced MRA is a widely available and commonly used noninvasive and low-risk examination that provides a highly accurate, sensitive, and specific evaluation of the vasculature [45-53]. At present, contrast-enhanced MRA shows an increased ability to properly evaluate bypass grafts and bypass graft inflow and outflow vessels [54-58]. Studies by Reid et al [59], Bertschinger et al [60], and Meissner et al [61] confirmed excellent sensitivity and specificity with MRA use, with the latter study also detecting additional stenoses not seen on US but ultimately confirmed by DSA. Studies using high-resolution, 3-D fast-spin echo techniques have accurately measured inner volumes of bypass grafts and elucidated bypass graft layers, which can be useful in further prospective studies of graft maturation [62-64]. Additionally, new gadolinium-based contrast agents that have higher relaxivity are in development and promise an improved diagnostic performance, particularly in distal vessels [65-71].

Given the growing concerns about nephrogenic systemic fibrosis research of low-dose and nonenhanced MRA is increasing [72,73]. Preliminary studies at 3.0T, with low-dose contrast, have focused on high spatial resolution using dedicated multichannel array coils and accelerated parallel acquisition and continuous table movement with improved spatial resolution time-resolved imaging sequences [74,75]. Nonenhanced MRA techniques have used

relatively new technologies that show encouraging early results [76-79]. Further investigation of these methods is needed, particularly to improve diagnostic performance in calf and pedal vessels.

Computed Tomography Angiography

Technological improvements in multidetector CTA, [80] combined with rapid image acquisition, lower radiation doses, lower complication rates, and 3-D volumetric imaging, when compared with DSA, yielded tremendous interest in its use as a noninvasive imaging tool for evaluating PAOD and lower-extremity arterial bypass grafts. Early studies suggested CTA was a viable substitute for DSA [81-88]. Multiple studies have demonstrated the accuracy of CTA for evaluating PAOD and have shown strong concordance between CTA and DSA for establishing an accurate treatment plan [89-96]. Willman et al [97] concluded that multidetector CTA was reliable and accurate, after using duplex US to assess lower-extremity bypasses to detect graft-related complications. Note that CTA accuracy decreases in severely stenotic lesions or smaller caliber vessels, particularly in heavily calcified vessels or areas adjacent to metallic artifact [86,95,98]. However, there is a potential for dual-energy CTA to exploit elemental attenuation changes and, hence, differentiate between calcium and iodine [99-101].

The choice between CTA and MRA for evaluating clinically suspected lower-extremity bypass grafts can be difficult. Both modalities are effective substitutes for DSA in terms of physician confidence and clinical outcomes, as demonstrated by Ouwendijk et al [102,103]. However, the choice of modality is often made by a combination of availability and user expertise.

Summary

- Lower-extremity arterial bypass has been performed less frequently since the advent of effective endovascular techniques and aggressive medical management; however, it is still useful when either of these paths fail.
- Autogenous vein grafts have the highest patency rates, with the natural history of graft failure progressing from stenosis to thrombosis.
- Duplex US, ABI, and single-level pulse volume recording are adjuncts to clinical examination for the surveillance of asymptomatic grafts and can be particularly useful in suspected graft failure if prior examinations are available for comparison.
- DSA, MRA, and CTA are low-yield and unindicted examinations in an asymptomatic and otherwise well-functioning graft.
- MRA or CTA can confirm suspected abnormalities and are useful for treatment planning in cases of anticipated graft failure.
- Lower-extremity arteriography is best performed at the time of intervention.

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, $<30 \text{ mL/min/1.73m}^2$), 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 $<30 \text{ mL/min/1.73m}^2$. For more information, please see the [ACR Manual on Contrast Media](#) [104].

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
O	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

- [ACR Appropriateness Criteria® Overview](#)
- [Procedure Information](#)
- [Evidence Table](#)

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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.