

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

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

Variant 1: Infrainguinal vein graft, asymptomatic. Screening.

Radiologic Procedure	Rating	Comments	RRL*
US segmental Doppler pressures and pulse volume recordings	9		O
US lower extremity with Doppler	7	Conflicting data in the literature.	O
MRA lower extremity with contrast	3		O
CTA lower extremity with contrast	3		☢ ☢ ☢
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 graft, symptoms of ischemia and/or abnormal ABI.

Radiologic Procedure	Rating	Comments	RRL*
US segmental Doppler pressures and pulse volume recordings	9		O
US lower extremity with Doppler	9		O
Arteriography lower extremity	8		☢ ☢
MRA lower extremity with contrast	8	See statement regarding contrast in text under "Anticipated Exceptions."	O
CTA lower extremity with contrast	7		☢ ☢ ☢
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

Lower-extremity arterial bypass surgery can be broadly categorized as suprainguinal or infrainguinal and, when infrainguinal, as autologous vein or artificial graft. Postsurgical surveillance previously was limited to clinical observation of recurring symptoms, measurement of ankle-brachial indices (ABI), and segmental volume recordings [1,2]. Over the past two decades, routine duplex ultrasound (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 identified by clinical symptoms or duplex US.

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

The natural history of lower-extremity bypass graft failure is the development of stenoses within or adjacent to the graft and ultimately thrombosis, if left uncorrected [3,4]. Early failures are usually secondary to technical errors such as a retained valve or a kink in the conduit during tunneling. There is strong evidence that using intraoperative, duplex US during the creation of the graft reduces early graft failures [5,6]. In fact, the most sensitive predictor of subsequent graft stenosis formation is an abnormal duplex US during initial surgery [7]. Late

failures are usually due to intimal hyperplasia within the graft or at either anastomosis, or progression of atherosclerosis in the inflow or outflow arteries. During the first postoperative year, up to 30% of venous grafts develop stenoses [6]. There is evidence suggesting that repair of these stenoses, by either surgical or endovascular means, extends the patency of venous bypass grafts [7-12]. In addition, patency following revision of a thrombosed vein graft is inferior to patency following revision of a stenotic graft prior to thrombosis.

Ultrasound

Duplex US has been used as a method of vein graft surveillance for more than 20 years [13-15]. 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), the ratio of PSV 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 [16-18]. A PSFVR of >2.0-2.5 is often considered representative of a significant stenosis, although there are reports suggesting a higher value of 3.0-3.5 as a more appropriate threshold for intervention. Other values that may 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 seen in normal large-caliber vein grafts.

Despite the long-term use of duplex US for routine surveillance of lower-extremity bypass grafts, there are no large, randomized controlled trials available supporting US surveillance. Trials comparing duplex US surveillance versus clinical follow-up of lower-extremity bypass grafts have come to different conclusions. A study by Ihlberg et al [19] showed no difference in assisted primary or secondary patency for 185 vein grafts at 1 year. A study of 165 grafts by Lundell et al [20] did show a significant benefit in assisted primary and secondary patency for vein grafts at 3 years, but no benefit in patency for the surveillance of polytetrafluoroethylene (PTFE) grafts. A large, nonrandomized study of 615 bypasses found significant improvement in secondary patency and limb salvage for grafts followed by duplex US and ABI compared to clinical surveillance alone [21].

A recent multicenter prospective randomized control trial of 594 patients offered strong evidence to the contrary [22]. This study randomized patients into a clinical or duplex US follow-up group for 18 months. The primary, primary assisted, and secondary patency rates were nearly identical for both groups (69%, 76%, 80% versus 67%, 76%, 79%), but the diagnostic costs were significantly higher in the US group. The investigators concluded that routine lower-extremity bypass graft surveillance with US showed no additional health benefit but incurred greater cost.

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Digital Subtracted Angiography

Prior to reintervention in a bypass graft, interventionalists and surgeons need accurate anatomic mapping of not only the graft but also the native inflow and outflow arteries [23,24]. Selective DSA has remained the gold standard for this purpose, but it carries inherent risks due to the invasive nature of the procedure.

Magnetic Resonance Angiography

In recent years, MRA, specifically 3D contrast-enhanced MRA, has shown increasing ability to properly evaluate inflow and outflow vessels as well as bypass grafts [25-28]. Studies by Reid et al [29] and Bertschinger et al [30] confirmed excellent sensitivity and specificity with MRA. Meissner et al [31] not only confirmed excellent image quality with MRA but also detected four additional high-grade stenoses not seen on US and confirmed with DSA.

In addition to the regular MRA contraindications, artifacts from metallic clips and stents, as well as venous contamination can limit its utility for evaluating bypass grafts. New MRA techniques using dedicated calf and foot imaging and time-resolved MRA have improved the diagnostic performance of this modality [32-34]. Use of these state-of-the-art techniques will depend on the availability of local equipment and expertise.

Computed Tomography Angiography

Multidetector computed tomography (MDCT) angiography has gained tremendous momentum as a noninvasive imaging tool for evaluating peripheral atherosclerotic occlusive disease (PAOD), as well as lower-extremity bypass grafts, prior to reintervention. Early studies have suggested that CTA would be a viable substitute for DSA, but large randomized controlled trials are not available [35-41]. Studies by Scherthaner et al [42], Albrecht et al [43] and Ota et al [44] demonstrated the accuracy of CTA for evaluating PAOD, as well as strong concordance between CTA and DSA for establishing an accurate treatment plan. A randomized controlled trial comparing CTA (4-slice) to DSA demonstrated slightly lower physician confidence in CTA, but there were no significant differences in quality-of-life measures and outcomes, and CTA was significantly less expensive [45].

As MDCT has evolved, image quality has improved significantly with submillimeter z-axis resolution and isotropic data sets. A prospective randomized trial by Willmann et al [46] confirmed this when comparing CTA (16-detector) to DSA. They reported CTA sensitivity of 96% and specificity of 97%, including identical sensitivity and specificity when evaluating the small infrapopliteal runoff vessels at a much lower radiation dose than DSA causes.

The choice of CTA or MRA for evaluating clinically suspect lower-extremity bypass grafts can be difficult. Both modalities have proved to be an effective substitute for DSA in the evaluation of PAOD and bypass graft analysis. Ouwendijk et al [47,48] performed two randomized controlled trials comparing CTA and MRA.

Physician confidence was similar between modalities, clinical outcomes were similar, but MRA was more expensive.

Summary

- Routine duplex US surveillance of lower-extremity bypass grafts has not been shown to improve the long-term patency of the grafts in a recent large randomized controlled trial [22].
- Many vascular surgeons continue to routinely image the grafts along with clinical examination and noninvasive testing (US segmental Doppler pressures and pulse recordings), until further evidence is available. When there is suspicion that a graft is at risk for failure and ultimately occlusion, endovascular or surgical intervention should be planned based on accurate anatomic mapping of the graft and the native inflow and outflow arteries.
- DSA has been and remains the gold standard, but there are downsides, including invasive risks, higher radiation dose, and cost.
- MRA and CTA have proven themselves to be equally accurate for evaluating bypass grafts at risk for failure, as well as progressive native vessel peripheral vascular disease. The choice between MRA and CTA will often be based on whether local expertise with MRA is available, as CTA is technically a more simple examination to perform.

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](#) [49].

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 NS (not specified).		

Supporting Document(s)

- [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.