Techniques in
Vascular and
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CT Angiography of Lower Extremity Vascular Bypass Grafts

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Over the past several years computed tomography (CT) technology has advanced to such a degree that CT angiography (CTA) has become the study of choice at our institution for imaging lower extremity vascular bypass grafts. CTA quickly provides anatomic information about the state of the graft and identifies virtually all forms of bypass graft failure and related complications. Furthermore, detailed vascular anatomy is seen beyond the graft and affords sufficient anatomic detail for surgical revision without the need for other angiographic studies. Although catheter angiography, duplex-ultrasound, magnetic resonance angiography, and nuclear medicine studies all continue to play some role in the evaluation of vascular grafts, they are more often used as problem solving modalities when CTA findings are equivocal. Whereas it was once essential to catheterize directly through a failing bypass graft or pass catheters into the graft from a distant arterial puncture to obtain an angiogram of a failing bypass graft, CTA produces arteriograms with only intravenous contrast administration, a brief visit to the CT scanner, and return to daily activities without catheterization, discomfort, or risk to the bypass conduit.
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There are two main types of bypass grafts: Inflow and outflow. Inflow grafts supply blood to the common femoral artery level, bypassing occlusions, or aneurysms of the distal aorta and iliac arteries. These grafts may start from the axillary artery, so an understanding of the type of graft is essential before defining the region to be scanned. Outflow grafts carry blood from the femoral artery level to the popliteal, tibial, or pedal arteries and are usually placed to treat femoral, popliteal, and/or tibial artery injury or occlusion, as well as popliteal artery aneurysms.

Technique

The technique for obtaining optimal CTA images of bypass grafts is similar to other CTA techniques and requires some degree of customization based on anatomic considerations and vascular anatomy. A typical study does not usually require initial noncontrast enhanced imaging, though on occasion this may be useful or necessary. The study is tailored to the location of the bypass graft. Inflow (aortoiliac) bypass graft studies should include the origin of the renal arteries, typically located inferior to the vertebral body of T12, and extend inferiorly through the pelvis to the mid-thighs. If the patient has an axillo-femoral bypass graft then one would start acquiring images from the level of the thoracic inlet to the thighs. Outflow bypass grafts are usually studied with complete imaging from the renal arteries to the feet, because stenoses or occlusions of the aortoiliac arterial segments may compromise outflow graft flow and jeopardize graft patency.

There are various ways to determine the time between contrast administration and commencement of the scan, but we usually use dynamic bolus timing, selecting a region of interest (ROI) such as the abdominal aorta or the common femoral artery, and "watch" the rise in Hounsfield Units to determine the start of image acquisition. It may be important to examine the patient and assess the femoral pulse before selecting the ROI, because absence of a palpable pulse at the common femoral level may indicate occlusion of the distal aorta, iliac artery, or common femoral artery and enhancement may occur late or it may never occur at the common femoral artery level.

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When the femoral pulse is absent, timing of contrast arrival to the aorta at the level of the renal arteries should probably be followed with some additional delay to allow filling of all pelvic collaterals as well as the outflow vessels before scanning is performed. A somewhat prolonged delay will ensure that important distal revascularization anatomy will not be overlooked.

We typically image with collimation somewhere between 1.25 to 3.0 mm, using reconstructed spacing with 20 to 50% overlap. On occasion, thinner collimation is used, especially when outflow bypass grafts are being evaluated for distal stenosis. However, when extensive vascular territories are imaged, such as a patient with an axillo-femoral and femoro-popliteal bypass, the size of the image data set may be too large to postprocess on a three-dimensional (3D) workstation. In these cases, thicker collimation or less overlap of the data may afford a smaller data set, sacrificing only a minor degree of resolution. Alternatively, scans can be performed in two separate acquisitions or partitioned into two data sets after one acquisition. Regardless of the details of scanning technique, the fundamental rule in CTA is that the final study is only as good as the initial helical data set, and this "source" data must have adequate contrast enhancement and cover all vascular anatomy without interruption.

All acquired image data are sent to a 3D workstation and evaluated predominately using planar reformations and VRT. Most diagnostic information is actually gained from review of the axial data set, though curved planar reconstructions through areas of tortuosity or stenosis are very useful. Volume-rendered 3D images are useful for depicting anatomy that may be confusing on planar reforma-

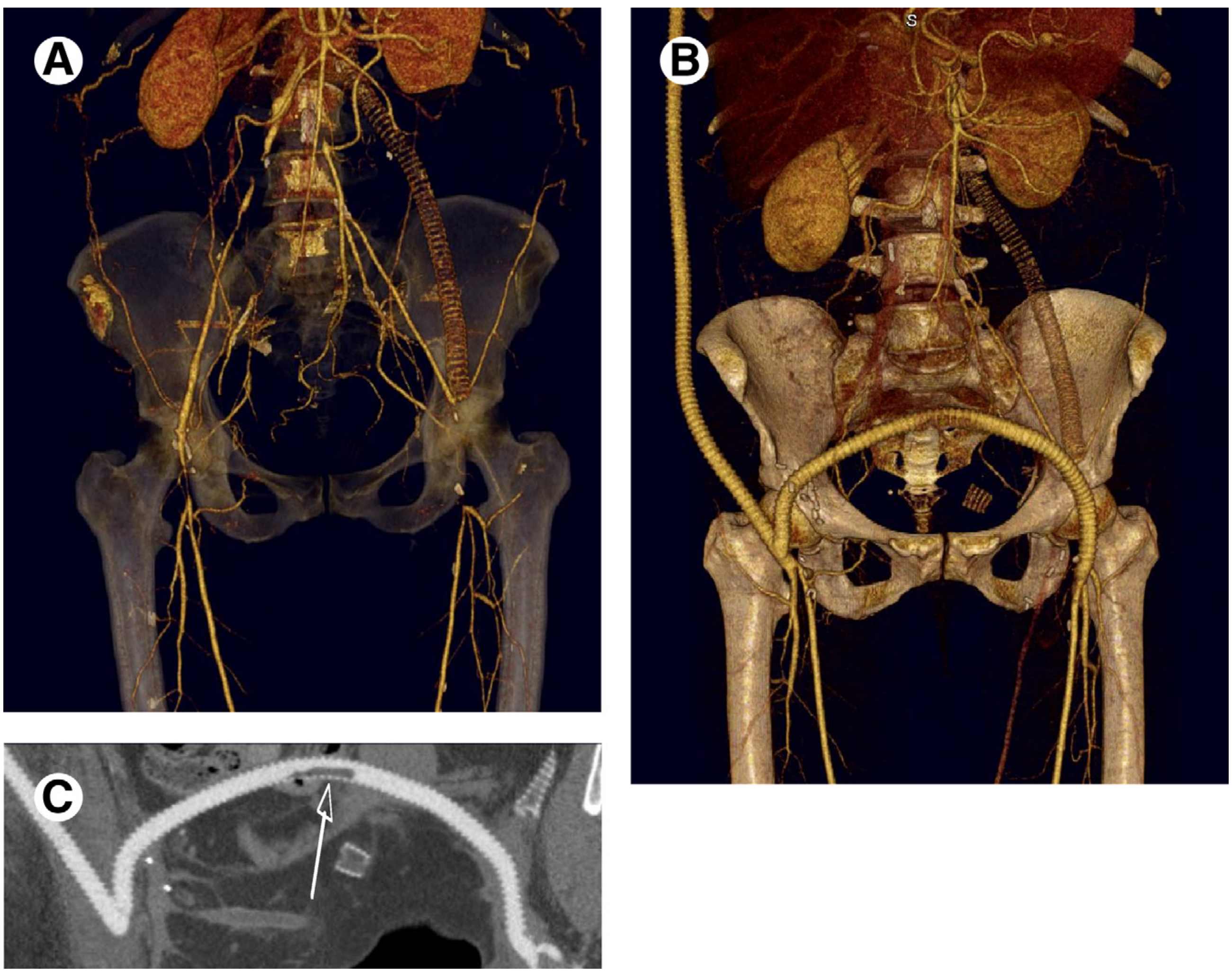

Figure 1 (A–C) Preoperative and postoperative CTA in a claudicant, showing anatomic details that guided surgery, diagnosed postoperative anatomic complication, and guided redo surgery. (A) Preoperative CTA volume rendered technique (VRT) image showing occlusion of the aorto-left femoral bypass graft and occluded left-to-right cross-femoral bypass graft, with various occluded and stenotic target vessels of note for re-do bypass grafting. (B) Postoperative VRT image of the right axillo-femoral and right-to-left cross-femoral bypass graft, demonstrating that the graft is anastomosed to the appropriate patent arteries. (C) Curved planar reformation (CPR) showing that the cross-femoral BPG has been tunneled through the small bowel, and there is intraluminal thrombus (arrow) as the graft passes through the bowel. (Color version of figure is available online.)