# CTA Runoff

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In my hospital, computed tomographic angiography (CTA) using 64-slice scanners has completely replaced conventional angiography as the initial diagnostic imaging test of choice for patients with peripheral vascular disease. Currently, conventional angiography is performed concurrently with treatment or, in rare patients in whom cross-sectional imaging presents with equivocal findings, in the face of strong clinical suspicion.

## TECHNIQUE

### Image Acquisition

All studies are done on a 64-slice scanner (Brilliance, Philips Medical Systems, The Netherlands). Oral contrast is not administered. Typical scanning parameters are:

- 0.9-mm slice thickness
- 0.9-mm slice interval
- 120 kVp and 200 to 250 mA
- collimation $64 \times 0.625$
- pitch 0.735
- rotation time 0.75 seconds
- field of view 450

Initial unenhanced images are obtained from diaphragm through feet and reconstructed in 2-mm axial contiguous slices. Nonionic contrast (120 cc of Omnipaque 350 or 100 cc of Visipaque 120) is then administered at a rate of 4 to 5 cc/s through a large-bore intravenous (IV) line. Using bolus tracking software to determine an appropriate delay, an arterially weighted study is obtained from the diaphragm through the feet and again reconstructed in 2-mm axial contiguous slices. Finally, a 2-minute delayed image is obtained from the knees to the feet and reconstructed using 2-mm contiguous axial slices. Coronal multiplanar reconstructions are automatically performed on all our computed tomography (CT) studies using 10 collimation.

### Postprocessing

After initial image acquisition, a dedicated vascular technologist performs reconstructions. Each reconstruction is typically displayed at one of three levels: abdomen and pelvis, thighs, and calves. Three-dimensional (3D) shaded surface 3D reconstructions (with and without bone subtraction) and coronal maximal intensity projections are grouped as a series at each level and displayed as a cineloop, which is rotated on the vertical axis.

## INTERPRETATION

### Normal Anatomy

#### INFLOW

The inflow arteries include the abdominal aorta, common iliac arteries, and external iliac arteries. Proximal disease often affects the aortic bifurcation, which includes the distal abdominal aorta and both common iliac arteries.

#### OUTFLOW

The arteries of the leg that should be evaluated and commented on are: common femoral artery, superficial femoral artery (SFA), profunda femoris or deep femoral artery, popliteal artery, anterior tibial (AT) artery, posterior tibial (PT) artery, and peroneal artery (Fig. 1). A "true" infrapopliteal trifurcation is rare. Typically, the AT artery arises first followed by the bifurcation of the PT-peroneal trunk. If possible, the dorsalis pedis (continuation of the AT artery at the ankle) and pedal portion of the PT artery should be evaluated.

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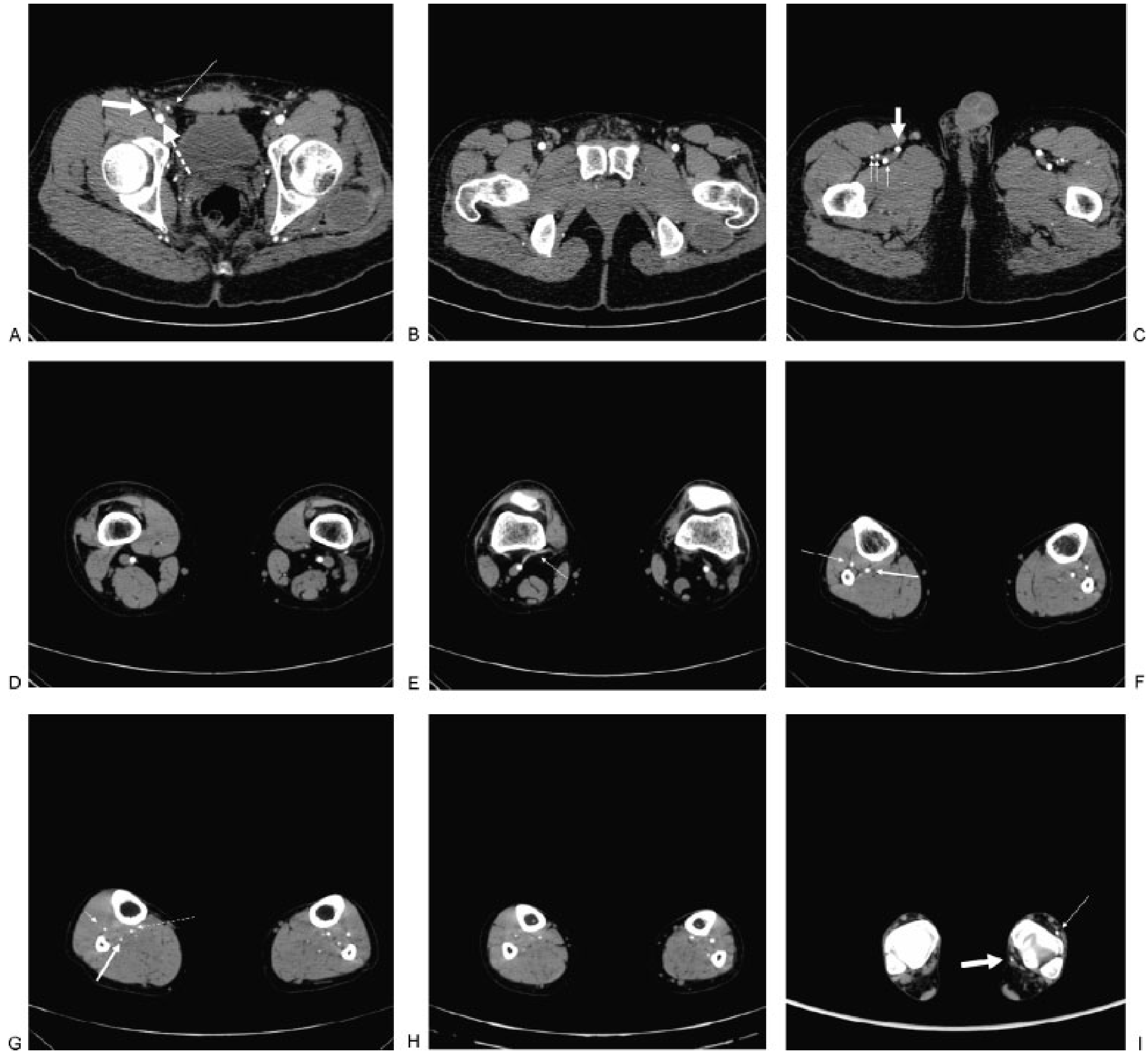


**Figure 1** Axial arterial-weighted computed tomography images of normal arterial anatomy of leg. (A) Level of the upper common femoral artery in groin shows deep circumflex iliac artery (large arrow), inferior epigastric artery (small arrow), and common femoral artery (dashed arrow). (B) Level of lower common femoral artery in groin is shown. (C) Level of common femoral artery bifurcation in upper thigh shows branches of deep (profunda femoris) femoral artery (small arrows) and superficial femoral artery (large arrow). (D) Level of popliteal artery at the distal femur is shown. Note close approximation of popliteal artery (enhanced) and vein (unenhanced). (E) Level of popliteal artery at tibial plateau is shown. Note geniculate collateral artery (arrow). (F) Level of the trifurcation shows anterior tibial (AT) artery (small arrow) and peroneal–posterior tibial (PT) trunk (large arrow). (G) Level of trifurcation vessels in upper calf shows AT artery (small arrow), peroneal artery (large arrow), and PT artery (dashed arrow). (H) Level of trifurcation vessels in lower calf is shown. (I) Level of the ankle mortis shows PT artery (large arrow) and dorsalis pedis artery (continuation of AT artery) (small arrow).

It is critical to know the exact expected location of each artery on an axial image. It is common to have one or two of the calf arteries occluded. Thus it is imperative to correctly identify the remaining patent arteries (which may be the target vessel in a distal bypass surgery). This is not straightforward (even for an interventional radiologist who has performed countless conventional angiograms of the legs) unless the normal cross-sectional anatomy is committed to memory. Collateral vessels are easily mistaken for the tibial or peroneal arteries on an axial image unless the normal anatomy is understood. Sagittal and/or coronal reformatted images provide a rapid overview of the relevant anatomy (Fig. 2). It is important to remember that the peroneal artery has communicating branches to the dorsalis pedis and pedal PT artery above the ankle mortis, which commonly provide collateral flow in the event of disease to either the AT or PT arteries.

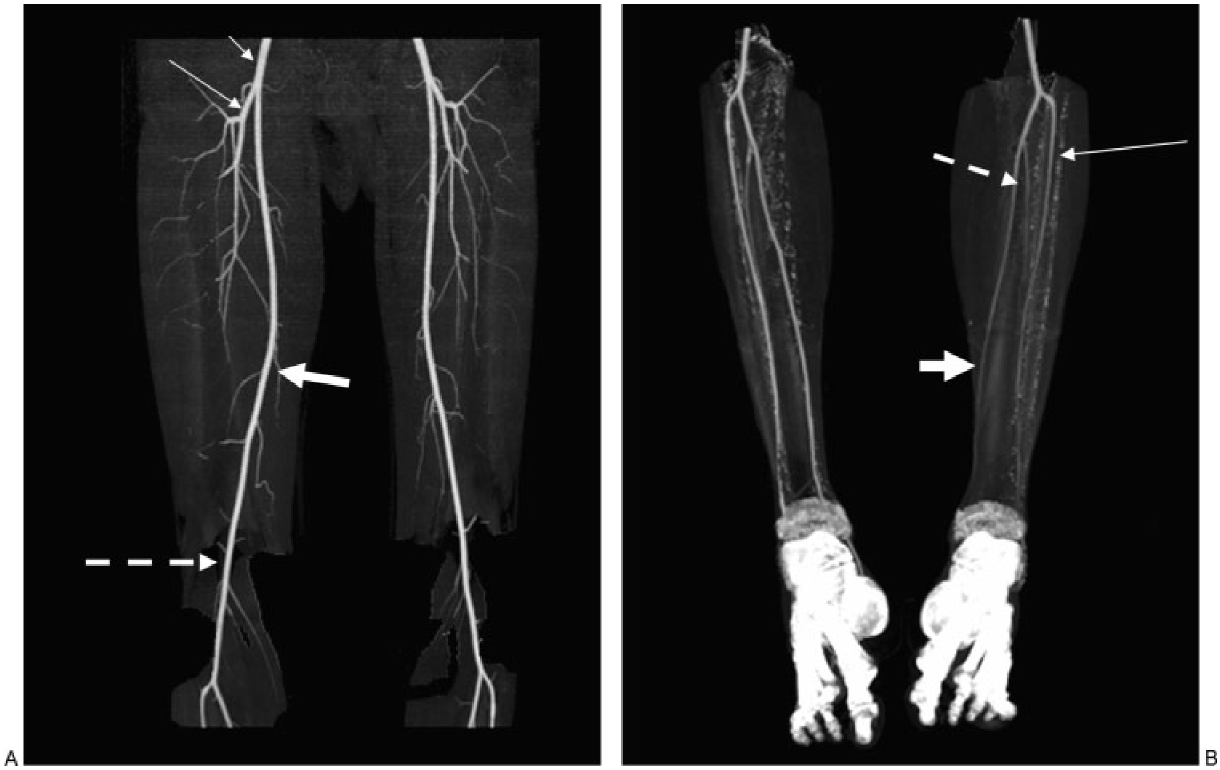


**Figure 2** Coronal maximum intensity projection images of normal arterial anatomy in the leg. (A) Level of the thigh and knees shows common femoral artery (short small arrow), deep femoral artery (long small arrow), superficial femoral artery (large arrow), and popliteal artery (dashed arrow). (B) Level of the calves shows anterior tibial artery (small arrow), posterior tibial artery (large arrow), and peroneal artery (dashed arrow).

## Abnormal Anatomy

### CHRONIC LIMB ISCHEMIA

The vast majority of runoff CTAs are done for patients with chronic limb ischemia. Typically, these patients have lifestyle-limiting claudication or limb-threatening ischemia (rest pain and/or tissue loss). Because atherosclerosis may affect every artery in the body, we evaluate the abdominal aorta, visceral arteries, pelvis, and legs in our CTA runoff protocols. As noted previously, by convention, stenoses of the arteries above the inguinal ligament are termed “inflow” disease (Fig. 3), whereas stenoses below the inguinal ligament are termed “outflow” disease (Fig. 4). Many patients have disease in both territories.

### UNENHANCED IMAGES

Unenhanced images are helpful to evaluate calcific atherosclerosis, which is common in diabetics and those with end-stage renal disease. Severely calcified arteries are very difficult to evaluate using CTA because the calcifications mask lesions on postenhanced arterial-weighted images. Patients with severely calcified arteries are better evaluated using magnetic resonance imaging or conventional angiography. Similar to calcifications, arterial stents may be difficult to appreciate on arterial-weighted axial images and are shown to best advantage on unenhanced images.

### ARTERIALLY WEIGHTED IMAGES

Arterial-weighted axial images are the most valuable in terms of diagnosis, although coronal maximum intensity projections (MIPs) are very helpful to garner an overview of disease and can demonstrate focal stenoses that are easily overlooked when scrolling through a stack of axial images. When I interpret axial images, I evaluate each leg sequentially and scroll through the entire slab following the course of the SFA, popliteal artery, and trifurcation arteries (AT, PT, peroneal). It is critical to be facile with the anatomy of the arteries below the knee—in occlusive disease, collateral vessels can easily be mistaken for trifurcation vessels.

### ARTERIAL RECONSTRUCTIONS

I find coronal MIPs most valuable in depicting arterial anatomy, and they are especially helpful to depict the infrainguinal vessels. These images provide a rapid overall image familiar to most interventional radiologists. One common pitfall of MIPs involves the AT artery. Because the distal portion of this vessel normally runs in close contiguity to the tibia, the use of bone subtraction algorithms may “subtract” a normal patent artery. Thus,

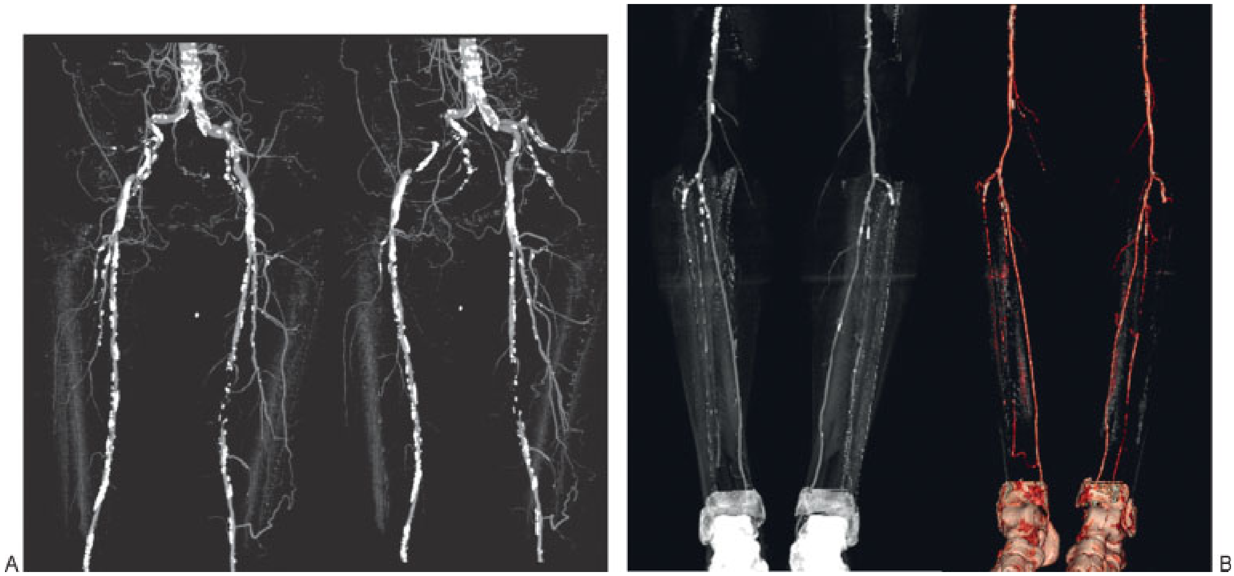

**Figure 3** Computed tomographic angiography of 68-year-old diabetic woman with claudication due to inflow disease. (A) Maximal intensity projections of the pelvis and thighs show occlusion of the right external iliac artery and left superficial femoral artery. Note heavy calcification of all visualized arteries. (B) Maximal intensity projection (right) and shaded surface reconstruction of the calves (left) show single vessel runoff bilaterally via the posterior tibial arteries.

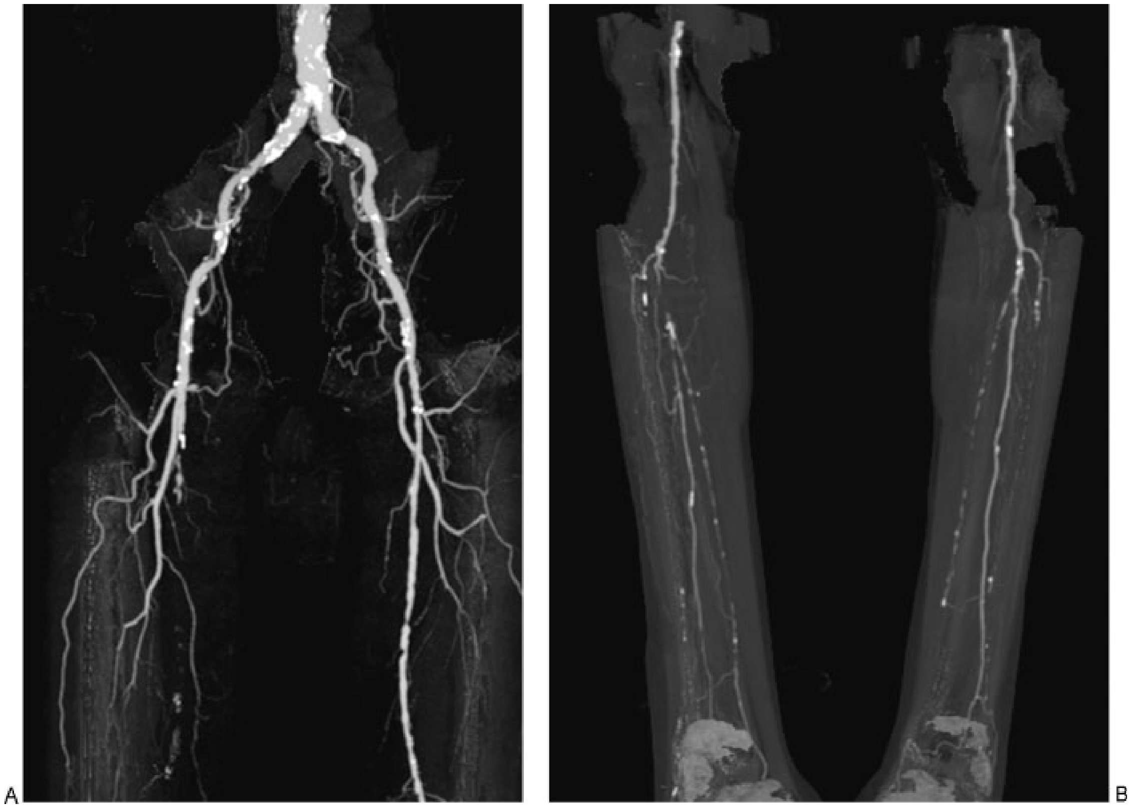

**Figure 4** Computed tomographic angiography of 63-year-old man with right lower extremity rest pain due to outflow disease. (A) Maximal intensity projection image of the pelvis and thighs shows mild stenoses of the right common iliac and external iliac arteries with occlusion of the right superficial femoral artery. Multiple high-grade stenoses of the left superficial femoral artery are also noted. (B) Maximal intensity projection image of the calves show occlusion of the right posterior tibial (PT)–peroneal artery trunk with runoff via a reconstituted diseased peroneal artery. The PT artery is reconstituted at the ankle mortise by the communicating branch of the peroneal artery. Single-vessel runoff to the left foot is via a continuous but proximally diseased peroneal artery.

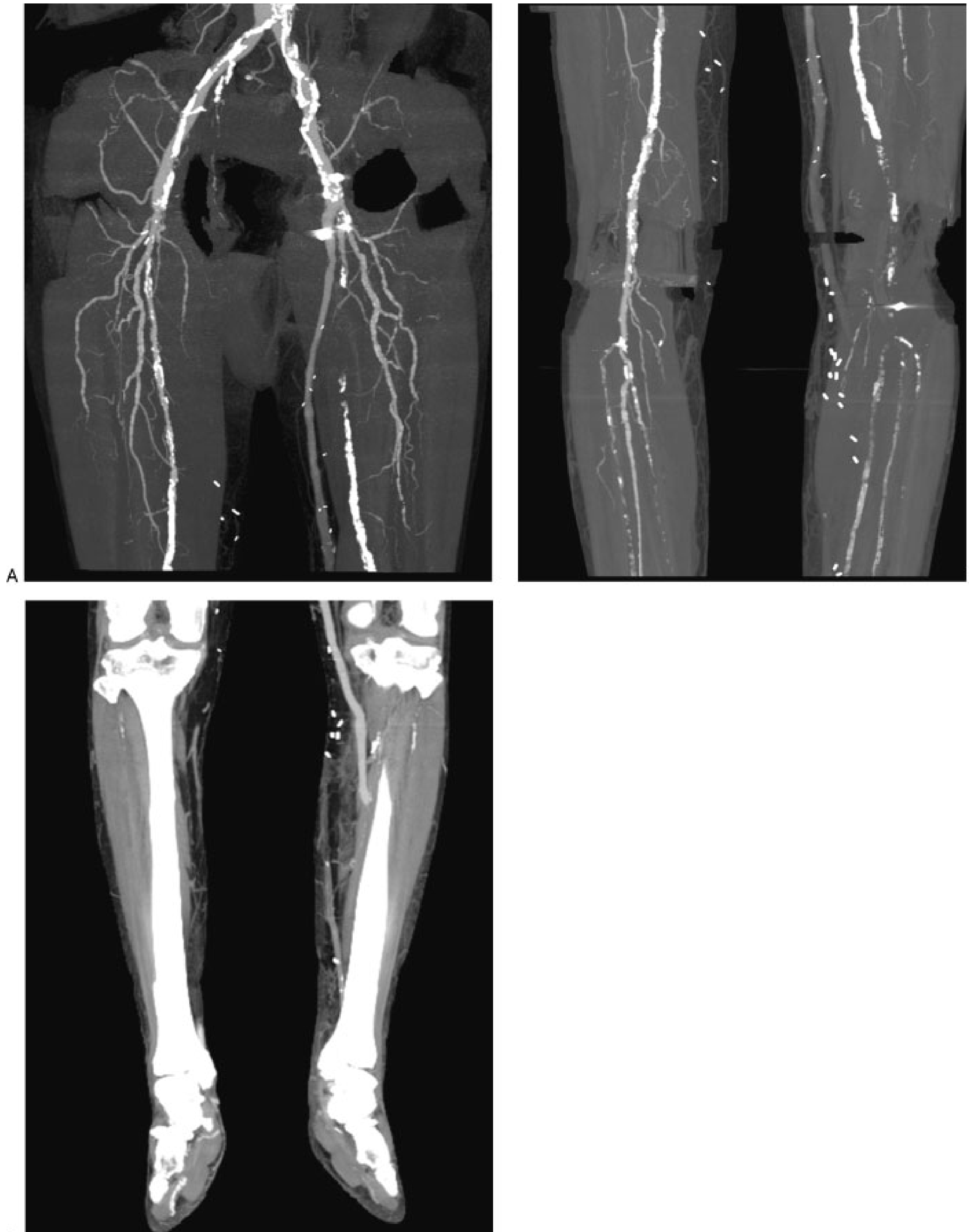


**Figure 5** A 70-year-old woman with left femoral–to–posterior tibial (PT) artery bypass graft and left foot rest pain. (A) Maximal intensity projection image of the pelvis and thighs shows severely calcified arteries and patency of proximal left femoral bypass graft. Left superficial femoral artery is occluded. (B) Maximal intensity projection image performed in arterial phase of study of the calves shows occlusion of the left popliteal artery and visualized portions of all three trifurcation vessels. Note bypass graft composed of vein in soft tissues in medial left thigh and calf. Slow flow in the graft results in poor opacification. (C) Maximal intensity projection image performed in venous phase of study of the calves shows bypass is patent to ''blind'' ending PT artery. Axial venous weighted image of the calves (not shown) demonstrated severely calcified infrapopliteal arteries in the right leg and patent distal bypass graft in the left leg.

lesions in this area must be confirmed on axial images. Shaded surface reconstructions may also be valuable but should be scrutinized carefully. Calcification in occluded vessels may give the false impression of vessel patency.

### OCCLUSIVE DISEASE

If the SFA is occluded, I evaluate the profunda femoris because it is the primary outflow to the leg. In terms of surgical or endovascular planning, it is important to note the level of occlusion and what vessels are "reconstituted" via collaterals to the feet. Lower extremity bypass grafts are typically performed from the common femoral artery to the above-the-knee popliteal artery, below-the-knee popliteal artery, or to one of the trifurcation arteries ("femoral-to-distal bypass"). The vessel chosen is typically the most robust with uninterrupted flow to the foot (Fig. 5).