Assessment of lower-extremity arterial inflow and outflow is among the most challenging applications of computed tomographic angiography (CTA). This article will discuss the techniques used in multidetector CT (MDCT) examinations of the lower extremities, including patient preparation, the CT acquisition itself, the use of contrast medium, and data processing.

Patient preparation
Almost any type of MDCT scanner, from 4- to 64-row, can be used for performing CTA of the lower extremities. A key step in patient preparation is stabilization of the legs near the isocenter of the scanner. For lower-extremity studies, the patient enters the scanner feet first. We use laser-guided techniques to ensure proper positioning. We also tape the knees and feet together. If the knees were to move apart from one another during data acquisition, it would be necessary to open the field-of-view in the reconstruction in order to include the proximal anterior tibial arteries, and in-plane resolution would be lost. To keep the tape from sticking to the skin, we wrap a pillowcase, sheet, or towel around the patient first. If we need to study only 1 lower extremity, we put the patient in the scanner asymmetrically in order to position that extremity as close to the isocenter as possible.

We do not place a pillow under the patient’s knees, as this position would cause the vessels to rise and fall relative to the table as the table moved through the scanner, creating problems in the reconstruction field-of-view.

We use a 20-gauge intravenous catheter to deliver nonionic, iodinated contrast medium. The entire examination takes approximately 20 minutes to complete. During image interpretation, 3-dimensional (3D) visualization is essential, including volume renderings, maximum-intensity projections (MIPs), and curved planar reformations (CPRs).

CT acquisition
The scan range is from the celiac artery to the toes (105 to 130 cm) in almost all cases. Such full anatomic coverage is particularly necessary in patients with athero-sclerotic occlusive disease. More limited distal coverage, from the knees to the toes (40 to 60 cm), may be sufficient prior to reconstructive surgery.

Table 1 describes the detector configurations available for full anatomic coverage on 4-, 8-, and 16- to 64-row scanners. Generally, we select a pitch of approximately 1.5. As will be discussed later, when using a scanner with more than 16 detector rows, we typically select a pitch of approximately 1.0.

For each type of scanner, there are a number of scan modes available; however, we usually find that only one is acceptable. With a 4-row scanner, we use a 2.5- to 3.0-mm slice thickness. A 1.0- to 1.5-mm acquisition is too slow to cover the necessary anatomic range. With an 8-row scanner, we seldom use a detector collimation of 2.5 to 3.0 mm. A higher-resolution alternative, 1.0 to 1.5 mm, is available. With a 16- to 64-row scanner, we also use a 1.0- to 1.5-mm slice thickness, as the 0.5- to 0.75-mm sections have a substantial amount of image noise, particularly in the abdomen and the pelvis.

Exclusively, distal anatomic coverage enables the use of thinner sections in...
many cases. With a 4-row scanner, we are able to scan with a detector collimation of 1.0 to 1.5 mm, because the scan time is only about 30 to 40 seconds. With an 8-row scanner, section width remains 1.0 to 1.5 mm. With a 16- to 64-row scanner, we can take advantage of submillimeter section thicknesses (0.5 to 0.75 mm), as image noise is less of an issue in the legs than in the abdomen.

CT angiography of the lower extremities can be performed very effectively, even on early-generation MDCT scanners. Figure 1 shows a 4-row CT scan of a patient with severe claudication and no femoral pulses. Based on this scan, the patient underwent successful aortobiliac and left femoral-popliteal bypass grafting without the need for additional presurgical imaging.

The 4-row CT scan reveals occlusion of the aorta and proximal common iliac arteries. Extensive collateralization providing blood supply to the legs is visualized, including a tiny cross-collateral going under the interosseous membrane between the tibia and fibula to reconstitute the distal anterior tibial artery.

With more advanced CT scanners, visualization improves as a result of higher spatial resolution. Section thicknesses of 1.0 to 1.5 mm improve the crispness of the vessels, and the collaterals are visualized a bit better. In general, however, the study provides no more diagnostic information than a study acquired on a 4-row scanner. Sixteen-row scanners enable visualization of substantially more detail in the pedal vessels, both frontally and on the plantar aspect of the foot (Figure 2).

**FIGURE 1.** Maximum-intensity projections of a patient with severe claudication and no femoral pulses. (A) Anteroposterior and (B) left lateral images are shown. The scan, acquired on a 4-row CT scanner, demonstrates occlusion of the aorta, proximal common iliac arteries, left superficial femoral artery, and right anterior tibial artery. Extensive collateralization allows blood supply to the legs through the inferior epigastric arteries. Collaterals from the intercostal and lumbar arteries as well as from the large inferior mesenteric artery supply the deep lateral circumflex iliac arteries. A well-developed collateral network reconstitutes the distal superficial femoral artery. The peroneal artery appears to reconstitute the dorsalis pedis. The lateral projection shows a tiny cross-collateral going under the interosseous membrane between the tibia and fibula, reconstituting the distal anterior tibial artery. (Figure reprinted with permission from 1. Rubin GD, Schmidt AJ, Logan LJ, Sofilos MC. Multi-detector row CT angiography of lower extremity arterial inflow and runoff: Initial experience. Radiology. 2001;221:146-158.)
Contrast medium

The success of CTA often depends on achieving adequate opacification and visualization of small vessels—a challenge, given that the lower extremities encompass such a long anatomic territory.

At Stanford, we conducted a study of 89 patients who underwent contrast-enhanced peripheral runoff studies using 4-, 8-, and 16-row MDCT scanners (Table 2). One of the most striking trends is the substantial reduction in scan times with each new generation of scanner, from 70 seconds with a 4-row scanner to 22 seconds with a 16-row scanner.

The reduction in scan time has had an enormous impact on the delivery of contrast medium. Take, for example, the concentration of contrast medium. Initially, with 4-row scanners, we used contrast medium with a concentration of 300 mgI/mL. Since the introduction of the 8-row scanner, we have migrated to a higher-concentration contrast medium (350 mgI/mL) for use with shorter studies.

<table>
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<th>Table 2. Peripheral runoff studies (n = 89)</th>
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<td><strong>Scanner</strong></td>
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<td>Attenuation (HU)</td>
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<td>Contrast efficiency (HU/gI•mm)</td>
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Data collected by Alessandro Napoli, MD.

<table>
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<th>Table 3. Influence of contrast flow rates on image acquisition</th>
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<td><strong>Blood flow (mm/sec)</strong></td>
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<td>65</td>
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Data collected by Dominik Fleischmann, MD.
Contrast use in CTA applications.

Contrast efficiency, defined as the degree of opacification per gram of iodine delivered per millimeter of coverage. Contrast efficiency improves further with the 16-row scanner. Average attenuation drops, however, because there is less time for the contrast bolus to fully develop and opacify the vessels.

For all of their advantages, fast scan acquisitions can complicate contrast delivery. The greatest challenge is the marked variability in physiology from one patient to another, particularly in the flow rate from the aorta to the feet.

A study at our institution by Dominik Fleischmann, MD, examined peripheral arterial enhancement in 20 patients with substantial peripheral arterial occlusive disease (Fontaine class IIb and III/IV). After injecting a 16-mL contrast bolus at 4 mL/sec, he measured a time-attenuation curve to determine peak contrast transit time. He observed aortic contrast transit times of 14 to 28 seconds, with a mean of 20 seconds—typical findings for aortic CTA.

To measure the contrast transit time between the aorta and the popliteal artery, Dr. Fleischmann injected a second contrast bolus and documented its arrival in the popliteal artery. The data are striking. The aortopopliteal transit time averaged 10 seconds, representing an average contrast flow rate of 65 mm/sec. There was substantial variability among patients, however, with a minimum of 4 seconds (177 mm/sec) and a maximum of 24 seconds (30 mm/sec)—almost a 6-fold difference.

Furthermore, there was no correlation between the contrast flow rate and the clinical stage of disease. Since contrast transit times are predictable only by direct measurement, and since it is impractical to measure aortopopliteal transit time in each patient, we are faced with a significant challenge in
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developing scan protocols that produce consistently good results in all patients.

Clearly, we cannot follow the general trend in CT angiography, compensating for shorter scan times by reducing the duration of the contrast bolus and increasing the rate of injection. That approach would result in missing the contrast bolus during data acquisition in many patients.

Instead, it is helpful to consider scan protocols as falling into 2 categories—slow scans and fast scans. We can then overlay what we have learned about aortoiliac transit times in patients with peripheral arterial occlusive disease.

As shown in Table 3, with a slow-scan protocol (detector collimation: 4 × 2.5 mm, 8 × 1.25 mm, or 16 × 0.625 mm), table speed is 30 mm/sec. The time it takes to scan from the aorta to the ankle, or a distance of about 1200 mm, is 40 seconds. In a patient with a low blood flow rate (30 mm/sec), contrast flows in lockstep with the table speed. In a patient with an average blood flow rate; however, contrast flow from the aorta to the ankle outpaces the table speed. The contrast bolus must be at least 22 seconds long to ensure that opacification is still adequate as the foot is being scanned. In a patient with fast blood flow (177 mm/sec), the contrast bolus must be at least 33 seconds long.

With a fast-scan protocol (detector collimation: 8 × 2.5 mm or 16 × 1.25 mm), the time it takes to scan from aorta to ankle is only 20 seconds. In a patient with slow blood flow, the scanner can outrun the contrast bolus, rather than lag behind it. In such cases, it is necessary to wait 20 seconds after contrast arrival in the aorta to begin the scan, so that the vessels of the feet are opacified at the time of data acquisition. With this approach, we image the tail of the bolus in the abdomen and the head of the bolus in the feet.

With a 64-row scanner, the table speed is even faster, reaching >130 mm/sec. This means that an aortic runoff study would take <10 seconds. At first, this sounds appealing, but in reality, it is almost impossible to achieve adequate opacification of distal vessels with a 10-second bolus. The scanner will almost certainly outrun the contrast bolus.

At Stanford, we use either a 16- or a 64-row MDCT scanner to image the lower extremities. We reduce the pitch to approximately 1.0, and we increase the gantry rotation time to 0.6 to 0.8 seconds, rather than 0.33-second minimum, in order to slow the scan and improve the contrast-to-noise ratio (Table 4). We use 350 mgI/mL contrast medium, delivering a total volume of 100 to 180 mL, depending on the patient’s weight. (Patients who receive the largest dose typically weigh >300 pounds.) We inject contrast medium at 4 to 5 mL/sec. Most important, in all cases, the scan is automatically

FIGURE 4. A second-phase scan from the knees to the toes, 20 seconds after the first, yields excellent visualization of the pedal vessels. This scan was done on a 64-row scanner.
triggered 20 seconds after the arrival of iodine in the aorta.

A challenge in imaging, and a hindrance in interpretation, is the potential for simultaneous opacification of veins and arteries. In a patient with an arteriovenous fistula, venous opacification is unavoidable, even when using a fast scanner. With a 4-row scanner, long scan times can result in simultaneous opacification of the arteries and veins, even in the absence of arteriovenous fistula. Now, in the era of 64-row CT scanners, we see veins only when there is pathology present, for example, as a result of cellulitis and osteomyelitis of the foot.

Certain physiologic states result not only in delays in contrast flow, but also in differential flow between one leg and another. Figure 3 shows a patient with a high-grade stenosis of the external iliac artery. On digital subtraction angiography (DSA), it is immediately clear that there is less distal opacification of the right external iliac artery; whereas on 4-row CTA, there is homogenous opacification on both sides. A further benefit of imaging with a slower, 4-row scanner is that by the time the scanner is imaging the knees, the popliteal and proximal crural arteries in both legs can be visualized on CTA. By comparison, on DSA, visualization is very asymmetrical. There is almost no opacification of the right proximal popliteal artery, whereas there is good visualization of the trifurcation region on the left. In this patient, it took 13 seconds for full opacification on DSA.

Just as with DSA, the challenge of imaging patients with asymmetric flow becomes greater with 16- and 64-row CT scanners. Often, we can achieve excellent opacification of the proximal vessels but see nothing from the knees down. The solution to this problem is to scan a second phase from the knees to the toes, 20 seconds later. This step is now a routine part of our protocol. The technologist quickly looks at the reconstructions of the pedal vessels and triggers the second-phase scan if there is inadequate opacification in the feet. As shown in Figure 4, we have achieved excellent results using this approach.

**Data processing**

There are a number of useful 3D visualization techniques. Maximum-intensity projections provide an excellent overview of the vessels. Extensive bone editing is required, however, and calcifications can obscure the arterial lumen. We often use CPRs, which are curved tomograms that follow the vascular lumen. As Figure 5 illustrates, use of this technique enables us to see through much of the calcium and to visualize soft plaque. The ability to evaluate the vessel wall is very important in the characterization of arterial disease.

When viewing calcified plaque, it is important to select the appropriate window level setting. Unless a bone window
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Level setting is used, calcifications will “bloom” and appear larger than they actually are. Despite taking these steps, calcium presents a considerable problem in CTA. In very small vessels, such as the peroneal artery, even a CPR may not be able to discriminate arterial lumen from calcification.

Volume renderings provide an excellent overview of 3D relationships; however, calcification remains a challenge. In Figure 6, the “frosted” appearance of the superficial femoral arteries on volume rendering suggests extensive calcification but does not indicate the degree of luminal patency. It is much more helpful for making the diagnosis to, in addition, review a side-by-side multipath CPR.

At Stanford, we use 2 models for delivering postprocessing services. One is physician-driven and involves a 3D workstation in the reading room that radiologists use as the primary viewing station. With the second model, technologists in a 3D lab reconstruct protocol-driven views for interpretation by the radiologist.

Physician-driven postprocessing enables the greatest control for achieving clinically relevant visualization. Figure 7 shows opacification of the left femoral vein, caused by a small communication between the inferior gluteal artery and vein. Detection of this subtle evidence of arteriovenous fistula and tracking its origin would not necessarily be included in the technologist’s analysis. A physician, interacting in real time with the 3D workstation, enables the diagnosis to be made.

Physician-driven visualization requires that there is a workstation in the reading room within arm’s length. It should be fast and very easy to use, and the data must be available at the workstation when the physician is ready to read it. The workstation need not be equipped with all the bells and whistles for specialized postprocessing. Its purpose is to enable the radiologist to really interact with the data. It should, however, be equipped with convenient and secure communication protocols that enable the radiologist to send images to referring physicians or post them to secure Web pages.

Despite its advantages, physician-driven postprocessing necessitates developing procedures for printing images and ensuring proper storage of data in the pic-
FIGURE 7. (A and B) Opacification of the left femoral vein is caused by a small communication between the inferior gluteal artery and vein.

FIGURE 8. (A) A maximum-intensity projection reveals occlusion of the right superficial femoral artery. (B) Using a software program that lays out a measurement rule along the centerline of the vessel, the curved planar reformation provides fine details about the diseased segments and enables mapping of their exact length. This information can be very helpful in treatment planning. (Images courtesy of Dominik Fleischmann, MD.)
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through the peripheral arteries: Implications for CT angiography. Radiology. 2005;236(3). In press.

Discussion

ELLIO T. FISHMAN, MD: Thanks very much, Geoff. I definitely agree that runoff studies are one of the most challenging studies we do. They are also probably studies we use the largest volumes of contrast on. In terms of contrast selection, recognizing that most of these patients are probably older, with comorbidity factors, which contrast are you typically using for these studies?

GEOFFREY D. RUBIN, MD: Well, just as some of the other guidelines that we discussed, we typically do not use isosmolar agents. We always use nonionic agents. We only use isosmolar agents in people who have documented level of azotemia, and in our practice, we define that as a serum creatinine of 1.3 and for diabetics, 1.0.

FISHMAN: You mentioned that the range of contrast volumes from 100 to 180 mL. How do you determine who gets what volume?

RUBIN: It’s based on patient weight. We have a little nomogram that we use, where we put people into 4 weight classifications. Typically, if a person were ≤120 pounds, we would use 100 mL of contrast. If they’re from 120 to 180, we would use 120 mL, and then it stratifies up to 300-pound patients who get 180 mL.

JULIA FIELDING, MD: What about using a saline chaser, then perhaps diminishing the volume of contrast that you use?

RUBIN: We always use a saline chaser. I didn’t mention that, but that’s a given.

FIELDING: How much do you use?

RUBIN: We use 50 mL of saline.

FIELDING: Even with that, you still require that volume of contrast in some larger patients?

RUBIN: Oh yes. I think that really large people, ≥300 pounds, are typically underdosed for contrast medium. The key for this study to be diagnostic is the visualization of small vascular channels. Not only are you dealing with the challenge of just getting adequate opacification, but you are also going to have a much higher level of background noise in a big person. So your contrast opacification has to be even higher to get the same level of contrast-to-noise that you would get in a normal person. So I think the greatest mistake you can make is not giving an obese person an adequate amount of contrast. I don’t think 180 mL is outrageous. In fact, I’ve had patients who weighed as much as 420 pounds and I wished I had an injector that could hold >200 mL of contrast. But that’s our max.

FISHMAN: I agree with your comment that the timing is very difficult in runoff studies. The reality is that in some patients you just need to do a second run. So you have the technologist basically looking at the pedal vessels.

RUBIN: Right. Once again, the second run isn’t going to be the whole thing. I’ve never had a case where the timing has been so bad that we miss the superficial femoral arteries. It’s usually just from the knees down, so that’s what we have programmed in. The technologists prioritize the reconstruction of those sections and, if they don’t see good opacification, they just run that second scan. Of course, there’s no hemopoietic marrow down there in any adult patient, the risk of the radiation exposure is nil, and the contrast is there to be imaged. Fortunately, the infrapopliteal flow is typically relatively slow, so the accuracy of placing that second scan in the bolus is less important than just getting it within 20 to 40 seconds after the first scan ends.

FISHMAN: How often do you think you have to do the second run?

RUBIN: It’s not that common for us. I would say it’s <10% of the time. But it can be a real exam saver for those patients.

FIELDING: Would you consider scanning from the foot up?

RUBIN: Fundamentally, I always scan in the direction of blood flow. It just seems more logical to me. I just can’t really appreciate any advantage of scanning up in the opposite direction.

FIELDING: Well, I was wondering if you have such a very fast scanner, could you time it so that when the contrast hit the foot, you would scan up and get the whole thing and beat the venous
RUBIN: No. What would happen, if you tried to scan all the way up to the top, you would definitely pass your bolus on the way, and you would have no opacification up high. I mean, the way to think about the bolus is that... let’s say it’s a 50-second long bolus. So you have this moving wave that stays this long as it goes down the patient. You’re just trying to keep your scan somewhere in that frame. If, on the other hand, you’re going the opposite direction, it’s sort of like passing someone on the freeway, right? You can drive by in your car and wave at them much better if you’re going the same direction in traffic. If you travel in the opposite direction, you may not see them.

FIELDING: You are going to miss it.

FISHMAN: I think on a technical note, people have to realize that basically, for most scanners, you always have to put in that second run when you put in the first run. You don’t have the time to reinitialize the scanner. So you put it in. Whether you use the second run or not is a different issue. I’ve noted that, as well. Sometimes you get great studies on one run. Sometimes just the asymmetry is so significant, particularly in patients with significant SFA disease.

RUBIN: What’s interesting is that with the 4- and 8-row scanners, we never had to worry about this. It’s just a new phenomenon with 16- and 64-row scanners.

FISHMAN: In terms of postprocessing, to get the bone away, it’s particularly an issue the further down you get in the lower extremities. Are there any special techniques you’re using for that?

RUBIN: Our technologists have become very adept at using the tools they have on their workstations very quickly. They do not go slice-by-slice and circle the bone. They use techniques that involve some spectrum of region growing and region selection. More and more, there are more intelligent segmentation algorithms with which the computer actually detects those edges. I think this is an evolving area. We’ve developed some software in our lab that can automatically do it with 2 mouse clicks in about 20 seconds, but that’s not available on any commercial workstations. I think it will only get better and better.

FISHMAN: I think it’s a very challenging area. Are you doing many runoff studies?

FIELDING: Yes. We are.

ELLA KAZEROONI, MD: We do very few runoff studies with CT.

FISHMAN: Do you do everything with MR?

KAZEROONI: Yes, most of the studies are done with MR.

FIELDING: My problem with MR was the time, and I also had a problem with getting the fourth station; it was often an issue. So if I can do the CT in 70 or 75 seconds, that’s a huge advantage to me over tying up an MR scanner for a long time. I think, despite some of my staff’s reservations, we culturally evolved into a CT angiography place.

FISHMAN: With the runoffs on the 4- and the 16-row scanners, it was a real challenge getting through the areas. On the 64-row scanner, the biggest challenge is how many slices you end up with. You end up with 2500 slices, depending on how you want to display the data and depending on what workstation you have. Some workstations can’t display more than 1500 slices; some can display 3800 slices. So that’s also a challenge. Have you been using much MRA?

RUBIN: No. Our challenge with MRA has been with consistency of results. In my experience—and obviously this will be somewhat vendor-specific in terms of which MR equipment you have—I find that for virtually every part of the body, with the exception maybe of intracranial where I don’t have a lot of experience, CTA provides a more consistent result. If I’m going to run 50 patients through in CT, I know I’m going to have diagnostic studies a lot more frequently than I would if I ran them through MR. There’s probably no greater CTA application than the lower extremities where that becomes most evident.

Our surgeons and our interventional radiologists have voted clearly what their preference is, too. I think around the country and around the world, in fact, CT angiography has taken a major role. I think that the number of centers that preferentially use MRA for lower-extremity occlusive disease over CTA is diminishing.

FISHMAN: The issue for us typically relates to the patient who can’t get IV contrast, then we’ll go to MRA. What’s interesting about CTA—and this is true with the carotids and runoff studies in a lot of other areas—is the tremendous confidence by the referring clinician that what you see on CT is what you’ll find. There are no flow-related artifacts or other artifacts, usually. Sometimes with MR, that confidence level may not be there.

KAREN M. HORTON, MD: I don’t have a lot of experience with the lower extremities. I try to stay between the pelvis and the neck. It’s challenging not only because of the technique, but also because it’s a whole different area for people like me to learn in terms of the anatomy and the disease. You need a lot of experience to interpret them correctly. I can’t just start reading these tomorrow. It takes a little bit of effort and training.

KAZEROONI: That’s probably part of why we don’t do very much peripheral extremity CTA work. Our radiology group has become very comfortable with MRA, and it’s a different group from the CT group. The MR folks and the interventional radiologists do MRA together and provide a very consistent quality of service. The CT folks haven’t wanted to take on the additional diagnostic studies for which they have to learn a whole new set of anatomy and a whole new set of descriptors that they’re not used to using in their usual abdominal CT practice.

FIELDING: We hired two private practice interventionalists who are also good CT radiologists, so I put them on that. They have a wide variety of skills so they can combine the two. It’s actually their job to make sure the protocols are up to snuff for the vascular work.

FISHMAN: I think the single biggest advantage of MR in this situation is if you don’t have really good bone removal techniques for CT postprocessing, then you have issues.

RUBIN: I don’t want to overstate the importance of bone removal. I think that a curved planar reformation is actually much more important than a bone-removed...
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MIP. I think that the volume renderings will give the surgeon the overview of the 3D image, just like the MIP, but I think that what needs to happen for radiologists to maximize the appreciation of what’s in these data is to move to the appreciation of the assessment of the wall. Angiographers have never really been able to look at the wall because conventional angiography produces a lumenogram, and a lot of people still tend to display CTAs exclusively as lumenograms using MIP or VR. But curved planar reformations really allow us to assess the full extent of the vascular disease. I think that that really is a key element to assessing these studies.

FISHMAN: I definitely agree. As with all the CTA applications, we have all these tools, but in most situations, no one tool gives the only answer. I think that’s very critical and that’s true as we get into cardiac and kidneys and other CTA applications.

Are there any other comments?

KAZEROONI: I was just curious. You talked about the stratified processing of cases, the physician-driven and the technologist-driven. What percent of cases can be processed by the technologist alone? What percent requires you to do some additional processing?

RUBIN: Well, it’s difficult to answer because the processing that I do is part of my interpretation. I do it when I’m reading the case. Sometimes I won’t have what the technologist has created when I want to read it out, and I want to read it out right away. So in the end, I usually do 3D on every case. If I had what the technologist gave me, I would say that would probably suffice in at least 50% of cases. But I also know that there are specific findings that I’ve only picked up in 3D images. Some of those subtle arteriovenous fistulas and such, it’s really quite onerous on our PACS to move through 1500 slices, so I try to avoid it at all costs. If I have the data on a 3D workstation, I’m just going to look at it volumetrically. I don’t think, “Now I’m doing the 3D processing.” I just think, “I’m going to read the case,” and I’m not reading it on the PACS. I’m reading it on the workstation.

FIELDING: Do you find that your interventionalists and your vascular surgeons are fine with the endovascular stent protocols? There are always the issues of the curving away from the spine, the length measurements, and all that kind of stuff. When we switched over, there was a little reluctance at first to go from standard angiography to CTA. But we seem to be doing just fine with it.

RUBIN: You’re talking about CTA for planning aortic stent grafts?

FIELDING: Yes, for planning aortic stent grafts.

RUBIN: We’ve been using CTA exclusively now for well more than 10 years for that application. We have a dedicated protocol for providing measurements of path length and diameters and angles.

FIELDING: I think the path length was the big question a lot of the time for them.

RUBIN: Well, angiography has been pretty well established as being fairly inaccurate for measuring vessel lengths. Even if you have a marker catheter, there can be problems with it because of parallax and such. But it is more a practical issue. If you don’t have to do an invasive angiogram in order to plan the deployment of an aortic stent graft, then you’re much better off doing the CT.