Endovascular Imaging Options

An overview of today's imaging modalities and their ideal uses.

BY WAYNE FORREST

The reality today is that imaging the vascular system is a shared activity among computed tomography (CT), magnetic resonance (MR), x-ray, and ultrasound. With the advance of individual technologies, each modality has a very viable role in patient care and offers unique and increasingly valuable information.

The ongoing trend in health care to make diagnostic procedures less invasive carries over to endovascular imaging. Whereas x-ray angiography was the primary way to diagnose vascular disease and other suspected or known abnormalities in the past, the noninvasive modalities of CT and MR—and in particular CT angiography (CTA) and MR angiography (MRA)—continue to gain popularity among physicians and endovascular imaging specialists.

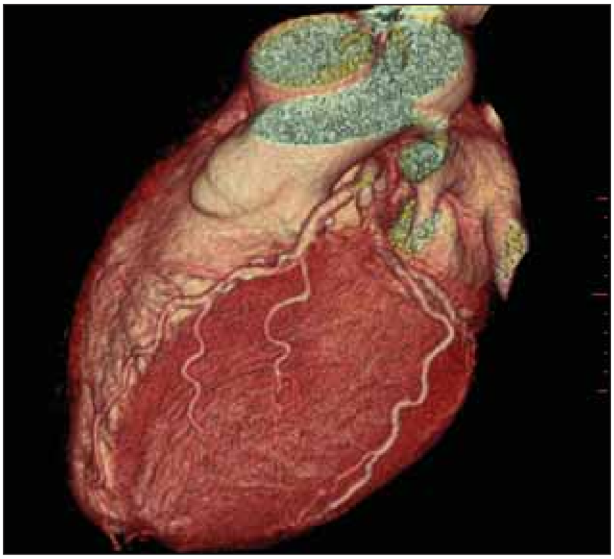
(Image courtesy of GE Healthcare)

Figure 1. An example of a 64-slice CTA.

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COMPUTED TOMOGRAPHY

Today, CTA is utilized for a variety of applications, including abdominal aortic aneurysms, branch vessel stenoses, renal artery stenoses, and dissections that are aptly imaged with the rapid-scanning technologies of 16-slice CT scanners.

Patients who have suffered hemorrhagic strokes often undergo CTA to determine the cause of the bleeding and to help physicians decide if it is best treated with an open surgical procedure. For patients with an ischemic stroke in which there is a blockage and the brain is not receiving enough blood, it must also be determined whether there is bleeding prior to any treatment or revascularization. Imaging with CTA helps to determine the location of the blockage and triage those patients to the appropriate therapy.

CT is currently advancing from 16-slice technology to 64 slices, or channels (Figure 1). The more advanced CT scanner creates markedly sharper images, shortens scan times and patient breath holds, and allows for lower doses of contrast media. A 64-slice CT scanner can image effectively with approximately 50 mL of contrast media, compared to 75 mL on a 16-slice CT scanner, according to Lawrence N. Tanenbaum, MD, Section Chief of MRI, CT, and Neuroradiology at Edison Imaging in Edison, New Jersey.

The advance to 64-slice CT technology also will "clearly accelerate" the use of CTA and allow for imaging of the chest, abdomen, and the legs in a fast enough period of time to trace contrast media down to the ankles, adds Thomas D. Hedrick, MD, Medical Director of Radiology with The Methodist Hospital in Houston.

"To get good CTA, you have to do slice thickness of approximately 0.5 mm," Dr. Hedrick says. "You can't cover a lot of ground with low rate-count scanners and 0.5 mm for each detector. When you get up to 64 [slices], now you can effectively cover the entire body in a reasonable amount of time and expect the iodide to still be on the arterial side."

Methodist has four 64-slice CT scanners on order, one of which was scheduled for installation in January.

CTA AND MRA

CTA and MRA can work collaboratively for patients who are not suitable candidates for one technology or the other. For example, patients with elevated renal function (elevated levels of creatinine) should not receive CTA contrast agent injections, as is the case with patients who are allergic to the contrast. Those patients appropriately are referred for MRA scans. MRA also has the benefit of not having the ionizing radiation that CTA does. Conversely, patients with certain implants and pacemakers cannot undergo an MRA, and subsequently undergo CTA as the alternative.

"For patients," says Dr. Hedrick, "that is a godsend, because you no longer have to take risks with one modality or the other."

MRA traditionally has been one of the imaging options for the carotid artery and the circle of Willis because the modality handles bone artifacts better, although CTA is increasing in use, at least at Methodist Hospital.

"If you asked me this time last year, we were probably doing 90% MRA and 10% CTA in the carotids and circle of Willis," Dr. Hedrick says. "That's probably changed today to 60-40. The thin slices, rapid acquisition and new workstation enhancements have really made CTA in the carotids and circle of Willis come alive."

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New techniques and enhanced software also have eliminated many of the issues with MR imaging relative to patient motion and imaging blood flow (Figure 2).

Just as CT is moving to faster scans with 64-slice technology, MR is progressing from 1.5-Tesla (T) systems to 3-T magnet strength. The 3-T MR systems acquire information faster, requiring shorter patient breath holds, while the higher signal-to-noise ratio enhances image resolution.

In addition, Dr. Tanenbaum notes that contrast dose can be reduced to 0.1 mmol for 3-T MRI scans, compared with 0.15 mmol for a 1.5-T MRI system.

At Edison Imaging, although CT is the imaging technology most frequently used to check for leaks after treatment with an endovascular device, Dr. Tanenbaum

(Image courtesy of GE Healthcare)

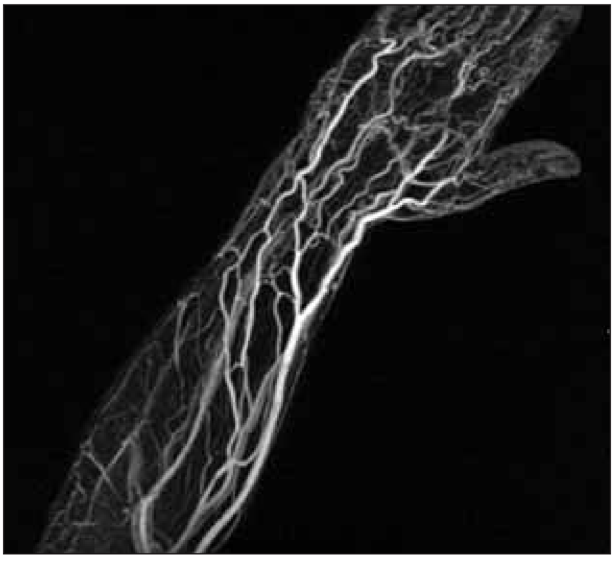
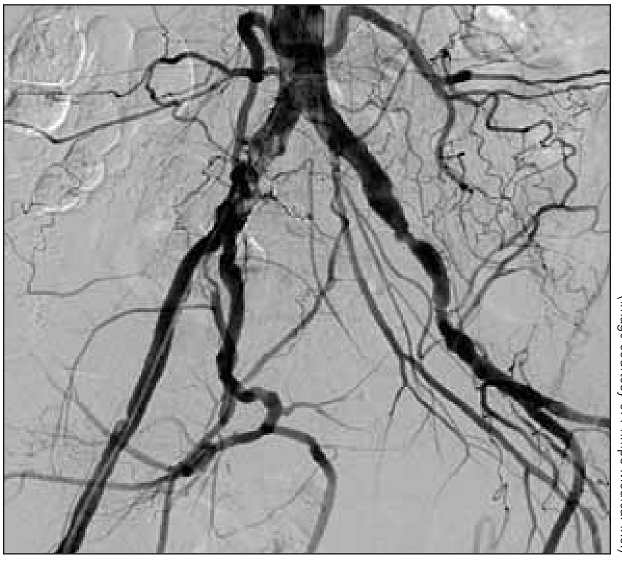


Figure 2. This case on a forearm shows the ability of MR to do high-resolution angiography.



(Image courtesy of Philips Medical Inc.)

Figure 3. X-ray angiography allows for tracking catheters and guidewires in real-time.

adds that MR may be slightly more sensitive because of its superior contrast resolution. "The combination of the greater sensitivity of MR, plus the dynamic information of MR, may lead to this becoming a more important modality in the future for following up endoleak patients," he adds.

MRI also allows clinicians to image in a time resolve fashion, much like conventional angiography, with a technique called TRICKS (time-resolved imaging of contrast kinetics). TRICKS takes advantage of the high-performance MR scanner, as well as "some clever software manipulations to enhance the temporal resolution," Dr. Tanenbaum says. "The bottom line is that we get an exam very much like a conventional angiogram."

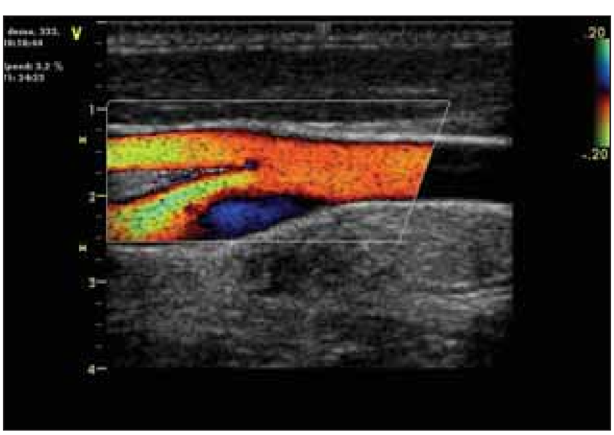
Edison Imaging's technology currently includes a 64-slice CT scanner, one 3-T MR system, and a 1.5-T MR system.

X-RAY ANGIOGRAPHY

With the trend toward less-invasive procedures, x-ray angiography is used less frequently in diagnostic imaging, whereas its role in interventional procedures continues to be prominent, particularly in cases of narrowing arteries in which angioplasty is necessary. The ability of x-ray angiography to track the path of catheters and guidewires also allows physicians to microscopically manipulate the devices in real-time (Figure 3).

What vendors have accomplished in advancing their respective x-ray technologies is to reduce radiation exposure to patients undergoing interventional procedures and enhance the clarity of the images for physicians with flat-panel detector imaging.

Unlike the round image intensifier, standard flat-panel detectors measure 16 inches X 16 inches and can cover the entire abdomen in one scan. The field-of-view also allows for one contrast injection to cover from the dome of the liver to the pelvis. With an image intensifier, a patient may be subjected to three or four injections to fully define the vasculature in that region.



(Image courtesy of GE Healthcare)

Figure 4. An example of carotid ultrasound imaging.

Today, with flat-panel detector technology, a physician can look at microvessel detail across the entire area and not have to perform separate runs or make imaging adjustments to see guidewires across the regions.

> "Flat-panel detectors have greatly reduced, if not virtually eliminated image artifacts, and maintain image quality to the very edge of the image."

In addition, image intensifiers have had inherent artifacts and tended to lose image quality from the center of the image to the edge. Flat-panel detectors have greatly reduced, if not virtually eliminated image artifacts, and maintain image quality to the very edge of the image.

The Methodist Hospital performs virtually all of its interventional neurological procedures in an x-ray angiography environment, utilizing a flat-panel detector biplane system that allows for both angiographic imaging and soft tissue imaging. Charles Strother, MD, Professor of Radiology at Baylor College of Medicine in Houston, says the system allows users to see if there has been bleeding during a procedure and if the ventricles are becoming large.

"To me, anything you can see is better than anything you can't see," Dr. Strother says. "The flat-panel detectors will replace the image intensifiers ultimately."

ULTRASOUND

Among ultrasound's contributions to endovascular imaging is its ability to detect the potential for heart disease (Figure 4). It can also be considerably less intimidating to a patient than CT, MR, or x-ray angiography.

Ultrasound can measure intima-media thickness of the carotid arteries to determine the thickness of muscle layers in the middle of the artery wall. This noninvasive procedure can assess the presence of plaque in the arteries and help characterize the plaque as soft, partially calcified, or completely calcified. Recent research on the cause of stroke has shown that soft plaque is more likely to be a risk to a patient, reversing traditional beliefs that calcified plaque was more culpable.

Ultrasound also can supply information on early-stage arterial sclerosis, even if there is no calcification, and chart the progression or regression of a patient's arterial condition to track the effects of intervention.

"You cannot do that with CT," maintains Regina W. Drueding, MD, an internal medicine physician with an office-based practice in Bountiful, Utah. “You wouldn’t want to expose somebody to radiation every year. [Ultrasound] is a very convenient and safe tool to see where your patient is heading and whether they are responding to treatment.”

ON THE HORIZON

As for the future, hybrid imaging—combining two complementary technologies to provide health care providers with enhanced, detailed patient images—will begin to make more of a mark in endovascular imaging.

> “When and if CT progresses beyond 64-slice technology will depend, in part, on where physicians see the additional benefits.”

Multimodality systems with the benefit of CT or MR, for example, would help define the size and location of a tumor, while x-ray angiography would help to guide a catheter in the endovascular system to deliver chemotherapy agents to the tumor. CT or MR then would help evaluate if the tumor is destroyed.

There would also be the benefits of combining the temporal resolution of x-ray and the physiological resolution of the MR. Image intensifiers cannot work in a high magnetic field environment, but MR is not an issue with flat-panel detectors.

Although there are techniques on the horizon for MR to track devices and catheters, Strother does not believe the technology is “ready for prime-time global use, but it is coming. I believe in the future we will see more combined systems where there is an MR system and an x-ray system.”

With 64-slice CT technology, Dr. Tanenbaum says cardiac coronary CTA “really comes into its own. You also have the opportunity to image quickly enough to do a single exam to exclude pulmonary embolic disease, aortic dissection, and coronary disease.”

When and if CT progresses beyond 64-slice technology will depend, in part, on where physicians see the additional benefits.

“I think we need to stop the slice wars for now, digest what we have, and see what we can accomplish with these 64-slice scanners,” says Dr. Hedrick. “Several years down the road, there will be the introduction of ‘volume’ scanners, which can acquire large areas of data with one rotation that would make it even quicker. At the moment, 64 is pretty versatile and powerful, and from what I have seen, can solve most of the clinical questions we have today.”

X-ray angiography also is expected to have its place in the endovascular imaging environment with its real-time imaging capabilities and economics. It is not financially prudent to occupy a high-end CT scanner for a 2-hour procedure that can be done through x-ray angiography.

With the advent of three-dimensional imaging, x-ray angiography adds measuring capabilities and the ability to image both soft tissue and vascular system to see the vessel, the bone, and the anatomy that surrounds the vessel. ■

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