CT angiography steps up role in interventional planning

December 13, 2007
By Catherine Carrington

CT angiography is playing an increasingly important role in planning for cardiovascular interventions. Improvements in spatial and temporal resolution, scan times, and scan range— together with advanced image postprocessing—have made CTA a critical tool for identifying patients in need of invasive therapy and for mapping out the best percutaneous or surgical approach.

In some cases, CTA provides complementary information to that of conventional angiography. In others, it is sufficient on its own.

"Previously, with the four-slice scanner, we'd look at an image and say, 'That's an interesting finding, but I'd rather see the angiogram.' Now we often look at the CTA and make a decision," said Dr. Peter S. Fail, director of cardiac catheterization and interventional research at the Cardiovascular Institute of the South (CIS), in Lafayette, LA., between New Orleans and Texas.

CTA is particularly promising for carotid artery, aortoiliac, and coronary imaging, as well as for electrophysiologic procedures.

CAROTID ARTERIES
About a year ago, CIS took the leap and purchased a 16-slice CT scanner rather than continue to refer patients to a nearby hospital for imaging. Since then, CTA has proved to be a valuable tool in interventional planning.

In patients with suspected carotid stenosis, for example, CTA defines the anatomy of the aortic arch and common, external, and internal carotid arteries, all the way to the circle of Willis. CTA also accurately assesses the degree of stenosis, which gives it an edge over other commonly used technologies. Ultra sound, for example, may indicate that a carotid artery is 60% to 80% stenosed. That range is uncomfortably wide, Fail said.

"You might leave a 60% stenosis alone but treat an 80% stenosis," he said. "CTA can refine the assessment of stenosis and guide you in deciding whether to proceed to angiography and intervention."

CTA's ability to define lesion characteristics can also guide decision making. Plaque that appears to be fibrotic on CTA would be suitable for stenting, whereas one that appears to be filled with lipid and thrombus might be better treated surgically.

Sometimes CTA can reveal a lesion that is completely missed by conventional angiography, particularly at the takeoff of the left common carotid artery from the aortic arch. If the angiography catheter is advanced past the stenosis before the injection of contrast medium, a lesion that would be obvious on CTA may not show up on the invasive angiogram.

CTA is earning a place in neuroimaging of trauma patients as well, said Dr. W. Dennis Foley, a professor of radiology at the Medical College of Wisconsin.

"We're beginning to see that physicians are excluding injury to the vertebral and carotid arteries by doing multidetector CT angiography in patients who have suffered blunt trauma," he said.

AORTOILIAC IMAGING
CTA has staked out a leading role in evaluating patients with abdominal aortic aneurysm. Serial
surveillance can indicate when intervention is indicated. CTA can then help determine whether a patient should undergo surgery or is a good candidate for stent-grafting, as well as the size and type of stent-graft to use.

In evaluating a patient for possible stent-grafting, the radiologist needs visual and quantitative information on such key anatomic features as vascular access, length and diameter of the stent-graft's proximal placement zone, dimensions and configuration of the aneurysm, length and diameter of the stent-graft's distal placement zone, and degree of atherothrombosis or calcification in the vessel walls.

Details are critical in planning for stent-grafting. For example, the endovascular approach may not be possible if atheroma has invaded more than 25% of the circumference of the proximal landing zone or if the angle between the superior neck and the long arm of the aneurysm is too great. A patient with a short proximal landing zone may need a stent-graft designed for transrenal fixation. If the aneurysm involves the iliac bifurcation, extension into the external iliac artery will be necessary. Distal fixation in the external iliac artery occludes the hypogastric artery supplying the pelvis, however, so this approach can be done on only one side of the body. It is also important to determine whether any of the major aortic branches are occluded.

Earlier generation scanners have proved adept at providing this information and more, but 64-slice scanners represent a clear advance, Foley said.

"The 64 is an extremely rapid and versatile system. If you inject contrast appropriately and time the scan accurately, you'll get extremely good studies," he said. (See accompanying article.)

An aortoiliac study takes just 3.5 seconds with a 64-slice scanner, as opposed to 14 seconds with a 16-slice scanner. Foley selects a 0.625-mm slice width with both types of scanner. The resulting beam width, however, is 40 mm on the 64-slice scanner, as compared with 10 mm on the 16-slice scanner. Therefore, the scan is four times as fast for the same longitudinal resolution.

One advantage of such rapid scanning is increased safety when imaging patients who are extremely ill. Another is a reduction in pulsation artifact in certain vessels, such as the mesenteric arteries, which run along the plane of acquisition. With earlier generation scanners, pulsation would lend an irregular appearance to the walls of the mesenteric arteries. Because images are acquired so quickly with the 64-slice scanner, the arterial wall appears markedly smoother, Foley said. The faster scan speed also means that the scan range can be increased, perhaps to include the carotid arteries and the thoracoabdominal aorta in a single scan.

The 64-slice scanners permit new uses for gating as well. In a patient with chest pain of unknown etiology, a gated scan could acquire data from the coronary arteries, pulmonary arteries, and thoracic aorta, all in one rapid study.

"Even when we're fully gated at a pitch of 0.25, we can do the chest in 12 seconds," Foley said. "It still gives us a pretty rapid acquisition."

Such an approach would enable a high-quality coronary scan while improving image quality in the thoracic and pulmonary arteries by eliminating the cardiac pulsation effect.

**CORONARIES**

Whether 64-slice scanners will have the right combination of spatial and temporal resolution to finally conquer coronary artery imaging is unknown. The consensus is that although 16-slice scanners have made substantial strides in cardiac imaging, they have fallen short of that goal.

"Grading percent stenosis, which is a strength of coronary angiography, is not reliably possible with 16-slice scanners," said Dr. Paul Schoenhagen, a cardiovascular imaging specialist at the Cleveland Clinic. "Certainly, we're moving in that direction, but we're not at that point yet."

CT has so far been unable to pass another crucial test in interventional cardiology. Primarily because of the small size of coronary artery stents, CT is unable to reliably assess in-stent restenosis.

CTA is at an inherent disadvantage compared with invasive angiography on two fronts: Spatial resolution is lower, and calcification-common in high-grade coronary lesions-causes blooming artifacts that may result in overestimation of lesion size. Both of these problems are expected to recede in importance, though not disappear, with the 64-slice scanner.

But CTA does have an important potential role in preparing for coronary interventions, Schoenhagen said. It can be used to identify patients with significant coronary artery disease who would benefit from invasive coronary angiography and intervention. CTA can also reliably assess bypass graft patency, determining how diffusely diseased the graft is and identifying atherothrombotic material with the potential for distal embolization.

Because it is a tomographic imaging technique, CT can evaluate aspects of arterial disease that angiography cannot, much like intravascular ultrasound does. In the case of high-grade stenosis, for example, the adjacent reference vessel may look comparatively normal on angiography but in fact
be significantly diseased. Such a condition would be apparent on CTA and might prompt the use of a longer stent or consideration of bypass surgery. Similarly, CTA evidence that a target lesion is highly calcified may lead the interventionalist to predilate the lesion before stenting or use an atherectomy catheter.

"These are situations where the CT scan may provide information that would help the interventionalist determine how to approach the lesion," Schoenhagen said. "If you compare four- to 16- to 64-detector scanners, the assessment of plaque in the vessel wall is certainly improved."

In fact, with the introduction of the 64-slice scanner, the time may have come to put CT plaque characterization to the test, validating it against IVUS, the gold standard.

"There have been multicenter trials evaluating the ability of CT to identify significant stenosis in comparison to conventional angiography, and this will be done again for the newer scanners. But the same is necessary for plaque assessment in comparison to IVUS. I think it's certainly the right time," he said.

If the 64-slice scanner proves able to meet the challenges of coronary imaging, its role in guiding interventions could become even broader, as the definition of intervention itself expands. A patient who undergoes stent placement almost certainly has atherosclerotic plaque elsewhere in the coronary vasculature, some of it vulnerable and inflamed. CT could help in making that assessment and in prompting the physician to initiate lipid-lowering therapy with statins and newer drugs, Schoenhagen said.

Fail foresees CTA being used to guide medical intervention even earlier in the disease process for evaluation of people who have a worrisome risk profile but are symptom-free.

"When CTA gets to the point where you can define a 30% or 40% lesion relatively comfortably, then we'll use it as part of the risk profile, and that is when we're going to see an impact on myocardial infarctions," he said. "The CT scanner could become the next stress test."

Fail feels confident that with the right cardiac imaging software, the 64-slice scanner will come very close to achieving comprehensive coronary angiography. Certainly, the next generation of scanners will.

"I've seen coronary images acquired on 64- and 128-slice scanners. On the 64-slice scanner, the coronary anatomy is absolutely phenomenal," he said. "With the 128, the images are unbelievable. They're as clear as an angiogram I would do in a lab."

**ELECTROPHYSIOLOGY**

At Long Beach Memorial Hospital in southern California, Dr. Serge Tobias uses CTA for a different type of cardiac application: to guide certain electrophysiologic procedures in which detailed depiction of the cardiac chambers is helpful.

One example is the placement of biventricular pacemakers. These devices synchronize contraction in the two sides of the heart in patients with electrical conduction delays. Unlike standard pacemakers, they require insertion of a lead in a branch of the coronary sinus to pace the left ventricle. Tobias, who directs electrophysiology at Long Beach Memorial, has performed hundreds of left-ventricular lead placements without the aid of CT. Still, he wants to know more about the anatomy in certain patients before considering the procedure.

"Just like CT can depict coronary artery anatomy of large proximal vessels, it can generate the coronary venous anatomy. It allows us to know ahead of time whether there are branches of the coronary sinus that we can readily access," Tobias said. "It's very impressive."

CTA is also being used as part of a new program at Long Beach Memorial: radio-frequency catheter ablation for atrial fibrillation. Research has shown that in many cases, the abnormal electrical impulses that cause atrial fibrillation arise in tissue adjacent to the pulmonary veins that drain into the left atrium. Before ablating that tissue, Tobias turns to CTA for 3D images of the left atrium and the pulmonary veins.

Advance knowledge about pulmonary venous anatomy is important because RF energy must be delivered in the left atrium near the ostia of the pulmonary veins but not in the veins themselves. Anatomy varies from one patient to another, however. Some patients have four separate orifices, as expected, and others do not. Pulmonary venous branches take various configurations as well.

"A CT image can give you a preoperative idea of what those veins look like, so you're not surprised by a very large orifice or a common orifice that immediately splits into two separate veins. You know what to expect," Tobias said.

It is also important to take baseline measurements of the diameter of the pulmonary vein. Mistakenly ablating inside the pulmonary vein can result in scarring and stenosis. Comparison of a baseline and follow-up CT can diagnose the problem if the patient develops symptoms such as shortness of breath or cough weeks or months after the procedure.
Electrophysiologists have traditionally used a cruder, more time-consuming method to map the left atrium and pulmonary veins, generating a 3D image point by point as an electrical mapping catheter makes contact with the cardiac vessels and chamber walls. Using this method, the boundary between the pulmonary vein and left atrium is defined by catheter drop-off and changes in the amplitude of the electrical signal.

"To have a very accurate representation, we'd have to collect hundreds of points from every possible recess in the atrial chamber," Tobias said.

One day, electrophysiologists may have the best of both worlds. Researchers are working to integrate the CTA image of the left atrium with data gathered by electrophysiological recording equipment. Ultimately, it may be possible to manipulate an electrophysiology catheter in the heart, using the CT image as the correct anatomic guide.

"Instead of traveling through a generated 3D image, which is not necessarily accurate, we'd be navigating through a true 3D CT image," Tobias said. "This work is in very, very early stages, but the time will come."

**New scanners affect contrast use**

Speed means lower dose and quicker injections but longer waits

To get the most out of advanced CT scanners, modification of the contrast delivery protocol is a must. Consider aortoiliac CTA. At the Medical College of Wisconsin, Dr. W. Dennis Foley has found that faster scanners enable a reduction in the volume of contrast material. With a 16-slice scanner, Foley typically uses about 80 mL of 350 to 370 mgI/mL contrast material. With the 64-slice scanner, he has been able to reduce contrast volume to 50 mL.

Contrast administration has changed in other key ways as well. Regardless of the type of scanner, Foley injects a minibolus of contrast material to gauge contrast transit time in each patient. With the 16-slice scanner, he measures time to peak aortic enhancement. After injection of the contrast bolus, he initiates scan acquisition at the time to aortic peak as determined by the preliminary minibolus. With the 64-slice scanner, he adds an additional four seconds to the waiting time. In addition, Foley increases the contrast injection rate from 5 mL/sec with the 16-slice scanner to 6 mL/sec with the 64-slice scanner.

"We're injecting faster and waiting longer after the contrast has arrived to begin scanning," Foley said. -CC

**Disclosures:**

**Source URL:**
http://www.diagnosticimaging.com/articles/ct-angiography-steps-role-interventional-planning

**Links:**