

# CT Coronary Angiography: Where Does It Fit?

In the last 3 y, we have witnessed an impressive injection of new imaging technology for the evaluation of patients with known or suspected coronary artery disease (CAD). Indeed, the introduction of multidetector CT scanners with submillimeter spatial resolution and subsecond gantry rotations made noninvasive imaging of the coronary arteries possible. Therefore, CT angiography (CTA) is without a doubt a powerful noninvasive modality for evaluating and excluding CAD and will likely play an important role in the diagnosis of CAD.

There has been much discussion and intense controversy as to whether radiologists or cardiologists should be

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See *J Nucl Med*; 47:797-806

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performing and interpreting these imaging studies. In these discussions, the role of nuclear medicine and nuclear cardiology specialists for conducting or interpreting CTA has somehow been lost or overlooked. However, the sharp race for hybrid nuclear/CT scanners (SPECT/CT and PET/CT) capable of providing not only the means for attenuation correction of myocardial perfusion images but also the ability to image the coronary arteries in an integrated single study will likely add a new dimension to this debate. Thus, it is important that nuclear medicine and nuclear cardiology specialists gain expertise in cardiac CT because of the likelihood that integrated assessments of anatomy and function will become

routine (just as they did in oncology) in at least some patient groups.

In the May issue of *The Journal of Nuclear Medicine*, Hoffmann et al. (1) provided an excellent primer on how to perform and interpret coronary CTA. The review also discussed the strengths and potential clinical applications of CTA for evaluating patients with suspected CAD. I believe it would be appropriate to discuss in a little more detail how this test might fit into the evaluation of patients with chest pain.

## DIAGNOSIS AND MANAGEMENT OF CAD

There is growing, consistent evidence that CTA is an accurate test for excluding the presence of coronary atherosclerosis. As pointed out by Hoffmann et al., (1) the negative predictive value of the test is high (>95%), especially when using 64-slice CT. This information is clinically useful because normal coronary CTA findings will likely decrease the need for further testing and because management of patients with risk factors but normal epicardial coronary arteries is relatively straightforward. Thus, this test is likely to become clinically effective and cost effective in patients in whom the yield of normal scan findings is high (>80%).

CTA also provides excellent diagnostic sensitivity for identifying stenoses in the proximal and mid segments (>1.5 mm in diameter) of the main coronary arteries. The sensitivity for mid to distal coronary segments and side branches is significantly reduced even when using 64-slice CT (2-4). Although it may be argued that only stenoses in large vessels are of practical interest because they can be revascularized with stents, this information is still relevant for guiding medical management. An additional problem with coronary CTA is that its

accuracy for defining the actual degree of stenosis severity is limited. Indeed, recent evidence obtained with 64-slice CT indicates that quantitative estimates of stenosis severity by CT correlate only modestly with quantitative coronary angiography results, with the former explaining only 29% of variability in the latter (3). Image degradation by motion or calcium may lead to under- or overestimation of luminal narrowing by CTA. Because of similar effects, metal objects such as stents, surgical clips, and sternal wires can also interfere with the evaluation of underlying coronary stenoses.

Preliminary data from our laboratory and others suggest that the positive predictive value of CTA for identifying coronary stenoses producing objective evidence of stress-induced ischemia is suboptimal (~50%) (5,6). This apparent discrepancy between anatomic and physiologic measurements of stenosis severity is probably multifactorial. First, as already discussed, the ability of CTA to accurately assess the degree of luminal narrowing is only modest. Second, the percentage diameter of stenosis on coronary angiography is only a modest descriptor of coronary resistance, a key determinant of myocardial perfusion. Numerous other anatomic and physiologic factors that are important determinants of myocardial blood flow are not accounted for by measures of stenosis severity, including factors related to plaque (shape, eccentricity), cardiac hemodynamics (left ventricular end-diastolic pressure and contractility), arterial physiology (vasomotor tone, endothelial function), stenosis characteristics (composition, stenoses in series), and collateral blood flow (7).

Because decisions regarding revascularization are governed by the severity of patient symptoms and the magnitude of inducible myocardial

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Received Jun. 4, 2006; revision accepted Jun. 9, 2006.

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ischemia (8,9), the limited accuracy of CTA in predicting physiologic significance would suggest that additional noninvasive testing (e.g., myocardial perfusion imaging) would be required after CTA before consideration of invasive catheterization, a step currently recommended by guidelines (10). This suggests that the use of coronary CTA as a gatekeeper to the catheterization laboratory would result in excessive invasive angiography with the potential for numerous unnecessary revascularizations, as previously shown with catheter-based coronary angiography (11). Thus, this test is likely to be less effective in patients in whom the yield of normal scan results is low (<50%).

### EVALUATION OF CAD

The integration of nuclear imaging and multidetector CT (SPECT/CT and PET/CT) provides a potential opportunity to delineate the anatomic extent and physiologic severity of coronary atherosclerosis and obstructive disease in a single setting. Together, by revealing the degree and location of anatomic stenoses and their physiologic significance, the plaque burden and its composition, the integrated approach can provide unique information that may improve the noninvasive diagnosis of CAD and the prediction of cardiovascular risk.

One advantage of the integrated approach to the diagnosis of CAD is the added sensitivity of myocardial perfusion imaging and CTA, potentially providing a correct diagnosis in virtually all patients. The diagnostic sensitivity of CTA is reduced substantially in more distal coronary segments and side branches. This limitation may be offset by the perfusion information, which is rarely affected by the location of coronary stenoses. On the other hand, the known limitation of stress perfusion imaging to assess the extent of underlying CAD can be overcome by the coronary CTA information, which is effective for uncovering left main and proximal 3-vessel CAD.

Because not all coronary stenoses detected by coronary CTA are flow

limiting, the stress myocardial perfusion imaging data complement the CTA information by providing instant readings about the clinical significance (i.e., ischemic burden) of such stenoses, thereby facilitating appropriate management decisions. In addition, an integrated approach with nuclear imaging/CT also facilitates identification of patients without flow-limiting disease (i.e., normal perfusion) who have extensive, albeit subclinical, CAD. Preliminary data from our laboratory suggest that as many as 50% of patients with normal stress perfusion PET results may show extensive (non-flow-limiting) coronary atherosclerosis (both calcified and noncalcified plaques) (5). Although these patients lack ischemia and thus do not require revascularization, they probably warrant more aggressive medical therapy.

### OUTCOMES DATA

Although the existing body of evidence correlating CTA with invasive coronary angiography provides an important and necessary first step, there is a need for clinical outcomes data to help establish the role of CTA and its relative accuracy compared with other modalities (i.e., perfusion imaging and integrated nuclear/CT), as well as how these tests optimally fit together in testing strategies in various patient groups. This need is especially important now that the cardiologist has a large menu of options for noninvasive diagnosis of CAD. The Study of Myocardial Perfusion and Coronary Anatomy Imaging Roles in CAD (SPARC) trial is a prospective, open-label, multicenter, sequentially sampled, observational registry to define the clinical value of stress perfusion (stress SPECT, stress PET), noninvasive angiography (CTA), and combined perfusion/anatomy (PET/CT) studies in patients with known or suspected CAD with respect to posttest resource use, prediction of cardiac death and nonfatal myocardial infarction, and cost-effectiveness. In addition, image interpretation and scoring is standardized across sites, further reducing the potential for uncontrolled heteroge-

neity between sites. The approach embodied by SPARC as applied to technology comparison and assessment is a step forward compared with the historical approach. The multicenter approach improves the ability to collect large, well-powered cohorts, even for a newer modality, and enhances the generalizability of the results because many different types of testing centers participate in the study. Although we await the final word on the value of different noninvasive testing strategies to evaluate patients with CAD, the review by Hoffmann et al. (1) provides an excellent opportunity for nuclear medicine and nuclear cardiology specialists to become familiar with coronary CTA, which is likely to become an important adjunct to myocardial perfusion imaging.

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### Erratum

In Table 6 of the article “Tissue Distribution of <sup>18</sup>F-FDG-Labeled Peripheral Hematopoietic Stem Cells After Intracoronary Administration in Patients with Myocardial Infarction,” by Kang et al. (*J Nucl Med.* 2006;47:1295-1301), the unit of measure for radiation dose was mistakenly stated to be mGy/Bq instead of the correct unit, mGy/MBq. The authors regret the error.