



Dual Source CT for Cardiac Imaging

- Dual source CT has very high temporal and spatial resolution, making it possible to freeze cardiac motion and obtain diagnostic quality images of the coronary arteries regardless of heart rate
- Preliminary data suggests the sensitivity for detecting stenoses >50% is 91-100% and the negative predictive value is 97-100%
- A number of clinical indications have been proposed in a multi society consensus document (see table) based on available published data
- Cardiac CT angiography is not recommended for screening asymptomatic patients

The constant motion of the heart and the small size of coronary arteries present a considerable challenge for the acquisition of diagnostic quality images. Fast multidetector CT scanners and gated cardiac imaging overcame many of the cardiac motion challenges. However, even with 64-detector scanners, it was not possible to obtain diagnostic quality images in many patients with heart rates greater than 65 beats per minute because of distortions from myocardial motion. One solution therefore, was to administer beta blockers prior to imaging in order to lower the heart rate (see [Radiology Rounds, August 2004, Coronary CTA](#)). However, this was not always possible nor was it effective in some patients. Furthermore, because some of the reconstruction methods combined data from several consecutive cardiac cycles, it was not possible to image patients with any arrhythmias.

With the recent introduction of dual source CT scanners, these limitations no longer apply; there are no restrictions concerning heart rate and it is even possible to image patients with arrhythmias or atrial fibrillation. The dual source CT scanner houses two x-ray tubes that are arranged at a 90° angle and two corresponding sets of detectors in the gantry. The gantry only has to rotate 90° to acquire data in 180° projections for image reconstruction. In addition, the gantry rotation speed is faster than most previous scanners, resulting in a temporal resolution of 83 ms. In comparison, the fastest 64-slice multidetector CT scanners have a temporal resolution of 165 ms.

Image reconstruction software can analyze data from a single cardiac cycle at a phase when there is minimal motion in order to produce planar images at any chosen angle, 3-dimensional images that flatten the coronary arteries into a single plane, and 3-dimensional volumetric images (Figure 1). By reconstructing images



Figure 1. Volume rendered dual source CT image obtained at a heart rate of 83 bpm shows motion-free coronary arteries with plaque in the left anterior descending artery (arrowheads) and an ostial stenosis (arrow) off the first diagonal branch.

from multiple phases of the cardiac cycle, cine images can be made that show myocardial wall motion or valve function. In addition, images of the lung are included in the scan and, depending on the scan protocol, can be examined for other causes of chest pain, such as pulmonary embolism.

Table 1. Appropriate Indications for Cardiac CT Angiography	Score
Evaluation of chest pain syndrome: Intermediate pre-test probability of CAD ECG uninterpretable OR unable to exercise	7
Evaluation of chest pain syndrome: Intermediate pre-test probability of CAD No ECG changes and serial enzymes negative	7
Evaluation of suspected coronary anomalies	9
Evaluation of chest pain syndrome: Uninterpretable or equivocal stress test (exercise, perfusion, or stress echo)	8
CT Angiography for Assessment of Structure and Function - Morphology	
Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves	7
Evaluation of coronary arteries in patients with new onset heart failure to assess etiology	7
Cardiac CT for Assessment of Structure and Function - Intra- and Extra-Cardiac Structures	
Evaluation of cardiac mass (suspected tumor or thrombus) Patients with technically limited images from echocardiogram, MRI, or TEE*	8
Evaluation of pericardial conditions (pericardial mass, constrictive pericarditis, or complications of cardiac surgery) Patients with technically limited images from echocardiogram, MRI, or TEE*	8
Evaluation of pulmonary vein anatomy prior to invasive radiofrequency ablation for atrial fibrillation	8
Noninvasive coronary vein mapping prior to placement of biventricular pacemaker	8
Noninvasive coronary artery mapping, including internal mammary artery prior to repeat surgical revascularization	8
CT Angiography for Evaluation of Aortic and Pulmonary Artery Disease	
Evaluation of aortic and pulmonary disease: Evaluation of suspected aortic dissection or thoracic artery aneurysm	9
Evaluation of aortic and pulmonary disease: Evaluation of suspected pulmonary embolism	9
<i>From ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR Appropriateness Criteria for Cardiac Computed Tomography and Cardiac Magnetic Resonance Imaging, 2006. The scores for appropriateness criteria range from 1-9; those that score 7-9 indicate that the test is generally acceptable and a reasonable approach for a given clinical indication.</i>	
<i>*TEE, transesophageal echocardiography</i>	

At this time, a few preliminary studies have been completed on the accuracy of dual-source coronary CT angiography (CTA). In one study of 109 patients with acute chest pain, overall sensitivity for the cause of chest pain was 98% and correlation with invasive angiography demonstrated 100% sensitivity and 97-100% negative predictive value for coronary stenoses. In another study of 90 patients with an intermediate pre-test probability for coronary artery disease (CAD), the per-patient sensitivity for detecting stenoses >75% was reported to be 100% and that for stenoses 50-75% was 88%. The specificities were 96% and 91%, respectively and the negative predictive values 100% and 98%, respectively.

Indications for Cardiac CT Angiography

At this time, the clinical indications for coronary CTA are not completely established. However, a multi-society consensus panel has agreed on a list of currently accepted indications (Table 1). Patients who are most likely to benefit from coronary CTA are those who have atypical symptoms and are of intermediate risk for coronary artery disease. In patients with a typical presentation, conventional angiography may be more suitable, as this procedure can be followed by an

intervention. In rare cases, myocardial ischemia can be missed on a nuclear cardiology test due to balanced ischemia. If a nuclear cardiology examination is negative but there is reason to suspect multivessel CAD, a coronary CTA can show whether there are stenoses present. In cases of indeterminate nuclear perfusion scans cardiac CT can be performed to confirm or exclude obstructive coronary artery disease.

Cardiac CT angiography can also be used to assess cardiac morphology and function of structures such as the cardiac chambers, the great vessels, and valves, as well as pericardial structures and pulmonary disease.

Exclusion Criteria

Relative contraindications include renal insufficiency (eGFR <30 ml/min/1.73 m²), known anaphylactic reaction to iodinated contrast material, unstable clinical condition, and CT imaging with contrast administration within the past 24 hours. Other contraindications include inability to maintain a breath hold for a minimum of 10 seconds and an inability to cooperate with instructions.

Limitations

Image quality may be limited by severe calcification of the coronary arteries, which can cause “blooming” artifacts and obscure the lumen. In patients with small

coronary arteries and severe disease (for example, some diabetic patients) the spatial resolution may not be sufficient to allow detailed analysis of the coronary arteries. Dual source cardiac CTA is limited in its ability to rule out stent restenosis in stents <3.0 mm.

Radiation dose is still a concern with the dual source scanner but is usually less than that of a single source scanner because the complete scan takes less time and the current can be modulated so that it is at the high setting for a shorter time than a 64-slice scanner. Moreover, if information regarding myocardial function is not required, a prospective triggered scan can usually yield a diagnostic study with a radiation dose that is substantially less than a nuclear cardiology scan and comparable to a diagnostic coronary angiogram.

Scheduling

A cardiac dual source CT scanner was installed on the main campus in the fall of 2007. Coronary CTA examinations can be scheduled online through Radiology Order Entry (ROE) (<http://mghroe>) or by contacting [Georgia Bufford](#), 617-724-4752. Most insurance carriers cover coronary CTA.

Further Information

For further questions, please contact [Suhny Abbara, M.D.](#), Director Cardiovascular Imaging Division, Department of Radiology, Massachusetts General Hospital at 617-726-0796.

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