CT Coronary Angiography

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Coronary CT Angiography (CTA) is the only noninvasive technique available for imaging the coronary arteries. However, visualization of the small, tortuous, and rapidly moving coronary arteries stretches the temporal and spatial resolution of CT to its limits.

2 factors essential in getting a good scan are, stable low heart rate and a good breath-hold. A heart rate of 60 to 65 beats per minute is ideal. To achieve this, 50 mg of an extended release metoprolol is given to the patient (after having excluded any contraindication to the same) two nights before the test. Having said this, we have performed CTangiograms in patients with rates as high as 90 when required and obtained diagnostic images. The key to an acceptable study is a steady heart rate. This implies that patients with arrhythmias are poor candidates for this study.

Multislice CT scanners (MSCT) generate a huge number of images in the transverse plane, each slice being 0.625mm thick (in a 64slice scanner). This implies that high resolution images can be obtained in almost any plane and clinically meaningful post-processed images are paramount for accurate and efficient interpretation of the data. Besides assessing the coronary arterial anatomy the multiphasic dataset can be post processed to assess the cardiac contractility and hence functional information can also be obtained. The cardiac valves can also be analysed to an extent.

MSCT in IHD:

In 2006, the American Heart Association laid down the Appropriateness Criteria for CT Coronary Angiography, the salient features of which are:

1. For the detection of obstructive coronary artery disease in the evaluation of a patient with **chest pain** who has an **intermediate pretest probability** of the same, an **EKG that is uninterpretable or is unable to exercise.**

2. For the detection of obstructive coronary artery disease in the evaluation of a patient who presents with the **acute onset of chest pain** who has an **intermediate pretest probability** of the same, no **EKG changes, and serial cardiac enzymes that are negative.**

3. For the detection of obstructive coronary artery disease in the evaluation of a patient with **chest pain** who has **uninterpretable or equivocal stress test results**.

4. For the evaluation of the coronary arteries in patients with **new onset heart failure to assess etiology.**

5. For the **evaluation of complex congenital heart disease** including anomalies of coronary circulation, great vessels and cardiac chambers and valves.

6. For the evaluation of **suspected coronary anomalies**.

7. For the evaluation of **coronary arterial mapping, including internal mammary arteries, prior to repeat cardiac surgical revascularization**.

8. For the evaluation of **suspected aortic dissection especially to exclude coronary arterial involvement.**

All studies, even with the use of 16-slice CT, have consistently report a very high negative predictive value (96% to 99%). In presence of stenotic disease, there may be a difference of upto 15% between CTA and catheter coronary angiography. If there is calcification, then this discrepancy may be more.

With 64-MSCT, a sensitivity of 82% has been reported for detection of >50% stenosis and sensitivity of 86% has been reported for detection of >75% stenosis in the diagnosis of ischemic heart disease. Per segment, specificity and NPV were as high as 95% and 97%, respectively (1).

Prognostic value of MDCT coronary angiography in patients with known or suspected CAD

In a study published in *J Am Coll Cardiol 2007* [2] 100 patients were followed for 16mths following a CTA. Plaques were identified in 80 patients of which 2/3rds [63%] had cardiac events. 30% of patients with some evidence of CAD had a future event.

All patients who were free of disease on their MSCT scans lived through at least the next year without an incident.

Study of atheromatous plaque

CTA's cross-sectional nature enables assessment of the vessel wall and plaque characteristics. Fibrous, lipid-rich or calcified plaque components can be identified by measuring CT attenuation within the lesion. (fig 1,2) This feature has been used to measure the therapeutic affect of statins on coronary artery plaque. In a study published in AJR 2006 [3], 21 patients with coronary artery disease were treated with lipid-lowering atorvastatin (Lipitor). After 12 months of treatment, average LDL cholesterol levels reduced from 122 mg/dL to 96 mg/dL. The areas of noncalcified coronary plaques, manually measured from axial or multiplanar reconstructions, did not change significantly but plaque density increased from 55 HU to 62 HU after 12months of treatment suggesting a decrease in the fat component of the plaque with progression to fibrosis.

Triple Rule Out:

MDCT has been exploited in early triage of patients with acute chest pain. In Massachusetts General Hospital 40 patients with chest pain, nondiagnostic ECG, and normal cardiac enzymes were scanned. Acute coronary syndrome was confirmed in 5 patients and was ruled out in 35 patients. Significant coronary stenosis was excluded in 26 of 35 patients thereby potentially cutting the hospitalization rate for these patients by 70% [4]. The other causes of acute chest pain viz.

- Pulmonary Embolism
- Aortic dissection
- Pneumonia
- Pleural effusions; Can be evaluated on the same study.

Evaluation of stents is hampered by presence of wall calcifications, overlapping stents, stent diameter < 3mm. Stents oriented parallel to the x-ray beam and those with markers have diminished assessability at level of markers.

Rate of assessable stents by 64MDCT is low but in evaluable stents, accuracy for detection of in-stent restenosis can be high [5]. Pugliese et al have reported improved assessability of the in-stent lumen and capability to appreciate more subtle degrees of in-stent neointimal hyperplasia 64-MDCT despite image-degrading effects caused by the metallic scaffold of the stent [6] (fig 3).

Coronary Arterial bypass graft evaluation:

Bypass vessels are larger than the native coronary arteries and they move less rapidly making them easier to image than the native coronaries. It is possible to assess occlusions and stenoses of bypass grafts, the status of the native coronary arteries distal to the bypass anastomosis and of those branches that did not receive a graft (fig 4).

Role of CTCA in recurrent ischemia post CABG was assessed in 24pts in a study[7]. Occluded or stenosed grafts were detected in 63% (Sens: 100%, Spec: 95%); disease progression in native ungrafted vessels was detected in 38% (Sens: 100%, Spec: 81%) and disease in run-off vessels distal to graft was detected in 8% (Spec: 95%).

Coronary Artery Anomalies have been reported in 0.3% to 1% of the "normal" population. Conventional angiography may detect ≈50% of them.

MDCT is superior to conventional angiography in delineating the ostial origin and proximal path of an anomalous coronary artery[8]. Anomalous origins, anomalous course, myocardial bridging and coronary artery aneurysms are some of the entities which are commonly encountered (fig 5, 6).

Use of MSCT to detect significant CAD in patients referred for cardiac valve surgery

A recent study suggested that MDCT is "excellent" for confirming or ruling out CAD in patients scheduled for valve surgery [9]

Potential Application; Diagnosing nonvalvular thrombi and masses in the LA and LV:
As the opacification on the left heart is very good, 64-slice CTA may become an alternative to TEE for assessing left heart thrombi before cardioversion

LIMITATIONS OF CTA

- Patients with atrial fibrillation or other arrhythmias cannot be evaluated.
- Severe CAD with extensive calcification is unevaluable
- It is purely a diagnostic tool
- Cannot reliably assess stent lumina

When is coronary CTA not indicated and in fact probably contraindicated?

- Symptomatic patients at high risk for occlusive disease
- Patient with active objective evidence of ischemia
- ECG: ST elevation or depression
- elevated serum markers of cardiac damage

Why cardiac CT and not coronary catheterization?

- First line test to avoid catheterization in patients unlikely to need intervention
- Test which provides the identification of patients with subclinical atherosclerosis who are then aggressively treated medically

Major indications for CTA will be:

- Screening for patients with atypical angina or risk factors
- Coronary assessment before every cardiac & vascular surgery
- Chest pain (with exploration of the entire thorax)
- CABG, stent follow up

References:

1. Nikolaou K et al AJR 2006 July; 187(1):111-117.

2. *J Am Coll Cardiol 2007;49(2):62-70*

3. Nikolaou K et al. AJR 2006;186:1659-1668.

4. *AJR 2006;187:1240-1247*

5. Eur HJ Oct 2006

6. Pugliese F et al. RadioGraphics 2006; 26:887-904.

7. RSNA Nov 2006

8. RadioGraphics 2006;26:317-334

9. *JACC* 2006;48:1658-1665