Role of Cardiac MSCT

Current:
- Structural / congenital heart imaging
- Extra-cardiac / Great vessel imaging
- Volumes and ejection fractions (cine + gating)
- Calcium Scoring
- Coronary artery imaging (contrast enhanced)
- Perfusion / viability imaging (contrast enhanced)
- Plaque characterization (?)

Imaging of the heart is technically difficult because:
- Cardiac Motion
- Respiratory Motion
Multi-Slice CT
Technical Issues

To overcome this
- Cardiac motion
  - ECG gating
  - Fast imaging: temporal resolution 100-200 ms
- Respiratory motion
  - Breathhold imaging
  - Fast imaging: duration < 10 sec

Principles of multislice CT

Improvements of latest generation (64 slice vs 4 slice) MS CT Scanners

- Higher Rotation Speed: 330 ms
- Larger Number of Detectors: 64 instead of 4

Allows:
- Higher temporal resolution:
  - 83 ms instead of 250 ms
- Higher spatial resolution 0.5 x 0.5 mm (CMR 0.7 mm, Contrast Angiography 0.1 mm)
- Shorter breathholds:
  - 5-10 sec instead of 40-50 sec
**MS-CT scanners**
**New features**
- Near motion-free Cardiac imaging
- Cine Imaging → Cardiac Function
- Calcium Scoring
- Contrast Enhanced Coronary Imaging
- Plaque Imaging (?)

**Assessment of Cardiac Function**

**Applications of MSCT**
**Calcium Scoring**
**New Applications:**
Contrast Enhanced Coronary Artery Imaging

Clinical Applications of MS CT

- Detection of Coronary Artery Disease
- Improved Performance for “Classical” Indications of CT
  - Cardiac Tumors
  - Pericardial Disease
  - Congenital
- Integrated Cardio-Thoracic Exam
Coronary Artery Disease

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<th>% of evaluable segments</th>
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Overall 87 % 91%

Detection of Coronary Artery Disease

One problem remains: calcification….

Three cases with corresponding conventional and MSCT angiograms. A and B, Occluded (arrow) LAD with distal collateral filling. C and D, Triple LAD lesions (arrows): 80%, 67%, and non-obstructed stent. E and F, High-grade CX lesion (arrow). CX indicates circumflex; D1, diagonal branch; RM, marginal branch; and GCV, great cardiac vein.
Patient with an ostial stenosis of the left main coronary artery. A, Curved multiplanar reconstruction of the left main and left anterior descending artery, showing the ostial stenosis (arrow). B, Curved multiplanar reconstruction of the left main and circumflex coronary arteries, again showing the left main stenosis (arrow). C, Curved multiplanar reconstruction of the right coronary artery. In accordance with results shown by invasive coronary angiography (not shown), no stenoses are present. D, Invasive angiogram showing severe left main ostial stenosis (92% diameter reduction; arrow).

CAG (left) and plain and contrast-enhancement CT (middle and right, respectively) of 50-year-old man with angina pectoris. Coronary angiogram depicts LAD stenoses (75% stenosis in segment 6 [arrow] and 50% stenosis in segment 7 [arrowhead]). Plain CT depicts left coronary arteries, and no calcification is observed. Contrast-enhancement CT depicts LAD stenoses consistent with CAG.

Coronary Calcification

3D Reconstruction of the Heart and Coronaries with Volume Rendering Technique

3D Reconstruction of anomalous RCA arising from the Left Sinus of Valsalva
Coronary artery calcium prevalence, 10-year event risk, and prevalence/risk ratio in asymptomatic men. Event risk and calcium prevalence are plotted against right axis, and prevalence/risk ratio is plotted against left axis. Prevalence/risk curve decreases with age, suggesting that although serious over-prediction will occur in the young, over-prediction will be only moderate in the elderly.

**Absence of Detectable Coronary Artery Calcification Using Electron Beam Computed Tomography (Negative Test)**

- Does not absolutely rule out the presence of atherosclerotic plaque, including unstable plaque.
- Highly unlikely in the presence of significant luminal obstructive disease.
- Observation made in the majority of patients who have had both angiographically normal coronary arteries and EBCT scanning.
- Testing is gender independent.
- May be consistent with a low risk of a cardiovascular event in the next 2-5 years.

**Presence of Detectable Coronary Artery Calcification Using Electron Beam Computed Tomography (Positive Test)**

- Confirms the presence of coronary atherosclerotic plaque.
- The greater the amount of calcification (i.e. calcium area or calcium score), the greater the likelihood of obstructive disease, but there is no one-to-one relation, and findings may not be site specific.
- Total amount of calcification correlates best with total amount of atherosclerotic plaque, although the true “plaque burden” is underestimated.
- A high calcium score may be consistent with moderate to high risk of a cardiovascular event within the next 2-5 years.

Kaplan-Meier survival curves for 123 patients with CAC score <100 (5 hard events) and 165 patients with CAC score >100 (17 hard cardiac events). Patients with CAC scores >100 had significantly poorer outcome than patients with scores <100 ($P <0.01$).
EBCT (top) and SPECT (bottom) images of asymptomatic subject who had high-risk CACS of 937. Circles define regions of coronary calcification. Upsloping (<1 mm) ST-segment depression occurred 9.0 minutes into ETT, which was terminated because of patient fatigue. Although Duke score was calculated as low risk (6.5), SPECT demonstrated large, reversible 48% perfusion defect (green) within distribution of all 3 major coronary arteries (COMP-SC) (bottom). This patient had severe 3-vessel disease on angiography and underwent CABG. PDS indicates perfusion defect size.

Serial Calcium Scoring

Effects of Statin therapy on the progression of coronary calcification (LM-pLAD) by EBCT

A=Baseline
B=12 months w/o statin
C=12 months after statin therapy

Achenbach, Circulation 2002;106:1077-1082
Characterization of myocardial infarction

Contrast-enhanced chest MSCT reveals an infarct zone as a non-contrast-enhancing area on the posterolateral wall and both papillary muscles. The subject had an acute lateral MI on ECG and had acute PTCA w/i 1 hour of onset of chest pain.
As an 85-year-old woman with anteroseptal acute myocardial infarction, contrast-enhanced non-contrast CT (CE-CT) started at 50 seconds of injection of contrast material (1.2 mL/s, 100 mL total). A 64-slice CT scanner with 0.625-mm collimation was used. The patient was scanned in supine position with 10-mm slice intervals. CE-CT images were reconstructed with a 256-mm z-axis image thickness and a 5-mm slice thickness. 1 mm-thick slice thickness for non-contrast. 2 mm-thick slice thickness for CE-CT images. Imaging was performed with a 0.625-mm collimation. The contrast material used was iodine (300 mg/mL) at a flow rate of 2 mL/s for 30 seconds. Images were reconstructed with a 256-mm z-axis image thickness and a 5-mm slice thickness. The contrast material used was iodine (300 mg/mL) at a flow rate of 2 mL/s for 30 seconds. Images were reconstructed with a 256-mm z-axis image thickness and a 5-mm slice thickness. In 8 minutes, the whole lesion is depicted as a higher density area than the non-infarcted left ventricular wall (arrows, bottom row).

**Cine MSCT**

64 and 63 images of 1 of 4 direct, 4-chamber view slices (5 mm thick x 2 slices) during dynamic cine CT. Illustration of anatomic information is on right. Movie was produced by paging images reconstructed in 0.1-second intervals (10 to 26 seconds from beginning of intravenous administration of contrast material). AO indicates the aorta; MV, mitral valve; and PV, pulmonary vein. Open mitral valve is visible in ED image, and closed mitral valve is visible in ES image. MV, mitral valve; PV, pulmonary vein; and RCA, right coronary artery.
Imaging in Stented Coronary Arteries

- More difficult due to hyper-enhanced signals from the coronary stents, thus in-stent re-stenosis can be missed
- Stents with bigger 'holes' easier to image
- Contrast enhanced imaging useful to look for ISR

Axial source and volume rendered images of the pLAD using end diastolic data in enhanced MSCT, showing a stent in the pLAD, and no evidence of restenosis. Correlation with coronary angiography

Multislice spiral CT coronary angiogram. The axial source and the volume rendered axial and multiplanar images are shown of the left anterior descending coronary artery (LAD). No intraluminal hypodensities are noted within the area of the stent (arrow). Cross-sectional and volume rendered images of the proximal shape of the stent can be observed. The multiplanar reconstructed representation (D) can easily be highlighted by altering the image settings.

Left Main Rapamycin-Coated Stent

MSCT images. A, CT scan through the aortic root showed 2 stents in the mid left anterior descending LAD: total length was 23 mm (dotted line) with a 3-mm overlapping segment (solid line). B, 3D rendering of the heart and coronary arteries with manual segmentation of cross-sectional images. LMCA indicates left main coronary artery, LCX, left circumflex; 1stD, 1st diagonal branch; and GCV, great cardiac vein. The stented segment (arrow) is located in the mid LAD.
Flat Panel CT System

Advantages:
- Single Breathhold
- Single Contrast Injection
- Non-nephrotoxic Barium

Future Perspectives

Will MS-CT replace Invasive Coronary Angiography?
ILIAC ARTERY STENOSIS