Cardiac CT Angiography

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Why do we need a better test for C.A.D?

1. CAD is the leading cause of death in the US
   - CAD 31%
   - Cancer 23%
   - Stroke 7%

2. The prevalence of atherosclerosis of the coronary arteries is high
   - <25 25%
   - 25-40 50%
   - >40 75%
3. Sudden death is the first and last sign of CAD in >450,000 people per year

4. 4% of patients with acute MI are discharged from the ER with the wrong diagnosis (3 fold increase in mortality)

5. It is difficult to clinically identify patients destined to develop an acute coronary event

6. >50% of CAD death and MI’s in the US occur in patients considered low to intermediate risk

7. 50% of patients with an acute MI have normal cholesterol profiles
Assessing CAD Risk

1. Risk Factors

- Age
- HDL
- Total Cholesterol
- Systolic BP
- Smoking
2. FRS seems to underestimate the burden of CVD in men <60 and women <70

3. The presence of risk factors does not always equal the presence of disease

4. Traditional tests (cholesterol, stress test, EKG) do not tell us if vulnerable plaques are present

5. The ideal test should identify high risk asymptomatic individuals before CAD occurs

6. Earlier detection of CAD should correlate with more treatment options and improved outcomes
CCTA vs. Other Imaging Modalities

1. 25 – 30% of all cardiac caths done in the US are normal
2. 30 – 40% reveal mild disease which does not warrant intervention
3. Stress tests effectively diagnose end stage CAD
4. 64 slice CCTA is the only non-invasive means of detecting vulnerable plaques in the end organ responsible for CAD – vessel wall.
5. Cardiac caths cost thousands; CCTA costs hundreds

6. By the year 2010 the estimated number of cardiac caths could approach 3,000,000 in the US

- 900,000 normal studies
- 1-2% complication rate
- 9,000 – 18,000 complications
- Up to 900 deaths/yr
Why 64 Slice CT?

1. Temporal Resolution

- How well can we freeze cardiac motion
- Faster tube rotation
- 0.35 seconds
- 40-200msec vs. 5-10msec for angio
- Still need to slow down HR ≤ 60 with use beta blockers
2. Spatial Resolution
   • How well can we visualize small vessels
   • 64 0.5mm wide detectors
   • 0.4mm isotropic spatial resolution
   • Vs. 0.1 – 0.2mm for cardiac cath

3. Low Contrast Resolution
   • How well can we differentiate between soft plaque and vessel wall; between contrast and calcium
   • Multi phase injectors
   • Surestart

4. Improved computing power
   • 20-25 gigabytes of data
   • 3,000 – 4,000 DICOM images
Why is 64 slice CCTA a Good Non-Invasive Test for CAD

1. Fast
   - 8 to 9 seconds

2. Non-Invasive
   - 18g peripheral IV access

3. Radiation Dose
   - 13mSev
   - Similar radiation dose to cardiac cath, nuclear perfusion test
   - We all receive approximately 3mSev a year from natural sources (cosmic radiation, radon gas)
4. CCTA provides a 3D data set (infinite projections)
5. Coronary Artery Calcium Score (CACS)
6. Cardiac Function Analysis
   • Ejection fraction
   • Stroke Volume
   • Cardiac output
   • Left ventricular mass
7. Detection of calcified and non-calcified plaque
   • Before there is detectable luminal encroachment on angio
8. Coronary artery anomalies
9. Coronary bypass grafts
10. Pericardium, myocardium, cardiac chambers, mediastinum, pulmonary arteries
11. 98% negative predictive value
The Nursing Roll in CCTA

1. Nursing performs the pre-test screening evaluation to qualify the patient for the CCTA

2. Beta blockers are administered by the nurse

3. Nurse monitors patients vital signs

4. Nursing performs the post procedure monitoring
What is Coronary Artery Calcium Score (CACS)

1. Agatston Score
2. 1.5mSev
   - Step and scan
   - Prospective gating
3. CACS does not identify the vulnerable plaque
4. CACS identifies the vulnerable patient
5. Negative predictive power >99%
   - In a study of 2,111 patients only 0.7% had no calcium and a significant luminal stenosis
6. 2006 AHA Guidelines
   - It may be reasonable to measure atherosclerosis burden using cardiac CT in clinically selected intermediate-CAD risk patients (10-20% Framingham 10-yr Risk Estimate) to refine risk prediction and to select patients for more aggressive target values for lipid lowering therapy
7. ACCF/AHA 2007 Clinical Expert Consensus

- It may be reasonable to consider use of CACS in asymptomatic patients with intermediate CAD risk (10-20% 10-yr risk of coronary event)
- Not recommended in low risk patients
- Not recommended in asymptomatic patients with high CAD risk (>20% 10-yr risk), or those with established CAD
- Low risk patients with atypical chest symptoms may benefit from CACS to help in ruling out the presence of obstructing CAD
Clinical Application of CACS

1. Symptomatic Patient
   • Atypical chest pain, absence of established CV disease
   • Indeterminate stress test, absence of established CV disease

2. Asymptomatic Patient
   • Refine the CV risk of patients at intermediate risk of a CV event and assist physician regarding initiation or change of drug therapy
3. **Not Indicated In:**
   - Children or pregnant women
   - Low risk asymptomatic patients
   - Patients with known CV disease

4. **CACS may prove to have a role not only in diagnosis of CAD, but also in improving adherence to treatment**
   - One study showed patient compliance with Statins improved 9-fold when patients were presented with high calcium scores
The total calcium score of 0 is between the yellow (100) and green (0) lines on the graph for age and gender. This means that there are no significant differences in the distribution of total calcium scores between age groups. The calcium score, relative to other age groups, is indicated by the highlighted square on the graph.
The total calcium score of 377 is between the 50th and 75th percentile for men between the ages of 50 and 59. This means that 25% of people this age and gender had less calcium than was detected in this study. The graph above (a) shows the distribution of total calcium scores for each age group by percentile. The calcium score, relative to other age groups, is indicated by the highlighted squares in the graph.
The total calcium score of 2215 between the 75 and 85 percentile for men between the age of 50 and 70. This means that 2215 percent of people the age and gender had less calcium than was detected in the study. The graph above (left) shows the distribution of calcium scores for each age group by percentile. The calcium scores relative to other age groups is indicated by the highlighted square in the graph.

### Calcium Score

<table>
<thead>
<tr>
<th>Region</th>
<th>Calcium Score (Agammase)</th>
<th>Volume (mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Main</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Right Coronary Artery</td>
<td>941</td>
<td>775</td>
</tr>
<tr>
<td>Left Anterior Descending</td>
<td>1591</td>
<td>1245</td>
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<tr>
<td>Coronary</td>
<td>696</td>
<td>560</td>
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<tr>
<td>Posterior Descending Artery</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Other 1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other 2</td>
<td>0</td>
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<tr>
<td>Other 3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>3225</td>
<td>2860</td>
</tr>
</tbody>
</table>

Total Calcium Score: 2215

### Calcium Percentile Score

- **Calcium Scores (Gm²)**
  - 0: No identifiable plaque
  - 1-10: Mildly calcified plaque
  - 11-18: Definitely at least mild atheromatous plaque
  - 19-499: Definite, at least moderate atheromatous plaque
  - 500-4000: Definite, at least severe atheromatous plaque
  - 4001 or higher: Extensive atheromatous plaque

- **Application**
  - Low, general health, low risk
  - High risk, high mortality, high risk

- **Risk of Coronary Artery Disease**
  - Minimal
  - Mild
  - Moderate
  - Severe
  - Extensive

- **Benchmark**
  - Low
  - Moderate
  - High
  - Very high

- **Sensitivity**
  - Low
  - Moderate
  - High
  - Very high
The Vulnerable Plaque

- Thin Cap Fibroatheroma
- Rupture of a lipid laden plaque with a thin cap is the usual cause of ACS
- A majority of plaques (60-70%) are not hemodynamically significant before rupture
- Soft plaques can be present without predisposing risk factors or significant vessel stenosis
- Soft plaques may not be apparent during cardiac cath due to vessel remodeling
• Currently these plaques can only be detected with IVUS and MDCT

• Vulnerable plaques are generally large, with vessel remodeling, necrotic core, plaque hemorrhage, covered by a thin inflamed fibrous cap; not heavily calcified
Who Should Have A CCTA?

1. Intermediate to high risk profile for CAD, but who do not have typical symptoms (especially chest pain, sob or fatigue during heavy physical activity)

2. Unusual symptoms for CAD (chest pain unrelated to physical activity), but low to intermediate risk profile for CAD

3. Unclear or inconclusive stress test results
Who Should Not Have A CCTA

1. Intermediate to high risk patient with typical signs or symptoms of CAD
2. History of positive stress test
3. Known history of CAD or MI
4. Limited in patients with
   - Obesity
   - Irregular heart rhythm
   - Heavily calcified arteries