Diagnostic and Prognostic Value of Coronary Ca Score

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Madina, June 2
Coronary Calcium

- From the **pathologic** point of view → advanced and non-reversible stage of atherosclerosis.

- From the clinical point of view → suggest CAD but correlate neither with the site nor with the degree of vessel stenosis and myocardial ischemia.

*The presence of arterial calcifications is specific for atherosclerosis*
In June 2000, ACC and AHA Consensus Panel wrote the following in the Journal of the American College of Cardiology:

“Coronary calcium is part of the development of atherosclerosis; ...it occurs exclusively in atherosclerotic arteries and is absent in the normal vessel wall.”

One hypothesis
Ca in coronaries may mean that there was at least one incidence of a healed soft plaque rupture with inflammation
Clinical Use of Ca score

- Early detection/prevention in asymptomatic pt
- Diagnosis of CAD in symptomatic pt
20. Recommendations for Calcium Scoring Methods

CLASS IIa
1. Measurement of CAC is reasonable for cardiovascular risk assessment in asymptomatic adults at intermediate risk (10% to 20% 10-year risk) \( (52,53) \). (Level of Evidence: B)

CLASS IIb
1. Measurement of CAC may be reasonable for cardiovascular risk assessment in persons at low to intermediate risk (6% to 10% 10-year risk) \( (53-55) \). (Level of Evidence: B)

CLASS III: NO BENEFIT
1. Persons at low risk (<6% 10-year risk) should not undergo CAC measurement for cardiovascular risk assessment \( (52,53,56) \). (Level of Evidence: B)
### Table 2: Detection of CAD/Risk Assessment in Asymptomatic Patients Without Known CAD

<table>
<thead>
<tr>
<th>Indication</th>
<th>Low</th>
<th>Intermediate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global CHD Risk Estimate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Family history of premature CHD</td>
<td>A (7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Asymptomatic</td>
<td>I (2)</td>
<td>A (7)</td>
<td>U (4)</td>
</tr>
<tr>
<td>No known CAD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coronary CTA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Asymptomatic</td>
<td>I (2)</td>
<td>I (2)</td>
<td>U (4)</td>
</tr>
<tr>
<td>No known CAD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coronary CTA Following Heart Transplantation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Routine evaluation of coronary arteries</td>
<td>U (6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A indicates appropriate; I, inappropriate; and U, uncertain.
### Table 2. Comparison of a Sample of Global Coronary and Cardiovascular Risk Scores

<table>
<thead>
<tr>
<th></th>
<th>Framingham</th>
<th>SCORE</th>
<th>PROCAM (Men)</th>
<th>Reynolds (Women)</th>
<th>Reynolds (Men)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>5,345</td>
<td>205,178</td>
<td>5,389</td>
<td>24,558</td>
<td>10,724</td>
</tr>
<tr>
<td>Age (y)</td>
<td>30 to 74; M: 49</td>
<td>19 to 80; M: 46</td>
<td>35 to 65; M: 47</td>
<td>&gt;45; M: 52</td>
<td>&gt;50; M: 63</td>
</tr>
<tr>
<td>Mean follow-up (y)</td>
<td>12</td>
<td>13</td>
<td>10</td>
<td>10.2</td>
<td>10.8</td>
</tr>
<tr>
<td>Risk factors</td>
<td>Age, sex, total cholesterol, HDL cholesterol, smoking, systolic blood pressure, antihypertensive medications</td>
<td>Age, sex, total-HDL cholesterol ratio, smoking, systolic blood pressure</td>
<td>Age, LDL cholesterol, HDL cholesterol, smoking, systolic blood pressure, family history, diabetes, triglycerides</td>
<td>Age, HbA1C (with diabetes), smoking, systolic blood pressure, total cholesterol, HDL cholesterol, hsCRP, parental history of MI at &lt;60 y of age</td>
<td>Age, systolic blood pressure, total cholesterol, HDL cholesterol, smoking, hsCRP, parental history of MI at &lt;60 y of age</td>
</tr>
<tr>
<td>Endpoints</td>
<td>CHD (MI and CHD death)</td>
<td>Fatal CHD</td>
<td>Fatal/nonfatal MI or sudden cardiac death (CHD and CVD combined)</td>
<td>MI, ischemic stroke, coronary revascularization, cardiovascular death (CHD and CVD combined)</td>
<td>MI, stroke, coronary revascularization, cardiovascular death (CHD and CVD combined)</td>
</tr>
</tbody>
</table>

**URLs for risk calculators**
- Framingham: [nhgbhin.net/atpii/calculator.asp?usertype=prof](http://nhgbhin.net/atpii/calculator.asp?usertype=prof)
European Guidelines on Cardiovascular Disease Prevention in Clinical Practice (2003) which state that

“Coronary calcium scanning is thus especially suited for patients at medium risk”, and use CAC to qualify conventional risk analysis.
Ca Score For Symptomatic patient

- NOT for symptomatic patients with obvious myocardial ischemia.
- Symptomatic patients with atypical chest pain.
- Equivocal results Stress Imaging
How to Assess?

- **Fluoroscopy**
- **Intravascular Ultrasound**

**Quantitative;**
- **Electron-beam CT (EBCT)**
  - better temporal resolution, lower radiation exposure, and slightly better reproducibility
- **MDCT**
  - Fast, increased availability, better spatial resolution, and reduced image noise.
Technical aspects

- No patient preparation
- No Blood samples
- No contrast
- Low radiation

For calcium scoring the effective radiation dose of standard CT scan protocols is about 1 mSv in EBCT and between 1 and 6 mSv in MDCT
QUANTIFYING CORONARY CALCIUM

Agatston Score
Traditional method (EBCT : MDCT ) established by Agatston et al. in 1990.
- score = Area × density
- Total Agatston score = sum score of all lesions

Volume Equivalent : Plaque area x slice thickness (mm^3)

Mass Equivalent : Plaque volume x mean plaque density

Keep in mind
• The greater the amount of Ca, the greater the likelihood of occlusive disease BUT not 1:1 correlation
• Not site specific
• Zero calcium = No atherosclerotic plaque

ACC/AHA expert consensus 2000
In younger patients suffering from atypical chest pain, coronary calcifications may be absent. These patients may have noncalcified plaques only, resulting in coronary artery stenosis.
Diagnostic Value of Ca score

- **Absence of coronary calcification**
  Associated with a NORMAL myocardium perfusion study in patients with chest pain in a community hospital chest pain center.


  For asymptomatic individuals, a calcium score of 0 indicates absence of detected calcium and an extremely low likelihood (<1%) of any CAD.

- **Ca score 10-100 HU, low risk**
  < 2% chance of having +ve perfusion study
Diagnostic Value of Ca score

- **At Score of 100 – 400 (intermediate risk)**
  - 2%/year of coronary event.
  - 20-22% likelihood of positive stress test (< 2% if score< 100)
  - 87% Sensitivity, 79% specificity of predicting significant stenoses on angiography

- **At score > 400 (High risk)**
  - 70-90% of having significant stenosis
  - 45% likelihood of +ve stress test

Diagnostic Value of Ca score

- Mayo clinic CP unit; 100 pt. ( > 40 y. old) presented to ER with CP were screened with EBCT;
  - All future coronary events occurs in pt with coronary Ca
  - **Sens. 100%** and Spec. 63% of Ca score in identifying those with CAD
  - **-ve predictive value =100%**
  - After the age 65, Ca score become less predictive

Acute atypical CP in ER

Laudon et al demonstrated that in patients presenting to an ER with **atypical complaints**, the exclusion of coronary Ca by EBCT has a **high NPV** (95% to 98%) in ruling out CAD.
St Frances study
- 4,500 men and women (ages 50 to 70),
- free of signs and symptoms of coronary disease.
- natural history study of the relationship between calcium scores and cardiovascular events.

Male, LDL, HDL and 2 year CHANGE of Ca score were significantly associated with subsequent cardiac event ( > 15%)
Prediction of Cardiac Events in Asymptomatic Patients by EBT

The St. Francis Heart Study, JACC 2005
PACC Study – JACC 2005

Young, asymptomatic men (2000 patients, mean age 43).

11.8-fold increased risk for incident coronary heart disease (CHD) \( p \ 0.002 \).

Taylor et al – PACC Study – JACC 2005
Prognostic Value of Ca score

- followed up a 10,377 asymptomatic individuals undergoing cardiac risk factor evaluation and **coronary calcium** screening with EBCT.
  - **Coronary Ca** provides **independent incremental** information in addition to traditional risk factors in the prediction of all-cause mortality
  - **Coronary CA** is **More powerful risk factor** for coronary event than traditional Framingham Risk indicators
  - Diabetic pt with 0 Ca can e reclassified as low risk.

*Shaw et al. Radiology 2003;228:826-833*
All Cause Mortality [NDR]

n = 10,377
asymptomatic men and women
f/u = 5.0±3.5 yrs.

EBT found to be independent and incremental to risk factors

Shaw et al. Radiology 2003;228:826-833
## Prognostic Value of Ca score

### Ca score and Framingham risk

<table>
<thead>
<tr>
<th>Framingham 10 yr risk</th>
<th>$CAC = 0$</th>
<th>$CAC 1-80$</th>
<th>$CAC 81-400$</th>
<th>$CAC 401-600$</th>
<th>$CAC &gt; 600$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>0.3%</td>
<td>0.6%</td>
<td>2%</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>2%</td>
<td>0.6%</td>
<td>1.1%</td>
<td>4%</td>
<td>7%</td>
<td>13%</td>
</tr>
<tr>
<td>3%</td>
<td>0.9%</td>
<td>1.7%</td>
<td>6%</td>
<td>10%</td>
<td>18%</td>
</tr>
<tr>
<td>4%</td>
<td>1.2%</td>
<td>2.2%</td>
<td>7%</td>
<td>13%</td>
<td>23%</td>
</tr>
<tr>
<td>5%</td>
<td>1.5%</td>
<td>2.8%</td>
<td>9%</td>
<td>16%</td>
<td>27%</td>
</tr>
<tr>
<td>6%</td>
<td>1.7%</td>
<td>3.2%</td>
<td>11%</td>
<td>19%</td>
<td>31%</td>
</tr>
<tr>
<td>7%</td>
<td>1.9%</td>
<td>3.8%</td>
<td>13%</td>
<td>22%</td>
<td>35%</td>
</tr>
<tr>
<td>10%</td>
<td>2.4%</td>
<td>5.4%</td>
<td>16%</td>
<td>25%</td>
<td>36%</td>
</tr>
<tr>
<td>15%</td>
<td>3.2%</td>
<td>8.3%</td>
<td>23%</td>
<td>33%</td>
<td>45%</td>
</tr>
<tr>
<td>20%</td>
<td>3.8%</td>
<td>9.8%</td>
<td>28%</td>
<td>38%</td>
<td>48%</td>
</tr>
</tbody>
</table>
All Cause Mortality and CAC Scores: Long Term Prognosis in 25,253 patients

Budoff, et al. JACC 2007; 49: 1860-70
Prognostic Value of Ca score

- Pooled analysis of Asymptomatic and Symptomatic patient;

- 5 years cardiac events was

<table>
<thead>
<tr>
<th>Ca score</th>
<th>Asymptomatic (75585)</th>
<th>Symptomatic (10355)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.48 %</td>
<td>4.9%</td>
</tr>
<tr>
<td>&gt; 0</td>
<td>7%</td>
<td>68%</td>
</tr>
</tbody>
</table>

Sarawar et al. JACC img 2010
These data imply that the 3 to 5 year risk of any detectable calcium elevates a patient’s CHD risk of events by nearly 4-fold ( > 10 times for Ca score > 1000), $p < 0.0001$. 

Summary RR Ratio  

4.3 (3.5-5.2)  

364 / 19,039  

49 / 11,815*  

<0.0001
<table>
<thead>
<tr>
<th>Calcium Score</th>
<th>Plaque Burden</th>
<th>Probability of Significant Coronary Artery Disease</th>
<th>Implications for CV risk</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No identifiable plaque</td>
<td>Very low, generally, 5%</td>
<td>Very Low</td>
<td>Reassure patient, discuss general public health guidelines for primary prevention of CV disease.</td>
</tr>
<tr>
<td>1 - 10</td>
<td>Minimal identifiable plaque burden</td>
<td>Very unlikely, under 10%</td>
<td>Low</td>
<td>Discuss general public health guidelines for primary prevention of CV diseases</td>
</tr>
<tr>
<td>11 - 100</td>
<td>Definite, at least mild atherosclerotic plaque burden</td>
<td>Mild or minimal coronary stenoses likely</td>
<td>Moderate</td>
<td>Counsel about risk factor modification, strict adherence with primary prevention goals. Daily ASA.</td>
</tr>
<tr>
<td>101 - 400</td>
<td>Definite, at least moderate atherosclerotic plaque burden</td>
<td>Non-obstructive CAD highly likely, although obstructive disease possible</td>
<td>Moderately High</td>
<td>Institute risk factor modification and secondary prevention goals. Consider exercise testing for further risk stratification. Daily ASA.</td>
</tr>
<tr>
<td>400+</td>
<td>Extensive atherosclerotic plaque burden</td>
<td>High likelihood (90+%) of at least one significant coronary stenosis</td>
<td>High</td>
<td>Institute very aggressive risk factor modification. Consider exercise for pharmacologic nuclear stress testing to evaluate for inducible ischemia. Daily ASA.</td>
</tr>
</tbody>
</table>
Algorithm for Ca score

Ca Score 0
- V. good prognosis
- > 90% has no sig CAD
- No further testing

Ca Score <400
- ↑ risk of MACE & chance of CAD
- Consider CTA

Ca Score >400
- CAD > 70%
- 5y MACE 15%
- CTA + MPI
Conclusion

- Ca score is appropriate in asymptomatic pt with intermediate risk
- Ca score has an important diagnostic and prognostic value
- With Ca score 0, there is < 2% of having significant CAD
  - Ca score > 400 there is > 70-90% chance of sig CAD
- Ca score has an independent and incremental risk
- Ca score is more powerful risk factor than the traditional Framingham risk factors
Thank You