National Lipid Association Update on Coronary Calcium Scoring to Guide Preventive Strategies for ASCVD Risk Reduction
Outline

I. Performance, reporting standards, reproducibility, and significance of absolute scores versus percentiles

II. Guideline recommendations for the use of CAC scoring

III. Race/ethnicity, sex and age considerations in CAC scoring

VI. Management of incidentally found pulmonary nodules and incidental coronary calcium found on chest CT studies
Part 1 - Section 1 of NLA CAC Statement

PERFORMANCE, REPORTING STANDARDS, REPRODUCIBILITY, AND SIGNIFICANCE OF ABSOLUTE SCORES VERSUS PERCENTILES
Coronary Artery Scanning

- NORMAL CONDITION
Coronary Artery Scanning

- SEVERE CALCIFICATION
### CAC Scores and CV Risk

<table>
<thead>
<tr>
<th>CAC Score</th>
<th>Plaque Burden</th>
<th>Implication for CV Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Minimal</td>
<td>Low</td>
</tr>
<tr>
<td>1-100</td>
<td>Definite, Mild</td>
<td>Moderate</td>
</tr>
<tr>
<td>101-300</td>
<td>Definite, Moderate</td>
<td>High</td>
</tr>
<tr>
<td>&gt;300</td>
<td>Severe</td>
<td>Very High</td>
</tr>
</tbody>
</table>
CAC Scan Parameters

• Tube voltage of 120kv
• Variable tube current (e.g. mA) depending on patient size
  (to achieve a sufficient balance between radiation dose and image noise).
• The scans should be acquired using an axial mode with prospective ECG triggering during diastole.
• Images should be reconstructed using 2.5-3mm slices for the purpose of calculating the Agatston score
• Additional thin slice reconstruction (e.g. 1mm slice thickness) may be helpful in some cases
The Agatston Score
120 KvP Acquisition

- Density = 130–200; coefficient 1
- Density = 201–300; coefficient 2
- Density = 301–400; coefficient 3
- Density >401; coefficient 4

Calcified plaque
area=A; density=D

Vessel lumen

Agatston score = A \times D_{\text{coef}}
HOW REPRODUCIBLE ARE CAC SCORES?

Part 1 - Section 2 of NLA CAC Statement
Comparison in Agatston score between MDCT and EBT

$R^2 = 0.9744$
Interscan Reproducibility 12-17%
HOW USEFUL ARE TOTAL CAC SCORES VERSUS AGE, GENDER AND ETHNICITY PERCENTILES IN PREDICTING CHD RISK?
MESA Risk Score Calculator

Overview

An accurate estimate of 10-year CHD risk can be obtained using traditional risk factors and CAC. The MESA risk score, which is available online on the MESA web site for easy use, can be used to aid clinicians in the communication of risk to patients and when determining risk-based treatment strategies.

This online calculator is most appropriate for patients in the 45-85 year age range and in one of the following racial/ethnic groups: Caucasian, Chinese American, African American, or Hispanic.

To use the score you will need information on the following risk factors:

- age, gender, race/ethnicity, diabetes (yes/no), current smoker (yes/no), total and HDL cholesterol, use of lipid lowering medication (yes/no), systolic blood pressure (mmHg), use of anti-hypertensive medication (yes/no), any family history of heart attack in first degree relative (parent/sibling/child) (yes/no), and a coronary artery calcium score (Agatston units).

Ten Year Coronary Heart Disease Risk Prediction Using Coronary Artery Calcium and Traditional Risk Factors: Results from the Multi-Ethnic Study of Atherosclerosis with Validation in the Heinz Nixdorf Recall Study and the Dallas Heart Study.
Journal of the American College of Cardiology. (In press)

MESA Risk Score Calculator please click 'Start' button below:

Start Risk Score Calculator

CAC Score Reference Values
<table>
<thead>
<tr>
<th>Risk Communication</th>
<th>In Whom to Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absolute CAC Score</strong></td>
<td><strong>All patients</strong></td>
</tr>
<tr>
<td>Best predictor of absolute cardiovascular risk</td>
<td></td>
</tr>
<tr>
<td><strong>CAC Score Percentile</strong></td>
<td></td>
</tr>
<tr>
<td>Predicts relative risk vs. age, sex, and race/ethnicity-matched peers</td>
<td>Young patients (i.e. age &lt;50)</td>
</tr>
<tr>
<td>Predicts lifetime risk trajectory</td>
<td>Older patients (i.e. age &gt;70)</td>
</tr>
</tbody>
</table>
### MESA 10-Year CHD Risk with Coronary Artery Calcification

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Gender</strong></td>
<td>Male ○</td>
<td>Female ○</td>
</tr>
<tr>
<td><strong>2. Age (45-85 years)</strong></td>
<td></td>
<td>Years</td>
</tr>
<tr>
<td><strong>3. Coronary Artery Calcification</strong></td>
<td></td>
<td>Agatston</td>
</tr>
<tr>
<td><strong>4. Race/Ethnicity</strong></td>
<td><strong>Choose One</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Caucasian ○</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chinese ○</td>
<td></td>
</tr>
<tr>
<td></td>
<td>African American ○</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hispanic ○</td>
<td></td>
</tr>
<tr>
<td><strong>5. Diabetes</strong></td>
<td>Yes ○</td>
<td>No ○</td>
</tr>
<tr>
<td><strong>6. Currently Smoke</strong></td>
<td>Yes ○</td>
<td>No ○</td>
</tr>
<tr>
<td><strong>7. Family History of Heart Attack</strong></td>
<td>Yes ○</td>
<td>No ○</td>
</tr>
<tr>
<td>(History in parents, siblings, or children)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>8. Total Cholesterol</strong></td>
<td></td>
<td>mg/dL or</td>
</tr>
<tr>
<td><strong>9. HDL Cholesterol</strong></td>
<td></td>
<td>mg/dL or</td>
</tr>
</tbody>
</table>

- **November 18, 2020**
Key points:

- The absolute CAC score is the best predictor of absolute 5- to 10-year ASCVD event risk and should be used to estimate number needed to treat and guide pharmacologic treatment decisions.

- The CAC score percentile from MESA is the best predictor of relative risk and of lifetime risk trajectory and should be used to estimate lifetime treatment benefit.
**Recommendations**

Physicians reporting CAC scores should report both the absolute Agatston CAC score and the age, sex, and race/ethnicity-based CAC percentiles (Class I, LOE B-NR).
GUIDELINE RECOMMENDATIONS FOR THE USE OF CAC SCORING
2017 SCCT CAC Guidelines

- **10-Year ASCVD Risk <5%**
  - Confirm low-risk status or up classify risk based on CAC score

- **10-Year ASCVD 5-20%**
  - Reclassify up or down based on CAC score

- **10-Year ASCVD >20%**
  - CAC not recommended except in special circumstances
CONCLUSIONS

• NEW CHOLESTEROL GUIDELINES advocating for more therapy with CAC >100 and less therapy with CAC =0

If risk decision is uncertain:
Consider measuring CAC in selected adults:
CAC = zero (lowers risk; consider no statin, unless diabetes, family history of premature CHD, or cigarette smoking are present)
CAC = 1-99 favors statin (especially after age 55)
CAC = 100+ and/or ≥75th percentile, initiate statin therapy
2. In whom is CAC assessment not recommended for ASCVD risk assessment?

- General population with <5% 10-year risk of ASCVD
  - considered to be reasonable in such individuals by the SCCT in the presence of a strong family history of premature ASCVD\(^4\).

- Less established value in most individuals with a 10-year risk ≥20%
  - except in older patients with a paucity of major risk factors, in whom the estimated 10-year risk using the Pooled Cohort Equations is largely driven by age, and in whom CAC=0 or a low CAC score may result in decision to withhold statin therapy.

- CAC scoring is not recommended for those with clinical ASCVD.
**Recommendations**

- For adults 40-75 years of age, with LDL-C 70-189 mg/dL and a 10-year ASCVD of 5-19.9%, CAC scoring, can be useful to decide on the need for and intensity of preventive therapies. (COR IIa, LOE B-NR)

- For adults 40 years of age or older, with LDL-C 70-189 mg/dL and a 10-year ASCVD risk of <5%, CAC scoring is reasonable in those with a strong family history of premature ASCVD, to decide on the need for and intensity of preventive therapies (COR IIa, B-NR)

- For adults with clinical ASCVD, CAC scoring is not recommended. (COR III, no benefit)

*type 1 diabetes of ≥20 years duration or type 2 diabetes of ≥10 years duration
Part 3 - Section 1 of NLA CAC Statement

RACE/ETHNICITY, SEX AND AGE CONSIDERATIONS IN CAC SCORING
<table>
<thead>
<tr>
<th></th>
<th>MESA n=6813</th>
<th>CAC Consortium n=42224</th>
<th>MASALA n=803</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td><strong>Total # studied</strong></td>
<td>3213</td>
<td>3600</td>
<td>27436</td>
</tr>
<tr>
<td>% Whites CAC&gt;0</td>
<td>70.4</td>
<td>44.6</td>
<td>64.0</td>
</tr>
<tr>
<td>% Blacks CAC&gt;0</td>
<td>52.1</td>
<td>36.5</td>
<td>59.7</td>
</tr>
<tr>
<td>% Hispanics CAC&gt;0</td>
<td>56.5</td>
<td>34.9</td>
<td>63.3</td>
</tr>
<tr>
<td>% Chinese CAC&gt;0</td>
<td>59.2</td>
<td>41.9</td>
<td>-</td>
</tr>
<tr>
<td>% Asians CAC&gt;0</td>
<td>-</td>
<td>-</td>
<td>59.9</td>
</tr>
<tr>
<td>% South Asians CAC&gt;0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
MESA STUDY 10 year outcome

- **White**
  - CAC Categories:
    - 300+
    - 101 to 300
    - 1 to 100
    - 0
  - Cumulative Incidence of Hard ASCVD (%) over 12 years from Baseline Exam.

- **Chinese**
  - CAC Categories:
    - 300+
    - 101 to 300
    - 1 to 100
    - 0
  - Cumulative Incidence of Hard ASCVD (%) over 12 years from Baseline Exam.

- **Black**
  - CAC Categories:
    - 300+
    - 101 to 300
    - 1 to 100
    - 0
  - Cumulative Incidence of Hard ASCVD (%) over 12 years from Baseline Exam.

- **Hispanic**
  - CAC Categories:
    - 300+
    - 101 to 300
    - 1 to 100
    - 0
  - Cumulative Incidence of Hard ASCVD (%) over 12 years from Baseline Exam.
3. In which patients younger than 40 years of age should coronary calcium scoring be considered and what are the treatment implications?
Figure 2. Incidence Density of Coronary Heart Disease (CHD) Events per 100 Persons

- CAC 0
- CAC 1-19
- CAC 20-99
- CAC ≥100
### Table 3: Cardiovascular Risk Reclassification Comparing the Framingham Refitted Model With the Model Additionally Including CAC

<table>
<thead>
<tr>
<th>Framingham Refitted 10-Year Risk Categories</th>
<th>Framingham Refitted + CAC 10-Year Risk Categories</th>
<th>n (%) Reclassified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;10%</td>
<td>10%-20%</td>
</tr>
<tr>
<td>&lt;10%</td>
<td>n = 1,438</td>
<td>1,278 (88%)</td>
</tr>
<tr>
<td></td>
<td>Observed risk (95% CI)</td>
<td>0.03 (0.02–0.05)</td>
</tr>
<tr>
<td>10%-20%</td>
<td>n = 451</td>
<td>134 (30%)</td>
</tr>
<tr>
<td></td>
<td>Observed risk (95% CI)</td>
<td>0.09 (0.05–0.16)</td>
</tr>
<tr>
<td>&gt;20%</td>
<td>n = 144</td>
<td>7 (5%)</td>
</tr>
<tr>
<td></td>
<td>Observed risk (95% CI)</td>
<td>0.49 (0.15–0.94)</td>
</tr>
</tbody>
</table>

CAC = coronary artery calcium; CI = confidence interval; NA = not applicable.
CAC CONSORTIUM - ELDERLY

A

Cardiovascular Mortality: Females

Cardiovascular Mortality: Males

Wang FM, AJM 2020
Key points

- Racial/ethnic differences have been demonstrated in the prevalence of CAC. However, the CAC score is independently associated with ASCVD events, regardless of race and ethnicity.
- Relative ASCVD risk increases proportionally with CAC scores similarly with all races and ethnicities. For a given CAC score incidence rates of CVD and all-cause mortality are higher in Blacks and Hispanics compared to Whites and Asians.
- CAC scoring may be used selectively to risk stratify adults <40 years of age to more intensive CVD preventive therapies when CAC is identified.
- In adults 76-80 years of age, CAC scoring may be selectively used to re-classify ASCVD risk and aid in statin treatment decisions.
**Recommendations**

- Clinicians should use CAC scoring, when indicated, for ASCVD risk assessment, regardless of the patient’s race/ethnicity or gender. (COR I, B-NR)
- In selected individuals <40 years of age with multiple major ASCVD risk factors or a strong family history of premature ASCVD, it is reasonable to use CAC>0 as a factor favoring intensification of lifestyle therapy and, if necessary, initiation of statin therapy. (COR IIa, B-NR)
- In adults 76-80 years of age with an LDL-C of 70-189 mg/dL in whom the decision to employ statin therapy is uncertain, CAC scoring is useful in ASCVD risk reclassification. (COR IIa, B-R)

*type 1 diabetes of ≥20 years duration or type 2 diabetes of ≥10 years duration*
Section VI of NLA CAC Statement

MANAGEMENT OF INCIDENTALLY FOUND PULMONARY NODULES AND INCIDENTAL CORONARY CALCIUM FOUND ON CHEST CT STUDIES
### Table 1 Fleischner Society 2017 Guidelines for Management of Incidentally Detected Pulmonary Nodules in Adults

<table>
<thead>
<tr>
<th>Nodule Type</th>
<th>Size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low risk¹</td>
<td>&lt;6 mm (&lt;100 mm³)</td>
<td>No routine follow-up. CT at 6–12 months, then consider CT at 18–24 months. Consider CT at 3 months, PET/CT, or tissue sampling. Nodules &lt;6 mm do not require routine follow-up in low-risk patients (recommendation 1A).</td>
</tr>
<tr>
<td>High risk¹</td>
<td>6–8 mm (100–250 mm³)</td>
<td>CT at 6–12 months, then CT at 18–24 months. Consider CT at 3 months, PET/CT, or tissue sampling. Certain patients at high risk with suspicious nodule morphology, upper lobe location, or both may warrant 12-month follow-up (recommendation 1A).</td>
</tr>
<tr>
<td>Multiple</td>
<td>&gt;8 mm (&gt;250 mm³)</td>
<td>CT at 3–6 months, then consider CT at 18–24 months. CT at 3–6 months, then at 18–24 months. Use most suspicious nodule as guide to management. Follow-up intervals may vary according to size and risk (recommendation 2A).</td>
</tr>
</tbody>
</table>

¹ Low risk includes patients with a low lifetime risk of lung cancer. High risk includes patients with a high lifetime risk of lung cancer.
Incidental CAC

The SCCT and the Society of Thoracic Radiology recommend at least qualitative interpretation of CAC on all CT scans of the chest, regardless of indication (Class I recommendation).

Qualitative indication of severity (mild, moderate, heavy/severe) should be reported.

For those with mild calcification, a dedicated coronary calcium scoring study is useful to aid in clinical decision making.

The presence of moderate or severe calcification generally correlates with a CAC score of $\geq 100$, a guideline-based indication for statin benefit$^{1,7}$
Recommendations

- In adults found on a CAC scoring exam to have one or more pulmonary nodules, follow-up testing should be done in accordance with the Fleischner Society recommendations. (COR I, E-O)
- In adults found on a chest CT exam to have incidental mild CAC, it may be reasonable to obtain a dedicated CT scan for coronary calcium scoring to guide preventive treatment decision-making (Class IIb, C-LD)
- In adults found on a chest CT exam to have incidental moderate or severe CAC, initiation of statin therapy without dedicated CAC imaging is reasonable. Class (IIa, LOE B-NR)
Superior doctors prevent the disease. Mediocre doctors treat the disease before evident. Inferior doctors treat the full-blown disease.

--Huang Dee: Nai-Ching (2600 BC First Chinese Medical Text)