Coronary Artery Calcium Screening for Early Detection of Coronary Artery Plaque to Determine Risk for Heart Attack and Potential Need for Preventive Medication

Project Brief as of January 18, 2018

Cardiovascular Disease Indicator; Coronary Artery Calcium (CAC) is an Effective Indicator of Cardiovascular Risk

Heart attacks are the leading cause of death in the United States. They are caused by plaque buildup in the walls of the arteries to the heart. The plaque usually includes calcium, which makes it visible on a CT scan. For this reason, it is possible to identify if plaque is present in the heart (coronary) arteries long before a heart attack strikes. Therefore, a CT scan of the coronary arteries is a means of screening for patients without symptoms who may be at high risk for a heart attack, refining clinical risk prediction and informing treatment decision-making to obtain better health outcomes and reduce costs. The presence of coronary artery calcification increases the likelihood of having deposits in other arteries, including those that supply the brain. Therefore, finding coronary artery calcium may indicate an increased risk of stroke as well as heart attack.

Table 1: Direct economic cost for selected conditions, U.S., 2009

<table>
<thead>
<tr>
<th>Condition</th>
<th>Total Direct Cost (in Billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Disease</td>
<td>$99.2</td>
</tr>
<tr>
<td>COPD, Asthma</td>
<td>$64.2</td>
</tr>
<tr>
<td>Hypertension</td>
<td>$47.5</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>$37.3</td>
</tr>
<tr>
<td>Stroke</td>
<td>$22.8</td>
</tr>
<tr>
<td>Other Circulatory Conditions</td>
<td>$22.6</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>$17.3</td>
</tr>
<tr>
<td>Anemias</td>
<td>$4.7</td>
</tr>
</tbody>
</table>

Table 1: Direct economic cost for selected conditions, U.S., 2009

Source: National Institute of Health, Disease Statistics: Medical Expenditure Panel Survey, Household Component Summary Data Tables

Notes: Conditions are bolded

Coronary Artery Calcium (CAC) is an Effective Indicator of Cardiovascular Risk

Conventional risk factors of vascular disease that aid in early detection include: family history, diabetes, elevated LDL cholesterol, low HDL cholesterol, tobacco use, hypertension, obesity/physical inactivity and stress. In addition, measuring coronary artery calcium (CAC) is an effective indicator of cardiovascular risk that has proved to be a very effective indicator of CVD risk while being also cost-effective. 

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Figure 1: Leading causes of death for all males and females in the United States (2014)
Source: Health, United States, 2015. Centers for Disease Control and Prevention, National Center for Health Statistics. US Department of Health and Human Services

Notes: Total CVD includes Diseases of the Heart and Cerebrovascular Diseases

Figure 2: Preventable Cerebrovascular Deaths in the U.S. (2001-2010).

Figure 3: Myocardial infarction (MI), stroke or death as initial presentation of coronary heart disease

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Coronary Artery Calcium is a Cost-Effective and Reliable Indicator of Cardiovascular Risk and Mortality

All Cause Mortality and CAC Scores:
Long Term Prognosis in 25,253 patients

Figure 4: (Left) All-Cause Mortality and Coronary Artery Calcification Scores: Long Term Prognosis in 25,253 patients

Notes: With greater CAC score, cumulative survival decreases. Relative risk calculation uses those with 0 CAC score to compare.

Coronary Artery Calcium Scanning Improving Outcomes by Increasing Adherence

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CAC No Scan</th>
<th>CAC Scan</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in LDL-C</td>
<td>-11 mg/dL</td>
<td>-29 mg/dL</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Change in SBP</td>
<td>-5 mm Hg</td>
<td>-9 mm Hg</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Exercise</td>
<td>36%</td>
<td>47%</td>
<td>0.03</td>
</tr>
<tr>
<td>New Lipid Rx</td>
<td>19%</td>
<td>65%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>New BP Rx</td>
<td>18%</td>
<td>46%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>New ASA Rx</td>
<td>7%</td>
<td>21%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lipid Adherence</td>
<td>80%</td>
<td>88%</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Table 2: Outcomes improved by coronary artery calcification scanning

Notes: Coronary Artery Calcification score 0: n=631. CAC score >400: n= 109. All differences within parameters listed above are statistically significantly

Low Mortality for Persons with Coronary Artery Calcification Scores of Zero

Figure 5: Mortality rate by risk factor burden and CAC score

Figure 6: Survival estimates for individuals with coronary artery calcification scores of zero

Notes: n = 6944. FH: Family History. (+) indicates inclusion of family history as a risk factor in coronary heart disease calculation. Deaths are classified as all-
**Coronary Artery Calcification Scanning is a Cost Effective, Non-Invasive Test for Early Detection of Atherosclerosis**

**Figure 7**: Data on early detection of vascular disease and cost of various non-invasive and invasive procedures

*Notes: Horizontal axis indicates earliest level of atherosclerosis detectable.*

Source: R. Erbel, et al. Herz Journal of Cardiovascular Diseases (as presented at the University of Best Practices Leadership Summit, University of California, Berkeley Nov. 2015)

**Figure 8**: Reduction in costs associated with coronary artery calcification scan versus no scan group

*Source: Rozanski, et al. Journal of the American College of Cardiology 2011*

*Notes: p<.005 for both measures*

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**Society for Heart Attack Prevention and Eradication (SHAPE) Algorithm. Maron, et al. MD, Chief Preventive Cardiology, Stanford Med School & Health System. (As Presented to the Right Care Initiative Leadership Summit at the University of California, Berkeley; Nov. 2015)**

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**CAC Expert Panel Algorithm**

**For Individuals Age 40-75, LDL 70-189, and Without Clinical ASCVD**

1. **Step 1**: Calculate 10 yr Risk Using ACC/AHA ASCVD Risk Calculator
   - 10 yr Risk <5%
   - 10 yr Risk 5% to <7.5%
   - 10 yr Risk >7.5%

   - Follow ACC/AHA guidelines for low risk
   - >50% of CAD events occur in the <7.5% Risk Group

2. **Step 2**: Family history of ASCVD
   - Coronary Artery Calcium (CAC) Score
     - CAC = 0
     - CAC = 1-299
     - CAC ≥300

   - Lifestyle Management
     - Reassess risk at 4-6 years
     - Consider pharmacologic lipid Rx
     - Add pharmacologic lipid Rx

3. **Step 3**: Updated Risk Classification

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1. ASCVD = atherosclerotic cardiovascular disease
3. ACC/AHA 2013 Cholesterol Guidelines state “for those with a 5% to <7.5% estimated 10-year ASCVD risk, the potential for adverse effects may outweigh the potential for ASCVD risk reduction benefit when high-intensity statin therapy is used in this risk group. However, for moderate-intensity statin therapy the ASCVD risk reduction clearly exceeds the potential for adverse effects.”
4. ACC/AHA 2013 Cholesterol Guidelines state “Before initiating statin therapy, the clinician and patient discussion should include consideration of the potential for ASCVD risk reduction benefits, adverse effects, and drug-drug interactions. Additional factors may also be considered to inform treatment decision making in selected individuals. Factors that may contribute to assessment of ASCVD risk include...coronary artery calcium score ≥300 Agatston units or ≥75 percentile for age, sex, and ethnicity.” For additional information, see [http://www.mesa-nhlbi.org/CACReference.aspx](http://www.mesa-nhlbi.org/CACReference.aspx).
Prevention of Cardiovascular Events Decision Tree (American College of Cardiology, California Chapter)

1. Check One:
   - >21 years, clinical ASCVD go to 4
   - >21 years, LDL >190 go to 4
   - 40–75 years, Diabetes Mellitus and LDL 70-189 go to 4
   - 40–75 years and LDL 70-189 go to 2
   - >21 years and LDL <70 go to 5

2. Enter the following data into ACC ASCVD calculator to calculate 10-year risk score:
   - Gender __
   - Cholesterol __
   - Smoking __
   - Age __
   - HDL __
   - Diabetes Mellitus __
   - Race __
   - Systolic BP __
   - HTN on medication __

   10-year risk
   - If >7.5% go to 4
   - If 5-7.5% go to 3
   - If <5% go to 5

3. Enter:
   - Family history of early ASCVD? Yes
   - High-sensitivity C-reactive protein (hs-CRP) > 2.0 mg/L
   - Abnormal Coronary Artery Calcium score > 200 Agatston Units
   - Ankle Brachial Index < 0.9
   - If checked go to 4, if unchecked go to 5

4. Recommend Both:
   - a. Lifestyle: healthy diet (vegetables, fruits), exercise 150 minutes/week, weight BMI 20–25, avoid smoking, stress reduction, alcohol consumption 1-2 drinks/day, control blood pressure and diabetes.
   - b. Statin (moderate/high dose) preferred or non-statins.

5. Recommend Only:
   - a. Lifestyle: healthy diet (vegetables, fruits), exercise 150 minutes/week, weight BMI 20–25, avoid smoking, stress reduction, alcohol consumption 1-2 drinks/day, control blood pressure and diabetes.

Coronary Artery Calcification CT Scan Priority Scanning Groups

Society for Heart Attack Prevention and Eradication (SHAPE), noting that 50% of heart attacks and strokes occur in people currently classified as having a less than 10-year risk of 7.5% according to ACC/AHA risk calculator, recommends a coronary artery calcification CT scan as a screening for all people at age 40 who either have an early family history of heart attacks and/or strokes, or people with a less than 10-year risk of 7.5%.

American College of Cardiology and American Heart Association statements on proactive screening using CAC, 2013 and 2010:
   - “The coronary artery calcification CT scan is likely to be the most useful of the current approaches to improving risk assessment among individuals found to be at intermediate risk after formal risk assessment.” (2013)
   - “The coronary artery calcification CT scan is reasonable for cardiovascular risk assessment in asymptomatic adults at intermediate risk (10% to 20% 10-year risk).” (2010)
   - “The coronary artery calcification CT scan may be reasonable for cardiovascular risk assessment persons at low to intermediate risk (6% to 10% 10-year risk).” (2010)
   - “In asymptomatic adults with diabetes, 40 years of age and older, coronary artery calcification is reasonable for cardiovascular risk assessment.” (2010)

United Kingdom’s National Health Service Guidelines for Chest Pain Recommend Heart Scan for CT Chest Pain12

Updates to United Kingdom’s national guidelines for chest pain involve recommendations that “cardiac CT is the first-line investigation for patients presenting with new-onset chest pain due to suspected coronary artery disease because of the diagnostic accuracy and cost effectiveness”12.

“If a patient’s pre-test likelihood of significant cardiovascular disease was low (10–29%), a coronary artery calcium score was the recommended first-line investigation with subsequent CT coronary angiography if the calcium score was between 1 and 400 Agatston Units”13.

Source: American College of Cardiology, California Chapter application for Atherosclerotic Cardiovascular Disease Prevention for Health Care Providers and Patients. Notes: ASCVD is Atherosclerotic Cardiovascular Disease.


Treatment of Cholesterol: Lipid-Lowering Therapy to Reduce Risk of Atherosclerotic Cardiovascular Disease (ASCVD)
The Importance of Coronary Artery Calcification Screening: Case Study

An asymptomatic 55-year-old white with unremarkable cardiovascular risk factors (no hypertension, no smoking, no diabetes, lipids: TC:222; TG:122; HDL:42; LDL:156, family history: father is alive at 78; had a myocardial infarction at 50 and 55; had CAB; athletic) presents a 10-year atherosclerotic cardiovascular disease (ASCVD) risk score of 6.6%. With this ASCVD risk score, providers may consider prescribing a statin or aspirin and discuss lifestyle management, however a coronary artery calcification scan shows a calcium score of 1153 (shown left). The risk factors described, taken with the calcium score, indicates that the patient is at high risk for cardiovascular disease and it is recommended that a statin and aspirin are prescribed along with intensifying lifestyle management.

Occupational Use of Coronary Artery Calcification CT Scan

- **The President of the United States**
  - Previous presidential physical examinations have included a Coronary Artery Calcium (CAC) CT scan.
  - This scan is used as a tool in determining fitness for duty by predicting cardiovascular risk and yielding actionable information to prevent heart attacks and strokes.

- **Astronauts**
  - Astronauts’ medical assessments include calculating a 10-year cardiovascular Framingham Risk Score, measuring high-sensitivity C-reactive protein levels and using coronary artery calcium scores to screen for cardiovascular disease and decrease the likelihood of a crewmember experiencing a cardiac event during spaceflight.
  - The 2014 NASA Human Research Program Investigators’ Workshop developed a tool using CAC scores along with other risk factors to calculate astronaut cardiovascular health and risk.

- **Firefighters**
  - Cardiovascular disease contributes to 45% of on-duty fatalities and is the leading cause of on-duty death among firefighters.
  - The Los Angeles Fire Department has developed a protocol that uses coronary CT calcium scans to triage firefighters for cardiovascular risk to provide counsel or lipid management if necessary.

**References:**

1 Center for Disease Control and Prevention, Heart Disease Fact. Accessed: Jan 2017
2 Health, United States, 2015. CDC, National Center for Health Statistics. US Department of Health and Human Services (2014 Data)
8 Rozanski et al. EISNER (Early Identification of Subclinical Atherosclerosis by Noninvasive Imaging Research) prospective randomized trial." Journal of the American College of Cardiology 57.15 (2011): 1622-1632
9 Budoff, et al. Progression of Coronary Artery Calcium Predicts All-Cause Mortality. Journal of the American College of Cardiology: Cardiovascular Imaging 3(12) 2010
13 Moss, et al. The Updated NICE Guidelines: Cardiac CT as the First-Line Test for Coronary Artery Disease. Current Cardiovascular Imaging Reports. 2017
Since 2007 The Right Care Initiative’s goal has been to apply scientific evidence and outcomes improvement strategies to reduce patient morbidity and mortality through a collaborative focus on achieving quality goals where performance metrics indicate that evidence-based, life-saving practices are not fully deployed.

Data from the Integrated Health Care Association, the National Committee for Quality Assurance, the federal Agency for Health Care Quality and Research, the Commonwealth Foundation, CMS, and the Centers for Disease Control indicate that approximately 80,000 Californians die yearly from heart attacks, strokes and diabetic complications. Many of these deaths and associated disabilities and health care costs could be prevented with evidence-based patient management, clinical quality improvement and adoption of the latest medical knowledge.

Our work is focused in these high-leverage areas of better management of cardiovascular disease and diabetes, with particular emphasis on control of blood pressure, cholesterol and blood sugar.

The Right Care Initiative, operated by the UC Berkeley School of Public Health, was publicly launched with the Department of Managed Health Care, NCQA and the Deans of UC Berkeley and UCLA Schools of Public Health in March 2008 at the 1st annual Clinical Quality Improvement Leadership Summit.

Since the first leadership summit, more than a dozen Right Care summits have been held around the state, along with over 150 monthly University of Best Practices. Each Right Care gathering is a collaborative effort to close the gap between science and practice to improve patient outcomes working with medical directors, pharmacy and quality improvement directors, as well as thought leaders in evidence-based medicine.

More information on The Right Care Initiative can be found at: https://RightCare.Berkeley.edu/

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**Supplemental Information on Coronary Artery Calcification Screening:**

1) Irish Heart Disease Awareness’ video Widowmaker (discusses evidence-base for using the CAC scan for proactive screening similar to a mammogram for the heart, but with much less frequency): [Irish Heart Disease Awareness – Heart Attacks, The Facts](https://RightCare.Berkeley.edu/

### Studies Featured/ Further Readings

- **The St. Francis Heart Study** (Treatment of Asymptomatic Adults With Elevated Coronary Calcium Scores With Atorvastatin, Vitamin C, and Vitamin E)
- **The EISNER Study** (Early Identification of Subclinical Atherosclerosis by Noninvasive Imaging Research)
- **The Courage Trial** (Optimal Medical Therapy with or without percutaneous coronary intervention (PCI) for Stable Coronary Disease)
- **The Multi-Ethnic Study of Atherosclerosis (MESA)** (MESA is a medical research study involving more than 6,000 men and women from six communities in the United States. MESA is sponsored by the National Heart Lung and Blood Institute of the National Institutes of Health)
- **2010 ACCF/AHA Guideline for Assessment of Cardiovascular Risk in Asymptomatic Adults**
- **2013 European Society of Cardiology Guidelines on the Management of Stable Coronary Artery Disease**

2) Precision Medicine for Early Detection and Treatment of Coronary Artery Disease for People without Symptoms – Preventive Cardiology Expert Panel

- Video: [Part 1](https://www.youtube.com/watch?v=Lx3w_kc7BNY)
  - [Part 2](https://www.youtube.com/watch?v=cjpYbADJ9c)
  - [Part 3](https://www.youtube.com/watch?v=znvbrFeWfYs)

3) Stanford Health Care and UC Davis Medical Center Preventive Cardiology are lowering the barrier to receiving the coronary artery calcium scan as a preventive screening test by offering it to patients for a cash price of $150 to receive this precision prevention information for understanding patients’ actual risk profile.

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**About the Right Care Initiative**

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