**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.

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**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</td>
<td>$22.6</td>
</tr>
<tr>
<td>Conditions</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>$17.3</td>
</tr>
<tr>
<td>Anemias</td>
<td>$4.7</td>
</tr>
</tbody>
</table>

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

Notes: CVD conditions are bolded

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**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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**Table 2: Patients Diagnosed with Coronary Heart Disease (%)**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>62%</td>
</tr>
<tr>
<td>Women</td>
<td>46%</td>
</tr>
</tbody>
</table>

---

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.
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 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

Parameters | CAC No Scan | CAC Scan | P
--- | --- | --- | ---
Change in LDL-C | -11 mg/dL | -29 mg/dL | <0.001
Change in SBP | -5 mm Hg | -9 mm Hg | <0.001
Exercise | 36% | 47% | 0.03
New Lipid Rx | 19% | 65% | <0.001
New BP Rx | 18% | 46% | <0.001
New ASA Rx | 7% | 21% | <0.001
Lipid Adherence | 80% | 88% | 0.04

Low Mortality for Persons with Coronary Artery Calcification Scores of Zero

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
Notes: p<.005 for both measures

CAC Expert Panel Algorithm

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

Step 1

Calculate 10 yr Risk Using ACC/AHA ASCVD Risk Calculator

- 10 yr Risk <5%
  - Follow ACC/AHA guidelines for low risk

- 10 yr Risk 5% to <7.5%
  - >50% of CAD events occur in the <7.5% Risk Group
  - Family history of ASCVD

- 10 yr Risk ≥7.5%
  - Follow ACC/AHA guidelines for ASCVD Statin Benefit Groups

Step 2

Coronary Artery Calcium (CAC) Score

- CAC = 0
  - Lifestyle Management Reassess risk at 4-6 years

- CAC = 1-299 & <75th %
  - Lifestyle Management Consider pharmacologic lipid Rx

- CAC ≥300 or ≥75th %
  - Lifestyle Management Add pharmacologic lipid Rx

Step 3

Updated Risk Classification

1 ASCVD = atherosclerotic cardiovascular disease
2 http://tools.cardiosource.org/ASCVD-Risk-Estimator/
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.
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. Calculator can be accessed at: http://tools.acc.org/ascvd-risk-estimator/
   - 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  ≥ 300 Agatston Units
   - Ankle Brachial Index  <0.9

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-statin

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.

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

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 people starting at age 40 who either have an early family history of heart attacks and/or strokes, OR people with 10-year risk of 5-7.5%. If zero, retest in five years while continuing healthy lifestyle (exercise, stress reduction, plant centric diet, weight control).

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

Treatment of Cholesterol: Lipid-Lowering Therapy to Reduce Risk of Atherosclerotic Cardiovascular Disease (ASCVD)

1. Determine patient’s ASCVD risk. If the patient does not have clinical ASCVD, use an ASCVD risk calculator and/or measure coronary artery calcium score.
2. Encourage a healthful lifestyle (smoking cessation; healthful diet; regular physical activity; optimal weight).
3. Discuss benefits, risks, and costs of lipid-lowering medication to reduce patient’s ASCVD risk. As ASCVD risk increases, benefit of evidence-based lipid-lowering treatment increases.
4. If patient favors treatment with lipid-lowering medication, use drugs supported by evidence.
5. Regularly reassess patient goals for ASCVD risk reduction, tolerance to medication, and treatment plan.

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

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.

- **The President of the United States**
  - After President Clinton's heart attack, the Coronary Calcium CT Scan was added to presidential physicals to enable a more preventive approach to protecting the President's health. This test enables greater clarity on whether cardiovascular medications are needed, and at what dose, as well as needed lifestyle modifications.

- **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.14
  - 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.15

- **Firefighters**
  - Cardiovascular disease contributes to 45% of on-duty fatalities and is the leading cause of on-duty death among firefighters.16
  - Forward leading fire departments across the country, such as Los Angeles, CA and Gwinnett County, GA have determined this scan to **be useful for preventing cardiovascular events and are also cost saving.**16,17

**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
About the Right Care Initiative

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/](https://RightCare.Berkeley.edu/)

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://www.heartaware.org/)

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](https://www.youtube.com/watch?v=Lx3w_kc7BNY)
  Part 2: [https://www.youtube.com/watch?v=cjpyBAdJ3c](https://www.youtube.com/watch?v=cjpyBAdJ3c)
  Part 3: [https://www.youtube.com/watch?v=znvfrFwYFs](https://www.youtube.com/watch?v=znvfrFwYFs)

3) Stanford Health Care, LA BioMed in Los Angeles, UC Davis Medical Center Preventive Cardiology and Gundersen Health System 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.

Project Brief produced September 2017 by Cardiologists: William J. Bommer, MD (UC Davis; Governing Board CA Chapter, American College of Cardiology); David J. Maron, MD (Stanford University, Director of Preventive Cardiology); Matthew Budoff, MD (UCLA Medical Center, Endowed Chair of Preventive Medicine); and Right Care Initiative Team: Hattie Rees Hanley, MPP, Right Care Initiative Director; Warren Barnes, JD, Regulatory Consultant UC Berkeley School of Public Health, Former Chief Lawyer CA Department of Managed Health Care, and Bryan Vuong, UC Berkeley Research Assistant