NON-INVASIVE TESTING FOR CORONARY ARTERY DISEASE

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OBJECTIVES

Review current clinically relevant non-invasive testing modalities for detecting CAD
  - Coronary calcium scoring
  - Exercise stress testing
  - Stress echo
  - Stress nuclear
  - Coronary CT angiography

Strengths, weaknesses, limitations, clinical quirks of each
# Leading Causes of Death

By AMERICAN HEART ASSOCIATION NEWS

Heart disease continues to kill more Americans than any other cause, followed by stroke at No. 5, according to 2015 federal data.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Total Deaths</th>
<th>Share of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease</td>
<td>633,842</td>
<td>23.4%</td>
</tr>
<tr>
<td>Cancer</td>
<td>598,930</td>
<td>22%</td>
</tr>
<tr>
<td>Chronic lower respiratory diseases</td>
<td>155,041</td>
<td>5.7%</td>
</tr>
<tr>
<td>Accidents</td>
<td>146,571</td>
<td>5.4%</td>
</tr>
<tr>
<td>Stroke</td>
<td>140,323</td>
<td>5.2%</td>
</tr>
<tr>
<td>Alzheimer’s disease</td>
<td>110,561</td>
<td>4.1%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>79,535</td>
<td>2.9%</td>
</tr>
<tr>
<td>Flu, pneumonia</td>
<td>57,062</td>
<td>2.1%</td>
</tr>
<tr>
<td>Kidney disease</td>
<td>49,959</td>
<td>1.8%</td>
</tr>
<tr>
<td>Suicide</td>
<td>44,193</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

Source: Centers for Disease Control and Prevention
Published Dec. 8, 2016
ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/SCCT/SCMR/STS 2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease


WHICH TEST FOR WHICH PERSON?

Pretest Probability
History and Physical Exam!!!
Baseline EKG
Baseline medications
Ability to walk
History of prior non-invasive testing

Pre Test Probability of Coronary Disease by Symptoms, Gender and Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Non-Anginal Chest Pain</th>
<th>Asymptomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-39</td>
<td>Males</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>low (&lt;10%)</td>
<td>Very low (&lt;5%)</td>
</tr>
<tr>
<td>30-39</td>
<td>Females</td>
<td>Intermediate</td>
<td>Very Low (&lt;5%)</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>40-49</td>
<td>Males</td>
<td>High (&gt;90%)</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>low</td>
</tr>
<tr>
<td>40-49</td>
<td>Females</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>50-59</td>
<td>Males</td>
<td>High (&gt;90%)</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>50-59</td>
<td>Females</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>60-69</td>
<td>Males</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>60-69</td>
<td>Females</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
</tbody>
</table>

High = >90%  Intermediate = 10-90%  Low = <10%
Very Low = <5%
NONINVASIVE TESTING FOR CAD

Asymptomatic Patients
  Coronary Calcium Scoring
Symptomatic Patients
  Exercise Stress Testing
  Stress Echo
  Stress Nuclear Perfusion Imaging
  Coronary CT Angiography
CORONARY CALCIUM SCORING

Risk stratification tool in asymptomatic patients with intermediate risk by traditional risk factor evaluation

Low cost

Low radiation

Can be diagnostic for CAD in a previously undiagnosed and asymptomatic patient

Can change goals for risk factor modification if abnormal
CORONARY CALCIUM SCORING

Does not tell you anything about degree of active ischemia or degree of stenosis, only presence/absence of underlying CAD and the volume of plaque
SYMPTOMATIC PATIENTS OR ASYMPTOMATIC PATIENTS WITH HIGH RISK CLINICAL FINDINGS

Non-invasive
  Functional
  Anatomic
Invasive

FUNCTIONAL TESTING FOR CAD

Stress testing
  Stress EKG
  Stress echo
  Stress SPECT/PET
  Stress MRI
CONTRAINDICATIONS TO STRESS TESTING

Acute MI within 2 days
   Pharmacologic Nuclear stress
Unstable angina
Uncontrolled arrhythmia
   VT, Atrial fibrillation, etc
Severe symptomatic aortic stenosis
 Decompensated CHF
Active Endocarditis/Myocarditis/Pericarditis
Acute aortic dissection
Acute PE
Acute noncardiac conditions that are not stable

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Sensitivity and Specificity of Non-invasive Tests for the Diagnosis of CAD*

<table>
<thead>
<tr>
<th>Diagnostic Test</th>
<th>Sensitivity % (range)</th>
<th>Specificity % (range)</th>
<th># Studies</th>
<th># Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMT</td>
<td>68</td>
<td>77</td>
<td>132</td>
<td>24,027</td>
</tr>
<tr>
<td>Planar MPI</td>
<td>79</td>
<td>73</td>
<td>6</td>
<td>510</td>
</tr>
<tr>
<td>SPECT</td>
<td>88</td>
<td>77</td>
<td>8</td>
<td>628</td>
</tr>
<tr>
<td>Stress echo</td>
<td>76</td>
<td>88</td>
<td>10</td>
<td>1174</td>
</tr>
</tbody>
</table>

* NEJM Vol. 344, No. 24 June 14, 2004
Treadmill Stress Test
Determining Duke Treadmill Score (DTS)

DTS = Exercise time* – (5 x ST deviation†) – (4 x exercise angina‡‡)

* Exercise time in minutes
† ST deviation in millimeters
‡‡ Exercise angina: 0 = None
              1 = Non limiting
              2 = Exercise limiting

- Low Risk  >5
- Moderate Risk  -10 to +4
- High Risk  < -10

DTS AND SURVIVAL

STRESS ECHO

Exercise
Pharmacologic Stress
  Dobutamine
No radiation
Lower cost
Quick and easy with right equipment and personnel
STRESS NUCLEAR

SPECT and PET tracers
Exercise
Pharmacologic stress
   Dobutamine
   Vasodilator (Regadenoson, Adenosine, Persantine)
Higher cost
More time consuming
More costly
Radiation
Useful in patients who cannot walk, cannot be titrated off rate lowering meds, or have baseline indecipherable EKGs (LBBB, LVH, WPW, marked baseline STT changes)

STRESS NUCLEAR

Best studied stress imaging modality
Certainly the most quantitative
Pharmacological Stress Tests
nuclear perfusion scan

**Adenosine or Dipyridimole**
- direct coronary vasodilator
- causes shifts in flow leading to relative reduction in flow distal to coronary stenosis
- minimal change in HR, BP, and contractility
Moderate Severe Ischemia

Transmural Inferior Wall MI
ANATOMIC NON-INVASIVE EVALUATION

Coronary CT Angiography

Higher Cost

Contrast

Radiation exposure

More technically difficult

Sinus, controlled Heart Rate, Cooperative, and able to hold their breath for 8-10 seconds

<table>
<thead>
<tr>
<th>Type of CT scan</th>
<th>First author</th>
<th>No. of articles in the analysis</th>
<th>Patient-based sensitivity</th>
<th>Patient-based specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>64-slice coronary CT angiography</td>
<td>Abdulla et al. 2007 (9)</td>
<td>27</td>
<td>97.5 [96-99]</td>
<td>91 [87.5-94]</td>
</tr>
<tr>
<td></td>
<td>Stein et al. 2006 (10)</td>
<td>23</td>
<td>98 [96-98]</td>
<td>88 [85-89]</td>
</tr>
<tr>
<td></td>
<td>Mowatt et al. 2008 (11)</td>
<td>28</td>
<td>99 [97-99]</td>
<td>89 [83-94]</td>
</tr>
<tr>
<td></td>
<td>Sun et al. 2008 (7)</td>
<td>15</td>
<td>97 [94-99]</td>
<td>88 [79-97]</td>
</tr>
<tr>
<td></td>
<td>Guo et al. 2011 (14)</td>
<td>24</td>
<td>98 [99-99]</td>
<td>87 [83-90]</td>
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<tr>
<td></td>
<td>Salavati et al. 2012 (73)</td>
<td>25</td>
<td>99 [97-99]</td>
<td>89 [84-92]</td>
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<tr>
<td>Prospectively ECG-triggered coronary CT angiography</td>
<td>Von Ballmoos et al. 2011 (74)</td>
<td>16</td>
<td>100 [98-100]</td>
<td>89 [82-89]</td>
</tr>
<tr>
<td></td>
<td>Sun et al. 2012 (75)</td>
<td>14</td>
<td>99 [98-100]</td>
<td>91 [88-94]</td>
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<td></td>
<td>Sun et al. 2012 (76)</td>
<td>22</td>
<td>97.7 [93.7-100]</td>
<td>92.1 [87.2-97]</td>
</tr>
<tr>
<td></td>
<td>Sabarudin et al. 2013 (77)</td>
<td>23</td>
<td>98.3 [96-100]</td>
<td>90.5 [85.7-96]</td>
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<tr>
<td>320-slice coronary CT angiography</td>
<td>Gaudio et al. 2013 (79)</td>
<td>7</td>
<td>95.4 [88.8-98.2]</td>
<td>94.7 [89.1-97.5]</td>
</tr>
<tr>
<td></td>
<td>Li et al. 2013 (80)</td>
<td>10</td>
<td>93 [91-95]</td>
<td>86 [82-89]</td>
</tr>
</tbody>
</table>

CT, computed tomography; ECG, electrocardiogram.

Zhonghua et al. QIMS Volume 4, Number 5, October 2014, 2223.
Figure 2. Correlation of quantitative coronary angiography (QCA) and 64-slice computed tomography (CT) angiography: Visualization and quantification of a high-grade stenosis in the left circumflex artery. (A) Diameter in the reference section 3.1 mm on QCA, 3.0 mm on 64-slice CT; minimal diameter within the stenotic section 0.6 mm on QCA, 0.5 mm on 64-slice CT. (B) Intravascular coronary angiogram of the left coronary artery (right anterior oblique projection). (B) Multiplanar reformation projection of the left coronary artery by 64-slice CT.
THE FUTURE: PLAQUE IMAGING

Vulnerable Plaque

CTA – most accepted currently
MRA
Nuclear

Vulnerable plaque: from plaque to thrombus
CONCLUSIONS

CAD is an enormous public health issue
Noninvasive testing preferable when feasible to limit procedural risk and cost
Numerous options for noninvasive testing based on patient history and symptoms
  Asymptomatic
  Symptomatic
  Functional
  Anatomic