Which Test When? Avoid the Stress of Stress Testing

Marc Newell, MD, FACC, FSCCT
Minneapolis Heart Institute
Outline

- Understand the importance of coronary artery disease assessment
- Understand the basics of:
  - Stress testing
  - Non-invasive coronary artery disease assessment:
    - Strengths of tests
    - Weaknesses
    - When to use, when to avoid
Acute Chest Pain

- Accounts for 10% of all ED visits in the US
  - 128 million visits/year = almost 13 million CP cases in the ED/year
- CAD remains the leading cause of death in the US
- Chest pain remains the predominant symptom of CAD
Acute Myocardial Infarction

- Incidence*: 660,000 cases/year
  - One new MI in US every 42 seconds
  - Lowest incidence: Minnesota
- 2-5% of AMI patients were discharged from an ED prior to diagnosis
  - Leading cause of malpractice in the ED
- Cost of admission to the hospital for “rule out MI” chest pain admission estimated at $6 Billionª.

AHA Stats 2012ª and 2016*
Storrow & Gibler, Acad Emerg Med.
A little math...

660,000 Acute Myocardial Infarctions per year

12-13 million chest pain evaluations per year
Current Non-Invasive Coronary Testing Options

- Treadmill Stress EKG
- Stress Echo
- Stress Nuclear/Perfusion
- Coronary CT Angiography
- Coronary Calcium Scoring
- Adenosine MRI
Treadmill Exercise

- Symptoms
- Arrhythmias
- Duration
- EKG ST change
- Inexpensive
Treadmill Exercise

Contra-indications

- Severe aortic valve stenosis
- Inability to exercise adequately
- Unstable symptoms
Treadmill Exercise

Non-diagnostic EKG’s

❤️ LBBB
❤️ Baseline ST-T wave changes
❤️ LVH, particularly with strain
❤️ Digoxin therapy
❤️ WPW
Non-Invasive Coronary Assessment: Approach

- Pretest probability of CAD
- What question are you trying to answer?
  - Presence or absence of CAD?
  - Ischemic burden?
- Understand how disease prevalence plays a role
Stress Imaging Positives

**Stress Echo**
- Direct heart image
- Valve assessment
- Accurate EF
- Convenient
- Relatively inexpensive

**Nuclear Perfusion**
- Indirect image of flow
- EF – Adequate in most
- Long experience
- Lower “ischemic threshold”
Exercise vs Pharmacologic

**Exercise**

- Almost anyone with reasonable exercise tolerance for age
- Prognostic information regardless of other findings

**Pharmacologic**

- Orthopedic limitations
- Claudication
- Severe COPD
- LBBB
Abnormal Nuclear Scan, Antero-Lateral Ischemia
PET scan
Stress Echo Example
### Stress Imaging

**Downsides**

#### Stress Echo
- Inadequate test in up to 10%
- Less sensitive if prior MI/ wall motion abnormality
- Tech/reader dependent
- FALSE NEGATIVES

#### Nuclear Perfusion
- Technically demanding
- Requires nuclear isotopes
- Relatively expensive
- FALSE POSITIVES (artifacts)
Coronary CT Angiography
Cardiac CT Angiography

Strengths

• Definitive anatomical coronary assessment
  - As diagnostic for predicting need for revascularization as invasive catheterization*

• Very high negative predictive value
  - “safe and reliable exclusion of CAD”**

• Excellent prognostic value and risk prediction

*Miller et al. NEJM 2008
**Min et al. JCCT 2018
Weakness of Cardiac CT

- Need to use IV contrast
  - Typically 80-110 ccs for coronary
  - Can use less for peripheral/structural cases
  - If GFR <45: caution; If <30: no go.

- Arrhythmia concern now minimal

- Radiation
  - Often brought up, poorly understood (in terms of long-term effects of medical radiation)
## Relative Radiation Doses: Medical Imaging

<table>
<thead>
<tr>
<th>Type</th>
<th>Dose mSv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearly ambient exposure (U.S.)</td>
<td>3.0-6.0</td>
</tr>
<tr>
<td>Chest PA and Lat</td>
<td>0.04</td>
</tr>
<tr>
<td>Mammogram</td>
<td>0.7</td>
</tr>
<tr>
<td>CT Chest (non-gated)</td>
<td>8 to 12</td>
</tr>
<tr>
<td>CT Abdomen</td>
<td>8 to 12</td>
</tr>
<tr>
<td>Diagnostic CA</td>
<td>2.3 to 5.6</td>
</tr>
<tr>
<td>* Calcium score (prospective)</td>
<td>0.3 to 0.7</td>
</tr>
</tbody>
</table>


*MHI experience*
Radiation Doses in Cardiology

<table>
<thead>
<tr>
<th>Type</th>
<th>Dose mSv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress-rest Tc99 (Sestamibi)</td>
<td>11</td>
</tr>
<tr>
<td>Stress-rest Tc99 (Tetrofosmin)</td>
<td>9</td>
</tr>
<tr>
<td>Stress-rest Tl-201 (Thallium)</td>
<td>17</td>
</tr>
<tr>
<td>Dual Isotope (stress-rest)</td>
<td>24</td>
</tr>
<tr>
<td>• PET Scan</td>
<td>4-8</td>
</tr>
<tr>
<td>• CCTA (PROTECTION VI trial, 2018)</td>
<td>2-5</td>
</tr>
<tr>
<td>• Current generation CTA scanner /flash mode</td>
<td>0.25-1.2</td>
</tr>
</tbody>
</table>

*Early experience prior to radiation reduction techniques
Can we do full Coronary CT with low radiation?

mSv dose 0.45
# CTA: Application in Symptomatic Pts

## Impact of MDCTA on Various Estimated Pre-test Probabilities of Significant CAD

<table>
<thead>
<tr>
<th>Pre-test Probability</th>
<th>High pre-test probability for CAD</th>
<th>Intermediate pre-test probability for CAD</th>
<th>Low pre-test probability for CAD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test Probability Est: 87%(^1)</td>
<td>Pre-test Probability Est: 53%(^1)</td>
<td>Pre-test Probability Est: 13%(^1)</td>
</tr>
<tr>
<td></td>
<td>Obs: 78%(^2)</td>
<td>Obs: 39%(^2)</td>
<td>Obs: 18%(^2)</td>
</tr>
<tr>
<td></td>
<td>CTCA (N:105)</td>
<td>CTCA (N:83)</td>
<td>CTCA (N:66)</td>
</tr>
<tr>
<td>Positive (n=86)</td>
<td></td>
<td>Positive (n=40)</td>
<td>Positive (n=16)</td>
</tr>
<tr>
<td>Obs: 93%(^2)</td>
<td></td>
<td>Obs: 11%(^2)</td>
<td>Obs: 75%(^2)</td>
</tr>
<tr>
<td>Negative (n=19)</td>
<td></td>
<td>Negative (n=43)</td>
<td>Negative (n=50)</td>
</tr>
<tr>
<td>Post-test Probability Est: 17%(^3)</td>
<td></td>
<td>Post-test Probability Est: 0%(^3)</td>
<td>Post-test Probability Est: 0%(^3)</td>
</tr>
<tr>
<td>Obs: 80%(^2)</td>
<td></td>
<td>Obs: 0%(^2)</td>
<td>Obs: 0%(^2)</td>
</tr>
</tbody>
</table>

Coronary CT in the ER / Acute Chest Pain

- High rates of discharge from the ED
- Time savings
- Cost savings
- Low rates of downstream testing

Hoffman et al. NEJM 2012
Litt et al. NEJM 2012
Coronary CT: Prognosis

- CONFIRM registry of 23,854 patients
  - No known CAD
  - Primary endpoint - time to death from all causes
  - Mean f/u >5 years

<table>
<thead>
<tr>
<th>Severity</th>
<th>Non-Obstructive</th>
<th>1-Vessel CAD</th>
<th>2-Vessel CAD</th>
<th>3-Vessel CAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>8114</td>
<td>3118</td>
<td>1346</td>
<td>1130</td>
</tr>
<tr>
<td>Survival (Years)</td>
<td>7437</td>
<td>2873</td>
<td>1228</td>
<td>1034</td>
</tr>
<tr>
<td>Survival (Years)</td>
<td>4081</td>
<td>1747</td>
<td>742</td>
<td>664</td>
</tr>
<tr>
<td>Survival (Years)</td>
<td>1930</td>
<td>782</td>
<td>324</td>
<td>324</td>
</tr>
</tbody>
</table>

Unadjusted All-Cause 3-Year Kaplan-Meier Survival by the Presence, Extent, and Severity of CAD by CCTA

Min et al JACC 2011
Case

• 61 year old male, presents to PMD for pre-op Left shoulder surgery/rotator cuff

• Describes “burning” chest pain with exertion
  - Two negative stress tests in past 10 years
  - Brother with MI/stent age 59
  - Risk factors: Fam Hx, Former tobacco use, treated HTN

• Referred for stress echo pre-op
  - Positive symptoms of chest burning
  - 1 mm horizontal ST depression on EKG (equivocal)
Follow-up

• Abnormal stress echo
  - Subjectively positive (typical symptoms)
  - Objectively mild ischemia/small territory on images

• Next steps?
  - Options?
RCA lesion
LAD Lesion
Coronary Angiography
FFR- invasive

FFR 0.77
Pd/Pa 0.77
Pa:iPa 86:120
Pd:iPd 66:102
Pa-Pd(m) 20

HR 57

List of Runs | IFR | FFR
---|---|---
09:14:10 AM | 0.91 |
09:15:29 AM | 0.77 |
LAD Proximal
Question:

• 42 year old male with mixed hyperlipidemia, a strong family history of CAD (father had nonfatal MI at 48) and atypical chest pain presents for evaluation. When considering both chest pain assessment and risk of future MI, what test should be ordered?
  - A) Nuclear perfusion stress imaging
  - B) Stress echocardiogram
  - C) Stress EKG
  - D) Coronary CT Angiogram
Answer

• D

• Explanation: Recent data suggests in low or intermediate risk patients with chest pain, a strategy of coronary CT angiography versus stress testing leads to similar mortality outcomes, but lower rates of myocardial infarction at 5 years. This is likely due to many factors: 1) higher diagnostic accuracy leading to appropriate early PCI and aspirin in appropriate pts, and 2) long-term preventative interventions (diet, lifestyle, statin therapy)

Conclusions

• Chest pain, coronary artery disease, and acute myocardial infarction are common
• Many options are available to assess for underlying CAD in symptomatic patients
• Each test has relative strengths and weaknesses
• We are always here to help!
Thank you!

Marc Newell, MD, FACC, FSCCT
marc.newell@allina.com