Chest Pain Wave I
Making Dollars and Sense Out of Stress Testing
Presenters

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Michael Kontos, MD, FACC
Disclosures

Dr. Newby:
• None specifically related to this activity
• All RWI are available at https://www.dcri.org/about-us/conflict-of-interest

Dr. Kontos:
Consultant--Roche
Defining Low-Risk

- Normal/near-normal ECG
- Negative baseline cardiac injury markers
- Low-risk score (e.g., TIMI [0/1], GRACE [<109], HEART [<3])
- But low risk is not no risk

# The ADAPT ADP

All parameters had to be negative for the ADP to be considered negative and for the patient to be considered low risk

1. cTnl level at 0 and 2 hours below institutional cutoff for an elevated troponin concentration
2. No new ischemic changes on the initial ECG
3. TIMI score = 0
   a. Age $\geq$ 65 years
   b. Three or more risk factors for CAD
   c. Use of aspirin in last 7 days
   d. Significant coronary stenosis (e.g., previous coronary stenosis 50%)
   e. Severe angina (e.g., 2 angina events in past 24 hours or persisting discomfort)
   f. ST-segment deviation of $\geq$0.05mV on first ECG
   g. Increased troponin and/or creatinine kinase-MB blood tests (during assessment)

Proportion of patients safely discharged within 6 hours of ED arrival increased by 8%.

Outpatient stress testing within 72 hours of discharge.

Challenges of Current State of Stress Testing in Low Risk Chest Pain Patients

• 80-90% of patients evaluated in the ED will not have ACS
• But, approximately 50% of chest pain patients will have stress testing, other noninvasive testing, or angiography
• Among low risk patients (ACS risk <2%) yield of stress testing is low and false positive tests are increased without improved outcomes
  • Prevalence of CAD is only approximately 5% in this population
Use and Results of Stress Testing in Low-Moderate Risk Chest Pain Patients

Table 4. Yield of Routine Provocative Cardiac Testing Before Discharge Among Patients in the Emergency Department–Based Chest Pain Unit

<table>
<thead>
<tr>
<th>Variable</th>
<th>No./Total No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive provocative study result</td>
<td>470/4181 (11.2)</td>
</tr>
<tr>
<td>Confirmed true positive by angiography</td>
<td>63/123 (51.2)</td>
</tr>
<tr>
<td>Confirmed false positive by angiography</td>
<td>60/123 (48.8)</td>
</tr>
<tr>
<td>Angiography results</td>
<td></td>
</tr>
<tr>
<td>New diagnosis of obstructive CAD</td>
<td>63/4181 (1.5)</td>
</tr>
<tr>
<td>Anatomic disease classified as having potential for benefit via revascularization, AHA class I or IIa</td>
<td>28/4181 (0.7)</td>
</tr>
<tr>
<td>Disease classified as AHA class I or IIa if coronary artery bypass graft performed</td>
<td>28/4181 (0.7)</td>
</tr>
<tr>
<td>Disease classified as AHA class I or IIa if percutaneous coronary intervention performed</td>
<td>7/4181 (0.2)</td>
</tr>
</tbody>
</table>
Cost-effectiveness of Non-invasive Testing in ED Chest Pain Patients without MI

N=421,774
Claims data, primary or secondary diagnosis of chest pain

Overall MI rates:
7 days 0.11%
190 days 0.33%

Tested vs Not Tested

Defensive Medicine—Legally Necessary but Ethically Wrong?

Inpatient Stress Testing for Chest Pain in Low-Risk Patients

Allen Kachalia, MD, JD
Michelle M. Mello, JD, PhD

JAMA INTERN MED/VOL 173 (NO. 12), JUNE 24, 2013

Editor’s Note

Stress Testing in the Emergency Department: Not Which Test but Whether Any Test Should Be Done

Rita F. Redberg, MD, MSc

JAMA Internal Medicine  March 2015  Volume 175, Number 3
Bayes Theorem

\[ P(A|B) = \frac{P(B|A)P(A)}{P(B)} \]

The ability of a test to predict the presence or absence of disease is dependent not only on the sensitivity and specificity of the test, but also the pretest probability of disease.
Bayes Theorem

• An abnormal test is more likely to be a false positive in a patient with a low pretest likelihood of disease

• A negative test is more likely to be false negative in a patient with a high pretest likelihood of disease
Bayes Theorem
Effect of Disease Prevalence on Predictive Ability
Test with 90% SN and 80% SP
Bayes Theorem
Effect of Disease Prevalence on Predictive Ability
Test with 90% SN and 80% SP
Bayes Theorem

• When the pretest likelihood of disease is <10% or >90%, the test has limited diagnostic ability

• However, it still may still have prognostic value
**History**

**EKG**

**Age**

**Risk factors**

**Troponin**

Low score ≤3 = low risk

High score >4 = high risk


RCT of HEART Pathway vs Usual Care

RCT of HEART Pathway vs. Usual Care

Results

Objective testing  -12.1% (68.8% vs. 56.7%)
LOS  -12 hrs (9.9 vs. 21.9)
Early DC  +21.3% (39.7% vs. 18.4%)
No increase 30-day MACE in early DC group (6% overall)
ACC/AHA Guidelines on Stress Testing in Patients with Possible ACS

Class IIa (Level of Evidence B)

It is reasonable for patients with possible ACS who have normal serial ECGs and cardiac troponins to have a treadmill ECG*, stress myocardial perfusion imaging of stress echocardiography before discharge or within 72 hours after discharge.

*Level of evidence A

## Appropriate Use of Stress Modalities

### Table 1.1. Symptomatic

Refer to pages 16 and 17 for relevant definitions, in particular Table A and text for age, sex, symptom presentation, and risk factors relevant to each pre-test probability category.

<table>
<thead>
<tr>
<th>Indication Text</th>
<th>Exercise ECG</th>
<th>Stress RNI</th>
<th>Stress Echo</th>
<th>Stress CMR</th>
<th>Calcium Scoring</th>
<th>CCTA</th>
<th>Invasive Coronary Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Low pre-test probability of CAD</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
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<td>ECG interpretable AND able to exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>2. Low pre-test probability of CAD</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>M</td>
<td>R</td>
<td>R</td>
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<tr>
<td>ECG uninterpretable OR unable to exercise</td>
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<td></td>
</tr>
<tr>
<td>3. Intermediate pre-test probability of CAD</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>R</td>
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<tr>
<td>ECG interpretable AND able to exercise</td>
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<td></td>
<td></td>
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<tr>
<td>4. Intermediate pre-test probability of CAD</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>ECG uninterpretable OR unable to exercise</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. High pre-test probability of CAD</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>ECG interpretable AND able to exercise</td>
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<td></td>
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<tr>
<td>6. High pre-test probability of CAD</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>A</td>
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<tr>
<td>ECG uninterpretable OR unable to exercise</td>
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</table>

### Appropriate Use

<table>
<thead>
<tr>
<th>Stress echo</th>
<th>53%</th>
<th>28.4% (8-44% symptomatic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress MPI</td>
<td>72%</td>
<td>15.7% (5-52% symptomatic)</td>
</tr>
</tbody>
</table>


Exercise Treadmill Testing
Bruce Protocol
NOT YOUR REGULAR GYM WORKOUT!

• Up to seven 3 minute stages
• Each stage increases in speed and grade
  • Initial: 1.7 mph and 10% grade
  • Maximum: 6.6 mph and 22% grade
• Each minute exercised is approx 1 MET
• If not able to go up 2 flights of steps without stopping, unlikely to be able to adequately perform an ETT
What Do I Learn from an Exercise Stress Test?

- Allows assessment of functional capacity in individuals who are able to exercise
- High negative predictive value of the exercise ECG for obstructive CAD (major epicardial lesions)
- Prognostic and diagnostic information (Duke treadmill score)
  - DTS = Exercise time (min) – (5 x ST deviation) – (4 x Angina Score Index*)
    - Range -25 to +15
    - Low risk (≥ +5) 3% 5-year mortality 60% no sig CAD
    - Intermediate risk (+4 to -10) 10% 5-year mortality
    - High risk (< -11) 35% 5-year mortality 74% 3V/LM CAD

*0=no angina; 1=nonlimiting angina; 2=exercise-limiting angina

What Do I Learn from an Exercise Stress Test?

Protocol: Treadmill Baseline 20 MET
Drugs: None
Target Heart Rate: 154  Maximum Predicted Heart Rate: 182
Resting ECG: Normal

<table>
<thead>
<tr>
<th>TYPE</th>
<th>STAGE</th>
<th>TIME</th>
<th>HR</th>
<th>BP</th>
<th>COMMENTS</th>
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<tr>
<td>Baseline</td>
<td></td>
<td>53</td>
<td>105</td>
<td>76</td>
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<tr>
<td>Stress 1</td>
<td>120 sec.</td>
<td>67</td>
<td>110</td>
<td>68</td>
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</tr>
<tr>
<td>Stress 2</td>
<td>120 sec.</td>
<td>80</td>
<td>120</td>
<td>70</td>
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<tr>
<td>Stress 3</td>
<td>120 sec.</td>
<td>96</td>
<td>120</td>
<td>82</td>
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<tr>
<td>Stress 4</td>
<td>120 sec.</td>
<td>137</td>
<td>142</td>
<td>88</td>
<td>PT RUNNING</td>
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<td>Stress 5</td>
<td>120 sec.</td>
<td>164</td>
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<td></td>
<td></td>
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<tr>
<td>Stress 6</td>
<td>11 sec.</td>
<td>166</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recovery 1</td>
<td>1 min.</td>
<td>127</td>
<td>130</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Recovery 2</td>
<td>2 min.</td>
<td>105</td>
<td></td>
<td></td>
<td>PVC'S IN RECOVERY</td>
</tr>
<tr>
<td>Recovery 3</td>
<td>4 min.</td>
<td>83</td>
<td>126</td>
<td>60</td>
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</tr>
<tr>
<td>Recovery 4</td>
<td>6 min.</td>
<td>86</td>
<td>110</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Recovery 5</td>
<td>8 min.</td>
<td>90</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Recovery 6</td>
<td>10 min.</td>
<td>84</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stress Duration: 10.18 minutes.  Max Stress H.R: 166
Target Heart Rate (154) Achieved: Yes
Max. workload of 19.10 METs was achieved during exercise.
BP Response: Normal resting BP - appropriate response
What Do I Learn from an Exercise Stress Test?

- Inability to achieve 85% of age-predicted maximum HR
  - Roughly 220-age
  - Do not stop ETT solely for achievement of 85% of age-predicted HR; continued to point of volitional fatigue, unless significant ischemia or sx

- Abnormal heart rate recovery
  - Decrease HR of <12 beats per minute from peak at 1 minute of recovery

- Hypotensive response with exercise
  - Fall in systolic BP >10 mmHg or a peak SBP of <110-120 mmHg

- Significant ST-segment depression
  - ≥1.0 mm of horizontal/downsloping depression 60 msec after J point (diagnostic sensitivity 47% and specificity 78%)
  - ≥2 mm ST-segment depression or ≥1 mm of ST segment elevation in non-q wave lead occurring at <5 METs or persisting >5 min into recovery
Types of Stress Modalities

• Exercise
  – Treadmill
  – Bicycle

• Pharmacological
  – Vasodilator
    • Dipyridamole
    • Adenosine
    • Regadenoson
  – Inotrope/Chronotrope
    • Dobutamine
Imaging Techniques

- None (ETT alone)
- Nuclear
  - Thallium
  - Sestamibi
  - Tetrofosmin
- PET—requires rubidium generator
- Echocardiography
  - Transthoracic—with or without Contrast
- CT angiography
- Coronary Calcium scorging
- MRI
  - Stress--Dobutamine or adenosine
How Are ED CP Patients Being Evaluated Currently?

- Insurance claim data from 421,774 ED visits for CP in 2011
- 70% of patients did not undergo further diagnostic testing

Foy AJ et al JAMA Int Med 2015;online

Tests in the 30% Who had additional testing:

- MPI: 64.8%
- SE: 18.8%
- ETT: 14.2%
- CTA: 2.1%
Imaging Techniques

- None (ETT alone)
- Nuclear
  - Thallium
  - Sestamibi
  - Tetrofosmin
- PET—requires rubidium generator
- Echocardiography
  - Transthoracic—with or without Contrast
- CT angiography
- Coronary Calcium scorging
- MRI
  - Stress--Dobutamine or adenosine
Different Types of Non-Invasive Evaluation
Absolute and Relative Contraindications to Stress Testing

- ECG not interpretable (LBBB, paced, LVH with strain)
- Moderate or severe stenotic valvular disease (eg, Aortic Stenosis)
- Electrolyte abnormalities (eg, hypokalemia)
- Severe hypertension
- Uncontrolled tachyarrhythmias (AF, PVCs)
- Hypertrophic stenosis or LVOT obstruction
Ex-ECG: Advantage/Disadvantages

• Advantages
  – Reasonable specificity (90%)
  – Lower cost
  – Availability
  – Less than 1 hr
  – Convenience
  – Measure exercise capacity
  – Logistically easier than adding imaging

• Disadvantages
  – Lower sensitivity (50%)
  – No ischemic localization (ST↓)
  – No LV function measure (EF)
  – Not suitable for certain groups
    • Abnormal ECG (LBBB, ST depression)
    • Unable to exercise
When Should You Consider Stress ETT Alone

• Good exercise tolerance
• Normal (or near normal) ECG
• Low pre-test probability of CAD
  – Young age
  – Atypical symptoms
Immediate Exercise Test
UC Davis CPER

<table>
<thead>
<tr>
<th>Category</th>
<th>% Patients</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>1/640</td>
<td>1 MI (0.15%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>66</td>
</tr>
<tr>
<td>Non-Dx</td>
<td>7/235</td>
<td>7 Revasc (3%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Positive</td>
<td>16/125</td>
<td>4 MI (13%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 Revasc</td>
</tr>
</tbody>
</table>

Amsterdam et al JACC 2002;40:251
Myocardial Perfusion Imaging
Ischemic Cascade

- Stenosis
  - Hypoperfusion
    - Diastolic Dysfunction
      - Systolic Dysfunction
        - ST Depression
          - Chest Pain
Types of Stress Protocols

- Sestamibi or tetrofosmin--same day
- Sestamibi or tetrofosmin--two day
- Dual isotope (Thallium rest, technetium stress)
Types of Stress Protocols

• Sestamibi or tetrofosmin--same day
• Sestamibi or tetrofosmin--two day
• Dual isotope (Thallium rest, technetium stress)
Myocardial Perfusion Imaging
Attenuations Artifacts (False Positive Defects)

• Women
  – anterior, breast
• Men
  – inferior, diaphragmatic
• Obese
  – overall decrease in photon counts secondary to soft tissue attenuation
Indications for Imaging (Echo or Nuclear)

- Unable to exercise
- LBBB
- Paced rhythm
- Patient taking Digoxin
- LVH with ST-segment depression
- Pre-excitation (WPW)
Annual Event Rate Death/MI In patients with Normal Scan
16 Studies, 27,855 Patients

ACC/AHA/ASNC Guidelines for Clinical use of Cardiac Radionuclide Imaging
What is the Warranty Period of A Normal Stress MPI?

Yearly Incidence OF Death/MI

Hachamovitch JACC 2003;41:1329
Incremental Risk Stratification with SPECT MIBI

![Bar chart showing event rates for different Duke TM Score categories.]

- **Normal Scan**
  - Low: 0.3% (n=762)
  - Intermediate: 0.4% (n=834)
  - High: 0.4% (n=228)

- **Mildly Abnormal Scan**
  - Low: 1.8% (n=113)
  - Intermediate: 6.4% (n=185)
  - High: 3.6% (n=28)

- **Severely Abnormal Scan**
  - Low: 7.8% (n=51)
  - Intermediate: 8.9% (n=168)
  - High: 9.1% (n=22)

*p < 0.05 for all categories compared to Normal Scan.*

Hachamovitch Circ 1996:93:910
**Incremental Risk Stratification with SPECT MIBI**

- **Normal Scan**: 0.3% (n=762)  
- **Mildly Abnormal Scan**: 1.8% (n=113)  
- **Severely Abnormal Scan**: 8.9% (n=168)

- **Low (4%)**: 5.8% low risk  
- **Intermediate (9%)**: 3.7% all pts  
- **High (7.7%)**: 10.0% (n=40)

*p < 0.05

Hachamovitch Circ 1996:93:910
Ischemia Stratified by TIMI Scores

Blue 5-10% ischemia
Red  >10% ischemia
Ischemia Stratified by TIMI Scores

Blue 5-10% ischemia
Red  >10% ischemia

59% of pts
ETT Alone?

Myocardial Perfusion Imaging Attenuations Artifacts (False Positive Defects)

- Women
  - anterior, breast
- Men
  - inferior, diaphragmatic
- Obese
  - overall decrease in photon counts secondary to soft tissue attenuation
Stress Echocardiography
Stress Echocardiography

• Suitable candidate; suitable window

• Bruce protocol

• Images acquired and recorded at base-line and within 30-60 sec of stress termination

Dobutamine stress echo (DSE)

• Suitable candidate; suitable window

• Dobutamine delivered by continuous IV
  – (up to 40 ug/kg)
  – Atropine added if target heart rate not reached

• Images acquired at base-line and within 30 sec of each infusion stage
Left Ventricular Opacification with Echo Contrast

Without contrast  With contrast

Images courtesy of Duke University.
Stress Echo in ED patients

- 839 patients admitted with acute chest pain non-diagnostic ECG, and (-) 12-hour troponin
- 811 (97%) had diagnostic SE results (78% DSE, 22% Ex)
- Event rate lower in NL versus abnormal SE groups
- Abnormal SE (HR, 4.1; P<0.001) and age (HR, 1.8; P<0.001) predicted hard events

Shah B, Circ CV Imaging 2013;6:202
Stress Echocardiography

- In general, indications for stress echo are the same as stress MPI
- Normal findings identify low risk patients (< 1% events)
- More segments or territories abnormal, the higher the risk
- Patient characteristics more likely to limit study quality and interpretation
Stress Echo vs Stress SPECT
Meta-Analysis

- Meta-analysis comparing stress echo and stress SPECT imaging for diagnosing CAD
- 44 studies from Jan 1990 to Oct 1997
  - 24 studies reported stress echo results on 2637 pts
  - 27 studies reported stress SPECT results on 3237 pts
- When adjusted for age and CAD, stress echo higher discriminatory power (1.18; 95% CI, 0.71-1.65)(although not significant)

<table>
<thead>
<tr>
<th>Stress Echo</th>
<th>MPI</th>
</tr>
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<tbody>
<tr>
<td>Less expensive</td>
<td>More expensive</td>
</tr>
<tr>
<td>No radiation</td>
<td>Radiation</td>
</tr>
<tr>
<td>Shorter test time</td>
<td>Time consuming</td>
</tr>
<tr>
<td>Function</td>
<td>Perfusion/Function</td>
</tr>
<tr>
<td>Qualitative</td>
<td>Quantitative</td>
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<tr>
<td>Variable windows</td>
<td>Tissue attenuation</td>
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</table>
How to Choose Between the Two

- Expertise of the institution performing the test
- Convenience
- Cost
- Patient factors limiting study interpretability
CT Angiography

Time Magazine, Sept 2005
Advantages of CTA

• Accelerate diagnostic ED CP evaluation

• Improved accuracy with each new generation ]
  – Sensitivity 99%, Specificity 89%
  – Standard is 64 slices; newer generation up to 512

• Identify pts with non-obstructive disease
  – Candidates for aggressive secondary prevention measures
  – Motivate patients to adopt life-style changes

• Identify other causes of chest pain

• Accelerate the ED diagnostic evaluation
Advantages of CTA

• Accelerate diagnostic ED CP evaluation

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• Identify pts with non-obstructive disease
  – Candidates for aggressive secondary prevention measures
  – Motivate patients to adopt life-style changes

• Identify other causes of chest pain

• Accelerate the ED diagnostic evaluation
## Randomized CTA Trials

<table>
<thead>
<tr>
<th>Study</th>
<th>CT-STAT</th>
<th>ACRIN</th>
<th>ROMICAT II</th>
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<td>Year</td>
<td>2011</td>
<td>2012</td>
<td>2012</td>
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<tr>
<td>Population</td>
<td>699</td>
<td>1370</td>
<td>985</td>
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<tr>
<td>TIMI RS 0-4</td>
<td>TIMI RS 0-2</td>
<td>Low-inter Risk</td>
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<tr>
<td>MI rate</td>
<td>0.9%</td>
<td>1%</td>
<td>2.5%</td>
</tr>
<tr>
<td>Control group</td>
<td>MPI</td>
<td>usual care</td>
<td>usual care</td>
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<tr>
<td>ACS dx</td>
<td>1.1%</td>
<td>1%</td>
<td>9%</td>
</tr>
<tr>
<td>Cath Rate</td>
<td>8.0%</td>
<td>5%</td>
<td>12%</td>
</tr>
<tr>
<td>Revasc</td>
<td>3.6%</td>
<td>2.7%</td>
<td>6.4%</td>
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<td>Time to dx/LOS</td>
<td>2.9</td>
<td>18.0</td>
<td>23.2</td>
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<td>Cost</td>
<td>2137</td>
<td>4028</td>
<td>3874</td>
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<tr>
<td>Cost</td>
<td>3458</td>
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Comparing CTA vs Functional Imaging

- **Upside**
  - Faster ED throughput

- **Downside:**
  - Significantly more exclusions
  - Increased costs
  - Higher rates of cath, revascularization
  - No difference in mortality

Jørgensen ME et al. JACC 2017;69;1761;Shreibati JB et al. JAMA 2011;306;2138
Williams MC et al. JACC 2016;67;1759; Bittencourt MS, et al Circ Imaging 2016;9;e004419
• ETT alone remains the preferred testing:
  • In the absence baseline changes
    – Able to adequately exercise
• Add imaging if there are baseline ECG abnormalities precluding interpretation
• Pharmacologic stress testing with imaging if cannot adequately exercise
## 2015 Appropriate CV Imaging in the ED
Suspected STE-ACS; Observational Pathway After Serial Troponin Assessment

<table>
<thead>
<tr>
<th>Indication</th>
<th>ETT</th>
<th>Echo</th>
<th>SPECT</th>
<th>CMR</th>
<th>CTA</th>
<th>Cath</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dx (+) for ACS</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>ECG/Tn (-) for ACS</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>ECG/Tn Equiv for ACS</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

Rybick FJ et al JACC 2016;67;853
What Do the Guidelines Say About CTA?

• Patients with an intermediate pretest probability of IHD who have:
  – Continued symptoms with prior normal test findings
  – Inconclusive results from prior exercise or pharmacological stress testing
  – Are unable to undergo stress MPI or echocardiography

• Appropriateness Guidelines:
  – Similar to those for Stress MPI and Echo
  – Intermediate pre-test probability of CAD, unable to exercise, or ECG not interpretable
  – Discordant stress ECG and imaging results
  – Caveats—known CAD, severe coronary calcium

Circulation 2008;118;586; JACC 2006;48:1475
Variables That Go Into the Decision Making Process

- Baseline ECG
- Patient characteristics
  - Ability to exercise
  - Known coronary disease
- Availability
- Local expertise
- Cost/reimbursement
Stress Pathway

Is the ECG interpretable?  
No

Can patient exercise sufficiently to get a good test?  
No

Yes

ETT

stress imaging

Cath  
Yes

Is the result not low risk?  
No

Yes

Is diagnosis and prognosis certain?  
No

Yes

Medical management
Stress Testing--High Risk Predictors

- Duration of exercise <6 METS (Stage 2)
- **ST-depression--High risk**
  - > 2 mm
  - Early onset
  - involving ≥ 5 leads
  - persistence ≥ 5 min into recovery
- **Ischemic ST-elevation**
- **BP response:**
  - failure to obtain SBP > 120 mmHg
  - fall in SBP ≥ 10 mmHg
  - fall in SBP below rest values
- **Sustained or symptomatic VT**
Clues that the ETT is a False Positive

• Rapid resolution of ischemic ST↓

• Absence of chest pain on Ex Test

• High functional capacity (>10 METS)

• High double product (>25,000)
Outcomes with Normal Stress MPI and (+) ETT

<table>
<thead>
<tr>
<th>Study</th>
<th># Pts</th>
<th>Annual Cardiac Death or MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fagan</td>
<td>70</td>
<td>0.7 %</td>
</tr>
<tr>
<td>Schalet (2 mm)</td>
<td>154</td>
<td>0.0 %</td>
</tr>
<tr>
<td>Krishnan (2 mm)</td>
<td>32</td>
<td>0.0 %</td>
</tr>
</tbody>
</table>
Revascularization vs Medical Treatment

Mortality rate, 1.9 years follow-up

Hachamovitch Circulation 2003;107;2899
Risk Stratification
High Risk (>3% annual mortality)
(Probably should be referred for cathed)

- Severe resting LV dysfunction (EF<35%)
- High risk treadmill score
- Stress induced large perfusion defect (especially anterior)
- Stress induced multiple defects of moderate size
- Large fixed perfusion defect with LV dilation or increased lung uptake
Risk Stratification
Low (<1%) and Intermediate (1-3% annual mortality)

- Intermediate (medical management)
  - Mild/moderate LV dysfunction (EF35-49%)
  - Intermediate risk treadmill score
  - Stress induced moderate perfusion defect without
    LV dysfunction or increased lung uptake

- Low (not likely to be cardiac)
  - Low risk treadmill score
  - Normal or small perfusion defect at rest or with
    exercise (probably not low risk if has EF < 35%)
Take Home Points . . .

• Stress testing and imaging should be used selectively based on - disease probability, patient characteristics, test characteristics, test availability, and cost.

• If you will be ordering these tests - work with your Cardiology and Radiology colleagues to develop an evidence based algorithm to order the right test on the right patient at the right time.

• Know the strengths, limitations, and outcomes of the tests that you will be working with.
Questions? Contact the E-QUAL team at equal@acep.org