Stress Echocardiography Boot Camp Review

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Indications for Stress Echo

- Diagnosis of CAD in patients with chest pain
- Determination of the location and severity of inducible myocardial ischemia
- Assessment of viability prior to revascularization
- Preoperative evaluation in select patients
- Risk stratification post-myocardial infarction and in stable CAD
- Assessment of severity of stenotic and regurgitant valvular disease
- Assessment of dynamic gradient in HCM
Ischemic Cascade

- Sensitivity
  - Myocardial perfusion
  - Echocardiography

- Specificity
  - Treadmill

Perfusion heterogeneity → Metabolic alteration → Diastolic dysfunction

Regional dyssnergy

LV filling pressure

Ecg changes

Angina

Rest Stress

Picano et al 1998
Cardiac Anatomy and Views
Myocardial Segments*
Coronary Territories*

1. Four Chamber
2. Two Chamber
3. Long Axis
4. Base
5. Mid
6. Apex

RCA
LAD
CX
RCA or CX
LAD or CX
RCA or LAD

Lang JASE 2005
Imaging in Stress Echocardiography

- Tissue harmonic imaging should always be used
  - Reduces near-field artifact
  - Improves resolution
  - Enhances myocardial definition

- Contrast should be used when two or more contiguous segments are not well visualized
Protocols for Stress Echo

- **Exercise**
  - Treadmill: Bruce protocol most used
  - Bicycle: Supine for ischemia or valve assessment

- **Pharmacologic:**
  - Dobutamine: 10-40 mcg/kg every 3 min
    - Can add atropine to improve HR response
  - Dipyridamole: 0.56 mg/kg to 0.84 mg/kg
  - Adenosine: 140 mcg/kg per min

- **Other**
  - Atrial pacing (if pt with pacemaker)
  - Programmed pacing
  - Handgrip (can use to augment HR response)
Exercise or Non-exercise Stress

- Exercise capacity adds prognostic information to the stress data
- It is independent of any demonstration of ischemia
- Generally use treadmill or bicycle
- Can be symptom limited or until target heart rate is achieved
Exercise Stress Protocol

- Treadmill: Imaging done at rest and immediately after exercise
  - Bruce protocol to achieve 85% of MPHR
- Bicycle: Imaging done at rest, initial workload of 25W, peak stress and recovery (4 stages)
  - In young pts, initial workload maybe higher
  - HR lower but BP higher, may not achieve good RPP if unable to exercise
  - Better for hemodynamic assessment for valvular disease
Pharmacologic Stress

- Dobutamine
- Adenosine or dipyridamole
- Atropine (usually added to dobutamine when target heart rate not achieved)
Pharmacology of Dobutamine

- β₁ agonist but also can activate α and β₂ receptors
- Increases myocardial oxygen demand by increased inotropy and chronotropy
- Half-life is 2 minutes
- Can increase BP at low/normal doses and can decrease BP at higher doses due to β₂ activation
Dobutamine Stress Protocol

- Dobutamine to assess regional wall motion abnormalities
  - Start at 5 mcg/kg/min, increasing every 3 min to 10, 20, 30 and maximum of 40 mcg/kg/min
  - In some instances can give up to 50 mcg/kg/min
- Atropine can be given in divided doses of 0.25 to 0.5 mg for maximum of 2.0 mg to achieve target heart rate
  - helps in those who are on beta blocker therapy
  - Increases sensitivity by 5% in single vessel CAD and in those on beta blockers
Contraindications to DSE

- Uncontrolled hypertension
- Uncontrolled dysrhythmia
- Unstable angina (as with any stress test)

- For atropine: untreated narrow angle glaucoma and severe urinary retention
Side Effects to Dobutamine

- Palpitations
- Chest pain
- Tremor
- Headache
- Dizziness
- Urinary urgency
- Nausea
- Dyspnea
- Hypertension
- Hypotension
- Arrhythmias
Endpoints to DSE

- Peak dose with atropine
- Target heart rate reached
- Moderate or extensive wall motion abnormalities
- Significant arrhythmias
- Hypotension or severe hypertension
- Intolerable symptoms (pt request)
Adenosine or Dipyridamol

- Vasodilators
- Increase adenosine (directly or indirectly with dipyridamole which increases endogenous levels)
- Usually response is mild hypotension with some reflex tachycardia
- Wall thickening is related to endocardial blood flow reserve rather than increase in oxygen demand
Side Effects of Vasodilator Stress

- Minor and greater with adenosine than dipyridamole
- Adenosine with much shorter half-life, less than 10 seconds (difficult for stress echo imaging)
- Flushing, AV block, headache, chest pain, nausea, bronchospasm, coughing
Vasodilator Stress Contraindications

- Adenosine
  - Severe bronchospasm
  - Theophylline
  - 2nd or 3rd degree heart block

- Dipyridamole
  - As above
  - Hypotension
  - Unstable carotid disease
# Comparisons of Patient Factors and Choice of Stressors

<table>
<thead>
<tr>
<th>Patient-Related Factors</th>
<th>Medications for Pharmacologic Stress Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dobutamine</td>
</tr>
<tr>
<td>Associated Medical Conditions addressed in detail following this table</td>
<td></td>
</tr>
<tr>
<td>a) Severe COPD or asthma</td>
<td>Indicated</td>
</tr>
<tr>
<td>b) Heart block (2° or 3°)</td>
<td>Indicated</td>
</tr>
<tr>
<td>c) Poorly controlled HTN</td>
<td>Contraindicated**</td>
</tr>
<tr>
<td>d) Relative hypotension</td>
<td>Contraindicated**</td>
</tr>
<tr>
<td>e) Unstable carotid cerebrovascular**** disease</td>
<td>Contraindicated**</td>
</tr>
<tr>
<td>f) Significant vent ectopy</td>
<td>Contraindicated**</td>
</tr>
<tr>
<td>g) Glaucoma***</td>
<td>Contraindicated</td>
</tr>
<tr>
<td>Medical Therapies</td>
<td></td>
</tr>
<tr>
<td>h) Theophylline</td>
<td>Indicated</td>
</tr>
<tr>
<td>i) Dipyridamole by mouth</td>
<td>Indicated</td>
</tr>
<tr>
<td>j) Beta-blocker†</td>
<td>Indicated</td>
</tr>
</tbody>
</table>
Pharmacologic Reversal Agents

- Dobutamine: IV esmolol or metoprolol
- Dipyridamole: IV aminophylline
- Adenosine: usually not necessary due to short half life, can use IV aminophylline
Safety of Stress Echocardiography

- Safety was evaluated using an international registry of over 85,000 examinations from 71 centers in over 17 countries
- From 1998-2004
- Cases included exercise, dobutamine and dipyridamole stressors
- All were shown to be safe, but there were relative differences
- There were 6 deaths: 5 with dobutamine and 1 with dipyridamole

Am J Cardiol 2006; 98:541-43
## Complications During Stress Echocardiography

<table>
<thead>
<tr>
<th>Complication</th>
<th>Dobutamine</th>
<th>Dipyridamole</th>
<th>Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute myocardial infarction</td>
<td>11</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Sustained ventricular tachycardia</td>
<td>27</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>11</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Cardiac rupture</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Asystole</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Transient ischemic attack/Stroke</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Hypotension/shock</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Third-degree atrioventricular block</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Modified from *Am J Cardiol* 2006; 98:541-43
Abdominal Aortic Aneurysms

- No cited incidence of aortic aneurysm rupture
- Compared to exercise, the blood pressure response tends to be less with dobutamine and therefore, it is likely safer than exercise
- Pellika in 1996 demonstrated no events in 98 pts with AAA ≥ 4 cm
Pacemaker Stress Protocol

- Patient with permanent pacemaker: can achieve MPHR by increasing pacing rate
- Can be done with or without dobutamine
- Transesophageal pacing can also be done in pts who are not able to exercise
  - Can increase heart rate every 2 min until 85% MPHR is achieved
## Comparison of Stress Modalities

<table>
<thead>
<tr>
<th></th>
<th>Bicycle</th>
<th>Treadmill</th>
<th>Dobutamine</th>
<th>Dipyridamole</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved sensitivity</td>
<td>Improved sensitivity</td>
<td>Easier protocol</td>
<td>Cumbersome protocol</td>
<td>Easier protocol</td>
</tr>
<tr>
<td>Decreased specificity</td>
<td>Images difficult to capture</td>
<td>Better image quality</td>
<td>Less sensitive</td>
<td></td>
</tr>
<tr>
<td>Lower workload</td>
<td>Higher workload</td>
<td>Easier to reach required workload</td>
<td>Not as much data</td>
<td></td>
</tr>
<tr>
<td>Leg fatigue</td>
<td>Better tolerated by patients</td>
<td>More side effects and risk</td>
<td>More side effects</td>
<td></td>
</tr>
</tbody>
</table>

Bicycle stress echo may be more sensitive than treadmill exercise
Validation

- **Sensitivity**
  - True positives/All positives

- **Specificity**
  - True negatives/All negatives

- **Accuracy**
  - True positives + True negatives/All tests

Always dependent on pre-test likelihood
## Sensitivity and Specificity of Stress Echo

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise</td>
<td>85%</td>
<td>77%</td>
<td>85%</td>
</tr>
<tr>
<td>Dobutamine</td>
<td>80%</td>
<td>86%</td>
<td>83%</td>
</tr>
<tr>
<td>Dipyridamole (Not well studied)</td>
<td>74%</td>
<td>94%</td>
<td>77%</td>
</tr>
</tbody>
</table>

Modified from *Heart* 2003 and Beleslin Circ 1994
## ECHO VERSUS SPECT

<table>
<thead>
<tr>
<th></th>
<th>ECHO</th>
<th>SPECT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACCURACY</strong></td>
<td>85%</td>
<td>~85%</td>
</tr>
<tr>
<td><strong>HYPERTENSION/LVH</strong></td>
<td>Better specificity</td>
<td>Better sensitivity</td>
</tr>
<tr>
<td><strong>WOMEN</strong></td>
<td>Better accuracy</td>
<td>Decreased accuracy</td>
</tr>
<tr>
<td><strong>COST</strong></td>
<td>&lt;$500</td>
<td>&gt;$500</td>
</tr>
</tbody>
</table>
Why Stress Echo

- Global LV and RV function
- Chamber sizes
- Wall thickness
- Valve structure and function
- Pericardium
- Aorta
- Hemodynamics
Normal Stress Echo
Interpretation of Stress Echo: Regional Wall Motion Scoring

- 0 = Hyperkinesis
- 1 = Normal
- 2 = Hypokinesis
- 3 = Akinesia
- 4 = Dyskinesis
- 5 = Aneurysmal

Baseline Scoring
Normal Responses to Stress

- Hypercontractile wall motion
- Wall thickening, normal is >50%
- Improved endocardial excursion
- Smaller LV chamber size in systole \textit{and} diastole
- Flat response is \textit{not} specific for ischemia
Wall Motion and Severity of Stenosis

- **At rest**, wall motion may be normal with *stenosis* of < 85% (when flow at rest is still within normal)
  - Hypokinesis can be seen in a reduction of coronary blood flow by 10-20%
  - Akinesis is observed when there is an 80% reduction in coronary blood flow

- **With stress**, a stenosis of ≥ 50% *can* cause regional wall motion abnormality

- The decrease in wall thickening is more closely coupled to subendocardial rather than subepicardial blood flow, i.e. can be affected by amount of stress, wall thickness, collaterals, diffuse disease
Abnormal Response to Stress

- **Hypokinesia**: less than normal (5 mm) degree of inward myocardial excursion or thickening (40%)
- **Akinesia**: complete lack of inward motion and thickening (<10%)
- **Dyskinesia**: paradoxical (outward motion during systole)
- **Aneurysm**: thinning and bulging during systole and diastole

*Otto, The Practice of Clinical Echocardiography*
Abnormal Response to Stress

Extreme example of myocardial stunning due to multivessel disease

Senior, et al *Heart* 2005
Case 1

58 yo man with history of hyperlipidemia, gastroesophageal reflux disease, and atypical chest pain with a treadmill ECG test that revealed ischemic ST changes in the absence of chest pain at 10 METs of exercise on a Bruce protocol. Duke treadmill score was -1 (intermediate risk). He, therefore, was sent for dobutamine stress echo for further risk stratification.
## Indications for Stress Testing in Symptomatic Patients

<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>
</table>
| 1. Low pre-test probability of CAD  
ECG interpretable AND able to exercise | A            | R          | M           | R          | R               | R    | R                             |
| 2. Low pre-test probability of CAD  
ECG uninterpretable OR unable to exercise | A            | A          | M           | R          | M               | R    | R                             |
| 3. Intermediate pre-test probability of CAD  
ECG interpretable AND able to exercise | A            | A          | A           | M          | R               | M    | R                             |
| 4. Intermediate pre-test probability of CAD  
ECG uninterpretable OR unable to exercise | A            | A          | A           | A          | R               | A    | M                             |
| 5. High pre-test probability of CAD  
ECG interpretable AND able to exercise | M            | A          | A           | A          | R               | M    | A                             |
| 6. High pre-test probability of CAD  
ECG uninterpretable OR unable to exercise | A            | A          | A           | A          | R               | M    | A                             |
Catheterization Results
Other Causes of Wall Motion Abnormalities

- LBBB
- Paced rhythm
- Nonischemic cardiomyopathy
- Myocarditis
- Right ventricular volume or pressure overload
- Post-operative septal motion
# Qualitative Interpretation: Clinical Implications of Stress Echo Responses

<table>
<thead>
<tr>
<th>Rest</th>
<th>Stress</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Hyperdynamic</td>
<td>No CAD, <em>no ischemia</em></td>
</tr>
<tr>
<td>Normal</td>
<td>Hypokinetic or akinetic</td>
<td>CAD present, ischemia induced</td>
</tr>
<tr>
<td>Abnormal</td>
<td>No change</td>
<td>CAD present, no inducible ischemia only scar</td>
</tr>
<tr>
<td>Abnormal</td>
<td>New hypokinesis or akinesis</td>
<td>CAD present, additional areas of ischemia are noted</td>
</tr>
<tr>
<td>Abnormal</td>
<td>Improved wall motion at all levels of stress (sustained)</td>
<td>Nonischemic cardiomyopathy</td>
</tr>
<tr>
<td>Abnormal</td>
<td>Improved at low dose dobutamine and hypokinesis/akinesis at high dose</td>
<td>Biphasic response suggestive of viability</td>
</tr>
</tbody>
</table>

Modified from *J Am Soc Echocardiogr* 1998; 11:97-104
Interpretation of Stress Echo

- Can be interpreted qualitatively with a descriptive summary of the myocardial response: for example, normal hyperdynamic response, decrease in cavity size, no new wall motion abnormalities.

- Can be interpreted quantitatively using the standardized segments with numeric descriptions.
Comparison among imaging modalities is done using the 17 segment model.

Apical cap is the thinnest portion of LV and does not contract or thicken and is not scored.
Quantitative Interpretation*:
ASE Guidelines for Calculating Summed Stress Score

- 1 = Normal
- 2 = Hypokinesis
- 3 = Akinesis
- 4 = Dyskinesis
- 5 = Aneurysmal

For each of the segments:
Scoring from 1-5

REGIONAL WALL MOTION SCORE INDEX (RWMSI) = sum of scores/number of segments visualized

RWMSI = 1 is normal
RWMSI > 1 is abnormal

RWMSI = 20/16 or 1.25

Changes in Sensitivity and Specificity with Abnormal Findings

- Flat response
- Single segment new WMA
- ≥2 segments new WMA
- Extensive new WMA
- LV dilation
Quantitation of Regional Function

- Centroid method: forming multiple radii, extending from a geometric center of mass (centroid) to the endocardial and epicardial surfaces.

- Centerline methods: generation of chords to the endocardium and epicardium generated perpendicular to the LV long-axis.

[Link: cardiovascres.oxfordjournals.org]
## Methods of Assessing Wall Motion

<table>
<thead>
<tr>
<th></th>
<th>Endocardial Excursion</th>
<th>Wall Thickening</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td>Relies on readily defined interface</td>
<td>Independent of a center of reference</td>
</tr>
<tr>
<td></td>
<td>More readily measured around entire circumference of ventricle</td>
<td>Unaffected by shape changes</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>Centroid-dependent</td>
<td>Difficult to measure around entire circumference due to poor epicardial definition</td>
</tr>
<tr>
<td></td>
<td>Affected by translation and rotation</td>
<td>Difficult to correlate with results of radionuclide or contrast ventriculograms</td>
</tr>
</tbody>
</table>

Mann et al: Prog Cardiovasc Dis, 1986
Appropriate Use Criteria

- Asymptomatic
- Symptomatic
- Preoperative assessment
## Testing in Asymptomatic Patients

<table>
<thead>
<tr>
<th>Indication Text</th>
<th>Exercise ECG</th>
<th>Stress RNI</th>
<th>Stress Echo</th>
<th>Stress CMR</th>
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<th>CCTA</th>
<th>Invasive Coronary Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Low global CHD risk</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Regardless of ECG interpretability and ability to exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Intermediate global CHD risk</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>M</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>ECG interpretable and able to exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Intermediate global CHD risk</td>
<td>M</td>
<td>M</td>
<td>R</td>
<td>M</td>
<td>M</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>ECG uninterpretable OR unable to exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. High global CAD Risk</td>
<td>A</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>ECG interpretable and able to exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. High global CAD Risk</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>R</td>
</tr>
<tr>
<td>ECG uninterpretable OR unable to exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Case Presentation

- 56 yo man with no significant PMH or risk factors for CAD, except maybe tobacco use in the past, needed a preoperative assessment prior to knee replacement due to osteoarthritis. Since patient could not walk effectively on a treadmill, he underwent a dobutamine stress echo.
Interpretation

- Sustained improvement in all segments with increasing stress without worsening at higher doses
- Nonischemic cardiomyopathy
# Preoperative Assessment

## Table 13

**Stress echocardiography for risk assessment: Perioperative evaluation for noncardiac surgery without active cardiac conditions**

<table>
<thead>
<tr>
<th>Indication</th>
<th>Appropriate use score (1–9)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low-Risk Surgery With Stress Echocardiography</strong></td>
<td></td>
</tr>
<tr>
<td>154. Perioperative evaluation for risk assessment</td>
<td>I (1)</td>
</tr>
<tr>
<td><strong>Intermediate-Risk Surgery With Stress Echocardiography</strong></td>
<td></td>
</tr>
<tr>
<td>155. Moderate to good functional capacity (≥4 METs)</td>
<td>I (3)</td>
</tr>
<tr>
<td>156. No clinical risk factors</td>
<td>I (2)</td>
</tr>
<tr>
<td>157. ≥1 clinical risk factor</td>
<td>U (6)</td>
</tr>
<tr>
<td>158. Poor or unknown functional capacity (&lt;4 METs)</td>
<td>I (1)</td>
</tr>
<tr>
<td><strong>Vascular Surgery With Stress Echocardiography</strong></td>
<td></td>
</tr>
<tr>
<td>159. Moderate to good functional capacity (≥4 METs)</td>
<td>I (3)</td>
</tr>
<tr>
<td>160. No clinical risk factors</td>
<td>I (2)</td>
</tr>
<tr>
<td>161. ≥1 clinical risk factor</td>
<td>A (7)</td>
</tr>
<tr>
<td>162. Asymptomatic &lt;1 y post normal catheterization, noninvasive test, or previous revascularization</td>
<td>I (1)</td>
</tr>
</tbody>
</table>

A indicates appropriate; I, inappropriate; U, uncertain.

---

Refer to pages 12 and 13 for relevant definitions

<table>
<thead>
<tr>
<th>Indication Text</th>
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<th>CCTA</th>
<th>Invasive Coronary Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>73. Low-risk surgery, ≥1 clinical risk factor</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>74. Intermediate-risk surgery, ≥1 clinical risk factor</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>75. Vascular surgery, ≥1 clinical risk factor</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>76. Kidney transplant</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>M</td>
</tr>
<tr>
<td>77. Liver transplant</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>M</td>
</tr>
</tbody>
</table>
Using Stress Echo to Delineate Myocardium at Risk

- Use to quantify severity and extent of myocardium at risk
- Can use this information to provide prognostic risk
- Total risk can be calculated by summing the abnormal segmental score at peak stress divided by the number of segments (16) according to the ASE guidelines
# Risk of MI and Death

<table>
<thead>
<tr>
<th>Very Low Risk (&lt;1%) Death, Cardiac Events</th>
<th>Low Risk (&lt;2%) Death, MI</th>
<th>High Risk (&gt;4% risk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal exercise stress echo at good workload</td>
<td>Normal pharmacologic stress echo with adequate &gt;85% of MPRHR</td>
<td>Extensive rest WMA (4-5 segments) Extensive ischemia (4-5 segments)</td>
</tr>
<tr>
<td>Women &gt;5METs</td>
<td>Low to intermediate pretest likelihood</td>
<td>Multivessel ischemia Rest WMA with new ischemia in different territory</td>
</tr>
<tr>
<td>Men &gt;7METs</td>
<td></td>
<td>Low ischemic threshold</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dobutamine &lt;20 mcg/kg/min or vasodilator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Baseline EF &lt;40%</td>
</tr>
</tbody>
</table>
Mortality of Patients According to Total Extent of WMA

Figure 4. Mortality of patients according to total extent of wall motion abnormalities (summed stress score) at peak stress.

Mortality after Dobutamine Stress Echo

Figure 7  Cardiac mortality after dobutamine stress echocardiography (n = 3156 patients).24

Stress Echo Adds to Duke Treadmill Score

Figure 6: Combination of clinical risk assessment using Duke’s score with extent of stress echocardiography abnormality, \( n = 5375 \) patients. 

Senior, et al *Heart* 2005
Dobutamine Stress Echo and Viability

- Viability (as seen in hibernating myocardium) is present if there is improvement in contractility with low dose, i.e. 2.5-10mcg of dobutamine.
- If there is return to baseline or further reduction in wall motion with higher dose, ischemia is demonstrated.
- A *biphasic* response is considered to predict the best outcome with revascularization.

*J Am Coll Cardiol* 1998;32:921-6
Evaluating Stress Echo Using Diastology

Recording from a 65-year-old patient with noncardiac dyspnea.

Recording from a 56-year-old patient with exertional dyspnea.

May be helpful in diagnosing patients with HFpEF.

*Circ Cardiovasc Imaging* July 2011
Agreement in DSE and SPECT

Intraobserver Agreement

Interobserver Agreement

Am J Cardiol 2007;100:1239-1244
Regional Diastolic Dysfunction: Strain

Strain imaging from apical 2-chamber view at baseline (left) and 5 minutes after completion of exercise (right) in a 72-year-old man with inferior wall ischemia, demonstrating delayed myocardial relaxation in the basal and mid-inferior wall (yellow) without demonstrable wall motion abnormalities.
Strain Imaging and Regional Deformation Abnormalities

Color M-mode SR tracings at rest (upper panel) and after treadmill stress (lower panel) of septum and lateral LV. The SR is normal (yellow brown hue, except at the apex, which is uninterpretable because of the perpendicular sampling angle) at rest, but there is a failure to increase SR (lack of a red hue) and postsystolic shortening (PSS) in the left anterior descending territory, indicative of ischemia.
Comparison Between Doppler and 2D Strain

<table>
<thead>
<tr>
<th><strong>DSI</strong></th>
<th><strong>STE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Doppler technique</td>
<td>Two-dimensional echo technique</td>
</tr>
<tr>
<td>High temporal and spatial resolution</td>
<td>Good temporal and spatial resolution</td>
</tr>
<tr>
<td>Well validated</td>
<td>Well validated</td>
</tr>
<tr>
<td>Measures natural strain</td>
<td>Measures Lagrangian strain</td>
</tr>
<tr>
<td>Unaffected by translational motion</td>
<td>Affected by translational motion</td>
</tr>
<tr>
<td>Highly insonation angle dependent</td>
<td>Independent of insonation angle</td>
</tr>
<tr>
<td>Longitudinal and radial strain</td>
<td>Measures multiple deformations</td>
</tr>
<tr>
<td>Requires high frame rates (&gt;100 to 130)</td>
<td>Requires high quality image, more modest frame rates</td>
</tr>
<tr>
<td>Substantial interpretative variability</td>
<td>Less sensitive to noise; better interpretative variability</td>
</tr>
</tbody>
</table>
Myocardial Contrast Echo

- Helps to discern the endocardium during stress echocardiography
- Allows for visualization in patients who might otherwise not have adequate images
- Several studies have shown significant improvement in the assessment of left ventricular function and volumes with the use of contrast when compared to MR as a gold standard

JASE, Article in press 2008
Contrast Safety

- The Food and Drug Administration (FDA) removed the black-box warning contraindicating the use of echo contrast agents in patients who are acutely unwell (eg, acute myocardial infarction or worsening congestive cardiac failure).

- Contrast is contraindicated in patients with known right to left shunts and previous hypersensitivity or anaphylactoid response to contrast.
Case Presentations
CASE 3

60 yo with HTN, HLD with atypical chest pain until 3 wks ago when started having pain after working or walking fast. Pain radiates to bilateral arms.

He had a treadmill test in which he had same sx after exercising for only 5.5 min with nondiagnostic ECG changes.

Underwent DSE in which he had same arm pain and had ST elevation in inferior leads but no other changes. He reached target HR.
CATHETERIZATION RESULTS
Possible Board Questions from ASE Echo Review Course
For comparative studies of MRI, SPECT and echo, how many segments are recommended?

1. 24
2. 27
3. 16
4. 17
5. 14
Which segment cannot be seen in the parasternal long view?

1. Mid inferoseptum
2. Basal inferolateral wall
3. Mid anteroseptum
4. Mid anterior wall
5. 1 and 4
6. 3 and 4
Regarding methods of quantitation of regional wall motion:

1. Endocardial excursion method is centroid independent
2. Wall thickening method is independent of center of reference
3. Translation and rotation do not affect endocardial excursion method
4. Centroid methods improve sensitivity of stress echo