Definition of Stress Echocardiography

The use of echocardiography as an imaging modality to evaluate wall motion during stress for the purpose of diagnosing coronary artery disease
Indications for Stress Echo

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

Temporal sequence of ischemic events

Perfusion heterogeneity
Metabolic alteration
Diastolic dysfunction
Regional dyssnergy
↑LV filling pressure
Ecg changes
Angina

Myocardial perfusion
Echocardiography
Treadmill

Rest Stress

Picano et al 1998
Cardiac Anatomy and Views
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
Echocardiographic Views for Stress Echocardiography

- Parasternal long and short
- Apical 4 and 2 chamber
- Apical 3 chamber
Regional Wall Motion Scoring

- 0 = Hyperkinetic
- 1 = Normal
- 2 = Hypokinesis
- 3 = Akinesis
- 4 = Dyskinesis
- 5 = Aneurysmal
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
Centroid Method

Figure 1. Example of an end-systolic color kinesis image of the left ventricle in transgastric short-axis view. The segmentation scheme used for analysis of endocardial motion is superimposed on the end-systolic color-encoded frame: ant = anterior; asp = anteroseptal; sp = septal; inf = inferior; post = posterior; lat = lateral.
Centerline Method

Fractional Shortening (%)

Chords

Akinetic

Chord
## 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
Methods to Correct for Cardiac Motion

- Fixed or floating reference point to assess endocardial excursion or myocardial thickening
- Fixed point does not realign with cardiac motion
- Floating point realigns with translational and/or rotational motion
Fixed and Floating Reference

- Fixed reference system: may cause artifactual hypokinesis in a normal heart
- Floating reference may present a dysfunctional segment as normal
- Parisi, et al found that both fixed and floating methods yield similar accuracy in assessing wall motion abnormalities, but fixed method may be better to localize the abnormality
Problems with Quantitation

- Problems with rotation and translation confer some degree of ambiguity on segmental localization (false positive)
- Tethering of ischemic segments to intact myocardium may result in underestimation of ischemic severity
- Endocardial excursion of nonischemic segments may be limited if they are adjacent to ischemic segments that move poorly resulting overestimation of ischemic severity (false positive)
- Overall, centroid methods do NOT improve sensitivity of stress echo
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 blood flow by 10-20%
  - Akinesis is observed when there is an 80% reduction in 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
Normal Responses to Stress

- Hypercontractile wall motion
- Wall thickening, normal is >50%
- Improved endocardial excursion
- Smaller LV chamber size in systole and diastole
- Flat response is not specific for ischemia
Normal Response to Stress

Senior, et al *Heart* 2005
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.
Catheterization Results
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.
## Qualitative Interpretation: Classification and Clinical Implications of Stress Echo Responses

<table>
<thead>
<tr>
<th></th>
<th>Rest</th>
<th>Stress</th>
<th>Implication</th>
<th>Clinical situation</th>
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</thead>
<tbody>
<tr>
<td>I</td>
<td>Normal</td>
<td>Normal</td>
<td>Hyperdynamic</td>
<td>No CAD, no ischemia</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No CAD</td>
</tr>
<tr>
<td>II</td>
<td>Ischemic</td>
<td>Normal</td>
<td>Abnormal</td>
<td>CAD present, ischemia induced</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Fixed</td>
<td>Abnormal</td>
<td>Stable</td>
<td>CAD present, no inducible ischemia</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Mixed</td>
<td>Abnormal</td>
<td>New abnormality</td>
<td>CAD present, additional areas of ischemia</td>
</tr>
</tbody>
</table>
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.
Quantitative Interpretation:
ASE Guidelines for Calculating Summed Stress Score

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

Changes in Sensitivity and Specificity with Abnormal Findings

- Flat response
- Single segment new WMA
- ≥2 segments new WMA
- Extensive new WMA
- LV dilation
Protocols for Stress Echo

- **Exercise:**
  - Bruce protocol
  - Supine bicycle (25-100 watts in 4 stages)
  - Upright bicycle
- **Dobutamine:** 10-40 mcg/kg every 3 min
- **Dipyridamole:** 0.56 mg/kg to 0.84 mg/kg
- **Adenosine:** 140 mg/kg per min
- **Atropine** can be added to the pharmacologic agents if target heart rate is not reached
Protocols for Stress Echo

- **Exercise**
  - Treadmill
  - Bicycle

- **Pharmacologic:**
  - Dobutamine
  - Dipyridamole or Adenosine

- **Other**
  - Atrial pacing
  - Programmed pacing
  - Handgrip
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
Pharmacologic Stress

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

- Beta 1 agonist
- Increases myocardial oxygen demand by increased inotropy and chronotropy
- Half-life is 2 minutes
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 Dipyridamole

- 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
  - 2\textsuperscript{nd} or 3\textsuperscript{rd} 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>Associated Medical Conditions addressed in detail following this table</td>
<td></td>
</tr>
<tr>
<td>a) Severe COPD or asthma</td>
<td>Dobutamine: Indicated</td>
</tr>
<tr>
<td></td>
<td>Adenosine*: Contraindicated</td>
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<tr>
<td></td>
<td>Dipyridamole*: Contraindicated</td>
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<tr>
<td>b) Heart block (2° or 3°)</td>
<td>Dobutamine: Indicated</td>
</tr>
<tr>
<td></td>
<td>Adenosine*: Contraindicated</td>
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<tr>
<td></td>
<td>Dipyridamole*: Contraindicated</td>
</tr>
<tr>
<td>c) Poorly controlled HTN</td>
<td>Dobutamine: Contraindicated**</td>
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<td></td>
<td>Adenosine*: Indicated</td>
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<tr>
<td></td>
<td>Dipyridamole*: Indicated</td>
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<tr>
<td>d) Relative hypotension</td>
<td>Dobutamine: Contraindicated**</td>
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<tr>
<td></td>
<td>Adenosine*: Indicated</td>
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<tr>
<td></td>
<td>Dipyridamole*: Contraindicated</td>
</tr>
<tr>
<td>e) Unstable carotid cerebrovascular**** disease</td>
<td>Dobutamine: Contraindicated**</td>
</tr>
<tr>
<td></td>
<td>Adenosine*: Indicated</td>
</tr>
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<td></td>
<td>Dipyridamole*: Indicated</td>
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<tr>
<td>f) Significant vent ectopy</td>
<td>Dobutamine: Contraindicated**</td>
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<tr>
<td></td>
<td>Adenosine*: Indicated</td>
</tr>
<tr>
<td></td>
<td>Dipyridamole*: Indicated</td>
</tr>
<tr>
<td>g) Glaucoma***</td>
<td>Dobutamine: Contraindicated</td>
</tr>
<tr>
<td></td>
<td>Adenosine*: Indicated</td>
</tr>
<tr>
<td></td>
<td>Dipyridamole*: Indicated</td>
</tr>
<tr>
<td>Medical Therapies</td>
<td></td>
</tr>
<tr>
<td>h) Theophylline</td>
<td>Dobutamine: Indicated</td>
</tr>
<tr>
<td></td>
<td>Adenosine*: Contraindicated</td>
</tr>
<tr>
<td></td>
<td>Dipyridamole*: Contraindicated</td>
</tr>
<tr>
<td>i) Dipyridamole by mouth</td>
<td>Dobutamine: Indicated</td>
</tr>
<tr>
<td></td>
<td>Adenosine*: Contraindicated</td>
</tr>
<tr>
<td></td>
<td>Dipyridamole*: Indicated</td>
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<tr>
<td>j) Beta-blocker†</td>
<td>Dobutamine: Indicated</td>
</tr>
<tr>
<td></td>
<td>Adenosine*: Indicated</td>
</tr>
<tr>
<td></td>
<td>Dipyridamole*: 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
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>Increased image quality</td>
<td>Improved image quality</td>
<td>Better image quality</td>
<td>Less sensitive</td>
</tr>
<tr>
<td>Lower workload</td>
<td>Lower workload</td>
<td>Higher workload</td>
<td>Easier to reach required workload</td>
<td>Not as much data</td>
</tr>
<tr>
<td>Leg fatigue</td>
<td>Leg fatigue</td>
<td>Better tolerated by patients</td>
<td>More side effects and risk</td>
<td>More side effects</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
# Sensitivity and Specificity of Stress Echo

<table>
<thead>
<tr>
<th>Method</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
Appropriateness Guidelines 2013

- Multiple societies in collaboration published appropriateness guidelines for multimodality imaging for ischemic heart disease

- Tables are too numerous to display but cover diagnoses including stable chest pain, ACS, post-revascularization, pre-op and others
### 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>
<tbody>
<tr>
<td>1. Low pre-test probability of CAD, ECG interpretable AND able to exercise</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>2. Low pre-test probability of CAD, ECG uninterpretable OR unable to exercise</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>M</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>3. Intermediate pre-test probability of CAD, ECG interpretable AND able to exercise</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>M</td>
<td>R</td>
</tr>
<tr>
<td>4. Intermediate pre-test probability of CAD, ECG uninterpretable OR unable to exercise</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>5. High pre-test probability of CAD, ECG interpretable AND able to exercise</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>6. High pre-test probability of CAD, ECG uninterpretable OR unable to exercise</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>A</td>
</tr>
</tbody>
</table>
# 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>
<th>Calcium Scoring</th>
<th>CCTA</th>
<th>Invasive Coronary Angiography</th>
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<tbody>
<tr>
<td>7.</td>
<td>R</td>
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<td>R</td>
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<tr>
<td>• Low global CHD risk</td>
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<tr>
<td>• Regardless of ECG interpretability and ability to exercise</td>
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<td>M</td>
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<td>R</td>
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<tr>
<td>• Intermediate global CHD risk</td>
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<td>• ECG interpretable and able to exercise</td>
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<td>R</td>
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<td>• Intermediate global CHD risk</td>
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<td>• ECG uninterpretable OR unable to exercise</td>
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<td>10.</td>
<td>A</td>
<td>M</td>
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<td>M</td>
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<tr>
<td>• High global CAD Risk</td>
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<td>11.</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>• High global CAD Risk</td>
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</tbody>
</table>
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
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
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 ECG versus Stress ECHO: Prognosis

Group I: Normal stress ECHO, normal stress ECG

Group II: Abnormal stress ECHO, normal stress ECG

Group III: Normal stress ECHO, abnormal stress ECG

Group IV: Abnormal stress ECHO, abnormal stress ECG

Figure 1. Event-free survival probability function on a 4-group analysis based on proportional hazards model. A significant difference between a normal and an abnormal stress echocardiographic finding (groups I and III vs groups II and IV, p <0.001), independent of stress ECG results is shown. Group I = normal stress echocardiographic and ECG findings; group II = abnormal stress echocardiographic and normal stress ECG findings; group III = normal stress echocardiographic and abnormal stress ECG findings; group IV = abnormal stress ECG and echocardiographic findings.

Mahenthiran, Am J Cardiol 2005
Stress Echo Adds to Duke Treadmill Score

Senior, et al. *Heart* 2005

*Figure 6: Combination of clinical risk assessment using Duke’s score with extent of stress echocardiography abnormality, (n = 5375 patients).*
Prognosis Based on Wall Motion Abnormalities

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

- Viability 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
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
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