STRESS ECHOCARDIOGRAPHY:
THEORETICAL AND PRACTICAL CONSIDERATIONS

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DISCLOSURES

• NO FINANCIAL DISCLOSURES
• NO CONFLICTS OF INTEREST*

* Inherent personal distaste for both stress AND exercise
THE NBE IS NOT VERY SPECIFIC ABOUT CONTENT:

ASCeXAM Exam Content

The National Board of Echocardiography, Inc. (NBE) worked in collaboration with the National Board of Medical Examiners (NBME) to develop this examination to allow physicians to test and demonstrate their knowledge in echocardiography based on objective standards.

III. Chamber Size and Function

A. Coronary Artery Disease, Stress Echocardiography

From: Examination of Special Competence in Adult Echocardiography (ASCeXAM) brochure

OBJECTIVE – SCORE “YUUUGE” ON STRESS!!

• ASE SEGMENTAL MODEL – KNOW YOUR WALLS

• STRESS MODALITIES & METHODOLOGY
  • SELECTION, PREPARATION, CONCLUSION, SIDE EFFECTS

• DIAGNOSIS:
  • ISCHEMIA, VIABILITY

• PROGNOSIS

• NON-ISCHEMIC APPLICATIONS
  • DIASTOLIC STRESS; VALVULAR HEART DISEASE
KNOW THE ASE SEGMENTS

17-Segment Model

"ALTERNATE" ILLUSTRATION
SAME CONCEPT

KNOW YOUR PERFUSION DISTRIBUTION


ISCHEMIC CASCADE

Angina
ECG changes (ST segment deviation)
Hemodynamic changes
Visible systolic dysfunction
Systolic dysfunction by strain
Diastolic abnormality
Perfusion abnormality
Metabolic abnormality

Flow limiting stenosis
Duration
PROPER ASSESSMENT OF WALL MOTION

• **ENDOCARDIAL EXCURSION**
  • EASY FRAME OF REFERENCE
  • BEWARE THE “FAKE OUT” — PASSIVE DRAGGING

• **WALL THICKENING**
  • SOMETIMES MORE DIFFICULT TO DISCERN
  • % THICKENING ESTIMATE IS KEY
  • LESS ”FAKE OUT”
  • UNAFFECTED BY PASSIVE DRAGGING & SHAPE CHANGES

**GRADING WALL MOTION:**

<table>
<thead>
<tr>
<th>Score</th>
<th>Wall Motion Category</th>
<th>Endocardial Motion</th>
<th>Wall Thickening</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normokinetic</td>
<td>Normal, Inward</td>
<td>Normal (&gt;30%)</td>
</tr>
<tr>
<td>2</td>
<td>Hypokinetic</td>
<td>Reduced, Inward (&lt;5 mm)</td>
<td>Reduced (&lt;30%)</td>
</tr>
<tr>
<td>3</td>
<td>Akinetic</td>
<td>Absent (&lt;2 mm)</td>
<td>Absent (&lt;10%)</td>
</tr>
<tr>
<td>4</td>
<td>Dyskinetic</td>
<td>Outward</td>
<td>Thinning</td>
</tr>
<tr>
<td>5</td>
<td>Aneurysmal</td>
<td>Outward; Diastolic Deformity</td>
<td>Absent and Thinning</td>
</tr>
</tbody>
</table>
WALL MOTION SCORE INDEX (WMSI)  
= sum of scores / number of segments visualized

Rest
WMSI: 2.00 (nl = 1.00)

Anterior  Lateral
Inferior  Apex

Stress
WMSI: 2.38

Worsening wall motion abnormality with stress

CHAUDRY FA, ET AL. J AM COLL CARDIOL (1999) 34:730-738

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  - DIASTOLIC STRESS; VALVULAR HEART DISEASE
# Stress Echocardiography Modalities

- **Exercise**
  - Treadmill
  - Bicycle Ergometer
- **Pharmacologic Stress**
  - Dobutamine
- **Vasodilators**
  - Dipyridamole, Adenosine, Regadenoson
- **Pacing**

## Physiologic Differences

<table>
<thead>
<tr>
<th>Modality</th>
<th>Inotropic State</th>
<th>HR</th>
<th>BP</th>
<th>SVR</th>
<th>Venous Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upright Exercise</td>
<td>↑↑</td>
<td>↑↑</td>
<td>↑+</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Supine Bicycle</td>
<td>↑↑</td>
<td>↑+</td>
<td>↑↑</td>
<td>↓</td>
<td>↑↑↑</td>
</tr>
<tr>
<td>Dobutamine</td>
<td>↑↑↑</td>
<td>↑</td>
<td>↑+</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Vasodilators</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>↓↓↓</td>
</tr>
</tbody>
</table>

METHODOLOGY: EXERCISE STRESS

• ADVANTAGES OF EXERCISE:
  • DETERMINE FUNCTIONAL CAPACITY
  • EVALUATE HR AND BP RESPONSE

• BASELINE ECHO – BEYOND THE LV
  • VALVE FUNCTION (STENOSIS/REGRUGITATION)
  • ASSESS PROXIMAL AORTA
  • DIASTOLIC PARAMETERS (MV DOPPLER / MITRAL TDI)
  • RV – SIZE, FUNCTION, RVSP

METHODOLOGY: EXERCISE STRESS 2

• TREADMILL:
  • MULTISTAGE PROTOCOLS – BRUCE, MOD BRUCE, NAUGHTON
  • CONTINUOUS MONITORING – HR, BP, ECG
  • SYMPTOM LIMITED – IMAGES W/1 MIN POST-PEAK

• BICYCLE ERGOMETRY:
  • UPRIGHT, SEMI-RECUMBENT, RECUMBENT
    • VARIABLE RESISTANCE – WATTS / METS
  • CONTINUOUS MONITORING – HR, BP, ECG
  • SYMPTOM LIMITED – IMAGES AT PEAK
EXERCISE STRESS – STAGE IMAGES

**METHODOLOGY:** PHARMACOLOGIC STRESS

- **Dobutamine**
  - Low Dose (<10 mcg/kg/min) – Beta-1, Inotropic Effect
  - High Dose (11-40 mcg/kg/min) – Beta-2, Alpha-1, Chronotropic

- **Standard Protocol**
  - 3 minute stages; Continuous HR, BP, ECG monitoring
    - Start 5 mcg/kg/min, increase in stages to 40 mcg/kg/min
    - Atropine (0.5 mg, max 2mg) or Handgrip/Leg Exercise if HR submax
  - Imaging @ Baseline, Low Dose, High Dose (peak), Recovery

- **Termination:** 85% of maximal age-predicted heart rate
DOBUTAMINE STRESS – BASELINE IMAGES

DOBUTAMINE STRESS – STAGE IMAGES
DOBUTAMINE STRESS – STAGE IMAGES

WHEN DO I STOP??

• **Absolute Stopping Points**
  - ST elevations >1mm in leads without Q waves
  - VT
  - Decrease SBP>10mmHg (w/signs of ischemia)
  - Moderate to Severe Angina
  - Signs of poor perfusion

• **Relative Stopping Points**
  - ST depressions (horizontal, downsloping) >2mm
  - New BBB that cannot be distinguished from VT
  - Decrease SBP>10mmHg (w/o signs of ischemia)
  - Hypertensive response (>250 mmHg SBP / >115 mmHg DBP)
  - Increasing angina

### IS THIS SAFE?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Ex Echo n=8592</th>
<th>DSE n=6755</th>
<th>P value</th>
<th>Total n = 5349</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Complication Rate</td>
<td>8 (0.09%)</td>
<td>47 (0.7%)</td>
<td>&lt;0.001</td>
<td>55 (0.36%)</td>
</tr>
<tr>
<td>Arrhythmia Requiring Rx</td>
<td>4 (0.05%)</td>
<td>39 (0.58%)</td>
<td>&lt;0.001</td>
<td>43 (0.28%)</td>
</tr>
<tr>
<td>SVT / AF</td>
<td>4 (0.05%)</td>
<td>33 (0.49%)</td>
<td>&lt;0.001</td>
<td>37 (0.24%)</td>
</tr>
<tr>
<td>VT / VF</td>
<td>0</td>
<td>6 (0.09%)</td>
<td>&lt;0.005</td>
<td>6 (0.04%)</td>
</tr>
<tr>
<td>Markedly + / Prolonged CP requiring hospitalization</td>
<td>3 (0.03%)</td>
<td>5 (0.07)</td>
<td>0.56</td>
<td>8 (0.05%)</td>
</tr>
<tr>
<td>Symptomatic hypotension requiring hospitalization</td>
<td>1 (0.01%)</td>
<td>3 (0.04%)</td>
<td>0.44</td>
<td>4 (0.03%)</td>
</tr>
<tr>
<td>Transfer to Hospital</td>
<td>5 (0.06%)</td>
<td>21 (0.31%)</td>
<td>0.0005</td>
<td>26 (0.17)</td>
</tr>
<tr>
<td>Cardiac Rupture or Death</td>
<td>0</td>
<td>0</td>
<td>----</td>
<td>0</td>
</tr>
</tbody>
</table>


### OBJECTIVE – SCORE “YUUGE” ON STRESS!!

- **ASE Segmental Model – Know your Walls**
- **Stress Modalities & Methodology**
  - Selection, preparation, conclusion, side effects
- **Diagnosis:**
  - *Ischemia, Viability*
- **Prognosis**
- **Non-Ischemic Applications**
  - Diastolic Stress; Valvular Heart Disease
WHAT MAKES A “POSITIVE” TEST

- **Goal** – Diagnose hemodynamically significant coronary stenosis
  - >50% angiographic stenosis = WMA with stress

- **One Segment w/new or worsening HK = POSITIVE**
  - Maximizes sensitivity of the test
  - >1 segment = positive: ↓ sensitivity, ↑ specificity

- **Additional features raise suspicion**
  - Stress-induced LV dilation (>17% increase)
  - Failure to augment LV ejection fraction

DIAGNOSIS – ISCHEMIA

- **Coronary angiography**
  - “Gold Standard” for hemodynamically significant CAD
    - >50% stenosis by Quantitative angiography
    - >70% stenosis by visual estimation

- **Sensitivity – 75-85%**
- **Specificity – 80-90%**  
  For Stress Echo “Overall”

- **Comparable in Men and Women**

- **Best sensitivity when HR >85% age-predicted max HR**

ISCHEMIA DETECTION: COMPARING MODALITIES


n=136

- Exercise
- Dobutamine
- Dipyridamole

Sensitivity
n=119

Specificity
n=17

Accuracy
n=136

P=0.002

P=0.001

Sensitivity
Specificity
Accuracy

0 20 40 60 80 100

ISCHEMIA – FACTORS AFFECTING ACCURACY

**FALSE POSITIVE**

- CARDIOMYOPATHY
  - IDIOPATHIC, STRESS CMP
  - FOCAL MYOCARDITIS
- PARADOXICAL SEPTAL MOTION
  - LBBB, RV PACING
  - POST-TORACOTOMY
  - RV VOLUME OVERLOAD
- MICROVASCULAR DISEASE
  - SYNDROME X
  - DIABETES
  - LVH, HYPERTROPHIC CMP
- HYPERTENSIVE RESPONSE
- CORONARY VASOSPASM
- FOCAL BASAL INFERIOR WMA

**FALSE NEGATIVE**

- SUBMAXIMAL STRESS
  - <85% MAX PREDICTED HR
- DELAYED IMAGE ACQUISITION
- POOR IMAGE QUALITY
- ANTI-ANGINAL DRUG THERAPY
  - CA++ CHANNEL BLOCKERS, BETA BLOCKERS, NITRATES – DAY OF EXAM
- MILD ISCHEMIA
  - CIRCUMFLEX STENOSIS
  - BRANCH STENOSIS
  - DISTAL STENOSIS
- CORONARY COLLATERAL RESERVE
DECIDING WHEN TO USE S.E. FOR ISCHEMIA

- **Move beyond Sensitivity and Specificity**
- **Estimate “Pre-Test Probability”**
  - **Will the test help you? Will it change your mind?**

<table>
<thead>
<tr>
<th>Likelihood of CAD</th>
<th>CAD Prevalence</th>
<th>Does testing help?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt;10%</td>
<td>NO, CAD unlikely – SE predictive power poor</td>
</tr>
<tr>
<td>Medium</td>
<td>10-90%</td>
<td>YES</td>
</tr>
<tr>
<td>High</td>
<td>&gt;90%</td>
<td>NO, CAD likely – Move on to cath</td>
</tr>
</tbody>
</table>

- **How?**
  - Symptoms (typical/atypical), past ischemic events, ECG abnormalities, risk factors for CAD, family history
  - Diamond & Forrester, NHLBI Global CAD Risk, other models


IMPACT OF PRETEST PROBABILITY

- 100 Patients
- Pre test Likelihood 10%

- CAD + 10 pts
  - Sensitivity = 90%
  - Specificity = 80%

- CAD - 90 pts
  - True + 9 pts
  - False + 18 pts
  - True - 72 pts

- False - 1 pts
- True + 9 pts

27 + tests: 33% positive predictive value

Courtesy of S. Lester
IMPACT OF PRETEST PROBABILITY

100 Patients
Pre test Likelihood 40%

CAD + 40 pts

Pretest Likelihood
Sensitivity = 90%
Specificity = 80%

CAD - 60 pts

false - 4 pts

True + 36 pts

false + 12 pts

True - 48 pts

48 + tests:
75% positive predictive value

Courtesy of S. Lester

APPROPRIATE USE – DX ISCHEMIA
SYMPLECTIC 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</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</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>M</td>
<td>M</td>
<td>R</td>
</tr>
<tr>
<td>3. Intermediate pre-test probability of CAD</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>M</td>
<td>M</td>
<td>R</td>
</tr>
<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>A</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>A</td>
<td>A</td>
</tr>
<tr>
<td>6. High pre-test probability of CAD</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>M</td>
<td>A</td>
</tr>
</tbody>
</table>

A = Appropriate  M = May be Appropriate  R = Rarely Appropriate

### APPROPRIATE USE – DX ISCHEMIA ASYMPTOMATIC PATIENTS

<table>
<thead>
<tr>
<th>Indication Text</th>
<th>Exercise ECG</th>
<th>Stress RNI</th>
<th>Stress Echo</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>
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<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>
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<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>
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<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>M</td>
</tr>
<tr>
<td>ECG uninterpretable OR unable to exercise</td>
<td></td>
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</tbody>
</table>

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---

### OTHER FORMS OF STRESS

- **Vasodilator**
  - Dipyridamole, Adenosine
  - Differential flow (steal) **MAY lead to RWMA**
  - Less sensitive than Dobutamine
    - Atropine administration improves sensitivity

- **Pacing**
  - Using pacemaker or transesophageal wire
  - Chronotropic – min BP response / Inotropic change
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PROGNOSIS

NON-ISCHEMIC APPLICATIONS
- DIASTOLIC STRESS; VALVULAR HEART DISEASE

DIAGNOSIS – VIABILITY

- HYPOKINETIC MYOCARDIUM AT REST:
  - INFARCTED—PERMANENTLY DAMAGED/DEAD MYOCARDIUM
  - VIABLE—ACUTELY OR CHRONICALLY HYPOFUNCTIONAL

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>FATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STUNNED</td>
<td>ACUTE ISCHEMIC INJURY RECOVERS FUNCTION OVER TIME</td>
</tr>
<tr>
<td>HIBERNATING</td>
<td>CHRONIC HYPO-PERFUSION RECOVERS WITH REVASCULARIZATION</td>
</tr>
</tbody>
</table>

- LOW-DOSE DOBUTAMINE:
  - VIABLE, HYPOKINETIC MYOCARDIUM SHOWS IMPROVED CONTRACTILITY
  - PREDICTS RECOVERY OF FUNCTION – PPV 77%; NPV 84%
VIABILITY – WHY AND HOW?

• **Revascularization of VIABLE myocardium:**
  • Increased EF
  • Decreased CHF
  • Improved survival (likely)

• **What’s “low dose”?**
  • Typically <10 mcg/kg/min (4-8 mcg/kg/min “ideal”)
    • Start @ 2.5 mcg/kg/min – or – @ 5 mcg/kg/min
  • 3 min stages, through to high dose
    • Goal 85% HR or termination criteria

CLASSIFYING SEGMENTAL RESPONSE

• **Monophasic**
  • Improvement at Low dose; Improvement at high dose
  • VIABLE MYOCARDIUM – No Flow limitation

• **Biphasic**
  • Improvement at Low dose; Deterioration at high dose
  • VIABLE MYOCARDIUM – Flow-limiting Stenosis

• **Ischemic**
  • Decreased function/wall motion at all doses
  • Stress-induced ischemia – flow limiting stenosis

• **Nonphasic**
  • No changes seen
  • Non-viable myocardium - Scar
DOBUTAMINE RESPONSE

- Biphasic
- Monophasic
- Nonphasic

**MOST SPECIFIC**
79% Sens, 89% Spec

**MOST SENSITIVE**
86% Sens, 68% Spec

Usually thin (<5 mm), Hyper-refractile

DOBUTAMINE – MONOPHASIC RESPONSE

Rest 5 μgm 30 μgm Recovery

Courtesy of Sunil Mankad
DOBUTAMINE - BIPHASIC RESPONSE:

ECHO CONTRAST UTILIZATION

• **LV Opacification (LVO)** – FDA APPROVED
  - Two contiguous segments non-visualized at rest
    - Sens/Spec LVO = Sens/Spec High Quality non-contrast
  - MI <0.3; FR >30 Hz; Far Field Focus; 1-beat loop
    - MINIMIZE MYOCARDIAL TISSUE SIGNALS
    - 2 syringes; Begin Infusion 30 sec before ex termination

• **Real Time Perfusion Echo (RTPE)** – **NOT FDA APPROVED**
  - RTPE perfusion abn **BEFORE** Wall motion abn
  - MI <0.2; FR 20-25 Hz; Far Field Focus; 10-sec loop

Courtesy of Sunil Mankad
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PROGNOSTIC POWER – THE BAD

• HIGHER WMSI = WORSE PROGNOSIS
  • INDEPENDENT OF EXTENT OF CAD

• EXTENT OF ISCHEMIA:
  • MORE SEGMENTS = BAD

• SEVERITY OF ISCHEMIA:
  • MAGNITUDE OF SEGMENT(S) SEVERITY = BAD

• SEVERITY OF INDUCED LV SYSTOLIC ABNORMALITY
  • LOWER STRESS EF = BAD

• ISCHEMIC DILATATION of LV
PROGNOSTIC POWER – THE GOOD

• Normal wall motion response
• Decrease in LV volume
• Increase in LV ejection fraction
• Long duration of exercise

• Risk of MI, cardiac death or revascularization:

<table>
<thead>
<tr>
<th></th>
<th>&lt;1% per year</th>
<th>1-3% per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress</td>
<td>Maximal (&gt;85%)</td>
<td>Submaximal</td>
</tr>
<tr>
<td>Resting EF</td>
<td>&gt;50%</td>
<td>&lt;40%</td>
</tr>
<tr>
<td>Anti-ischemics</td>
<td>Off</td>
<td>On</td>
</tr>
</tbody>
</table>

OBJECTIVE – SCORE “YUUGE” ON STRESS!!

• ASE Segmental Model – Know your walls
• Stress modalities & methodology
  • Selection, preparation, conclusion, side effects

• Diagnosis:
  • Ischemia, viability

• Prognosis

• Non-ischemic applications
  • Diastolic stress; valvular heart disease
PROGNOSTIC POWER

• Not just when diagnosing CAD:
  • Chronic/Established CAD
  • Post-Myocardial Infarction
  • Perioperative Risk
  • Known Depressed EF

APPROPRIATE PROGNOSTIC USE

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</thead>
<tbody>
<tr>
<td>12. Newly diagnosed systolic heart failure</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>13. Newly diagnosed diastolic heart failure</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>M</td>
</tr>
</tbody>
</table>

Evaluation of Arrhythmias

<table>
<thead>
<tr>
<th>Evaluation of Arrhythmias</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>14. Sustained VT</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>15. Ventricular Fibrillation</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>16. Exercise induced VT or nonsustained VT</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>17. Frequent PVCs</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>18. Infrequent PVCs</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>19. New-onset atrial fibrillation</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>20. Prior to initiation of anti-arrhythmia therapy in high global CAD risk patients</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>M</td>
<td>R</td>
</tr>
</tbody>
</table>

Syncope Without Ischemic Equivalent

<table>
<thead>
<tr>
<th>Syncope Without Ischemic Equivalent</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>21. Low global CAD Risk</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>22. Intermediate or High Global CAD Risk</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>R</td>
<td>M</td>
<td>R</td>
</tr>
</tbody>
</table>

A = Appropriate  M = May be Appropriate  R = Rarely Appropriate

EACVI/ASE CLINICAL RECOMMENDATIONS

The Clinical Use of Stress Echocardiography in Non-Ischaemic Heart Disease: Recommendations from the European Association of Cardiovascular Imaging and the American Society of Echocardiography

Patrizio Lancellotti, MD, PhD, FESC (Chair), Patricia A. Pellikka, MD, FASE (Co-Chair), Werner Budts, MD, PhD, Farooq A. Chaudhry, MD, FASE, Erwan Donal, MD, PhD, FESC, Raluca Dulgheru, MD, Thor Edvardsen, MD, PhD, FESC, Madalina Garbi, MD, MA, Jong Won Ha, MD, PhD, FESC, Garvan C. Kane, MD, PhD, FASE, Joe Keeger, ACS, RCCS, RDCS, FASE, Luc Mertens, MD, PhD, FASE, Philippe Pibarot, DVM, PhD, FASE, FESC, Eugenio Picano, MD, PhD, Thomas Ryan, MD, FASE, Jane M. Tsutsumi, MD, PhD, and Albert Varga, MD, PhD, FESC, Liège, Belgium; Bari and Pisa, Italy; Rochester, Minnesota; Leuven, Belgium; New York, New York; Rennes, France; Oslo, Norway; London, UK; Seoul, South Korea; Atlanta, Georgia; Toronto and Québec, Canada; Columbus, Ohio; São Paulo, Brazil; and Seized, Hungary


DIAGNOSIS – DIASTOLIC STRESS TEST

• DIASTOLIC DYSFXN CAUSES DYSPNEA/CHF SX IN 40%
  • EXERCISE DOPPLER ECHO – DETECT “SUBCLINICAL” DYSFUNCTION
    • AKA – “IMPAIRED DIASTOLIC FUNCTIONAL RESERVE”

• SUPINE BICYCLE EXERCISE PREFERRED
  • INSTANTANEOUS DOPPLER AT EACH STAGE

• TREADMILL EXERCISE ALTERNATIVE
  • DIASTOLIC ABNORMALITIES PERSIST INTO RECOVERY
  • PASSIVE LEG LIFT MAY AUGMENT

• STAND-ALONE VS. COMBINED W/ISCHEMIC EVAL
WHEN IS DIASTOLIC STRESS TESTING INDICATED?

GRADING LV FILLING PRESSURES

- **Rule of 2's**
  1. Av E/e' > 14
  2. TR > 2.8 m/s
  3. LA vol > 34 cc/m²

- Normal LAP
  - Grade I DD

- **E/A ≤ 0.8** +
  - E ≤ 50 cm/s

- **E/A > 0.8** - < 2
  - **E/A ≥ 2**
  - Grade III DD

If symptomatic
- Consider CAD
- Proceed to Diastolic Stress Test

Courtesy of S. Lester
DIASTOLIC STRESS – METHODOLOGY

- In normals, E/e' ratio does not change with exertion
  - Both MV-E velocity and TD-e' velocity increase

- Capture “quad screens” first
  - Ischemic changes prominent in first minute

- Check TR velocity next

- Measure MV inflow and annular tissue Doppler next
  - Reduced HR minimizes fusion of E & A and e' & a' (100-110 BPM)
  - Diastolic abnormality persists longer than WMA

Clinical Factors
- Elderly
- Diabetes
- Hypertension
- Obesity
- Sedentary

Dyspnea
Breathlessness
Exertional Fatigue

Diastolic Stress Echo

- Exercise avg E/e’ > 14
  or sept E/e’ > 15

  AND

- Exercise Peak TR Vel > 2.8 m/s

  AND

- Rest septal e’ < 7 cm/s
  or lateral e’ < 10 cm/s

HFpEF

Alternative Dx:
- Ischemia / WMA
- LVOT obstruction
- Dynamic MR
- Chrono incompetence

67 MAN, DIABETES, HTN, LV HYPERTROPHY

- Dyspnea on mod exertion (NYHA II) – LVEF, Stress WM normal

Other SE Applications – Valve Disease

- Severe Valve Disease without Symptoms
  - AS, MS, AI, MR - Confirm absence of sx, assess hemodynamic response or determine prognosis (Class IIA, LOE B)

- Modest Valve Disease with Symptoms
  - MS - Eval response of MG and PASP when there is discrepancy between resting Doppler and symptoms (Class I, LOE B)
  - MR, AR – Symptoms disproportionate to severity of MR, AR at rest.

- Low Flow States
  - AS – Low dose DSE for PV<4 m/sec or MG <40 mmHg in presence of CA++ AV w/AVA<1 cm² (Class IIA, LOE B)
STRESS ECHO FOR MITRAL REGURGITATION

• Both structural and functional MR
• MR often **dynamic** and **load-dependent**
  • Treadmill/Bicycle may "unmask"; Dobutamine effects unpredictable
• MR may be **ischemic**
  • Treadmill, Bicycle, Dobutamine viable alternatives

• PISA and VC, TR/PASP — at rest and peak
  • Offline analysis
  • MR first — Ischemia Second (treadmill)

**Significant:**
• Incr. MR ≥ 1 grade
• Incr. in ERO ≥ 13 mm²
• Ex PASP ≥ 60 mmHg

STRESS ECHO FOR AORTIC REGURGITATION

• Symptoms = Poor prognosis
  • Not helpful for defining AR severity
• Severe AR = Asymptomatic
  • Exercise Stress — elicit sx in "sedentary asymptomatic"
  • Assess LV contractile reserve (<5% ↑ LVEF poor)
• Non-Severe AR = Symptomatic
  • Exercise Stress — rule out other etiologies
  • Assess LV contractile reserve
STRESS ECHO FOR MITRAL STENOSIS

• **Functional hemodynamics vs Anatomy**

• **Severe MS – Asymptomatic**
  • Elicit symptoms when MVA <1 cm²
  • Assess hemodynamics when 1.5 cm² > MVA >1 cm²

• **Non-Severe MS – Symptomatic**
  • Assess hemo’s when MVA >1-1.5 cm²
  • Change in MV gradient, PASP

SIGNIFICANT:
  • ↑ MG >15 mmHg (Ex)
  • ↑ MG >18 mmHg (Dob)
  • Ex PASP ≥ 60 mmHg

STRESS ECHO FOR AORTIC STENOSIS

• **Onset of Sx = Class 1 indication for AVR**

• SE can unmask the “Truly Asymptomatic”
  • Symptoms OR Abn BP response
  • Assess LV contractile reserve
    • Low sensitivity

• **SE for Low Flow / Low Gradient Aortic Stenosis**
  • Covered previously

SIGNIFICANT:
  • Symptoms
  • ↑ MG >18-20 mmHg
  • Ex PASP ≥ 60 mmHg
STRESS(FUL) SUMMARY

• KNOW WALLS & CORONARY DISTRIBUTION
• BICYCLE VS. TREADMILL VS. DOBUTAMINE
• CONTRAINDICATIONS TO SE
• STOPPING CRITERIA FOR SE
• WHEN TO USE CONTRAST
• DIASTOLIC STRESS TESTING
• VALVULAR APPLICATIONS

THANK YOU!

PEACE OUT!!

THANK YOU!