Stress Echo: Basics and Interpretation tips

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Disclosures

No Real or Potential Conflict of Interests for this Talk
Outline

Who should get a stress echo?
How do I perform a stress echo
How do I interpret a stress echo
Overview of false + / -
Prognostic findings
Risk Assessment Pyramid

Hierarchical assessment

Clinical Evaluation: ALL
Stress Testing: Some
Coronary Assessment: Few

Clinical Evaluation:
Low, IM, or High pretest
Able to exercise?
Look at baseline ECG
Stress Echo

The use of echocardiography as an imaging modality to evaluate wall motion during or immediately after exercise or pharmacologic stress for the purpose of diagnosing (or risk-stratifying) CAD.
Indications

- Diagnosis of CAD in patients with symptoms
- Determination of inducible myocardial ischemia location and severity
  - Risk stratification: post-infarct; SIHD
- Viability assessment ("PCI roadmap")
- Preoperative evaluation (*rarely indicated)
Protocols

- *Exercise (symptom-limited)
  - TMET (*Bruce, MB, other)
  - Supine / upright bike
- Dobutamine: 10-40(50) mcg/kg/min q 3’
  - Atropine 0.2-0.5mg (max 2.0mg) prn
- Persantine / adenosine / Lexiscan
- Pacing (atrial), emotional stress, handgrip
<table>
<thead>
<tr>
<th></th>
<th>Bicycle</th>
<th>Treadmill</th>
<th>Dobutamine</th>
<th>Vasodilator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved sensitivity</td>
<td>Improved image quality</td>
<td>Easier protocol</td>
<td>Cumbersome protocol</td>
<td>Highest specificity</td>
</tr>
<tr>
<td>Decreased specificity</td>
<td>Improved image quality</td>
<td>Easier protocol</td>
<td>Best image quality</td>
<td>Less sensitive</td>
</tr>
<tr>
<td>Lower workload</td>
<td>Higher workload</td>
<td>Easier to achieve target workload</td>
<td>Less data</td>
<td></td>
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<tr>
<td>Leg fatigue</td>
<td>Patient preferred (US)</td>
<td>Side effects</td>
<td>Side effects</td>
<td></td>
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</table>
TM-exercise Bruce

- Major goal: “exercise” (adds clinical info)
- MUST complete images <60s (<90s)
- Clock must start at stress termination
- “Practice run” worthwhile to reduce total time
  - Practice cooperation with breath-holds
- Inject UCA during stress (not at completion)
Conventional Views

- PSLAX and PSSAX
- A4C and A2C
  - Include multiple “sub-loops”

Additional views for consideration:
A3C, A5C, inferiorly tilted A4C, multiple SAX’s
Regional wall motion score

0 = Hyperkinetic (FT >50%; >5mm WT)
1 = Normal (40%; ~5mm)
2 = Hypokinesis (10-40%; 2-4mm)
3 = Akinesia (<10%; 0-1mm)
4 = Dyskinesis (AK plus abnormal motion)

Note: aneurysm = “diastolic deformation”
Termination

- Completion of ‘maximal’ stress
- Severe symptoms
- Hypo / hypertension severity
- Patient request
- Large WMA (dobutamine)
- Arrhythmia(s)
Normal

Depends on TYPE of modality:

EF increases in all types
(exception: atrial pacing = ~ change)
Note: Dobutamine = highest LVEF

ESV decreases
(exceptions: atrial pacing = no change)
Note: Dobutamine is smallest ESV

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Table 1: Normal and ischemic responses for various modalities of stress

<table>
<thead>
<tr>
<th>Stress method</th>
<th>Regional</th>
<th>Ischemic response</th>
<th>Global</th>
<th>Ischemic response</th>
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<tbody>
<tr>
<td>Treadmill</td>
<td>Postexercise increase in function compared with rest</td>
<td>Postexercise decrease in function compared with rest</td>
<td>Decrease in EF, increase in ESV</td>
<td>Increase in ESV, decrease in EF in multivessel or L. main disease</td>
</tr>
<tr>
<td>Supine bicycle</td>
<td>Peak exercise increase in function compared with rest</td>
<td>Peak exercise decrease in function compared with rest</td>
<td>Decrease in EF, increase in ESV</td>
<td>Increase in ESV and decrease in EF in multivessel or L. main disease</td>
</tr>
<tr>
<td>Dobutamine</td>
<td>Increase in function, velocity of contraction compared with rest and usually with low dose; may be less compared with rest</td>
<td>Decrease in function, velocity of contraction compared with rest</td>
<td>Greater decrease in ESV, marked increase in EF</td>
<td>Often same as normal response; occasionally, ischemia produces decreased EF, cavity dilatation rarely occurs</td>
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<tr>
<td>Vasoconstrictor</td>
<td>Increase in function compared with rest</td>
<td>Decrease in function compared with rest</td>
<td>Decrease in ESV, increase in EF</td>
<td>Often same as normal response; occasionally, ischemia produces decreased EF, cavity dilatation rarely occurs</td>
</tr>
<tr>
<td>Atrial pacing</td>
<td>No change or increase in function compared with rest</td>
<td>Decrease in function compared with rest</td>
<td>Decrease in ESV, no change in EF</td>
<td>No change or increase in ESV, decrease in EF</td>
</tr>
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EF, Ejection fraction; ESV, end systolic volume; L, left.

Pellika et al JASE 2007
Normal response

- Adequate exercise / dobutamine
  - Hypercontractile wall motion
  - Wall thickening >>50%
  - Endocardial excursion increased
  - LV cavity smaller in systole (& diastole)

Lack of response is not normal, but not diagnostic of ischemia
Abnormal

Depends on TYPE of modality:

Decrease in regional function compared to baseline / rest in all modalities

Note: Dobutamine decreased compared to LOW DOSE

ESV increases / LVEF decreases ONLY in LM or MVCAD

Note: Dobutamine ESV remains normal (or even decreases) despite MVAD

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EF, Ejection fraction; ESV, end systolic volume; L, left.
Abnormal response

- **New** wall motion abnormality
  - Hk / Ak / Dyskinesia

- **Severity of CAD** stenosis \( \sim \leq \) \textit{duration} of stunning
  - Consider “double-peak” or “repeat imaging”
## Qualitative interpretation

<table>
<thead>
<tr>
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<th>Rest</th>
<th>Stress</th>
<th>Implication</th>
<th>Clinical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Hyperdynamic</td>
<td>No “ischemia”</td>
<td>No “CAD”</td>
</tr>
<tr>
<td>Ischemia</td>
<td>Normal</td>
<td>Abnormal</td>
<td>Yes Ischemia</td>
<td>Yes CAD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No infarct</td>
</tr>
<tr>
<td>Fixed</td>
<td>Abnormal</td>
<td>Unchanged</td>
<td>No Ischemia</td>
<td>Yes CAD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Prior infarct</td>
</tr>
<tr>
<td>Mixed</td>
<td>Abnormal</td>
<td>New RWMA</td>
<td>Yes Ischemia</td>
<td>Yes CAD (MV)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Prior infarct</td>
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*Adapted from JASE 1998; 11:97*
## RWMA Assessment

<table>
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<tr>
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<th>Endocardial Excursion</th>
<th>Wall Thickening</th>
</tr>
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<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td>Relies on readily defined interface</td>
<td>Independent of center reference</td>
</tr>
<tr>
<td></td>
<td>More readily measured around entire circumference of LV</td>
<td>Unaffected by shape changes</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>Centroid-dependent</td>
<td>Difficult to measure around entire LV due to poor epicardial definition</td>
</tr>
<tr>
<td></td>
<td>Affected by translation / rotation</td>
<td>Poor correlation with RNA &amp; LV-grams</td>
</tr>
</tbody>
</table>
Sensitivity vs Specificity

Lack of hypercontractile response
WMA limited to 1-2 segments
WMA’s include >2 segments
WMA’s extend to multiple CA regions
LVEF falls and LV cavity dilates
Prognosis

Stress WMSI, LVEF fall, increased ESV –
- Cardiac death / MI

Rest WMSI and LVEF – All deaths
Ischemia or change in WMSI –
- predicts MI

Perfusion defects – Death / MI
Failure to reach THR (DSE) –
- MI, late coronary revascularization

Ischemic threshold (DSE) –
- cardiac death / MI

Post AMI – rest WMSI and remote isch –
- Cardiac death, MI, arr, HF
Imaging tips

- Tissue harmonics (default settings)
- Practice-run valuable
- Liberal use of manufactured UCA
  - >1 wall segment NOT seen (any apical view)
  - Improves accuracy, reproducibility, confidence
2 CHAMBER VIEW

? RV ?
? Translation ?
? Foreshortening ?
? Valve plane ?
? Coronary sinus ?
Harmonic Imaging default

![Graph showing frequency and power levels with peaks labeled Fundamental, Sub harmonic, Ultra harmonic, and 2nd harmonic.]

MI 0.4 → 0.8 → 0.4

Courtesy of the UK Advanced Imaging CV Physics Lab
1. Reduced near-field artefacts / noise
2. Improved endocardial delineation (especially lateral wall)
3. Combines penetration (low freq) with improved image quality
4. Additional enhancements with UCA
False POSITIVE (abnormal)

- Not unique to stress echo
  - #1 Ischemia in absence of obstruction (?)
    Severe BP response / HCM / LVH
    Syn X / Diabetes / myocarditis / spasm
  - #2 WMA in absence of ischemia
  - DCM
  - #3 Tethering / Basal Inferior / IVS conduction
False POSITIVEs (CAD gold standard ?)

- INTERPRETATIVE
  - Limited experience (inferobase; lateral; apex)

- TECHNICAL
  - Translation (BH important)
  - Tethering (scar)

- PHYSIOLOGIC
  - High BP response (relative)
  - Microvascular disease (x)

Is this normal?
False NEGATIVE (normal)

- Not unique to stress echo
  - #1 Suboptimal stress (THR, RPP, gender ?)
  - #2 Anti-ischemic Rx (BB, CCB, N2)
  - #3 Peak (bike) vs Post (TMT)
    - Offset partially by higher DP with TMT
  - #4 Small WMA (1VD, Cfx, Branch)
  - #5 LVH / CR and small LV (DSE)
False NEGATIVES (?) CAD Gold Standard ?)

- **INTERPRETATIVE**
  - Limited experience (1V, Branch dz, DSE)

- **TECHNICAL**
  - Poor quality (ECG gating, endocardial “drop-out”)
  - Delayed acquisition (>90s)
  - “Reverse tethering” (normal)

- **PHYSIOLOGIC**
  - Limited ischemia (false + Angio)
Tarnished “Gold”

- Comparison of Physiology (ischemia) to Anatomy (% stenosis) is an inherent flaw that is limited by the large number of ‘overlap’ cases.
Tips when starting new EXE

- Avoid the “See 1- Do 1 -Teach 1” philosophy
  - Observe the most experienced sonographer

- **Dobutamine stress echo advantages:**
  - Able to monitor wall motion during stress
  - Reduces “sonographer” stress (no 60s window)
  - Ischemic thresh-hold maintained longer
Left ventricular endocardial and epicardial border length delineation with perflutren contrast during transthoracic echocardiography.

Sorrell VD, Ross WD, Kumar S, Kaira N.

Abstract

OBJECTIVE: Precise estimation of wall motion abnormalities during routine echocardiography rests on optimal endocardial border visualization. Endocardial "dropout" may result in the misinterpretation of regional wall motion. Left ventricular opacification (LVO) with intravenous contrast improves the visualization of the left ventricular endocardial border length (EnBL). The purpose of this study was to determine if contrast also improves the visualization of the epicardial border length (EpBL) in addition to the EnBL.

METHOD: This is a single center retrospective observational study. From 200 consecutive patients referred to the Echocardiography Laboratory for the assessment and evaluation of coronary artery disease. 73 patients who received contrast were enrolled. All the images were standardized using offline software. The visualized segments of the epicardium and endocardium were measured in diastole and systole, without and with contrast-enhancement and these segments were summed to provide the total visualized EnBL and EpBL.

RESULTS: Contrast enhanced imaging improved EnBL by 65% and 45% in end-diastolic and end-systolic views, respectively. Similarly, EpBL was improved by 61% and 57% in end-diastolic and end-systolic views, respectively (all P values <0.05).

CONCLUSION: Contrast LVO improves the EnBL as previously reported. Additionally, based upon the blinded review of 1,752 regional myocardial wall segments, this study is the first to suggest that contrast also enhances the visualization of the EpBL. This finding has direct clinical implications as the improvement in both EnBL and EpBL with contrast may assist in evaluation of regional left ventricular wall thickening which is a critical parameter used to assess for myocardial ischemia.

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PMD 21545278 DOI 10.1111/j.1540-8175.2011.01420.x

EnBL as well as EpBL improvement = improved confidence in wall “thickening”
Value of Rapid Beta-Blocker Injection at Peak Dobutamine-Atropine Stress Echocardiography for Detection of Coronary Artery Disease

Wilson Mathias, Jr, MD, PhD, FACC, Jean M. Toussi, MD, PhD, Jose L. Asdrude, MD, PhD, Ingrid Kowarschik, MD, Pedro A. Lemos, MD, Santu M. R. Lead, MD, PhD, Bijoy Khadka, MD, FACC, Joel F. Knuurse, MD, PhD, FACC

São Paulo, Brazil

OBJECTIVES We studied the value of a rapid beta-blocker injection at peak dobutamine-atropine stress echocardiography (DASE) for the detection of coronary artery disease (CAD).

BACKGROUND The presence of ischemic and hyperemic wall motion may make it difficult to recognize a new wall motion abnormality (NWWMA) at peak stress.

METHODS We enrolled 106 patients (mean age 59 ± 5.8 years) who underwent effective DASE and coronary angiography. All patients received a rapid intravenous injection of metoprolol immediately after peak DASE image acquisition. Positivity is combined peak plus post-peak images were defined while there was only peak NWWMA, ischemic peak of NWWMA, or NWWMA detected only after metoprolol injection. Significant CAD was defined as ≥50% stenosis by quantitative angiography.

RESULTS There were 37 patients without and 69 with CAD. The sensitivity, specificity, accuracy, and positive and negative predictive values for the detection of CAD at peak stress were 90%, 53%, 87%, 53%, and 77%, respectively. Five patients with CAD had negative peak images that became positive only after metoprolol. Examinations of peak NWWMA during metoprolol were observed in 14 patients, and multivessel CAD was detected in 10 of them. The sensitivity, specificity, accuracy, and positive and negative predictive values for peak plus post-peak images were 90%, 89%, 91%, 94%, and 87%, respectively. The use of metoprolol injection at peak of dobutamine infusion improved the detection of CAD by DASE.

CONCLUSIONS Five patients with CAD had negative peak images that became positive only after metoprolol.
Unique patient populations

- Permanent pacemaker implantation
  - Preferable to perform SPECT MPI
  - If DSE necessary, use low dose, then program the pacer rate to target (graded)

- High risk / known CAD risk stratification
  - Consider vasodilator stress echo (only abnormal when there is critical stenosis)
CONCLUSIONS

- The most difficult aspect of echo to be expert
- Nuances of mild abnormalities require experience
- Contrast is highly valuable (even in ‘good quality’)
  - Adding perfusion is incrementally beneficial
- Exercise out-performs pharmacologic stress
- WMSI should always be measured
  - Limited Doppler (E/e’, RVSP) for dyspnea
“Disease is very old, and nothing about it has changed. It is we who change as we learn to recognize what was formerly imperceptible”.

Jean-Martin Charcot
Thank You for your Kind Attention

Drop the knife... press the shutter!

Vincent L. Sorrell – v.sorrell@uky.edu / 321-5699
“Remember, the danger of an appropriate noninvasive test lies not in its performance, but in the quality and accuracy of its interpretation”
ECHO in the Bluegrass

Oct 2018

Save
The
Date

@ Kentucky ACC17