Stress Testing in Management of Known or Suspected Coronary Disease

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Why Stress Testing?

• Diagnosis, Prognosis, and Response to Therapy
• Suspected Coronary artery disease
• Known coronary artery disease
• Prior to non-cardiac surgery
• Before and after cardiac revascularization
Why Stress Testing?

• Diagnosis, Prognosis, and Response to Therapy
  Special populations (women, diabetics)

• Evaluation of acute chest pain syndromes

• Post Myocardial infarction
Physiologic Changes during stress

• During a normal treadmill ECG study, the diastolic blood pressure usually:

  A- Increases by 20-40 mmHg
  B- Drops by 20-40 mmHg.
  C- is unchanged.
  D- Increases proportionally to the increase in SBP.
Exercise Physiology

• Increase in O2 extraction by 3 folds.
• SBP, MAP and pulse pressure increase.
• DBP remains unchanged (<10 mmHg variability)
• Reduction in MPHR with age is due to decreased beta-adrenergic responsiveness
• Post exercise: Vagal activation is essential for return to baseline (blunted in CHF patients)
A- Increases by 20-40 mmHg
B- Drops by 20-40 mmHg.
C- is unchanged.
D- Increases proportionally to the increase in SBP.
• Among the Disadvantages of a exercise treadmill testing:

  – A. It is not well studied for diagnosing ischemia
  – B. Its is not well studies in females and the elderly.
  – C. Prognostic Results of ETT is trumped by information from imaging tests
  – D. Does not accurately localize the site or extent of myocardial ischemia.
ETT

• Advantages
  – Standard treadmill assessment of ischemia, functional capacity, and prognosis is well established
  – Equipment widely available
  – Accuracy tested in different populations
ETT

Disadvantages

• Sensitivity lower than that of stress imaging techniques

• Specificity poor with marked ST-T abnormalities on resting ECG, with digoxin use, with LBBB or pacemakers, or in female population

• Does not accurately localize the site or extent of myocardial ischemia, which is important in patients who have undergone revascularization or who have a defined coronary anatomy.
Risks and Contraindications

• Risks of MI and death 1/2500.

• Absolute Contraindications (ACC/AHA guidelines)

  – Acute MI (48 hrs)
  – Unstable angina not stabilized by medical therapy.
  – Cardiac arrhythmia causing syx or hemodynamic compromise.
  – Symptomatic severe AS.
  – Uncontrolled CHF.
  – Acute pulmonary embolus.
  – Acute myocarditis or pericarditis.
  – Acute aortic dissection
How good is exercise ECG testing?

• Meta-analysis of 147 consecutive studies involving 24,074 patients

ETT: How does it compare to other tests?
Sensitivity
ETT: How does it compare to other tests?
Specificity

- Stress Nuclear
- Stress ECG
- Stress ECHO
Duke treadmill score

• The DTS is not:

   A- Validated in young men.
   B- Validated in women.
   C- Validated for diagnosis of ischemia.
   D- Validated in the elderly.
ETT: Duke treadmill Score

• Combination of
  – prognostic markers
  – Ischemia

• Validated in men and women.

• Not validated in the elderly.
• Which of the following markers is not included in the Duke Treadmill Score?

A. Number of METS achieved.

B. Development of angina.

C. ST depression.

D. Time on the treadmill.
ETT: Duke treadmill Score

- Duration of exercise on treadmill (in minutes)
- Amount of ST segment depression (in millimeters)
- Treadmill Angina index:
  - 0 = No Angina
  - 1 = Non-limiting Angina
  - 2 = Limiting Angina
ETT: Duke treadmill Score

- Duration of exercise on treadmill (in minutes) minus 5x (millimeters of maximal ST segment depression) minus 4X (treadmill anginal index)
A. Number of METS achieved.

B. Development of angina.

C- ST depression.

D- Time on the treadmill.
ETT: Duke treadmill Score

Four Year Event Rate

- +5 or Greater
- -10 to +4
- Less than -10
METs

A negative ECG stress test with a high exercise capacity indicates an excellent prognosis, it does not necessarily imply the absence of coronary artery disease. (55% of patients achieving 10 METs have significant CAD)
• 42 year old male patient with hypertension and family history of premature CAD is presenting for evaluation of atypical chest pain. His PMD forwarded an ECG on the patient to your office showing NSR with RBBB. Also, he was told by his PMD that he will undergo an imaging stress test given his ECG.
• You recommended:

A- Stress echo given lower radiation exposure.
B- Pharmacologic stress Nuclear test given resting ECG abnormalities.
C- Stress ECG. (More is less)
D- None of the above. He is at low risk for CAD.
Treadmill Test: Symptomatic Patients or Patients with CAD

• Class I indications:
  – Initial risk stratification in patients with normal ECG, RBBB or resting ST depression<1 mm
  – Patients with established CAD but with change in clinical status.
  – Low risk patient with unstable angina who have no active angina or CHF.
  – Intermediate risk patient 2-3 days after latest angina episode.
• You recommended:
  – A- Stress echo given lower radiation exposure.
  – B- Pharmacologic stress Nuclear test given resting ECG abnormalities.
  – C **Stress ECG. (More is less)**
  – D. None of the above. He is at low risk for CAD.
ETT-MPI

Advantages

• Well-validated ability to detect severe coronary disease and to assess prognosis
• Results are reproducible
• Can assess left ventricular size qualitatively
• Improved sensitivity and specificity
• More accurate determinant of extent of coronary disease and prognosis
• Assesses myocardial viability
ETT-MPI

Disadvantages

• Increased cost
• Requires longer time commitment
• Radiation exposure
• Specificity depends upon quality control of laboratory and specialty trained readers
• Artifact due to soft tissue (e.g., breast) or diaphragmatic attenuation
• Additional equipment and personnel needed
• In presence of LBBB has low specificity because of high proportion of false positive results
What Good is MPI? – Clinical Value

- A gated nuclear stress test is a powerful tool to risk stratify patients for optimal management.
- A “gate-keeper” to the cardiac cath lab

<table>
<thead>
<tr>
<th>Scan Result</th>
<th>Annualized risk of cardiac events</th>
<th>Treatment implications (majority of patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt;1% risk of both cardiac death and MI</td>
<td>Risk factor modification (RFM) in addition to current regimen</td>
</tr>
<tr>
<td>Mildly abnormal</td>
<td>Low risk of cardiac death; Intermediate risk of MI</td>
<td>Aggressive RFM/medical treatment</td>
</tr>
<tr>
<td>Moderately to severely abnormal</td>
<td>Intermediate-to-high risk of both cardiac death and MI</td>
<td>Catheterization (possible revascularization)/RFM</td>
</tr>
</tbody>
</table>
Stress Echo

Advantages

• Sensitivity and specificity are similar to nuclear imaging
• Provides information on the presence and extent of coronary disease
• Results available immediately
• Portable
• Less time commitments, lower cost compared
• Assesses multiple parameters including global and regional ventricular function, chamber size, wall thickness, and valvular function
• Useful for diagnosing coronary disease in presence of baseline ECG abnormalities
Stress echo

Disadvantages

• Interpretation subjective and nonstandardized
• Interpretation difficult when resting wall motion abnormalities exist
• Images are nondiagnostic due to poor image quality in a significant number of patients (can be improved by contrast use)
• Prognostic potential uncertain due to limited number of studies
• For patients with LBBB or paced ventricular rhythm, data are limited and guidelines do not recommend exercise echocardiography.
Pharm MPI

Advantages

• Accurately assesses coronary disease in patients unable to exercise

• Especially useful in preoperative risk assessment in patients with claudication or musculoskeletal limitations

• Relatively safe in selected patients, side effects are rapidly reversed by terminating the infusion or by administering aminophylline

• More specific for detecting coronary disease in patients with baseline LBBB than exercise perfusion imaging.
Pharm MPI

Disadvantages

• Cannot assess functional capacity

• ECG abnormalities less likely to occur compared with exercise testing

• Contraindicated in hypotension, sick sinus syndrome, high-grade heart block, and in patients with pronounced bronchospastic airway disease or in patients receiving oral dipyridamole therapy

• Must discontinue theophylline containing medications for 72 hours and caffeine for 24 hours before testing
Dobutamine Stress echo

Advantages

• Accurately assesses coronary disease in patients unable to exercise

• Relatively safe in selected patients, side effects are rapidly reversed by terminating the infusion or by administering beta blocker

• Accurately detects the threshold of myocardial ischemia

• Assesses myocardial viability
Dobutamine Stress echo

• Like exercise echocardiography, assesses multiple parameters including global and regional ventricular function, chamber size, wall thickness, and valvular function

• More specific than exercise perfusion imaging for detecting coronary disease in patients with baseline LBBB; in addition, it may be valuable for establishing prognosis in such patients, particularly in the absence of a previous myocardial infarction
Dobutamine Stress echo

Disadvantages

• Cannot assess functional capacity
• ECG abnormalities less likely to occur compared with exercise testing
• Results depend on obtaining good echocardiographic windows, which may be difficult to obtain in obese patients or those with chronic obstructive pulmonary disease
Dobutamine Stress echo

- Requires extensive experience by reader
- Labor intensive
- May cause dangerous ventricular arrhythmias, especially in patients with poor left ventricular function or severe coronary heart disease
- Contraindicated in patients with symptomatic aortic aneurysm
Stress Test Options

- ETT (EST / Regular) Bruce protocol
- ETT with Myocardial Perfusion Imaging
- Pharmacological Stress
  1. Dipyridamole (Persantine)
  2. Adenosine
  3. Dobutamine
  4. Regadenoson

Stress echo
  - Exercise
    - Dobutamine
38 year old female with mild obesity

• She is planning an exercise program to lose weight. She has no other known risk factors for CAD. You recommend:
  – A. Exercise stress echo.
  – B. Exercise SPECT.
  – C. Exercise treadmill test.
  – D. Proceed to exercise program no further testing.
38 year old female with mild obesity

• She is planning an exercise program to lose weight. She has no other known risk factors for CAD. You recommend:
  – A. Exercise stress echo.
  – B. Exercise SPECT.
  – C. Exercise treadmill test.
  – **D. Proceed to exercise program no further testing.**
38 year old female with mild obesity

• ACC/AHA guidelines for testing in asymptomatic person without CAD
  – Class I: none
  – Class IIa: Asymptomatic diabetic without known risk factors who are planning an exercise program.
  – Class III: Routine screening
Treadmill Test:
Patients with abnormal resting ECG

- 73 year old male patient with elevated cholesterol, and hypertension as risks for CAD. He is asymptomatic and describes himself as “very active”. His life insurance carrier asked for an exercise stress test to assess his prognosis. His ECG shows NSR with LBBB. You informed him:
  - A. We can proceed with the test for the above indication.
  - B. The ability of the test to predict prognosis is compromised by the presence of LBBB.
  - C. Prognostic information can only be derived from a pharmacologic imaging stress test.
  - D. The insurance carrier should pay for a CT angiogram.
Treadmill Test: Symptomatic Patients or Patients with CAD

• Patients should undergo exercise imaging test if they have:
  – Pre-excitation.
  – V paced rhythm
  – Widespread ST depression >1 mm.
  – LBBB.

• Exercise testing can be used in above patients for prognosis assessment but not for ischemia diagnosis.
• 73 year old male patient with elevated cholesterol, and hypertension as risks for CAD. He is asymptomatic and describes himself as “very active”. His life insurance carrier asked for an exercise stress test to assess his prognosis. His ECG shows NSR with LBBB. You informed him:

– A. We can proceed with the test for the above indication.
– B. The ability of the test to predict prognosis is compromised by the presence of LBBB.
– C. Prognostic information can only be derived from a pharmacologic imaging stress test.
– D. The insurance carries should pay for a CT angiogram.
Treadmill Test: Symptomatic Patients or Patients with CAD

• RISC study
  – 740 men with unstable angina and non-q wave infarcts
  – Predictors of infarct free survival
    – Number of leads with ST depression on ETT.
    – Duration of exercise.

• FRISC study
  – 766 patients with unstable angina
  – Predictors of death/MI
    – Troponin level
    – Number of leads with ST depression on ETT
Treadmill Test:
Post MI

• Class I
  – Before discharge for prognostic assessment.
  – Early after discharge for prognostic assessment.
  – Late after discharge for prognostic assessment.

• Class III
  – Patients who were selected for catheterization or who have undergone catheterization.

• Patient who had their coronary anatomy defined can undergo ETT in combination with an imaging test to localize ischemia.
Treadmill Test: Women

• 56 year old female patient (BMI of 29) who is presenting for evaluation of atypical chest pain. She has known elevated cholesterol and hypertension. Her resting ECG shows NSR and T wave changes. You recommended:
  – A. Pharmacologic SPECT imaging.
  – B. ETT test.
  – C. ETT/SPECT imaging test.
  – D. ETT/echocardiogram.
Treadmill Test: Women

- A. Pharmacologic SPECT imaging.
- **B. ETT test.**
- C. ETT/SPECT imaging test.
- D. ETT/echocardiogram.
Treadmill Test: Women

- Exercise induced ST depression has lower specificity.
  - Lower pretest likelihood for disease.
  - Inability of many women to reach maximal exercise capacity (can lower sensitivity).

- Exercise induced ECG abnormalities may be less specific.

- Baseline T wave changes do not affect the specificity of ST changes with exercise.

- Gender alone is not a justification for routine use of imaging stress tests in women. (ACC/AHA guidelines).

- Pharmacologic stress tests usually indicated in patients who cannot exercise.
Treadmill Test: Elderly

- 76 year old male with atypical chest pain, HTN, ex-smoker who is presenting for evaluation prior to traveling overseas on a vacation. You recommended an ETT. His resting ECG shows LVH. ETT in this population is known to yield
  - B. Similar accuracy compared to younger population.
  - C. Lower specificity.
  - D. ALL of the above.
Treadmill Test: Elderly

- B. Similar accuracy compared to younger population.
- C. Lower specificity.
- D. ALL of the above.
Treadmill Test: Elderly

• Sensitivity in this population is higher in view of higher pretest likelihood of disease.
• Specificity is lower given the prevalence of LVH.
• Accuracy is comparable to the younger population.
Treadmill Test: Valvular Heart Disease

• 57 year old male with severe mitral regurgitation in the setting of posterior mitral leaflet prolapse. He reports no symptoms and has an EF of 65 % with normal LV dimensions. An ETT test to assess his functional capacity was considered. Your medical student suggests that this approach is not supported by guidelines. You responded that:
  – A. Functional assessment in patients with valvular heart disease carries a Class I indication.
  – B. Class I indication is only for patients with aortic stenosis.
  – C. ETT would be useful for diagnosing CAD in such patients.
  – D. None of the above.
Treadmill Test: Valvular Heart Disease

- B. Class I indication is only for patients with aortic stenosis.
- C. ETT would be useful for diagnosing CAD in such patients.
- **D. None of the above.**
Treadmill Test: Valvular Heart Disease

- There are no Class I or IIa indications for ETT in patients with valvular heart disease.
- Using ETT to diagnose CAD in patients with valvular heart disease carries a Class III indication.
Treadmill Test: 
Post Revascularization

- 71 year old male patient who underwent a 3 vessel CABG 3 years ago. He presents to your clinic for evaluation and establishing care in the area. He reports no symptoms and he describes himself as very physically active. He swims 4 times a week and bike twice/week. You complemented him on his exercise regimen and agreed with his current regimen. His wife (a former head nurse) asks you if you are planning a “routine” ETT. She also reports that he gets these every year when checking with his former doctor. You reassured her that:
Treadmill Test: Post Revascularization

- A. There are no guidelines for routine testing in patients who are asymptomatic post revascularization.
- B. ST changes on ETT are more predictive of future angina development but not events.
- C. ST changes on ETT are not accurate for localizing ischemia.
- D. An ETT can be useful if he develops new symptoms.
- E. All of the above
Treadmill Test: Post Revascularization

- A. There are no guidelines for routine testing in patients who are asymptomatic post revascularization.
- B. ST changes on ETT are more predictive of future angina development but not events.
- C. ST changes on ETT are not accurate for localizing ischemia.
- D. An ETT can be useful if he develops new symptoms.
- E. All of the above
Treadmill Test: Post Revascularization

• Routine periodic monitoring of asymptomatic patients after revascularization carries a Class III indication.

• ETT can be useful when new symptoms develop in patients post revascularization (class I)
Keep in mind

• Stopping the ETT at an arbitrary heart rate risks underestimation of the exercise capacity as measured by METS.

• The ETT should be terminated on the basis of symptoms or maximal effort. Under these circumstances, a reduced exercise tolerance is indicative of a poor prognosis.

• Inappropriate rise of heart rate relative to workload indicates poor cardiac function or, at best, deconditioning.
Keep in mind

• If the effort tolerance is poor, prognosis is poor even in the absence of ECG changes.

• Effort tolerance of 7 to 10 METS with appropriate increased heart rate in the absence of ECG or unfavorable clinical findings implies good prognosis regardless of coronary artery disease and warrants less aggressive management.