Non Invasive Testing for CAD

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38 year old female with mild obesity

• She is planning an exercise program to loose 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
She is planning an exercise program to loose 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.
Historic perspective

• ECG stress testing first described in 1928 (Feil and Seigel)
• 1929, Master and Oppenheimer introduced standardized exercise stress protocol.
• Widely available and low cost.
• Combined with images, metabolic testing, bikes and pharmacologic.
• The choice of the imaging modality depends on many other factors,
  – local availability,
  – local expertise,
  – cost,
  – the patient's body habitus (eg, morbid obesity),
  – radiation exposure,
  – and the need for concomitant assessment of hemodynamics or valvular disease.
• In patients with higher pre-test likelihood of CAD and higher risk, higher sensitivity may be preferred over higher specificity, and stress radionuclide MPI with either SPECT or PET may be preferred.

• In patients with lower likelihood and lower risk, specificity may be more vital, and stress echocardiography may be preferred.
• In patients with symptoms suggesting CHD, cardiac stress testing is most often indicated to aid in making the diagnosis of CHD and for risk stratification
• In patients with known CHD and prior coronary revascularization or a change in clinical status, cardiac stress testing can be indicated for the diagnosis of new or progressive disease and/or for risk stratification.
• **Cardiac stress testing as a screening test for CHD is rarely indicated.**
Exercise Physiology

• With exercise:
  – Increase in HR
  – Stroke volume
  – CO
  – Vagal withdrawal
  – Sympathetic stimulation.

• Early exercise: CO increases by increasing SV
• Late exercise: CO increases by increasing HR
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 or deconditioned subjects)
Treadmill Protocols

• MET: resting volume of O2/minute for 70 Kg, 40 year old man.
• 1 MET = 3.5 ml/min/kg of body weight.
• Bruce protocol: starts at 5 METs (1.7 MPH and 10%) with 2 METs increments/3 minute stage.
Treadmill Protocols

• Modified Bruce: Starts at 0% grade (3 minutes) and 5% (3 minutes)
• Other protocols: Naughton, Weber, ACIP study
• Bike protocols: less ECG artifacts
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 syn or hemodynamic compromise.
  – Symptomatic severe AS.
  – Uncontrolled CHF.
  – Acute pulmonary embolus.
  – Acute myocarditis or pericarditis.
  – Acute aortic dissection
Relative Contraindications

- LM CAD
- Moderate stenotic valvular disease.
- Electrolyte abnormalities
- SBP>220, DBP>110.
Relative Contraindications

• Tachy or brady arrhythmia
• HOCM or other forms of LVOT obstructions
• Mental instability
• High degree AV Block
Treadmill Protocols: Indications to stop ETT

- Drop in SBP > 10 mmHg.
- Moderate/severe angina.
- Nervous system symptoms (syncope, dizziness)
- Cyanosis.
- Sustained VT
- ST elevation in leads without diagnostic Q waves (other than AVR or V1)
Treadmill Protocols: Relative Indications to stop ETT

- ST depression > 2 mm or marked axis shift.
- Multifocal PVCs, SVT, Heart block
- Fatigue, dyspnea, wheezing, leg cramps, or claudication.
- Development of IVCD that is difficult to distinguish from VT.
- Increasing chest pain.
- Hypertensive response (SBP >250 mmHg)
Treadmill Protocols: Interpretation

• Clinical, hemodynamic, and ECG response.
• Positive ETT: ST segment depression of >1 mm.
• Non-coronary causes of ST depression:
Non-coronary causes of ST depression:

- Severe hypertension.
- Severe Aortic stenosis.
- Cardiomyopathy.
- Anemia.
- Hypokalemia.
- Severe hypoxia.
- Digitalis.
- WPW.
- Volume overload.
- SVT.
Treadmill Test: When? Diagnosis or prognosis?

• Bayesian analysis
  – History, age, gender, rest ECG and symptoms
  – Diagnostic value of ETT is best when probability of CAD is (30-70%)

• Even when CAD diagnosis is certain:
  – ETT may be justifiable to determine prognosis.
  – ETT can guide management.
  – ETT can guide need for revascularization.
• Prognostic information that can be obtained during exercise stress testing
  – exercise duration,
  – chronotropic incompetence,
  – heart rate recovery,
  – exercise-induced hypotension,
  – ventricular ectopy as well as ST segment responses to exercise
Treadmill Test:
Diagnosis expressed as sensitivity and specificity

• Derived from comparison to angiography (>50% or 70% luminal diameter occlusion).

• Sensitivity (61%-73%)

• Specificity (59-81%)

• True value of ETT is specificity.
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

![Graph showing sensitivity comparison between Stress ECG, Stress ECHO, and Nuclear for 1, 2, 3 vessel, and All CAD cases.](image-url)
ETT: How does it compare to other tests?
Specificity

- Stress Nuclear
- Stress ECG
- Stress ECHO
ETT: Duke treadmill Score

• Combination of
  – prognostic markers
  – Ischemia

• Validated in men and women.

• Not validated in the elderly.
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)
ETT: Duke treadmill Score

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

Four Year Event Rate
• 43 year old male patient with past history of smoking, and hypertension. He is here for a check up at his wife's’ request. BMI of 32. He has a normal baseline ECG. He reports feeling well and doing all the things he wants to do without any difficulty. His wife insists that he gets a stress test. His PMD ordered a stress echo.

• He achieved 5.5 METs, NO ECG changes and his stress echo was normal.

• His wife (administrator in HVI) asks you if the test is normal.
• A. In the absence of ECG changes, symptoms and wall motion abnormalities, the test is normal and he has good prognosis.
• B. His pretest likelihood of disease is low and therefore the test would not have changed his post test stratification.
• C. Clearly a pharmacologic stress test is needed given the poor exercise capacity.
• He is doomed!!!!!
**METs**

- **10 to 15% increase in survival per MET**
- **METs can be increased by 25% by a training program**
- A score of 7 METS should serve as a useful ballpark figure to stratify patients into a low risk category.

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)
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.
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 carries 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.
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  – A. We can proceed with the test for the above indication.
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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 shown 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

- Exercise induced ST depression has lower sensitivity.
  - Lower pretest likelihood for disease.
  - Inability of many women to reach maximal exercise capacity.
- 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:
Women
  – A. Pharmacologic SPECT imaging.
  – **B. ETT test.**
  – C. ETT/SPECT imaging test.
  – D. ETT/echocardiogram.
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
  – A. Higher sensitivity.
  – 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: Elderly

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

• 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:
Valvular Heart Disease

– 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:
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

• 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)
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
Case

- 54 year old female patient with history of CAD.
- CABG 10 years earlier with LIMA-LAD, SVG-RCA. Cx was normal.
- Now with recurrent chest pain.
- Had a SPECT at another facility.
- SPECT: RCA territory infarct, no ischemia.
- She continued to have angina despite maximal medical therapy.
Case
Case
Case
Case

• She underwent a PCI to SVG-RCA with 2 drug eluting stents and she has been asymptomatic.
• 66 year old male patient who is admitted with refractory heart failure.
• Symptom onset was 9 months earlier.
• Creatinine of 2.4.
• LV dysfunction by echo with EF of 24 % and stage 3 diastolic dysfunction.
• A cardiac cath was considered but given renal function.
Ammonia Reg/FDG test was performed.
• You would recommend
  – A. Medical management with referral for to advanced heart failure therapies.
  – B. Consideration for revascularization given large amount of myocardium at risk.
  – C. Referral for STEM cell therapy.
  – D. ICD prophylaxis.
Severe LM stenosis on angiogram.

• B.
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 apt to be 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.

• Combining Imaging with stress test is a choice not a destiny.
• The following types of patients to be appropriate candidates for stress testing:
  – Patients with symptoms suggesting angina – Patients who have symptoms suggestive of angina and who have an intermediate or high pre-test likelihood of CHD are generally appropriate for stress testing.
  – One exception to this is patients with ongoing or unstable symptoms, in which case stress testing should not be performed prior to relief of symptoms.
  – Patients with acute chest pain – Patients presenting with acute chest pain or suspected acute coronary syndrome (ACS) may also undergo stress testing for the diagnosis of possible CHD. Stress testing in such patients should only be performed following the relief of symptoms and following the evaluation for ACS or infarction.
  – Patients with a recent ACS – In patients with a prior ACS who were treated conservatively without coronary angiography, stress testing may be used for risk assessment within three months post-ACS, assuming that the patient has stable or no further symptoms
• No conflicts