How to perform a useful stress ECG in your practice: Indications, contra-indications and correct interpretation

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Introduction

Stress ECG one of most commonly performed Cardiac tests
It has low cost
Safe
Absolute Contra indications

- Acute Myocardial infarction (< 2 days)
- High risk unstable angina
- Decompensated CCF
- Uncontrolled arrhythmia with hemodynamic compromise
- Advanced AV block
- Acute Myocarditis/Pericarditis
- Severe symptomatic Aorta stenosis
- Severe HOCM
- Uncontrolled HPT
- PE/ Aortic dissection
Relative Contra Indications

Left main stenosis
Moderate stenotic valve lesions
Electrolyte abnormalities
Tachy or brady arrhythmia
Hypertension
Outflow tract obstruction
High degree AV block
Ventricular aneurysm
Uncontrolled endocrine disorder
Neuro, Musculo skeletal or rheumatoid disorder exacerbated by exercise

Gibbons et al. 2002
ACC/AHA Practice Guidelines
Indications

- Coronary artery disease
- Valvular disease
- Evaluation of Cardiac transplant patients
- Dysrhythmias
Exercise stress testing in Coronary artery disease

Diagnosis
Mean Sensitivity of 68%
Mean Specificity of 77%

Bayes theorem
The probability of a patient having the disease after a test is performed will be the product of the disease probability before the test and the probability that the test provided a true result.

Diagnostic testing
Most value in intermediate pretest probability group as it has the largest potential effect on diagnosis.

Gibbons et al. 2002
ACC/AHA Practice Guidelines
Exercise stress testing in Coronary artery disease(2)

Prognosis
  - Left ventricular function
  - Severity of Coronary artery disease
  - Coronary plaque events
  - Electrical stability
  - General Health

Exercise testing divide into 3 groups
  - Low Risk  Annual mortality 0.5%
  - Intermediate Risk  Annual Mortality 0.5-5%
  - High risk  Annual Mortality >5%

Duke Treadmill score
  - Exercise time – {5XST segment depression}+(4xAngina index)}
Exercise Physiology

Increase in ventricular rate due to vagal withdrawal

Increased alveolar ventilation

Increased venous return due to sympathetic veno-constriction

Cardiac output increase 4 to 6x
  ◦ Early: Frank starling mechanism
  ◦ Late: Heart rate

Strenuous exercise
  ◦ Vasoconstriction except in muscle, cerebral and coronary beds

O2 extraction increase

Rise in Systolic Blood pressure, mean blood pressures and pulse pressure
Exercise Physiology (2)

Maximum heart rate
- 220 – age (males)
- 206 - 0.88(age) females

Post exercise
- Vagal reactivation

Metabolic equivalent
- 3.5ml O2/kg/min
Exercise Physiology (3)

Myocardial O2 consumption
- Heart rate
- Systolic blood pressure
- End diastolic volume
- Wall thickness
- Contractility

Rate pressure product
- Estimate perfusion requirements
- 20-35mmHg x beats/min
Exercise physiology (4)

Coronary blood flow
- Increased by decreasing coronary resistance as O2 extraction is at maximum
- In obstruction distal perfusion pressure falls
- Causes subendocardial ischemia

Ischemia causes
- Electrical gradients between epicardium and endocardium
- ST segment changes
- Mediated by $K^{\text{ATP}}$ channel
Performing a Stress ECG

No eating, drinking alcohol or caffeine or smoke 3 hours before test

Comfortable clothes

Rest ECG standard + Modification in supine and standing positions

Skin preparation
  ◦ Alcohol
  ◦ Rub with rough patch
  ◦ Silver chloride electrodes

Cables
  ◦ Light flexible and shielded
ECG

Mason–Likar modification
- Moving extremity electrodes to the torso
- Arms: most lateral aspect of infraclavicular fossae
- Leg stable position above iliac crests and below ribs
- Effects of lead changes
  - Right axis shift
  - Increased voltage in inferior leads
  - Loss of inferior Q waves
  - New Q waves in AVL
Exercise protocols

- Low intensity warm up
- Continuous progressive exercise phase
- Warm down period
Exercise Protocols (2)

Static exercise
- Isometric
- Low change in Cardiac output
- Increased peripheral resistance decrease blood flow

Dynamic exercise protocols
- Arm ergometry
- Bicycle 25w/minute increase
- Treadmill
  - Bruce protocol
  - Large increase in VO2 between stages
  - Naughton and webber 1MET increase between stages
  - Handrails should not be grabbed
Terminating exercise testing

Absolute indications

Drop in Systolic BP > 10mmHG with signs of ischemia
Moderate to severe Angina
Increasing nervous system symptoms
Signs of poor perfusion
Technical difficulty
Subjects desire to stop
Sustained Ventricular Tachycardia
ST elevation

Gibbons et al. 2002
ACC/AHA Practice Guidelines
Terminating exercise test

Relative indications

Drop in BP without ischemia
ST segment depression of >2mm
Arrhythmias other than sustained VT
Symptoms
Development of BBB or IVCD not able to distinguish from VT
Worsening chest pain
Hypertensive response (Systolic BP> 250, Diastolic BP>115)

Gibbons et al. 2002
ACC/AHA Practice Guidelines
Interpretation

Reason test was stopped

Heamodynamic data
- Heart rate
- Blood pressure
- Total exercise duration
- Peak METS
- Exercise Duration

Ischeamic evidence
- Time to symptoms
- ST segment changes
- Number of leads involved
ST segment Displacement

Measurement of ST segments
- PQ point=isoelectric point
- J point depression of > 0,1mV abnormal
- ST80 more than 1mm depressed if Heart Rate more than 130 ST60
- Horizontal or down sloping ST segments thus 0,7-1mV/sec
- 3 consecutive beats non computer rhythm,
- ST segment is depressed at rest additional 1mm ST depression
  - If more than 1mm depressed at rest less specific ? Imaging
ST segment depression

Types
- J Point depression
- Horizontal or downsloping ST segments
- May persist during rest
- 10% of patients only have ischeamic changes during recovery phase

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Upsloping ST segment displacement

J point depression maybe normal

But
- ST 80 < 1.5mV depressed
- Slope should be more than 1mV/sec

Slow upsloping
- Indicative of fixed obstruction
Causes of false positive ST depression

Aneamia
Digitalis
Cardiomyopathy
Glucose load
Hypokaleamia
Hyperventilation
LVH
Sudden excessive exercise

Inter Ventricular Conduction Defects
Mitral valve prolapse
Pre excitation
Aortic stenosis
Severe hypertension
Severe Volume overload
SVT
ST segment elevation

J Point elevation of more than 1mV in 3 consecutive beats

Infarct territory with Q waves
- Frequent in Anterior infarctions
- In Q wave leads not indicative of worsening ischemia

Non infarcted territory with nonQ waves
- Indicator of transmural ischemia
- Vasospasm or critical narrowing
T wave changes

Non specific

May indicate ischaemia if pseudo normalization occurs

Needs validation by more specific methods
Computerized Assessment

Medians obtained

Calculate
- J point
- ST segment slope
- ST60-80

Medians may be inaccurate due to signal distortion

ST/Heart rate slope assessment
- Improves sensitivity
- Exceeding 2.4mV/beats/minute
- >6mV/beats/minute
Other important observations

Blood pressure
- Fall in BP
- Exaggerated response

Maximal work capacity
- Risk of death decreased by 13% for each MET increase in work capacity
- Need to perform at least to 85-95% to test cardiac reserve

Heart rate response
- Failure to increase appropriately associated with a poorer prognosis
- Inability to increase HR to 85%
- Heart rate reserve \(\frac{HR_{peak} - HR_{rest}}{220 - age - HR_{rest}}\)

Heart rate recovery
- Slow deceleration of heart rate
- \(HRR = HR_{peak} - HR_{1\text{minute}}\)
- \(< 18\text{beats/min}\)

Rate pressure product
- Normal 20-35mmHg/beats/minute

Chest discomfort
Parameters associated with a poor prognosis

- Duration of symptom limiting exercise less than 5 Mets
- Failure to increase Systolic BP to 120 or sustained decrease of BP >10mmHg of baseline rest levels
- ST segment depression of more than 2mm, downsloping segments, starting at less than 5 METS, involving >5 leads, lasting 5 min into rest
- Exercise induced ST elevation
- Angina Pectoris at low workload
- Reproducible sustained VT
- Duke Treadmill score
  - -11
Asymptomatic patients

If abnormal stress test 9x greater risk over next 5 years
Selection should be based on risk profiles
Serial change from normal to abnormal have the same importance as initial abnormal test
20-30% of asymptomatic women will have an abnormal test
Dysrhythmia in stress ECG

Ventricular ectopy 0-5%, not associated with poor outcome in asymptomatic patients

Prognostic value in known IHD low

Ventricular ectopy in rest have a higher associated mortality

Exercise testing provokes VT in most patients with history of VT

RBBB ectopy has worse prognosis than LBBB

SVT not dx for IHD and has no prognostic implications

AV block: Helps determining the need for a pacemaker

Development of LBBB increase risk of death 3x

RBBB commonly has ST depression in V1-V4

WPW invalidates the use of ST segment analysis
Safety of exercise testing

Mortality is less than 0.01%
Morbidity is less than 0.05%
In population with VT risk 2.2% for sustained symptomatic VT
Resuscitation equipment and defibrillator should be available
Conclusion

Stress ECG is economic and safe to perform

Diagnostic value

Prognostic value

May be used in other settings than ischeamic heart disease
Specific clinical applications

Influence of drugs

Women
- Decreased diagnostic accuracy
- Higher sympathetic discharge during exercise
- Integrate all data
  - Exercise capacity
  - HR and BP changes
  - Consider imaging
- Hypertension
  - Peak systolic Bp > 214mmHg
  - Increased Sys/Diast BP at 3 minute of rest
  - High likelihood of developing HPT