Astellas Pharma US, Inc.
The patient’s perspective

"Do you mean just everyday living isn’t enough of a stress test?"
Choosing the Stress Protocol

- The best test is an *EXERCISE* test!
- Provides independent prognostic value
- Provides assessment of symptoms, exercise capacity
- Combining exercise data with perfusion data results in the best risk stratification
An Exercise Test is a Cardiac Consult

- Use all the available data and not just the ST segment
- Total exercise time or performance
- Heart rate response to exercise, at ischemia, and in recovery
- Blood pressure response
- Myocardial oxygen demand
- Symptoms
How Do You Measure the Power of an Engine?

- Horsepower or the amount of work done
- Fuel consumption such as liters of gas consumed
Fuel Consumption is Oxygen

External Workrate = Total Body Consumption \((\text{VO}_2)\)

Internal Workrate = Myocardial Consumption \((\text{MVO}_2)\)
Total Body Oxygen Consumption (VO₂)

- Fuel Consumption, a measure of engine power
- \( \text{VO}_2 = \text{Cardiac Output} \times \text{A-V O}_2 \text{ Differential} \)
- Cardiac Output = Heart Rate \times \text{Stoke Volume}
- Max A-V O₂ Diff is fixed 15-17 vol%
- So, excellent exercise tolerance means a good stroke volume
Myocardial Oxygen Consumption (MVO$_2$)

- Heart rate
- Systolic blood pressure
- Or the rate pressure product
- Like energy consumption with weight lifting
  - The weight x repetitions
Why Does SBP Go Up?

- Pressure equals flow x resistance
- Cardiac output is increasing
- Peripheral resistance is decreasing
- Cardiac output prevails
- Fall in blood pressure during exercise means a leveling or fall in cardiac output
Exercise ECG Predictors of Death

- Exercise capacity (metabolic)
- Heart rate response:
  - Chronotropic incompetence
  - Heart rate recovery
- Duke Treadmill Score
- Ventricular ectopy in recovery

*Lauer MS. Cardiol Clin 2001;19:401-14*
Maximal Estimated Heart Rates

- Usually estimated at 220 - age
- But the 95% confidence limit is 45 beats per minute
- *Do Symptom Limited Exercise Tests!*
Peak HR Response

- Predicts mortality
- Low HRs are associated with large cardiac dimensions
Blood Pressure & Prognosis

- A decrease is bad!
- An increase is good!
- Death rates decrease with higher exercise SBP:
  - $>200 = 6.6$ deaths/1000 men
  - $140-199 = 25.3$ deaths/1000 men
  - $<140 = 97.9$ deaths/1000 men
How Does Exercise Testing Work?

- The heart extracts approximately 70% of the oxygen in the blood at rest.
- The delivery of oxygen cannot be significantly increased by increasing the extraction.
- Coronary blood flow must increase in order to increase the myocardial supply.
In healthy people, coronary blood flow increases proportionally to the increased demand for oxygen by the myocardium. Myocardial ischemia is caused when coronary blood flow is unable to meet the demand for oxygen.
Manifestation of Myocardial Ischemia

- Anginal pain
- S-T segment/T-wave changes
- Ventricular dysfunction
- Arrhythmias
- Any combination of the above
Indications for Stress Testing

- Evaluate patients with chest pain or other findings suggestive of CAD
- Determine prognosis and severity of disease
- Evaluate effects of medical and surgical therapy
- Screen for latent CAD (only approx. 30% of pts. with ischemia have chest pain)
- Evaluation of arrhythmias, functional capacity or congenital heart disease
Exercise Stress Contraindication RELATIVE

- Clinically significant non-cardiac disorders
- Significant physical handicaps
- Debilitated or elderly patients
- Mentally unstable or uncooperative patients
- Severe anemia or high fever
RELATIVE Contraindications

- Moderate to severe hypertension
- Pulmonary hypertension
- Moderate aortic stenosis
- Other serious heart diseases
- Tachy-arrhythmias
- Brady-arrhythmias
ABSOLUTE Contraindications

- Acute myocardial infarction (within 2 days)
- Unstable or crescendo angina
- Significant left main coronary stenosis
- Serious cardiac arrhythmias
- Acute myocarditis/pericarditis
- Severe aortic stenosis
ABSOLUTE Contraindications

- Acute or severe congestive heart failure
- Cardiogenic shock
- Acute pulmonary embolism/infarction
- Any acute or serious noncardiac disorder
- Severe physical handicaps
Stress Test Protocols

- Bruce
- Modified Bruce
- Naughton
- Chung
- Manual
<table>
<thead>
<tr>
<th>Stage</th>
<th>Speed (MPH)</th>
<th>Grade (%)</th>
<th>Time (min)</th>
<th>Cum. Time</th>
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<td>7</td>
<td>6.0</td>
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* Inject tracer 1 min. prior to termination
# Modified Bruce Protocol

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<tr>
<th>Stage</th>
<th>Speed</th>
<th>Grade</th>
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<tr>
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<tr>
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<td>5</td>
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<tr>
<td>1</td>
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<td>10</td>
</tr>
<tr>
<td>2</td>
<td>2.5</td>
<td>12</td>
</tr>
</tbody>
</table>

*continue with Bruce stages (if appropriate)*

*Inject tracer 1 min. prior to termination*
1 MET = ~3.5ml Oxygen/Kg body weight/min²
Healthy, sedentary people seldom exercise beyond 10 to 11 METs
In most patients with CAD workloads of 8 METs are sufficient for angina evaluation
When to Terminate an Exercise Test

- UPON PATIENT REQUEST!!!!!!
- Malfunctioning equipment
- Uninterpretable ECG tracing
- Leads not being detected
When to Terminate an Exercise Test

- Atrial tachycardia, atrial fibrillation, atrial flutter
- Onset of 2nd or 3rd degree heart block
- Progressive anginal pain
- Severe ST depression (>3 mm)
- ST elevation of >2 mm in precordial or inferior leads that do not have a resting Q wave
- PVCs develop in pairs or with increasing frequency as exercise increases, or when ventricular tachycardia develops (runs of 3 or more PVCs)
When to Terminate an Exercise Test

- HR or SBP drops progressively
- Dyspnea, fatigue, faintness
- Severe musculoskeletal pain
- Extreme elevations in SBP and DBP associated with headache or blurred vision
- Achieval of 85% MPHR (may continue if no symptoms)
Functional Classes

- **Class I** - patient able to exercise beyond 7 or 8 METs
- **Class II** - patient becomes symptom-limited at 5 or 6 METs
- **Class III** - patient usually becomes symptom-limited at 3 to 4 METs
ACC/AHA 2002 Guideline Update for Exercise Testing
A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing)

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Sidney C. Smith, Jr., MD, FACC, FAHA
Impact of Exercise Intensity Upon Stress Results

Incremental vs. Sub-maximal Exercise

# Pharmacologic Stress Testing

## Contraindications to Exercise Stress

<table>
<thead>
<tr>
<th>Inability to exercise</th>
<th>Limited capacity</th>
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<tbody>
<tr>
<td>CNS</td>
<td>PVD</td>
</tr>
<tr>
<td>Orthopedic</td>
<td>COPD</td>
</tr>
<tr>
<td>Aortic stenosis (±)</td>
<td>Meds (eg, beta blockers)</td>
</tr>
<tr>
<td>AAA (±)</td>
<td>Poor motivation</td>
</tr>
<tr>
<td>LBBB (?)</td>
<td>Previous submaximal test</td>
</tr>
<tr>
<td>Paced rhythm</td>
<td>Heart failure</td>
</tr>
<tr>
<td>Post MI (&lt; 5 days)</td>
<td>Stroke</td>
</tr>
<tr>
<td>Extremity amputation</td>
<td></td>
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</tbody>
</table>
Good Things Will Happen if You Have the Right Attitude

Stress testing may not be a technologist responsibility but understanding it will only lead to better patient care!

Waterston: Calvin and Hobbs, mycomics.com