The Family Physicians’ Guide to
CARDIAC STRESS TESTING

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I have no conflicts of interest in relation to this program/presentation
Objectives

Review the various types of noninvasive stress testing modalities

Review stress testing terminology and concepts

Understand basic indications and contraindications to stress testing

Articulate the risks and benefits of various stress testing modalities

Understand the differences between stress test modalities and which test to order
The basic principle of stress testing is to provoke ischemia

Stress testing is designed to detect obstructive coronary artery disease in patients with chest pain syndromes (or symptom equivalents)

- Stress testing will not detect nonobstructive CAD

Other uses:
- Assessment of response to medical therapy
- Evaluation of exercise-related symptoms
- Assessment of chronotropic competence and arrhythmias
3 Basic Questions

1. What is the pretest probability of CAD?
   a. Age
   b. Sex
   c. Characterization of chest pain

2. Are there conditions precluding a diagnostic exercise ECG stress test?

3. Can the patient exercise?
Chest pain is the chief complaint in 1% of outpatient visits\(^1\)

Chest pain is a diagnostic challenge given the wide array of possible etiologies

Distinguishing between serious and benign causes of chest pain is imperative

How to perform an appropriate chest pain evaluation:

- Utilize a stepwise approach

1. Step 1: Assess the Clinical Classification of Chest Pain
2. Step 2: Determine Pretest Probability of CAD
3. Step 3: Determine the Most Appropriate Stress Test Modality
Chest Pain Classification – Is it “typical”?

What is angina?

- Substernal chest discomfort
- Provoked by exertional or emotional stress
- Relieved by rest or nitroglycerin

3/3 = TYPICAL ANGINA

2/3 = ATYPICAL CHEST PAIN

1/3 = NONCARDIAC CHEST PAIN
## INTRODUCTION

Determine Pre-Test Probability of CAD

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Typical</th>
<th>Atypical</th>
<th>Noncardiac</th>
<th>Asymptomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-39</td>
<td>Men</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Very low</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>40-49</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>50-59</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>60-69</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Very low < 5% | Low 5-10% | Intermediate 10-90% | High > 90%**
Determine Pre-Test Probability of CAD

Diagnostic power of stress testing is maximal when pre-test probability is intermediate.
Factors that influence choice of stress test modality:

- Patient’s ability to exercise
- Resting ECG
- Clinical indication to perform the test
- Body habitus
- History of prior revascularization
Methods of Stress

**Exercise**
- Treadmill
- Bicycle

**Vasodilator Pharmacologic Stress Agent**
- Regadenoson
- Adenosine
- Dipyridamole

**Chronotropic Pharmacologic Stress Agent**
- Dobutamine
INTRODUCTION

Methods to Detect Ischemia

Electrocardiography

Echocardiography

Myocardial Perfusion SPECT Imaging

Myocardial Perfusion PET Imaging

Magnetic Resonance Perfusion Imaging
INTRODUCTION

Ischemic Findings on Stress Testing

Signs and symptoms

• Reproduction of chest symptoms
• Hypotensive response to stress

ST elevation or depression on ECG

Regional wall motion abnormality on echocardiography

Perfusion defect on myocardial perfusion imaging
While rare, stress testing can be associated with serious complications

- Musculoskeletal injury
- Hypertension
- Arrhythmia (atrial fibrillation, SVT, VT, VF)
- Myocardial infarction
- Stroke
- Death

The frequency of serious adverse cardiac events (ie myocardial infarct, sustained ventricular arrhythmia or death) is approximately 1 in 2500.¹

Absolute Contraindications

- Acute myocardial infarction (within 2 days)
- Ongoing unstable angina
- High risk (based on pretest probability) of unstable angina
- Uncontrolled cardiac arrhythmias
- Decompensated heart failure
- Symptomatic severe aortic stenosis
- Acute pulmonary embolus
- Acute myocarditis or pericarditis
- Acute aortic dissection
INTRODUCTION

Relative Contraindications

Known obstructive left main coronary artery stenosis
Moderate to severe aortic stenosis with uncertain relationship to symptoms
Tachyarrythmia with uncontrolled ventricular rates
Acquired high degree or complete heart block
Hypertrophy cardiomyopathy with severe resting gradient
Recent CVA or TIA
Cognitive impairment with limited ability to cooperate
Resting BP >200/110
The Family Physicians’ Guide to Stress Testing

Methods of Stress
Exercise is the preferred method of stress

Provides physiologic data including heart rate response, blood pressure response and heart rate recovery

Allows for evaluation of exercise-induced arrhythmias

Contraindications:

- Significant orthopedic issues
- Unsteady gait
- Those unlikely to achieve 85% maximum predicted heart rate
Vasodilators

Vasodilate coronary arteries creating a steal phenomenon in stenosed vessels

Contraindications:
- Severe reactive airway disease
- Serious bradyarrhythmia/AV conduction defects

Caffeine interferes with effects – no caffeine for 24 hours prior
Dobutamine

Stimulates cardiac $\beta_1$-adrenoceptors to result in increased chronotropy and inotropy

Must hold $\beta$-blockers prior

Most serious contraindication is the presence of ventricular arrhythmia
The Family Physicians’ Guide to Stress Testing

Methods to Detect Ischemia: Electrocardiography
Overview

Widely available and can be performed with limited expense

Provide important physiologic data

Exercise ECG testing alone is not useful for localizing the distribution or extent of myocardial ischemia

Higher false-positive rate in women
**Contraindications**

- LBBB
- LVH with repolarization changes
- Digoxin therapy
- Ventricular paced rhythm
- Wolff-Parkinson White/pre-excitation syndromes
- >1mm ST depression on baseline electrocardiogram
- History of prior revascularization
Exercise Stress Test Measurements

Heart rate response and recovery

Blood pressure

Symptoms

Exercise capacity
  - Measured as METs – metabolic equivalent of task
Age-Predicted Maximal Heart Rate

Maximal Heart Rate (MHR) = 220 - age (in years)

Adequate test 85-100% MHR

Submaximal test <85% MHR
  - Nondiagnostic for obstructive CAD
Metabolic Equivalent of Task (METs)

Measure of functional capacity

Poor exercise capacity (<5 METS) identifies a high-risk population

Achieving 10 METs predicts good prognosis

Examples:

- 1 MET = watching television
- 2.3 METs = slow stroll on flat ground
- 4 METs = light housework, climb a flight of stairs, walking 4mph on flat ground
- 7 METS = jogging
- 10 METS = competitive soccer
Positive exercise stress test is defined as:

- ≥1.0 mm horizontal or downsloping ST depression 60-80 ms after the J point
ELECTROCARDIOGRAPHY

Duke Treadmill Score (DTS)

DTS = exercise time – (5 x max ST deviation in mm) – (4 x treadmill angina index)

Helps clinicians decide whether to refer patients for further evaluation or intervention

Strongest predictive value is in patients classified as high or low risk

- Low risk patients have excellent prognosis - further evaluation is generally unnecessary
- Moderate risk patients should be referred for stress testing enhanced with imaging
- High risk patients have poor prognosis and should be referred for coronary angiography

### Duke Treadmill Score: Prediction Of Coronary Heart Disease In A Patient With Chest Pain Undergoing A Treadmill Stress Test

<table>
<thead>
<tr>
<th>Exercise Test variables</th>
<th>Exercise Test values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise Time - in Minutes - Standard Bruce Protocol</td>
<td>8 min</td>
</tr>
<tr>
<td>Maximum ST deviation - in mm - At 80 msec after the J-Point</td>
<td>1 mm (always a positive figure, no matter if positive or negative deviation)</td>
</tr>
<tr>
<td>Angina Score During Exercise</td>
<td>Non-Limiting</td>
</tr>
<tr>
<td>Duke Treadmill Score</td>
<td>-1</td>
</tr>
</tbody>
</table>

- Probability of Significant CHD: 41% (probability of >75% stenosis in at least 1 coronary artery)
- Probability of Severe CHD: 31% (probability of 3 vessel CHD or >75% LMS)
- 5-Year Mortality: 22%

Overall risk subcategory: Moderate Risk

- Angiography may be indicated

<table>
<thead>
<tr>
<th>DTS value</th>
<th>Risk Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥+5</td>
<td>Low risk</td>
</tr>
<tr>
<td>+4 to -10</td>
<td>Moderate risk</td>
</tr>
<tr>
<td>≤-11</td>
<td>High risk</td>
</tr>
</tbody>
</table>
Methods to Detect Ischemia: Echocardiography
Overview

Widely available and can be performed at an intermediate cost

Provides pertinent information on the distribution and extent of coronary artery disease

Interpretation is subject to interobserver variability
Basics of Stress Echocardiography

Pre-exercise and post-exercise focused evaluation of left ventricular wall motion

Obstructive CAD results in regional wall motion abnormalities

Treadmill/exercise requires rapid transfer of patient from treadmill to exam table

Limited examination – it does not include information about right-sided chambers or valves

Limitations:

- Body habits
- Lung disease
- Breast implants
Dobutamine Stress Protocol
Methods to Detect Ischemia: Myocardial Perfusion SPECT Imaging
Overview

Underlying principle is that under conditions of stress, diseased myocardium receives less blood flow than normal myocardium.

Utilizes radioactive isotope that is absorbed and retained by viable cardiac tissue.

SPECT imaging performed after stress reveals the distribution of the radioisotope and therefore relative blood flow to the different regions of myocardium.

Compare stress images to rest images.
Perfusion Defects in MPI

Compare resting images to stress images

Rest and stress images look the same in a normal patient

Defects in the stress images suggest ischemia

Skip table salt

Majority of sodium comes from packaged and processed foods

When buying prepared and packaged foods, read the labels

Choose unsalted or low-sodium options

Ideal limit of 1,500 mg of sodium per day

Optimal Patient

Unable to perform treadmill stress test

Underlying LBBB

Pacemaker Dependent

Obese patients

Poor acoustic windows on echocardiography
Limitations

Expensive

Time-consuming

Artifacts due to breast tissue, diaphragm interference or extra cardiac tracer uptake

Balanced ischemia

Radiation exposure
In conclusion…

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## Comparison of Tests for Diagnosis of CAD

<table>
<thead>
<tr>
<th>Modality</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise test</td>
<td>68%</td>
<td>77%</td>
</tr>
<tr>
<td><strong>Nuclear Imaging</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Coronary artery stenosis ≥ 50%</td>
<td>87-90%</td>
<td>73-89%</td>
</tr>
<tr>
<td><strong>Stress Echo</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Coronary artery stenosis ≥ 50%</td>
<td>68-98%</td>
<td>44-100%</td>
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THANK YOU!!!

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