Non-Invasive Cardiac Stress Testing: Choosing the Most Appropriate Test to Get the Most Diagnostic Benefit for Your Patient

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CARDIOLOGY NURSE PRACTITIONER
VA LONG BEACH
Disclosures

- None

- I have no actual or potential conflict of interest in relation to this program/presentation.
Objectives

- Review the various types of noninvasive stress testing modalities
- Review essential stress testing terminology and concepts
- Articulate the risks and benefits of various stress testing modalities
- Describe the pharmacodynamics of various pharmacologic stress testing agents
- Discuss the value and limitation of stress testing results in assessment, diagnosis, clinical management and prognosis
Today’s Agenda

What we will be reviewing:

▪ Exercise Treadmill Stress Testing

▪ Exercise Nuclear Myocardial Perfusion Imaging (MPI)

▪ Pharmacologic Nuclear MPI

▪ Stress Echocardiography
Chest Pain

- Chest pain is the chief complaint in 1-2% of outpatient visits¹
- Chest pain is one of the most common reasons for seeking care in the emergency department²
  - 8 million ED visits annually in the United States²
- Acute Coronary Syndrome is missed in approximately 2% of patients, which can lead to substantial consequences²
- Distinguishing between serious and benign causes of chest pain is imperative

Purpose of Stress Testing

- Detection of coronary artery disease (CAD) in patients with chest pain syndromes or potential symptom equivalents
- Evaluation of the functional severity of CAD
- Prediction of cardiovascular events and all-cause death
- Evaluation of physical capacity and effort tolerance
- Evaluation of exercise-related symptoms
- Assessment of chronotropic competence, arrhythmias, and response to implanted device therapy
- Assessment of the response to medical interventions

Potential Complications

- Although rare, exercise testing can be associated with serious complications:
  - Chest pain
  - SOB
  - Musculoskeletal injury
  - Hypertension
  - Myocardial infarction
  - Arrhythmias (VT and VF)
  - Stroke
  - Death

- The frequency of serious adverse cardiac events (ie, myocardial infarction, sustained ventricular arrhythmia, and death) has been estimated to be about 1 in 2500.  

When performing the chest pain work up, you must have a method to your madness!

- Utilize a stepwise approach

Step 1: Assess the Clinical Classification of Chest Pain

Step 2: Determine Pretest Probability of CAD

Step 3: Determine the Most Appropriate Stress Test Modality
Step 1: Assess the Clinical Classification of Chest Pain

- **Typical Angina (definite)**
  - Substernal chest discomfort
  - Provoked by exertion or emotion stress
  - Relieved by rest or NTG

- **Atypical Angina (probable)**
  - Meets 2 of the above characteristics

- **Noncardiac Chest Pain**
  - Meets 1 or none of the typical anginal characteristics

Step 2: Determine the Pre Test Probability of Coronary Disease

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Non-Anginal Chest Pain</th>
<th>Asymptomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-39</td>
<td>Males</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>low (&lt;10%)</td>
<td>Very low (&lt;5%)</td>
</tr>
<tr>
<td>30-39</td>
<td>Females</td>
<td>Intermediate</td>
<td>Very Low (&lt;5%)</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>40-49</td>
<td>Males</td>
<td>High (&gt;90%)</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>40-49</td>
<td>Females</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>50-59</td>
<td>Males</td>
<td>High (&gt;90%)</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>50-59</td>
<td>Females</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>60-69</td>
<td>Males</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>60-69</td>
<td>Females</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
</tbody>
</table>

High = >90%
Intermediate = 10-90%
Very Low = <5%
Low = <10%

Pretest Likelihood of CAD in Symptomatic Patients According to Age and Sex* (Combined Diamond/Forrester and CASS Data)

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Nonanginal Chest Pain</th>
<th>Atypical Angina</th>
<th>Typical Angina</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>30–39</td>
<td>4</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>40–49</td>
<td>13</td>
<td>3</td>
<td>51</td>
</tr>
<tr>
<td>50–59</td>
<td>20</td>
<td>7</td>
<td>65</td>
</tr>
<tr>
<td>60–69</td>
<td>27</td>
<td>14</td>
<td>72</td>
</tr>
</tbody>
</table>

*Each value represents the percent with significant CAD on catheterization.
Diagnostic power of stress testing is maximal when the pre-test probability is intermediate.
Choice of stress testing modality depends on many factors, including but not limited to:

- The patient's ability to exercise
- The resting ECG
- The clinical indication for performing the test
- The patient's body habitus
- History of prior revascularization
Step 3: Determine Stress Test Modality

- Exercise Treadmill Stress Test
- Nuclear Myocardial Perfusion Imaging
  - Exercise
  - Pharmacologic
    - Vasodilators
      - Adenosine
      - Regadenoson
      - Dipyridamole
    - Chronotropic
      - Dobutamine
- Stress Echocardiography
EXERCISE STRESS TESTING
Exercise Stress Testing

- Myocardial ischemia occurs when the supply of oxygenated blood to myocardial cells is inadequate to meet demands.

- Aerobic exercise, progressively increasing to maximal tolerance, can elicit cardiovascular abnormalities not present at rest, while aiding in the determination of the adequacy of cardiac function.

Exercise Stress Testing

- Well validated for prediction of cardiovascular events and all-cause death
- Provides important physiological data
- Relatively safe (rate of MI or death about 1 in 2500 \(^1\))
- Fast
- Relatively inexpensive

Absolute Contraindications to Exercise Stress Testing

- Acute MI within 2 days
- Ongoing unstable angina
- Uncontrolled cardiac arrhythmia with hemodynamic compromise
- Active endocarditis
- Symptomatic severe aortic stenosis
- Decompensated heart failure

- Acute PE, pulmonary infarction, or DVT
- Acute myocarditis or pericarditis
- Acute aortic dissection
- Physical disability that precludes safe and adequate testing

<table>
<thead>
<tr>
<th>Contraindications to Exercise Stress Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known obstructive left main coronary artery stenosis</td>
</tr>
<tr>
<td>Moderate to severe aortic stenosis with uncertain relation to symptoms</td>
</tr>
<tr>
<td>Tachyarrhythmias with uncontrolled ventricular rates</td>
</tr>
<tr>
<td>Acquired advanced or complete heart block</td>
</tr>
<tr>
<td>Hypertrophic obstructive cardiomyopathy with severe resting gradient</td>
</tr>
<tr>
<td>Recent stroke or transient ischemic attack</td>
</tr>
<tr>
<td>Mental impairment with limited ability to cooperate</td>
</tr>
<tr>
<td>Resting hypertension with systolic or diastolic blood pressures</td>
</tr>
<tr>
<td>&gt;200/110 mm Hg</td>
</tr>
<tr>
<td>Uncorrected medical conditions, such as significant anemia, important electrolyte imbalance, and hyperthyroidism</td>
</tr>
</tbody>
</table>

Baseline Abnormalities That May Obscure ECG Changes During Exercise

- LBBB (Class III)
- LVH with repolarization abnormalities
- Digitalis therapy
- Ventricular paced rhythm
- WPW (Class III)
- ST abnormality associated with SVT or Afib
- ST abnormality associated with MVP or severe anemia
Measurements During Exercise Stress Testing

- ECG
- Exercise capacity
  - METS – metabolic equivalent
- Perceived exertion: BORG scale
- Symptoms
- Blood pressure
- Heart rate response & recovery
Maximal Heart Rate

MHR = 220 – age (in years)

- Adequate test 85-100% MHR
- Submaximal test <85% MHR
  - Nondiagnostic for obstructive CAD
Metabolic Equivalents (METs)

- Physiological measure expressing the energy cost of physical activities

- 1 MET = 3.5 ml O2 per kilogram of body weight per minute

<table>
<thead>
<tr>
<th>Physical activity</th>
<th>MET</th>
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<tbody>
<tr>
<td><strong>Light intensity activities</strong></td>
<td></td>
</tr>
<tr>
<td>sleeping</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>watching television</td>
<td>0.9</td>
</tr>
<tr>
<td>walking, 1.7 mph (2.7 km/h), level ground, strolling, very slow</td>
<td>2.3</td>
</tr>
<tr>
<td><strong>Moderate intensity activities</strong></td>
<td>3 to 6</td>
</tr>
<tr>
<td>bicycling, stationary, 50 watts, very light effort</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Vigorous intensity activities</strong></td>
<td></td>
</tr>
<tr>
<td>jogging, general</td>
<td>&gt; 6</td>
</tr>
<tr>
<td>rope jumping</td>
<td>7.0</td>
</tr>
</tbody>
</table>
The Importance of Functional Capacity

- Exercise is a well validated independent prognostic factor \(^1\)
- Poor exercise capacity (< 5METS) identifies a high risk population
- Achieving ≥ 10 METS: Medical therapy as good as CABG no matter how bad the CAD \(^2\)
- 13 METS = Excellent prognosis, regardless of exercise response

Exercise capacity is a more powerful predictor of mortality among men than other established risk factors for CV disease.

Exercise Stress Test Preprocedure Preparation

- NPO 3 hours pre test ¹
- For the diagnosis of ischemia:
  - Hold AV nodal blockers (Beta blockers, CCB) x 24 hrs ¹
  - Nitrates
- Resting ECG
- Supine and Standing ECG and BP
  - Standing ECG can shift frontal plane axis to the right, increasing voltage in inferior leads ¹

¹ Fletcher G et al. Circulation 2013;128:873-934
Which Protocol to use?

The test protocol should be selected according to the purpose of testing and the individual patient

▪ **Bruce Protocol**
  ▪ Most commonly used • Intense workload over a relatively short period • Progressively increases in speed and gradient • 3 minute stages

▪ **USAFSAM**
  ▪ Low, constant speed, progressive incline of ramp angle

▪ **Naughton**
  ▪ Longer protocol, gentle workload, used for high risk patients (post Infarction, CCF)

▪ **Ellstad**
  ▪ Constant incline • Increase in speed only

▪ **RAMP Protocol**
  ▪ Computer generated, gradual smooth acceleration to a determined MET level
### Exercise protocols

<table>
<thead>
<tr>
<th>Functional Class</th>
<th>Clinical Status</th>
<th>O₂ Cost mL/kg/min</th>
<th>METs</th>
<th>Bicycle Ergometer</th>
<th>Treadmill Protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bruce</td>
</tr>
<tr>
<td>Normal and I</td>
<td>Healthy dependent on age activity</td>
<td>1 watt = 6 kpd</td>
<td>For 70 kg body weight</td>
<td>3-min stages MPH %GR</td>
<td>5.5 20</td>
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<tr>
<td></td>
<td>SEDENTARY SEDENTARY</td>
<td>56.0 16</td>
<td>KPDS</td>
<td>5.0 18</td>
<td>4.6 17</td>
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<tr>
<td></td>
<td>Sedentary Limited</td>
<td>52.5 15</td>
<td>1500</td>
<td>4.2 16</td>
<td>4.2 16</td>
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<tr>
<td></td>
<td>Symptomatic</td>
<td>49.0 14</td>
<td>1350</td>
<td>3.8 15</td>
<td>3.8 15</td>
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<tr>
<td></td>
<td></td>
<td>45.5 13</td>
<td>1200</td>
<td>3.4 14</td>
<td>3.4 14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>42.0 12</td>
<td>1050</td>
<td>3.4 14</td>
<td>3.4 14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38.5 11</td>
<td>900</td>
<td>3.0 13</td>
<td>3.0 13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35.0 10</td>
<td>750</td>
<td>2.5 12</td>
<td>2.5 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31.5 9</td>
<td>600</td>
<td>2.1 11</td>
<td>2.1 11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28.0 8</td>
<td>450</td>
<td>1.7 10</td>
<td>1.7 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24.5 7</td>
<td>300</td>
<td>1.7 5</td>
<td>1.7 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.0 6</td>
<td>150</td>
<td>1.7 0</td>
<td>1.7 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17.5 5</td>
<td>3.0  7.0</td>
<td>2 13.5</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>14.0 4</td>
<td>3.0  3.0</td>
<td>2 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.5 3</td>
<td>3.0  3.0</td>
<td>2 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.0 2</td>
<td>2.5  2.0</td>
<td>2 3.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.5 1</td>
<td>2.0  2.0</td>
<td>2 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.5 1</td>
<td>1.5  1.0</td>
<td>1 0</td>
<td></td>
</tr>
</tbody>
</table>

**Treadmill Protocols**

- **ACIP**
  - 2-min stages
  - First 2 stages 1 min

- **mACIP**
  - 2-min stages

- **Naughton**
  - 2-min stages

- **Weber**
  - 2-min stages
Normal electrocardiographic changes during exercise

- P wave increases in height
- PR shortens
- QRS duration decreases
- J point becomes depressed
- ST segment becomes sharply upsloping
- Q-T interval shortens
- T wave decreases in height
Indications for Terminating Exercise Testing: Absolute

- ST-segment elevation (>1.0 mm) in leads without preexisting Q waves because of prior MI (other than aVR, aVL, and V1)
- Drop in systolic blood pressure >10 mm Hg, despite an increase in workload, when accompanied by any other evidence of ischemia
- Moderate-to-severe angina
- Central nervous system symptoms (eg, ataxia, dizziness, near syncope)
- Signs of poor perfusion (cyanosis or pallor)
- Sustained ventricular arrhythmia, second- or third-degree AV block, that interferes with normal maintenance of cardiac output during exercise
- Technical difficulties in monitoring the ECG or systolic blood pressure
- The subject’s request to stop

Indications for Terminating Exercise Testing: Relative

- Marked ST displacement (horizontal or downsloping of >2 mm, measured 60 to 80 ms after the J point in a patient with suspected ischemia
- Drop in systolic blood pressure >10 mm Hg (persistently below baseline) despite an increase in workload, in the absence of other evidence of ischemia
- Increasing chest pain
- Fatigue, shortness of breath, wheezing, leg cramps, or claudication
- Arrhythmias other than sustained VT, including multifocal ectopy, ventricular triplets, supraventricular tachycardia, and bradyarrhythmias that have the potential to become more complex or to interfere with hemodynamic stability
- Exaggerated hypertensive response (systolic blood pressure >250 mm Hg or diastolic blood pressure >115 mm Hg)
- Development of bundle-branch block that cannot immediately be distinguished from VT

Definition of ST-segment depression changes during exercise.

Clinical Pearls for Exercise Stress Testing

- Positive exercise stress test is defined as:
  - ≥ 1.0 mm of horizontal or downsloping ST depression at 60-80ms after the J point

- Exercise ECG should be the initial test for the majority of patients who can exercise adequately, who have an interpretable ECG, and do not have any contraindications

- Lateral precordial leads (V4 through V6) are capable of detecting 90% of all ST depression observed in multiple lead systems

- ST depression during demand-induced subendocardial ischemia during exercise does not localize the area of myocardium that is involved such as it does in STEMI.

1Fletcher G et al. Circulation 2013;128:873-934
Duke Treadmill Score Calculation and Utility

Equation for calculation of the Duke Treadmill Score and division into low-, intermediate-, and high-risk groups based on likelihood of having a stenosis $\geq 75\%$, multivessel disease, and 1-year all-cause mortality.
Duke Treadmill Score (DTS)

DTS = exercise time - (5x 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 an excellent prognosis: No further evaluation is generally unnecessary
  - High risk patients have a poor prognosis and should be referred for angiography
  - Moderate risk patients should be sent for another imaging modality (MPI)

![Duke Treadmill Score: Prediction Of Coronary Heart Disease In A Patient With Chest Pain Undergoing A Treadmill Stress Test](image)


NUCLEAR MYOCARDIAL PERFUSION IMAGING

“TO NUKE OR NOT TO NUKE?”
Myocardial Perfusion Imaging: Nuclear Stress Test

- Uses a radioactive isotope that is taken up and retained in viable cardiac tissue
- Produces an objective, quantifiable 3-D map of myocardial perfusion

Photo source: Ballard-Hernandez’s personal photo collection
Myocardial Perfusion Imaging

- Radio-tracer injection
- Isotopes:
  - Thallium-201
  - Technetium 99m (sestamibi)
- Myocardial uptake
- Photon emission captured by gamma camera
- Rest & redistribution phases
- Exercise or Pharmacologic protocols available
What are we looking for with MPI?

▪ Compare resting images to stress images
▪ Resting and stress images look the same in a normal patient
▪ Defects in the stressed images suggest ischemia

### Who is a Good Candidate for Nuclear MPI

<table>
<thead>
<tr>
<th>Optimal Patient for Nuclear MPI</th>
<th>CONTRAINDICATED in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Unable to perform TMST</td>
<td>- Severe LM disease</td>
</tr>
<tr>
<td>- LBBB</td>
<td>- AVB</td>
</tr>
<tr>
<td>- Pacemaker Dependent</td>
<td>- HOCM with outlet obstruction</td>
</tr>
<tr>
<td>- Obese patients</td>
<td>- Active Wheezing</td>
</tr>
<tr>
<td>- Poor LV windows for stress echo</td>
<td>- Adenosine / dipyridamole</td>
</tr>
<tr>
<td>- Baseline ST and T wave abnormalities</td>
<td>- NOT OK with COPD/Asthma</td>
</tr>
<tr>
<td>- Afib/Aflutter</td>
<td>- Regadenoson</td>
</tr>
<tr>
<td></td>
<td>- OK with COPD / Mild Asthma</td>
</tr>
<tr>
<td></td>
<td>- Caffeine or Dipyridamole</td>
</tr>
</tbody>
</table>
Nuclear MPI: Limitations

- Time-consuming
- Artifacts (attenuation)
  - Breast, inferior wall (diaphragm), extra cardiac tracer uptake
- Balanced ischemia
- Radiation exposure
  - Carcinogenic effects of ionizing radiation
Figure 1. Top, Relationship between units of organ absorbed dose, using a log scale.

### Units of Absorbed Dose

<table>
<thead>
<tr>
<th>Units not normalized by $w_R$</th>
<th>mGy</th>
<th>0.01</th>
<th>0.1</th>
<th>1</th>
<th>10</th>
<th>100</th>
<th>1,000</th>
<th>10,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>rad = cGy</td>
<td>0.001</td>
<td>0.01</td>
<td>0.1</td>
<td>1</td>
<td>10</td>
<td>100</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Gy</td>
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<td>0.001</td>
<td>0.01</td>
<td>0.1</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

### Units of Effective Dose, Equivalent Dose, and Weighted Equivalent Dose

<table>
<thead>
<tr>
<th>Units normalized by $w_R$</th>
<th>mSv</th>
<th>0.01</th>
<th>0.1</th>
<th>1</th>
<th>10</th>
<th>100</th>
<th>1,000</th>
<th>10,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>rem = cSv</td>
<td>0.001</td>
<td>0.01</td>
<td>0.1</td>
<td>1</td>
<td>10</td>
<td>100</td>
<td>1,000</td>
<td>1,000</td>
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<tr>
<td>Sv</td>
<td>0.00001</td>
<td>0.0001</td>
<td>0.001</td>
<td>0.01</td>
<td>0.1</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

- LD50: 5 Sv
- Average dose, atomic bomb survivors (RERF): 200 mSv
- Annual limit to radiation workers (10 CFR 20.1201): 50 mSv
- Dual isotope stress test: 29 mSv
- Sestamibi stress test or CTA with tube current modulation: 11 mSv
- Average US annual background radiation: 3 mSv
- Annual limit to general public from a licensed radiation operation (10 CFR 20.1301): 1 mSv
- Chest x-ray (lateral) or Dental x-rays (4 bitewing films): 0.04 mSv
- Roundtrip flight, New York-Los Angeles: 0.03 mSv
- Chest x-ray (single view, posteroanterior): 0.02 mSv

Pharmacologic Stress Testing Agents: Selective A2a Receptor Agonists and Adenosine

<table>
<thead>
<tr>
<th>Adenosine</th>
<th>Regadenoson</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Coronary artery vasodilatation via cAmp production</td>
<td>▪ Selective A2a Receptor Agonist causing coronary vasodilatation</td>
</tr>
<tr>
<td>▪ Short half life: &lt; 10 seconds</td>
<td>▪ Longer half life: 30 minutes</td>
</tr>
<tr>
<td>▪ Contraindicated in reactive airway disease, AV blocks</td>
<td>▪ Contraindicated with active wheezing, AV blocks</td>
</tr>
<tr>
<td>▪ Reversal agent: aminophylline</td>
<td>▪ OK with COPD, mild controlled Asthma</td>
</tr>
<tr>
<td><strong>Dipyridamole</strong></td>
<td>▪ Reversal agent: aminophylline</td>
</tr>
<tr>
<td>▪ Indirect coronary artery vasodilatation via increasing intravascular adenosine levels</td>
<td></td>
</tr>
<tr>
<td>▪ Reversal agent: aminophylline</td>
<td></td>
</tr>
</tbody>
</table>
Pharmacologic Stress Testing Agents: Dobutamine

- Synthetic catecholamine acts on $\beta_1$ and $\beta_2$ receptors resulting in increased HR, BP, and CO.
- Mimics physiologic response to exercise
- Protocol for infusion rate
- Reversal agent: Esmolol

CONTRAINDICATED in:
- LM disease
- LBBB
- HOCM
- Afib/flutter
- Significant ectopy
  - Ventricular or supraventricular
STRESS ECHOCARDIOGRAPHY
Stress Echocardiography

- Stress echo allows for dynamic evaluation of cardiac structure and function at rest and during stress
- Evaluate extent of ischemia secondary to obstructive CAD
- Cardiovascular stress can be obtained by:
  - Exercise
  - Pharmacologic: Dobutamine
Exercise Stress Echo with Moderate Ischemia

Dobutamine Stress Protocol
Stress Echocardiography: Limitations

- Factors which effect image quality:
  - Body habitus
  - Lung disease
  - Breast implants

- Contraindications
  - LBBB
  - HOCM
  - WPW
## Comparison of Tests for Diagnosis of CAD (Coronary artery stenosis ≥ 50%)

<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>Nuclear Imaging</td>
<td>87-90%</td>
<td>73-89%</td>
</tr>
<tr>
<td>Stress Echo</td>
<td>68-98%</td>
<td>44-100%</td>
</tr>
</tbody>
</table>

*Coronary artery stenosis ≥ 50%

CASE STUDIES
Case Study # 1

- 64 y.o. male
- CC: substernal chest pressure with vigorous exercise at the gym. Associated nausea
- PMH:
  - HTN, HLD, R carotid stenosis 60-65%
- SH:
  - Nonsmoker
- Meds:
  - Atorvastatin 20mg, HCTZ/Lisin 12.5mg/20mg, ASA 81mg
Unconfirmed
What test is the most appropriate for the patient?

- Exercise treadmill stress test
- Exercise Nuclear MPI
- Pharmacologic Nuclear MPI
- Stress Echo
- Angiogram
Outcome Case # 1

- Patient experienced 5/10 substernal chest pressure at peak exercise
- Achieved 94% PMHR, 5:32’; 4.8 METs
- Referred for cardiac angiogram
  - Left Main 40% distal left main stenosis
  - Proximal LAD 70% Ostial
  - Proximal Circumflex 70% Ostial, Diffusely Diseased,
  - RCA (overall) Luminal irregularities
- Referred for CABG
Case study #2

- 45 y.o. female
- CC: Reports intermittent sharp substernal pains lasting < 1min. Not associated with exertion
- PMH:
  - HTN, DM, DVT 2010 after travel, Asthma
- SH:
  - Nonsmoker
- Meds:
  - Metoprolol tart. 25mg BID, HCTZ/Losartan 12.5mg/50mg
What test is the most appropriate for the patient?

- Exercise treadmill stress test
- Exercise Nuclear MPI
- Pharmacologic Nuclear MPI
- Stress Echo
- Angiogram
Outcome

- Patient achieving 87% PMHR; 7.0 METS
- No chest pain
- Duke Treadmill Score: moderate
- Referred for nuclear MPI:
  - SSS 6 SRS 0 SDS 6 (likely artifactual)
- 1. Allowing for the breast attenuation, no significant perfusion defects identified.
In Summary...

- Reviewed the various types of noninvasive stress testing modalities
- Reviewed essential stress testing terminology and concepts
- Discussed the risks and benefits of various stress testing modalities
- Described the pharmacodynamics of various pharmacologic stress testing agents
- Discussed the value and limitation of stress testing results in assessment, diagnosis, clinical management and prognosis
Thank you for your attention

Questions?