Introduction – General Overview of Exercise Testing Procedure

Coronary artery disease (CAD) is a chronic disorder with a natural history that spans multiple decades. In each affected individual, the disease can go over to a number of well-defined clinical phases: asymptomatic, stable angina, progressive angina, unstable angina, and acute myocardial infarction. Therefore, the approach to diagnosis and risk stratification of the coronary disease patient varies according to the phase of the disease in which the patient presents.

Exercise testing is a well-established procedure in the diagnosis of CAD and has been in widespread clinical use for many decades. Overall, the sensitivity and specificity of exercise testing for diagnosing CAD are about 63% and 74%, respectively. Exercise testing requires consideration of Bayesian principles, according to which the predictive accuracy of the test is defined not only by its sensitivity and specificity but also by the prevalence of disease in the population studied. Table 14-1 is a modification of the review of Diamond and Forrester, and provides a reasonable estimation of the pretest probability of CAD based on clinical grounds. The value of stress testing is greatest when the pretest likelihood is intermediate because the result of the test will probably have the greatest impact on the posttest probability of CAD, and therefore on clinical decision-making.

Exercise testing is generally a safe procedure. The risk is determined by the clinical characteristics of the patient referred for the procedure. In a nonselected patient population, the mortality is less than 0.01% whereas morbidity is less than 0.05%. Good clinical judgment is therefore required to determine which patient can safely undergo an exercise test. Absolute and relative contraindications to exercise testing are summarized in Table 14-2. Exercise testing should be performed under the supervision of an appropriately trained physician, and equipment, medications, and trained personnel to provide advanced cardiac life support must be readily available.

The electrocardiogram (ECG), heart rate, and blood pressure should be monitored carefully and recorded during each stage of exercise and during chest pain or ST-segment abnormalities. Exercise testing is commonly terminated when patients reach a defined percentage of predicted maximum heart rate. However, there are a number of other standard indications to terminate a test, listed in Table 14-3, whose application significantly reduces the risk.

Interpretation of the exercise test includes exercise capacity (duration and metabolic equivalents), and clinical, hemodynamic, and electrocardiographic response. The most commonly used definition for a positive exercise test result, from an ECG standpoint, is the greater than or equal to 1 mm of horizontal or downsloping ST-segment depression or elevation for at least 60 to 80 milliseconds after the end of the QRS complex. The occurrence of chest discomfort consistent with angina is important, particularly if it forces termination of the test. Abnormalities in exercise capacity, systolic blood pressure response to exercise, and heart rate response to exercise are also important findings.
### Table 14.1. Pretest probability of coronary artery disease by age, gender, and symptoms*

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Gender</th>
<th>Typical/Definite angina pectoris</th>
<th>Atypical/Probable angina pectoris</th>
<th>Nonanginal chest pain</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>Low</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>Low</td>
<td>Very low</td>
</tr>
</tbody>
</table>

*No data exist for patients <30 or >69 years, but it can be assumed that prevalence of CAD increases with age. In a few cases, patients with ages at the extremes of the decades listed may have probabilities slightly outside the high or low range. High indicates >90%; intermediate, 10–90%; low, <10%; and very low, <5% probability.

### Table 14.2. Contraindications to exercise testing

**Absolute**
- Acute myocardial infarction (within 2 days)
- High-risk unstable angina*
- Uncontrolled cardiac arrhythmias causing symptoms or hemodynamic compromise
- Symptomatic severe aortic stenosis
- Uncontrolled symptomatic heart failure
- Acute pulmonary embolus or pulmonary infarction
- Acute myocarditis or pericarditis
- Acute aortic dissection

**Relative†**
- Left main coronary stenosis
- Moderate stenotic valvular heart disease
- Electrolyte abnormalities
- Severe arterial hypertension‡
- Tachyarrhythmias or bradyarrhythmias
- Hypertrophic cardiomyopathy and other forms of outflow tract obstruction
- Mental or physical impairment leading to inability to exercise adequately
- High-degree atrioventricular block

*ACC/AHA Guidelines for the Management of Patients with Unstable Angina/Non-ST Segment Elevation Myocardial Infarction.
†Relative contraindications can be superseded if the benefits of exercise outweigh the risks.
‡In the absence of definitive evidence, the committee suggests systolic blood pressure of 200 mmHg and/or diastolic blood pressure of >110 mmHg.

**Source:** Modified from Fletcher et al.†

### Table 14.3. Indications for terminating exercise testing

**Absolute indications**
- Drop in systolic blood pressure of >10 mmHg from baseline blood pressure despite an increase in workload, when accompanied by other evidence of ischemia
- Moderate to severe angina
- Increasing nervous system symptoms (e.g. ataxia, dizziness, or near-syncope)
- Signs of poor perfusion (cyanosis or pallor)
- Technical difficulties in monitoring ECG or systolic blood pressure
- Subject’s desire to stop
- Sustained ventricular tachycardia
- ST elevation (≥1.0 mm) in leads without diagnostic Q waves (other than V1 or aVR)

**Relative indications**
- Drop in systolic blood pressure of (≥10 mmHg from baseline blood pressure despite an increase in workload, in the absence of other evidence of ischemia
- ST or QRS changes such as excessive ST depression (>2 mm of horizontal or downsloping ST-segment depression) or marked axis shift
- Arrhythmias other than sustained ventricular tachycardia, including multifocal PVCs, triplets of PVCs, supraventricular tachycardia, heart block, or bradyarrhythmias
- Fatigue, shortness of breath, wheezing, leg cramps, or claudication
- Development of bundle branch block or IVCD that cannot be distinguished from ventricular tachycardia
- Increasing chest pain
- Hypertensive response*

*In the absence of definitive evidence, the committee suggests systolic blood pressure of >250 mmHg and/or a diastolic blood pressure of >115 mmHg.

**Source:** Modified from Fletcher et al.†