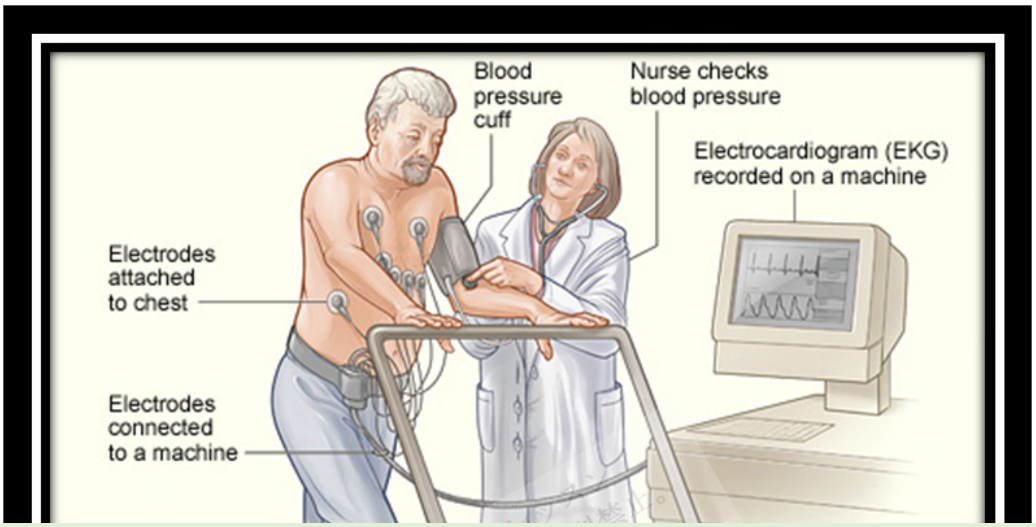
Stress Testing



In **stress testing**, the heart is monitored by ECG and often imaging studies during an induced episode of increased cardiac demand so that ischemic areas potentially at risk of infarction can be identified. Heart rate is increased to 85% of age-predicted maximum (target heart rate) or until symptoms develop, whichever occurs first.

Stress testing is used for diagnosis of coronary artery disease (CAD) and for risk **stratification** and monitoring of patients with known CAD. In patients with CAD, a blood supply that is adequate at rest may be inadequate when cardiac demands are increased by exercise or other forms of stress. Stress testing is less invasive and less expensive than cardiac catheterization, and it detects pathophysiologic abnormalities of blood flow; however, it is less accurate for diagnosis in patients with a low pretest likelihood of CAD. It can define the functional significance of abnormalities in coronary artery anatomy identified with coronary angiography during catheterization. Because coronary artery plaques that are not significantly **stenotic** (ie, do not result in ischemia

during stress testing) may nonetheless **rupture** and cause an acute coronary syndrome, a normal stress test result does not guarantee future freedom from MI.

Risks of stress testing include infarction and sudden death, which occur in about 1/5000 patients tested. Stress testing has several. Patients must be npo for 4 to 6 h before the test.

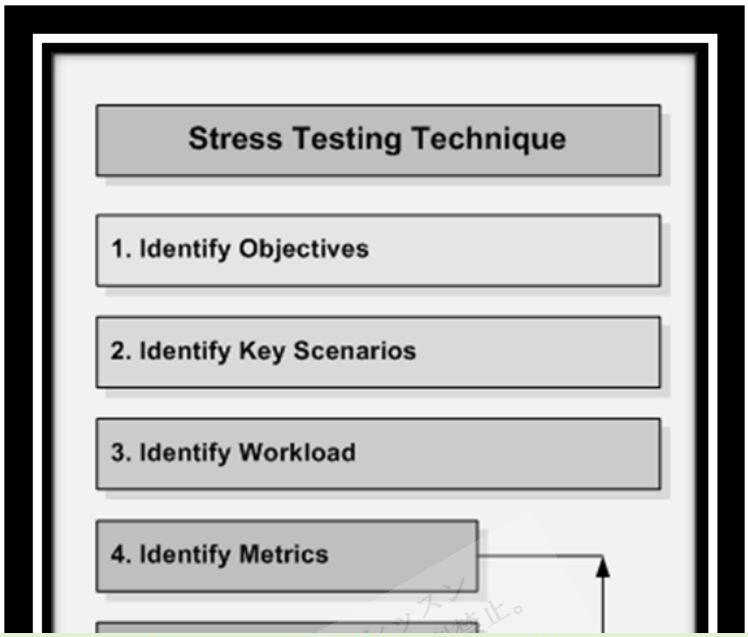
Table 7

Contraindications to Exercise Stress Testing

Contraindication	Conditions
Absolute	Acute coronary syndrome (MI within 48 h or uncontrolled unstable angina)
	Aortic dissection (acute)
	Electrolyte imbalance
	Hypertension (systolic > 200 mm Hg or diastolic > 110 mm Hg)
	Hypertrophic obstructive cardiomyopathy
	Inability to exercise adequately due to mental or physical impairment
	Stenosis of heart valve if moderate or severe
	Stenosis of left main coronary artery
	Systemic illness
	Tachyarrhythmias

Stress Methodology

Cardiac demand can be increased by exercise or drugs.



Exercise stress testing: Exercise is preferred to drugs for increasing cardiac demand because it more closely replicates ischemia-inducing stressors. Usually, a patient walks on a **conventional treadmill**, following the **Bruce protocol** or a similar exercise schedule, until the target heart rate is reached or symptoms occur. The Bruce protocol increases treadmill speed and slope **incrementally** at roughly 3-min intervals.

Pharmacologic stress testing: Pharmacologic stress testing is usually used when patients cannot walk on a treadmill long enough to reach their target heart rate because of **deconditioning**, musculoskeletal disorders, obesity, peripheral arterial disease, or other disorders. Drugs used include IV dipyridamole, adenosine, and dobutamine.

Dipyridamole augments endogenous adenosine, **causing coronary artery vasodilation**. It increases myocardial blood flow in normal coronary arteries but not in arteries distal to a stenosis, creating a “steal” phenomenon from stenosed arteries and an imbalance in perfusion. Dipyridamole-induced ischemia or other adverse effects (eg,

nausea, vomiting, headache, **bronchospasm**) occur in about 10% of patients, but these effects can be reversed by IV aminophylline. Severe reactions occur in < 1% of patients. Contraindications include asthma, acute phase MI, unstable angina pectoris, critical aortic stenosis, and systemic hypotension (systolic BP < 90 mm Hg).

Adenosine has the same effect as dipyridamole but must be given in a continuous IV infusion because it is rapidly **degraded** in the **plasma**. **Adverse effects** include transient flushing and chest pain, which can be reversed by **terminating** the **infusion**.

Regadenosine is a more selective adenosine agonist than either dipyridamole oradenosine and is non-inferior for the diagnosis of ischemia with fewer adverse effects and greater ease of administration.

Dobutamine is an inotrope, chronotrope, and vasodilator used mainly when dipyridamol and adenosine are contraindicated (eg, in patients with asthma or 2nd-degree atrioventricular block) and when echocardiography is used to image the heart. Dobutamine must be used with caution in patients who have severe hypertension or arrhythmia, left ventricular outflow tract obstruction, multiple previous MIs, or acute MI.

Xanthine compounds (eg, aminophylline, theophylline, caffeine) may produce a false-negative result during stress testing with dipyridamole, so such substances (including tea and coffee) should be avoided for 24 h before testing.

Diagnostic Methodology

Several imaging tests can detect ischemia after exercise or pharmacologic stress:

- ECG
- Radionuclide perfusion imaging
- Echocardiography

ECG is always used with stress testing to diagnose CAD and help determine prognosis. ECG is most useful in patients with intermediate likelihood of CAD based on age and sex and with a normal ECG at rest. Diagnosis involves assessment of ST-segment response (a measure of global subendocardial ischemia), BP response, and the patient's symptoms. Average sensitivity is 67%; average specificity is 72%. Sensitivity and specificity are lower in women partly because incidence of CAD is lower in young and middle-aged women. Prognosis worsens with depth of ST depression.

Radionuclide myocardial perfusion imaging is more sensitive (85 to 90%) and specific (70 to 80%) than ECG stress testing; combining findings from both tests increases sensitivity for CAD. Myocardial perfusion imaging is particularly useful for patients with baseline ECG abnormalities that may interfere with interpretation of ECG changes during a stress test (eg, patients with bundle branch block, those with fixed-rate pacemakers, those taking digitalis). It is also useful for groups with a high probability of false-positive results on exercise ECGs (eg, **premenopausal women**, patients with **mitral valve prolapse**). This imaging test can help determine the functional significance of coronary artery stenosis, identified by coronary angiography, when surgeons are choosing lesions to bypass or dilate via percutaneous transluminal coronary angioplasty.

Echocardiography is useful when information about more than just perfusion is needed; echocardiography detects wall motion abnormalities that are a sign of regional ischemia and, using Doppler techniques, helps evaluate valvular disorders that may contribute to or result from ischemia or valvular disorders unrelated to ischemia but which deserve concomitant evaluation. The **echocardiogram** is typically obtained immediately before and after an exercise treadmill test or during dobutamine infusion. Echocardiography is relatively portable, does not use **ionizing radiation**, has a rapid acquisition time, and is inexpensive, but it is difficult to carry out in **obese patients** and in patients with COPD and lung **hyperinflation**. Done by experts, stress echocardiography has a predictive value similar to that of stress myocardial radionuclide perfusion testing.

Radionuclide ventriculography is occasionally used with exercise stress testing instead of echocardiography to assess exercise ejection fraction (EF), the best **prognostic indicator** in patients with CAD. Normally, EF is ≥ 5 percentage points higher during exercise than at rest. Ventricular dysfunction (eg, due to valvular heart disorders, cardiomyopathy, or CAD) can decrease exercise EF below baseline or prevent it from increasing. In patients with CAD, the 8-yr survival rate is 80% with an exercise EF of 40 to 49%, 75% with an exercise EF of 30 to 39%, and 40% with an exercise EF of < 30%.