ECG criteria used to define a positive test. Clinical features that are most useful for predicting important angiographic coronary disease before exercise testing include advanced age, male sex, and typical (versus atypical) anginal chest pain.

The diagnostic accuracy and cost-effectiveness of exercise testing is best for patients at intermediate risk for CAD (30% to 70%) and when ischemic ECG changes are accompanied by chest pain during exercise. Exercise testing is less cost-effective in diagnosing CAD in a patient with classic symptoms of angina because a positive test result does not significantly increase the post-test probability of CAD, and a negative test result likely represents a false-negative result. Nonetheless, prognostic information and objective information about the efficacy of pharmacologic therapy may still be obtained. Similarly, exercise testing in young patients with atypical chest pain may not be diagnostically useful because an abnormal test result is likely a false-positive result and does not significantly increase the post-test probability of CAD.

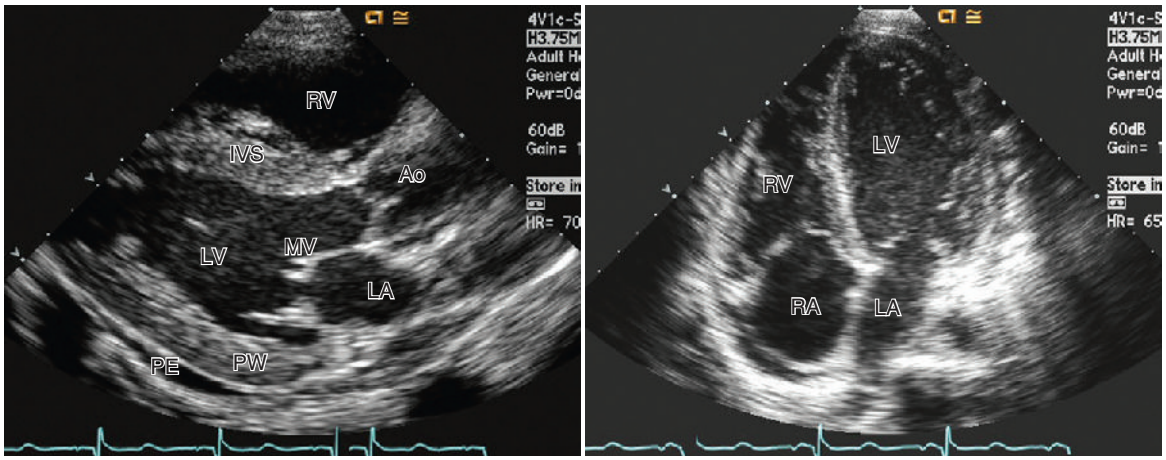
The normal physiologic response to exercise is an increase in heart rate and systolic and diastolic blood pressures. The ECG maintains normal T-wave polarity, and the ST segment remains unchanged or, if depressed, has a rapid upstroke back to baseline. An ischemic ECG response to exercise is defined as 1.5 mm of up-sloping ST-segment depression measured 0.08 second past the J point, at least 1 mm of horizontal ST depression, or 1 mm of down-sloping ST-segment depression measured at the J point. Given the large amount of artifact on the ECG that may occur with exercise, these changes must be seen in at least three consecutive depolarizations. Other findings that suggest more extensive CAD include early onset of ST depression (6 minutes); marked, down-sloping ST depression (>2 mm), especially if present in more than five leads; ST changes persisting into recovery for more than 5 minutes; and failure to increase systolic blood pressure to 120 mm Hg or more or a sustained decrease of 10 mm Hg or more below baseline.

The ECG is not diagnostically useful for left ventricular hypertrophy, LBBB, Wolff-Parkinson-White syndrome, or chronic digoxin therapy. In these instances, nuclear or echocardiographic imaging is needed to diagnose ischemia. For patients who are unable to exercise, pharmacologic stress testing with myocardial imaging has the sensitivity and specificity for detecting CAD equal to those of exercise stress imaging. Intravenous dipyridamole and adenosine and newer selective adenosine A2A receptor agonists are coronary vasodilators that increase blood flow in normal arteries without significantly changing the flow in diseased vessels. The resulting heterogeneity in blood flow can be detected by nuclear imaging techniques, and the regions of myocardium supplied by diseased vessels can be identified.

Another commonly used technique to evaluate ischemia is dobutamine-stress echocardiography. Dobutamine is an inotropic agent that increases myocardial oxygen demand by increasing heart rate and contractility. The echocardiogram is used to monitor for ischemia, which is defined as new or worsening wall motion abnormalities during the infusion. Demonstrating improvement in wall thickening with low-dose dobutamine suggests that there is myocardial viability of abnormal segments (i.e., segments that are hypokinetic or akinetic at baseline).

Echocardiography

Echocardiography is a widely used, noninvasive technique in which sound waves are used to image cardiac structures and evaluate blood flow. A piezoelectric crystal housed in a transducer placed on the patient's chest wall produces ultrasound waves. As the sound waves encounter structures with different acoustic properties, some of the ultrasound waves are reflected to the transducer and recorded. Ultrasound waves emitted from a single, stationary crystal produce an image of a thin slice of the heart (M mode), which can be followed through time. Steering the ultrasound beam across a 90-degree arc multiple times per second creates two-dimensional imaging (Fig. 4-9). Transthoracic echocardiography is safe, simple, fast, and relatively inexpensive. It is the most commonly used test to assess cardiac size, structure, and function.



A B

FIGURE 4-9 Portions of standard two-dimensional echocardiograms show the major cardiac structures in a parasternal long-axis view (**A**) and apical four-chamber view (**B**). Video 4-3 shows a moving image of a two-dimensional echocardiogram. Ao, Aorta; IVS, interventricular septum; LA, left atrium; LV, left ventricle; MV, mitral valve; PE, pericardial effusion; PW, posterior left ventricular wall; RV, right ventricle. (Image courtesy Sheldon E. Litwin, MD, Division of Cardiology, University of Utah, Salt Lake City, Utah.)