Exercise Techniques for Radionuclide Angiocardiography

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Evaluation of cardiac function during stress exercise provides important information unavailable from studies performed at rest. Adequate data are difficult to obtain during exercise because of the brief duration of the cardiac cycle, the rapid transit of tracer through the heart, and patient motion during exercise. During rest and exercise, we performed radionuclide angiocardiograms in the erect position on normal subjects and patients with coronary artery disease (CAD). The electrocardiogram (ECG) was telemetered and the blood pressure was monitored at regular intervals. A prior treadmill exercise test in all subjects with CAD had documented the heart rate-blood pressure (HR-BP) product at which ischemic myocardial changes occurred on ECG. A bicycle ergometer provided a gradually increasing work load from 200 kilopond meters/min to 700 kpm/min to achieve 80% of the maximal HR-BP product achieved during treadmill testing. Cardiac chamber wall motion and volume changes during individual cardiac contractions were assessed at heart rates greater than 200 beats/min. When properly performed, resting and exercise initial transit radionuclide angiocardiograms provide a large amount of important hemodynamic information with little patient risk or discomfort.

Since exercise commonly induces cardiac rhythm disturbances in patients with cardiac disease, attention to patient safety is of utmost importance (2). The second unique consideration imposed by exercise is that the rapid heart rate and brief duration of each cardiac contraction limit the statistical accuracy of data acquired. Therefore, a highly sensitive gamma camera is essential for performing these studies from the first transit of tracer through the heart (3). Also, body motion associated with exercise must be minimized. The stress exercise imposed should be similar to that commonly encountered in daily activity and should physiologically stress the cardiorespiratory system, rather than fatigue isolated muscle groups (4, 5). The fourth objective is efficiency, so that the study may be performed with patient comfort and convenience. Data acquisition and processing should be sufficiently simple to permit practical application of the study to routine clinical practice (6).

Methods

In preparation for the study, the technologist becomes familiar with the patient’s clinical history, particularly noting any previous episodes of significant arrhythmias or cardiopulmonary arrest. The patient is informed of the plan of study to relieve anxiety and ensure cooperation during exercise. The patient is then placed supine and ECG leads are applied to the chest in the orientation corresponding to the V-lead with the QRS complex of greatest magnitude. Telemetry of the ECG signal avoids encumbrances associated with wires attached to the patient. A blood pressure cuff is then applied for subsequent monitoring of systemic pressure; resting pulse and blood pressure are recorded.

The external jugular vein is an excellent injection site because of ease of needle insertion, patient acceptance, and the discrete tracer bolus that commonly results (Fig. 1A). A 1¼-in., 20-gauge indwelling Teflon® catheter is inserted, which allows the patient freedom of...
movement during exercise without risk of infiltration. To
insure a discrete injection, an assembled stopcock, intravenous tubing, and 20-cc syringe filled with saline are at-
tached to the catheter (Fig. 1B). At the time of injection a
15-mCi bolus of Te-99m pertechnetate is introduced
through the stopcock into the tubing and injected
through the needle by brisk emptying of the syringe. Data
are recorded over the precordium at 50-msec intervals
during the initial passage of the tracer.

The patient is placed in the erect position on a bicycle
ergometer (Fig. 2). A straight anterior view of the chest
is obtained by aligning the chest midline 2 cm to the right
of the center of the collimator. The field of view must ex-
 tend superior to the sternal notch and inferior to the
xiphoid. A transmission image of the cardiac silhouette
produced from a Co-57 flood source may be used to
document accurate patient positioning. Exercise is then
begun with a 200-kpm/min resistance on the bicycle
ergometer. A kilopond (kp) is defined as the force required
to accelerate 1 kg to 1 m/sec². This measurement obtained
in addition to the mileage traversed during the study per-
mits a measurement of work that can be related to oxygen
consumption for physiologic studies.

The resistance is increased at a rate of 100 kp/min to
a maximum work load, which does not exceed 700
kp/min. The patient is advised to request less resis-
tance as muscle fatigue is noted so that general body
fatigue occurs before fatigue of the legs. The ECG is mon-
itored continuously during exercise and recovery and
may be used to obtain pulse rates. Blood pressures are
obtained at 2-min intervals during exercise. Measure-
m ent of pulse and blood pressure documents the physio-
logic response to exercise and is important for safe per-
formance of the study.

The systemic blood pressure may increase during exer-
cise in normal subjects (Fig. 3). Patients with myocardial
ischemia may have decreased blood pressure such as oc-
curred in the patient illustrated (Fig. 3) indicating the
need to immediately inject and complete the study.

The single consideration of greatest importance in
patient safety is continuous monitoring of the ECG
(Fig. 4). The electrocardiographic change most typical of
ischemia is depression of the ST segment of the tracing.
The premature ventricular contraction (PVC) indicating
irritability of the ventricle is recognized by the broad
QRS complex commonly followed by a pause. The ap-
pearance of PVCs during exercise becomes particularly
ominous when it occurs during consecutive cardiac con-
tructions. When more than five PVCs occur sequentially,
the condition is termed ventricular tachycardia; this must
be considered an emergency since this unstable condition
commonly deteriorates to frank ventricular fibrillation.
Ventricular fibrillation is an erratic ECG signal without
a characteristic pattern; it requires immediate cardio-
pulmonary resuscitation.

Results and Discussion
While constant attention must be paid to patient safe-

The purpose of exercise is to induce a maximum cardiac output. Important information, however, may be obtained at submaximal exercise, and there is no need to press the patient beyond well-defined endpoints of exercise. The appearance of the previously mentioned electrocardiographic changes, which represent warning signs of myocardial ischemia and irritability, represent valid endpoints of exercise. A significant decrease in blood pressure is another important endpoint. Following the onset of significant angina, injection should be made and the study completed. In patients who continue exercise without angina or blood pressure or ECG alterations, an endpoint of 80% of the maximal heart rate-blood pressure product, as predicted by a prior treadmill exercise test, has been found to serve as a valid level of stress.

The normal response to exercise is little change in the end diastolic volume and an increase in ejection fraction in comparison to the resting state. During exercise, patients with myocardial ischemia increase the end diastolic and end systolic heart volume and may actually decrease left ventricular ejection fraction (7). Patients with minimal CAD increase ejection fraction to a subnormal level.

In summary, the protocol described, which induces physiologic stress by exercise, can be conveniently and safely performed on patients through careful attention to technical details. The resulting information about blood flow and cardiac function aids in the management of patients with heart disease.

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References


FIG. 3. Blood pressure readings indicate the patient's response to exercise. Note that injection was completed when systolic pressure dropped in the patient with CAD.

FIG. 4. Stylized ECG tracings represent conditions possibly encountered during stress exercise. Major points along normal tracing (A) are identified by letters. Patients with cardiac disease may appear normal at rest, but show symptoms of cardiac muscle ischemia (B) or impaired conduction of electrical impulses (C) when exercising. Ventricular fibrillation indicates that cardiopulmonary resuscitation should be started immediately.