Exercise-Radionuclide Ventriculograms: Methods for Eliminating Motion

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In attempting to add the important parameter of exercise to routine radionuclide-ventriculogram studies, motion becomes an important technical consideration. We identified four problems. They were solved by the development, selection and utilization of particular equipment and techniques. Our tests were conducted using a line source taped to a subject's chest. Profiles of the line-source data and subsequent graphs were developed to demonstrate the effects of motion reducing techniques.

An accurate determination of cardiac function during stress is often important in the diagnosis and prognosis of cardiac disease (*1,2*). The clinical evaluation of cardiac function including the use of electrocardiography, echocardiography, and plain chest roentgenograms may give erroneous results. Several investigators have described the use and validity of noninvasive stress techniques in the evaluation of cardiac disease (*3–5*). While some of these techniques are more helpful than others, they are still limited in their ability to "see" the total heart, and physiologic data of normal-to-pathophysiological cardiac function is difficult to obtain. Our nuclear radiology division found that noninvasive exercise-radionuclide ventriculograms are a very accurate method of cardiac evaluation. These studies, however, presented us with four major problems that resting ventriculograms do not cause. These problems are:

- □ Devising a method of exercising and scanning simultaneously;
- □ Decreasing patient-chest motion;
- □ Stabilizing the patient exercising table; and
- □ Eliminating motion induced by patient-camera contact.

We solved these problems by using a bicycle ergometer for supine patient exercising; a special patient harness for chest immobilization; a customized cart with four retractable legs; and a smaller than usual gamma detector head that will not interfere with the patient's knees while exercising.

Our laboratory has proved that these methods are valid in the elimination of noticeable resolution loss caused by exercise motion.

Materials and Methods

Instrumentation: Our institution uses a Picker Dyna Mo portable camera with 11-in. gamma-detector head (Picker Medical Products, Cleveland, OH) and a Medical Data Systems Pad computer, which has 32K-word memory and a single disk drive (Medical Data Systems, Inc., Ann Arbor, MI).

Position Technique: The patient is positioned supine on the imaging table with the gamma camera placed in an anterior projection for the first resting image. A second view is then acquired in approximately a 45° left anterior oblique (LAO) position over the patient's left anterior axillary line. The oblique view is necessary in that it provides separation of the right and left ventricular chambers and is valuable in calculating ejection fractions and assessing chamber size (*2,6*).

Injection Technique: 2 ml of stannous pyrophosphate are injected for in vivo labeling of radionuclide to the red blood cells (*7*). After a 20- to 30- min wait for adequate tagging, a radionuclide angiogram is acquired. We acquire 200-byte mode frames at 10 frames per sec, giving a total acquiring time of 20 sec. A bolus of approximately 20 mCi of [^{99m}Tc] pertechnetate in a 0.5–2.0-ml syringe is injected through a 19-gauge butterfly needle and male-adapter lock. Ten ml of normal saline is used as a bolus push and we prefer the medial basilic vein of the right arm for injections.

Imaging Techniques: With the patient positioned supine, a 12-lead electrocardiogram is connected to the patient's chest to evaluate his heart during stress. In addition, gating electrocardiogram leads are connected in a modified lead I position. These leads will detect the R-

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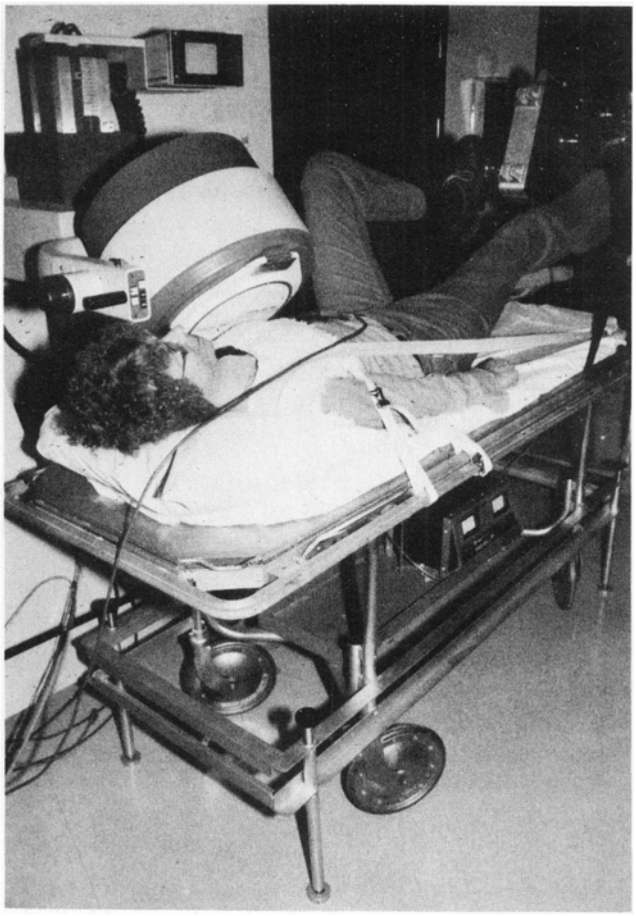

FIG. 1. Apparatus used for exercise include harness, cart, and bicyle ergometer.

wave for end-diastole. The patient's resting blood pressure is taken. The exercising harness is placed on the patient and connected to the cart; the bicycle ergometer is adjusted to the patient's feet. The patient's heart is positioned in the center of the camera. The retractable cart legs are locked down at that time. The patient is then injected with radionuclide and a radionuclide angiogram is acquired.

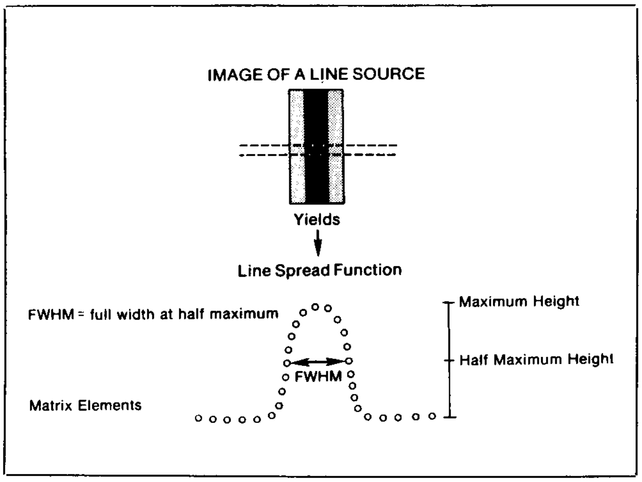

FIG. 2. Diagramatic representation of the line-spread function.

Figure 1 is a composite picture demonstrating devices mentioned (and the "patient" who is a volunteer). Two studies are then obtained at rest, an anterior view and a left anterior oblique view. After both resting studies have been acquired, they are viewed on the computer display. The patient is now ready for the exercise study. Nothing has to be adjusted, thereby eliminating such artifacts as camera angulation and patient placement. On completion of the exercise study, these scans are then processed. The completed study provides a left ventricular ejection fraction and ejection velocity data, as well as images of the end-diastolic and end-systolic anterior lateral, posterior lateral, anterior, septal, and apical cardiac wall motion.

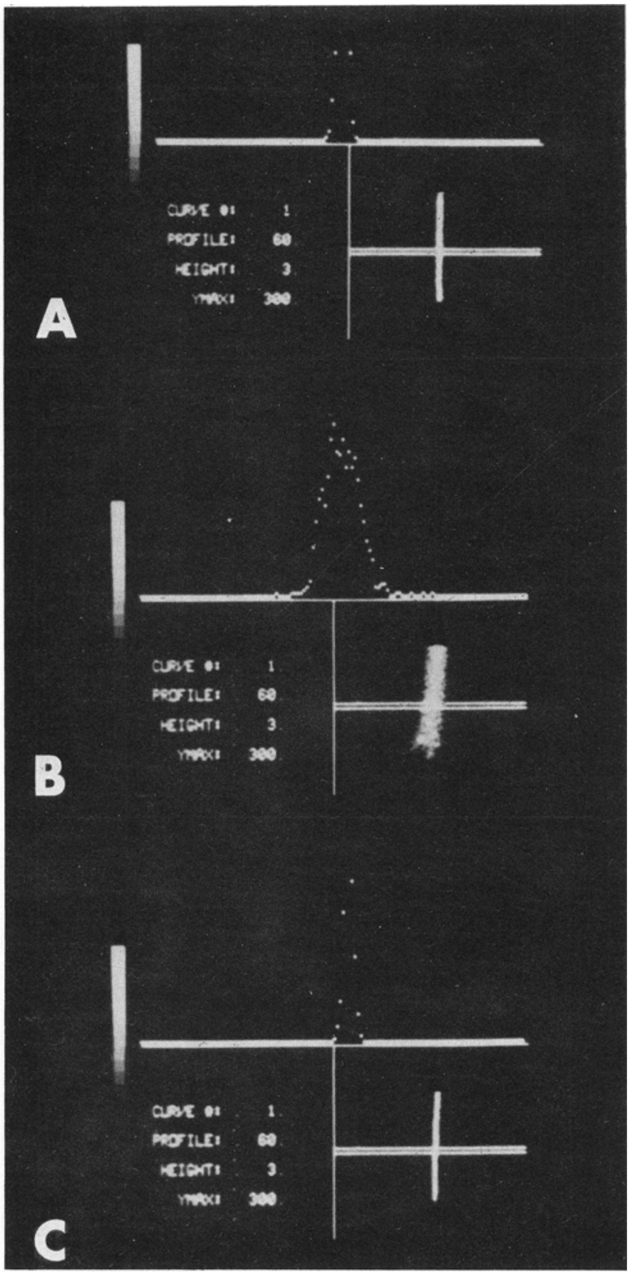

FIG. 3. (A) Line-spread at rest; (B) Line-spread without exercise equipment; and (C) Line-spread with exercise equipment.

Evaluation

Our institution has performed tests to ascertain the effectiveness of these motion-reducing techniques. We imaged a 1-mm inside diameter catheter, 20 cm in length, as a line source. This line source was placed on the subject's chest, and three separate tests were acquired in the LAO position—rest, exercise without our equipment, and exercise with our equipment. Using the computer, a graph was obtained over a section of counts in the image of the line source. This is called the line-spread function. The line-spread function will give a measure in width of the source at its half maximum counting rate point. This measurement is representative of matrix elements. On our system, one matrix element equals 2-mm resolution.

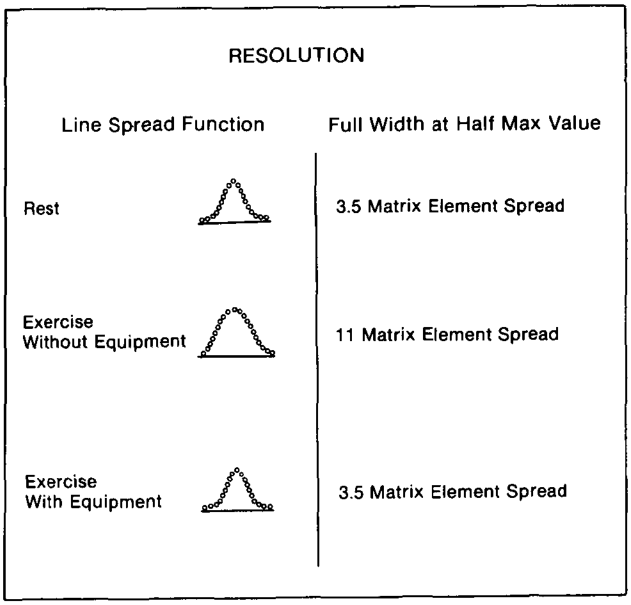

FIG. 4. Comparative results with and without exercise equipment.

Results

The results show marked improvement in resolution. Figure 2 is a diagramatic representation of the line-spread function. Figure 3(A) demonstrates the line spread at rest. Figure 3(B) represents the line spread without our exercise equipment and Fig 3(C) is our line spread with our exercise equipment. The graphic illustration of comparative results with and without our exercising equipment is shown in Fig. 4. Rest equaled 3.5-matrix elements. Exercise without our equipment equaled 11-matrix elements, the same as at rest.

In conclusion, our department cannot emphasize enough the importance of chest immobilization during exercise-radionuclide ventriculograms. Measures can be devised and should be utilized to eliminate motion.

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