Evolution of Stress Testing

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Stress testing of patients with known or suspected coronary artery disease is an important part of patient management. The resting state frequently does not provide a complete evaluation, and the introduction of a stressful condition may be necessary to detect underlying or latent ischemia.

The history of stress testing is long, varied, and highlighted by a series of technological advances in diagnostic methodology. The Master Two Step was probably one of the first clinically useful procedures for this purpose. With this test an electrocardiogram was obtained before and after a patient walked up and down two steps a given number of times. Despite the fact that the examination was helpful, there was an obvious need for improvement. By merely comparing the preexercise and postexercise electrocardiogram there were patients whose electrocardiographic abnormalities did not persist long enough to be detected. Furthermore, the type of exercise was limited and difficult to quantitate. Probably the first of the many technological advances in stress testing was the development of an electrocardiographic system that produced high quality, interpretable tracings during exercise. This development was the breakthrough necessary for meaningful electrocardiographic monitoring of the exercising individual.

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Electrocardiographic and clinical monitoring of exercise has been the mainstay for evaluating patients with coronary artery disease for decades. However, as with all diagnostic procedures, there are limitations. The sensitivity and specificity may be unsatisfactory, especially in certain subgroups such as patients with resting electrocardiographic abnormalities or women. Furthermore, the electrocardiogram provides only modest localization and relatively poor quantitation of myocardial ischemia. With the advent of therapeutic revascularization there is an increasing need not only for the detection of ischemia but also for localization and quantitation.

Because of these new demands brought about by therapeutic advances, there has been a desire to monitor more than just the electrocardiogram and clinical findings in the exercising individual. One means of obtaining such additional information uses nuclear techniques, either by blood pool imaging or myocardial perfusion. Both techniques have proved to be useful in providing additional information about stress-induced ischemia. And as would be expected, these techniques have their respective advantages and disadvantages. Probably the most popular current technique is thallium-201, single-photon emission computed tomography (SPECT). This examination provides tomographic slices of myocardial perfusion. The exercise perfusion scan is compared with a “resting” study represented by a reperfusion examination approximately 4 hours later. Ischemia is defined as a perfusion defect that occurs with exercise and normalizes in the follow-up examination. A fixed lesion or “scar” is diagnosed when a perfusion defect is present on both the exercise and reperfusion images.

Echocardiography is another technique that can be helpful in stress testing. Stress echocardiography is based on the premise that ischemia produces a regional motion abnormality. There are ample data indicating that such an abnormality is an early, sensitive, and reliable indicator of ischemia.\(^1\)\(^-\)\(^3\) The history of stress echocardiography is probably as long and varied as the history of stress testing in general. Early efforts using M-mode echocardiography demonstrated the feasibility of the technique.\(^4\)\(^-\)\(^6\) However, there were numerous technical limitations with an examination that was essentially one-dimensional. As a result the test never became practical. A variety of advances has brought stress echocardiography to the point that it is now a useful diagnostic tool. The first major advance occurred many years ago with the introduction of two-dimensional echocardiography.\(^7\)\(^-\)\(^9\) This tomographic technique was vastly superior to the single-dimensional M-mode examination for examining the total heart and left ventricle. The next major advance was the clinical observation that wall motion abnormalities persisted for several minutes, thus making immediate posttreadmill echocardiography valid for detecting exercise induced ischemia.\(^10\)\(^-\)\(^12\) The most recent technical enhancement has been the introduction of digital acquisition and display of the stress echocardiograms.\(^13\)\(^-\)\(^15\) Much of the respiratory artifact inherent in stress echocardiography can be eliminated with the digital technique. Furthermore, by placing the resting and exercise images side-by-side the interpretation is greatly facilitated. Thus, stress echocardiography, especially using digital techniques, provides another method for clinicians to evaluate their patients with known or suspected coronary artery disease.

With more than one option available, it is important to try to compare the various techniques to help the physician make a reasonable choice for a given patient.
The study published in this issue of Circulation by Quinones et al16 makes an effort to compare posttreadmill echocardiographic studies with thallium-201 SPECT imaging. The study is done in an institution that is known to have high quality nuclear and echocardiographic laboratories. This feature is extremely important because the expertise of an individual laboratory will probably be the dominant factor in choosing one examination over another. There is no question that a good nuclear study will always be better than a poor echocardiographic study and vice versa. All diagnostic techniques require expertise and experience. An important addage is that no information is far better than wrong information.

For those who are familiar with the stress echocardiography literature, the article in this issue of Circulation holds no major surprises. The percentage of patients who had diagnostic quality echocardiograms was extremely high (98%). This percentage is clearly higher than most laboratories can expect. On the other hand, it should help put to rest the misconception that exercise echocardiography is unsuccessful in a high percentage of patients.

Although myocardial perfusion and regional function are two different phenomena, almost every study in which the two techniques are compared shows amazing similarity.11,17-19 The bottom line appears to be that when there is ischemia, a perfusion defect occurs and there is a regional wall motion abnormality. It is uncommon to have one without the other. Where there are differences, there does not seem to be any predictable pathophysiological explanation. More likely than not, the differences are technical in nature. One possible exception, as pointed out in this study, is in patients who have a resting wall motion abnormality. If there is no improvement with exercise, the segment is considered to be “fixed.” Some of these areas show improved reperfusion with the thallium study. Therefore, these areas may be “mixed.” Part of the problem with the echocardiographic technique is that there is not universal agreement on how to differentiate a resting wall motion abnormality that worsens from one that is unchanged with exercise.

When comparing the two examinations with coronary angiography, there are no clear cut advantages for either test. There may be small differences in sensitivity at the expense of specificity and vice versa. Unfortunately coronary angiography is also not without limitations, and therefore the ultimate gold standard really does not exist.

I would certainly agree with the authors’ conclusion that exercise echocardiography offers a practical option for noninvasive testing in patients with known or suspected coronary artery disease. I would emphasize that the number one prerequisite for choosing a given examination is available expertise. Assuming competence in exercise echocardiography, this option becomes very attractive because of the convenience to both the patient and the physician, the time required for the examination and report, the lack of ionizing radiation, and the availability and cost of the necessary equipment and material.

References

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