THE EXERCISE ECG

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The exercise ECG is a useful investigation in the diagnosis of ischaemic heart disease. It is very much more accurate than the ECG taken at rest, but an abnormal exercise test does not absolutely predict the presence of coronary disease, and a normal response does not exclude the possibility. However, the probability of coronary disease being present in a patient with a positive test is about 90%, and about 85% of patients with a normal test will not have disease. It must be emphasised that the exercise ECG is a more complicated and elaborate procedure than the routine ECG at rest and to obtain good results the physician (and technician) must be prepared to take considerable trouble with technique and to devote about 45 minutes to each test. If more attention (and time) is given to haemodynamic changes during exercise rather than concentrating solely on ECG abnormalities, the accuracy of diagnosis is enhanced.

Doctor Ellastad and his colleagues, in an excellent "state of the art" paper in *Progress in Cardiovascular Diseases*[1], review the clinical application of stress testing. The commonest indication for an exercise test is to detect coronary artery disease in the patient with suggestive symptoms, or in the asymptomatic patient in whom the risk of coronary heart disease is deemed to be high. However, in recent years the indications have broadened to include the evaluation of arrhythmias, drug regimens, pre-operation and post by-pass performance, and the estimation of the physical work capacity and limitations of patients with ischaemic heart disease. The contraindications to stress testing are unstable angina, rapid arrhythmias, advanced atrio-ventricular block, uncompensated congestive heart failure, and, until recently, acute myocardial infarction (many centres now assess patients prior to discharge with a sub-maximal test).

Most exercise tests are conducted in a number of stages with increasing exercise loads until an age-related target heart rate is achieved, or symptoms make it necessary to terminate the test prematurely. A bicycle or threadmill may be used. The former gives a more stable ECG and blood pressure measurement is easier, but the threadmill probably gives more reproducible results because, unlike the bicycle, the subject does not regulate the workload. The mortality rate for exercise testing lies somewhere between 1/10,000 and 1/20,000, with serious complications (mostly infarction and arrhythmias) occurring at a rate of 8.86/10,000. The risks are therefore small, but the operator must judge each patient carefully and adequate resuscitation equipment and drugs must be at hand during every test.

The classical ECG abnormality induced by exercise is ST depression of 1 mm, although the specificity of the test can be improved if 2 mm depression is taken as the criterion for abnormality. The magnitude of ST segment depression appears to correlate with the degree of myocardial involvement, and it is probably reasonable to make the assumption that the greater the depression the more severe the disease. The time of onset of ST depression also correlates with the degree of coronary obstruction; the longer the duration of ST depression after exercise, the greater the severity of the disease, but the reverse does not apply.

Perhaps of even greater importance than depression is ST segment configuration in predicting both the presence and severity of disease. The down-sloping ST segment is highly specific, the horizontal ST segment less so, and the slowly up-sloping pattern gives the greatest instance of false positives. Rarely ST segment elevation rather than depression is induced by exercise, and this response is indicative of severe myocardial ischaemia. The significance of exercise-induced ventricular arrhythmias has always been controversial, but, from this review of the literature, it is concluded that the presence of premature ventricular contractions (PVCs) in subjects being tested routinely, who are apparently healthy, is of little or no prognostic significance unless associated with ST segment depression. However, subjects with both exercise-induced ventricular arrhythmias and significant ST depression are likely to have severe coronary artery disease.

These authors draw attention to the importance of R wave amplitude changes in the exercise ECG. An increase in R wave amplitude correlates with two- or three-vessel disease, and with poor ventricular function, whereas a decrease in R wave amplitude correlates with no disease or one- or two-vessel disease with good ventricular function. The sensitivity and specificity of R wave amplitude change as a predictor of coronary disease was found to be better than ST segment depression.

An inappropriate blood pressure and heart rate response to exercise may be of serious significance. Exertional hypotension at a low workload in coronary patients is usually associated with severe disease and a poor prognosis. Furthermore, failure of the systolic blood pressure to rise appropriately may also be prognostically significant, but the importance of an inappropriate blood pressure response in patients without other evidence of coronary heart disease is not so clear. Patients unable to increase their heart rate above 120 per minute with exercise would appear to be at high risk for future coronary events, whereas those achieving a rate of 160 per minute or greater are at low risk.

The occurrence of anginal pain during testing is important in predicting the presence and severity of coronary disease. Anginal pain without ischaemic ECG changes is associated with multivessel disease in 72% of patients, and if both chest pain and ischaemic changes are present the incidence of multivessel disease rises to 93%.

The authors, using 21 clinical variables in a computer-implemented multivariate analysis, have greatly improved the predictive value of exercise stress testing, and are able to decide with some confidence which patients should have coronary angiography. For the moment, for most of us, the exercise stress test will permit us to diagnose the presence, and to some extent the severity, of coronary artery disease, and so permit us to plan management. Stress testing, furthermore, serves as a means of determining a patient's work capacity and response to treatment and rehabilitation. It does not give us an accurate anatomical assessment of coronary obstruction.

[1]Ellastad M.H., Cooke B.M. and Greenberg P.S. (1979). *Progress in Cardiovascular Diseases*, **21**, 431.