Self-predicting stress tests

Predischarge modified stress testing after acute myocardial infarction

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SUMMARY The outcome of 50 consecutive modified predischarge exercise tests after acute myocardial infarction was predicted by three independent observers on the basis of ST segment displacement in the resting pretest 12 lead electrocardiograms. The mean predictive accuracy for the three observers was 82% for a positive test defined as additional ST segment depression or elevation ≥ 0.1 mV, and rose to 94% for a positive test defined as additional ST segment depression ≥ 0.1 mV alone. For the majority of patients, the test result was already apparent in the resting 12 lead electrocardiogram.

After acute myocardial infarction, the safety and usefulness in prediction of modified predischarge exercise electrocardiography have been documented in a large number of recent reports,¹⁻¹⁰ implying that the test is not merely desirable, but actually *de rigueur* in continued postinfarction management. For example, a recent editorial states that "not to do an exercise test before discharge is to ask the patient to do the treadmill test at home".¹¹ In our hospital, we used low-level exercise testing in the past and the outcome of this test frequently seemed predictable from the standard 12 lead control electrocardiogram. This study was undertaken to define the relation of the resting electrocardiogram to the outcome of predischarge exercise testing after acute myocardial infarction.

Subjects and methods

PATIENTS

We investigated 50 consecutive patients, 40 men and 10 women with mean age of 61.7 (range 33 to 82) years, who underwent modified exercise electrocardiography eight to 18 (average 13) days after acute myocardial infarction. All were clinically fit for discharge from the hospital on the day of testing. One patient with infarction and pre-existing left bundle-branch block was excluded from the study.

EXERCISE PROCEDURE

After baseline tracings taken from them supine, sitting, erect, and after hyperventilation, patients walked the treadmill during two three minute stages at slopes of 5 and 10 degrees at a constant speed of 1.7 miles per hour. Leads aVF, V4, and V5 were continuously monitored with printouts at the end of each stage and at two, five, and 10 minutes after exercise. Full electrocardiograms were obtained before and at the end of exercise, and again at the end of the 10 minute recovery period. The exercise was discontinued for the standard indications¹² or when the heart rate exceeded 110 beats per minute.

ELECTROCARDIOGRAPHIC CRITERIA

A positive exercise test was predicted blindly from the resting electrocardiographic abnormalities agreed upon in advance by three independent observers before reading the electrocardiograms; no subsequent modifications were allowed. The only abnormalities (Fig.) used for the prediction were (i) ST segment depression 0.1 mV 80 ms after the J point, (ii) ST segment elevation 0.1 mV 60 ms after the J point except in leads V1 to V3, and (iii) ST segment elevation 0.3 mV in leads V1 and V2, and 0.2 mV in V3.

The outcome of the exercise test was reported by two other independent observers, neither of whom took part in the predictive study. Their criteria for a positive test consisted of ST segment displacement 0.1 mV 80 ms after the J point in at least three consecutive cycles during or after the exercise.

Fig. Prediction of ST segment shift by the resting electrocardiogram. Above: leads aVF, V4, and V5 showing ST segment elevation at rest (left-hand panel) and further elevation with exercise (right-hand panel). Below: leads V4, V5, and V6 showing ST segment depression at rest (left-hand panel) and further depression with exercise (right-hand panel).

STATISTICAL METHOD

The results were tested for differences by χ^2 analysis. Sensitivity, specificity, predictive value of a positive test, and accuracy were calculated for each observer by the standard formulae (Table 1).

Results

The procedure was completed in 45 out of 50 (90%) tests reviewed. Five incomplete tests (reported as inconclusive) were interrupted because of musculoskeletal pain, fatigue, or dyspnoea in the absence of ST segment criteria for a positive test. These five patients were significantly older than the remaining

patients (mean age 72 vs. 60.5 years); their tests were excluded from the analysis.

There were no complications.

Of the 45 tests reaching a definite end-point, a mean of 37 (82%) were correctly predicted by the three observers from the pre-test resting electrocardiogram (Table 1). If additional ST segment elevation is not considered as "positive" (see Discussion), the figure rises from 82% to 94%.

No clinical or additional electrocardiographic features distinguished the patients whose tests were predicted correctly. In particular, the site of infarction (16 inferior, 13 anterior, six combined, and 10 without Q waves) had no effect on either the correctness of the prediction or the outcome of the test.

Comparison of the incorrect predictions (Table 2) among observers shows very little interobserver variation. This Table also shows that most false positive predictions were the result of the failure of the elevated ST segments to rise 0.1 mV further, while most false negative predictions involved ST segment depression.

Only three patients reported chest pain during the test (sharp left-sided pain in one); all three had a positive test with ST segment depression and the results of the exercise tests in these were correctly predicted from their resting electrocardiograms. An additional 14 patients had a "positive" test (nine with ST segment depression and five with ST segment elevation) without experiencing any symptoms.

Discussion

The data indicate that the resting electrocardiogram has a very high predictive value for the result of a modified predischarge exercise test after acute myocardial infarction, so long as there are minimal ST deviations in either direction (as defined in Subjects and methods section). A potential but unavoidable weakness of this study stems from its relatively conservative exercise procedure; on the other hand, more subtle criteria for prediction would have been required for more vigorous exercise. Our rate end-point of 110 beats per minute is lower than in the studies cited,¹⁻¹⁰ yet conforms to the rate target of Bruce's group in patients taking propranolol.¹³

None of the recent papers confirming¹⁻¹⁰ or denying¹⁴ the prognostic value of modified exercise electrocardiography addresses itself to this comparatively simple electrocardiographic aspect of the test itself, though all involve eliciting otherwise hidden additional risk in their subjects. If this putative added risk can be inferred from the resting electrocardiographic abnormalities—as described long before the modified exercise electrocardiography test became popular^{15 16}—the serious question arises as to the

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Table 1 Prediction of modified exercise electrocardiography test outcome by resting electrocardiogram

Observer No.	Electrocardiograph prediction	Modified exercise electrocardiography test	Statistical data
1	18 +ve	14 +ve tests (TP)	Sensitivity 82%
	27 -ve	4 -ve tests (FP) 24 -ve tests (TN) 3 +ve tests (FN)	Specificity 89% Predictive value 78% Accuracy 84% χ^2 20.42017 with 2 degrees freedom and $p < 0.001$ Contingency coefficient = 0.4117940
2	17 +ve	13 +ve tests (TP)	Sensitivity 76%
	28 -ve	4 -ve tests (FP) 24 -ve tests (TN) 4 +ve tests (FN)	Specificity 86% Predictive value 76% Accuracy 82% χ^2 17.37099 with 2 degrees freedom and $p < 0.001$ Contingency coefficient = 0.3847086
3	16 +ve	12 +ve tests (TP)	Sensitivity 71%
	29 -ve	4 -ve tests (FP) 24 -ve tests (TN) 5 +ve tests (FN)	Specificity 86% Predictive value 75% Accuracy 80% χ^2 15.42788 with 2 degrees freedom and $p < 0.001$ Contingency coefficient = 0.3655929
Combined observers: mean sensitivity 76%, specificity 87%, predictive value (for a +ve test) 76%, accuracy 82%			

TP, true positive; TN, true negative; FP, false positive; FN, false negative.

Sensitivity, TP/TP+FN; specificity, TN/TN+FP; predictive value, TP/TP+FP; accuracy, correct/total predictions.

Table 2 Incorrectly predicted tests

Case No.	Predictions			Cause of error	Test outcome
	1	2	3		
13	+	+	+	No further ST segment elevation	-
15	+	+	+	No further ST segment elevation	-
33	+	+	+	No further ST segment elevation	-
42	+	+	+	No further ST segment elevation	-
12	-	-	-	Unpredicted ST segment depression	+
22	-	-	-	Unpredicted ST segment depression	+
23	-	-	-	Unpredicted ST segment depression	+
38	-	-	-	Unpredicted ST segment depression	+
50	-	-	-	Unpredicted ST segment depression	+

need for further testing in many, if not most, patients. It should be borne in mind that the extensively validated prognostic tests such as coronary angiography, contrast or radionuclide ventriculography, or 24 hour continuous monitoring are not in any sense replaced by the modified exercise electrocardiogram.

A second issue arising from this study is what should be called a positive test in patients with recent infarction. Evidence suggests that the predictable¹⁷ ST segment elevation in leads with Q waves reflects wall dyskinesia rather than, simply, ischaemia,¹⁸⁻²⁰ but in view of the known significance of wall motion abnormalities²¹ and their ischaemic aetiology such elevation may be reasonably held to constitute a positive test. On the other hand, this "positivity" is fairly regularly induced at higher heart rates in those with pre-existing ST segment elevation,¹⁷ rendering interpretation difficult. Similar problems arise with ST segment depression from a depressed baseline, be it caused by "subendocardial" injury, hypertrophy, minor conduction defect, drugs, or electrolyte abnormalities. Since most electrocardiograms are abnormal after a recent infarction, it would be best, at

this stage of knowledge, to desist from calling the modified exercise electrocardiograph tests either positive or negative, and to report them descriptively.

This study also shows that, out of 50 patients tested, only three had chest pain associated with ST segment depression; the others had negative, incomplete, or "electrically" positive test. It would be difficult to imagine great therapeutic potential in such findings. When many are tested for the sake of a few, the test is inefficient. The authors feel that it need not be used routinely.

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