Submaximal exercise testing early after myocardial infarction

Prognostic importance of exercise induced ST segment elevation

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SUMMARY Seventy four patients (66 men, eight women; mean age 54.3 years) underwent submaximal exercise testing 7-23 days (mean 10.7) after acute myocardial infarction. Follow up was a mean period of 11.3 months. When compared with patients with no exercise induced abnormality, ST segment elevation, ST shift (depression or elevation or both), ST depression, inability to complete five metabolic equivalents, and inadequate blood pressure response to exercise were predictive of subsequent cardiac events (cardiac death, left ventricular failure, recurrent myocardial infarction, angina). When the presence or absence of specific variables was assessed, only ST elevation and ST shift predicted subsequent cardiac events. The presence of exercise induced ST elevation was the only exercise test variable which predicted cardiac death. ST segment elevation was, therefore, the exercise induced abnormality which best predicted the risk of future complications.

Exercise testing early after acute myocardial infarction has become widely practised to provide a guide to the presence of multivessel coronary disease¹⁻⁴ and subsequent prognosis.⁵⁻⁹ After acute myocardial infarction there are, however, often major persisting electrocardiographic abnormalities, and, particularly in subjects with transmural anterior infarction, exercise induced ST segment elevation is not infrequently seen. This study was undertaken to examine the relative importance of this feature in relation to other variables of known prognostic significance.

Patients and methods

PATIENT SELECTION

One hundred and ten consecutive patients (aged ≤ 65 years) with acute myocardial infarction were considered for early submaximal exercise testing, of whom 74 were exercised. Diagnosis of acute myocardial infarction was made when two of the following three criteria were fulfilled: (a) chest pain lasting longer

than 30 minutes; (b) increase in serum creatine kinase and lactate dehydrogenase activity to greater than twice the upper limit of the normal range, with a typical evolutionary pattern on serial estimations; and (c) evolutionary electrocardiographic changes. If the latter included the development of new significant Q waves, ≥ 0.04 s duration, with amplitude $> 25\%$ of the subsequent R wave, the infarction was considered to be transmural and classified as anterior if Q waves developed in any of leads I, aVL, V1 to V6, or inferior if Q waves occurred in at least two of leads II, III, aVF. Other evolutionary electrocardiographic changes consisted of symmetrical T wave inversion or ST segment elevation or depression > 1 mm or both, persisting for more than 24 hours. If new significant Q waves did not occur the infarction was considered to be non-transmural.

Thirty six patients did not undergo treadmill exercise testing before discharge because of: in-hospital death (14), persistent heart failure (2), insulin dependent diabetes mellitus (2), persistent angina with urgent coronary artery bypass grafting (1), previous coronary artery bypass graft surgery (4), other disease (leukaemia 1, cerebrovascular disease 5), expected follow up difficulties in patients who did not reside locally (5), and patient refusal to provide informed con-

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Accepted for publication 13 March 1984

sent (2). Seventy four patients (66 men, eight women; mean age 54.3 years, range 29–64) underwent sub-maximal treadmill exercise testing before hospital discharge (mean 10.7 days post-infarction, range 7–23 days). At the time of exercise testing all patients were ambulant without angina and free of clinical and radiological features of heart failure, although the presence of heart failure during the acute phase of infarction which had resolved before discharge was not a reason for exclusion. None had electrocardiographic evidence of left ventricular hypertrophy or left bundle branch block at the time of exercise testing. Twenty four patients had anterior, 35 inferior, and 15 non-transmural infarctions.

EXERCISE TESTING

The treadmill exercise protocol used was a modified Naughton protocol¹⁰ using a constant treadmill speed of 2 miles (1.2 km) per hour with the initial grade of zero increased by 3.5% every two minutes so that energy expenditure increased by approximately one metabolic equivalent with each two minute stage. One metabolic equivalent is the oxygen uptake per kilogram body weight at supine rest and has a mean value of 3.5 ml oxygen per kilogram body weight per minute.¹⁰ Twelve lead electrocardiograms and cuff blood pressure were recorded before exercise, at the end of each two minute stage during exercise, immediately after exercise, and at one minute intervals thereafter for a minimum of five minutes. Post-exercise electrocardiograms were recorded with the patient sitting. A three lead (II, V1, V5) rhythm strip was recorded continuously at slow paper speed during and after exercise. Exercise was terminated when any of the following occurred: (a) attainment of five metabolic equivalents, which is equivalent to approximately 17.5 ml of oxygen uptake per kilogram of weight per minute, (b) 70% of age predicted maximal heart rate, (c) angina, (d) severe dyspnoea or fatigue, (e) the occurrence of frequent (>10 per minute) multifocal or paired ventricular extrasystoles, (f) a fall in systolic blood pressure of ≥ 20 mm Hg during exercise, or (g) the appearance of >5 mm ST depression in any lead during exercise. Normal drug treatment was continued. Twelve patients were receiving beta blocking agents; none was receiving digitalis.

ST segment changes

ST segment depression was defined as horizontal or downsloping depression in any lead, except aVR, by at least 1 mm compared with the resting electrocardiogram in three consecutive beats with a stable baseline measured 0.06 s after the end of the QRS complex. ST elevation was defined as at least 1 mm elevation compared with the resting electrocardiogram in three consecutive beats with a stable

baseline measured 0.06 s after the end of the QRS complex. ST shift was defined as ST depression or elevation or both induced by exercise. Inadequate blood pressure response to exercise occurred when systolic blood pressure increased by ≤ 10 mm Hg during exercise with a peak systolic blood pressure of <140 mm Hg or a fall in systolic blood pressure of 20 mm Hg or more during exercise.¹¹

VENTRICULOGRAPHY

Resting left ventricular ejection fraction was determined by gated blood pool scanning in 52 patients before hospital discharge. Selection for this procedure was based solely on the availability of gammacamera time. Each patient received 20 mCi technetium-99m pertechnetate in vitro labelled red blood cells. Equilibrium images of the cardiac blood pool were acquired in the anterior and left anterior oblique projections collecting 3.5×10^6 counts in total. Each cardiac cycle was gated using 12 frames and resting left ventricular ejection fraction calculated from this by an area of interest method. The left ventricular silhouette was enhanced by a routine isocount contour method and the perimeter drawn free hand.

FOLLOW UP

Follow up was for a mean period of 12.1 (range 5–20) months in 67 patients. Seven asymptomatic patients with multivessel coronary artery disease who underwent coronary artery bypass surgery a mean period of three (range 1–9) months after infarction were considered lost to follow up at the time of surgery because of the uncertain influence on subsequent prognosis. Although the length of follow up was therefore short for some patients, inclusion was considered appropriate as 90% of deaths, non-fatal cardiac arrest, or recurrent myocardial infarction which occur in the year subsequent to acute myocardial infarction occur within the first six months.¹² Cardiac events were defined, in descending order of importance, as: (a) cardiac death, which was considered sudden if death occurred within 60 minutes of the onset of new symptoms; (b) left ventricular failure, which required symptomatic dyspnoea, a gallop rhythm with basal crepitations, and radiological confirmation of pulmonary venous congestion or interstitial alveolar oedema or both; (c) recurrent myocardial infarction diagnosed by the same criteria as those above; and (d) angina pectoris occurring despite antianginal medical treatment. Only one complication, the most serious, was documented for each patient. Drug treatment was at the discretion of individual physicians. Although 31 patients received beta blocking agents during the follow up period, only 13 of these received them as a secondary prevention measure in the absence of another indication for their use. Patients who had

exercise induced ST depression in any lead were asked to undergo left ventriculography and coronary arteriography six weeks after infarction. Otherwise, selection for this procedure was based on clinical grounds.

COMPARISON OF DATA

The proportion of patients with an abnormal exercise test variable who sustained a subsequent cardiac event was compared with the likelihood of a subsequent cardiac event in the group of patients who had a normal exercise test. The likelihood of a subsequent cardiac event in the presence or absence of a specific abnormal exercise test variable was also compared.

Differences between the means of independent observations were assessed by Student's *t* test; the χ^2 test with Yates's correction was used to assess differences between proportions.

Results

End points of the submaximal exercise tests were: (a) completion of five metabolic equivalents (31, 42%); (b) exceeding 70% of age predicted maximum heart rate (24, 32%); (c) angina (6, 8%); (d) fatigue or dyspnoea (9, 12%); (e) >5 mm ST depression (2, 3%); and (f) ventricular arrhythmias (2, 3%). No test was stopped because of a fall in systolic blood pressure of ≥ 20 mm Hg.

CARDIAC EVENTS

During the follow up period 40 patients remained free of complications. Thirty four experienced cardiac events (cardiac death (12), left ventricular failure (4), recurrent myocardial infarction (1), angina (17)). Recurrent myocardial infarction was suspected but unconfirmed in three further patients who were treated at home, and another undergoing coronary artery bypass surgery had evidence of perioperative myocardial infarction.

There were no complications of exercise testing; one man with a normal submaximal treadmill test died suddenly 52 hours later after the onset of severe chest pain.

Twelve patients died during follow up a median time of 14 (range 2–56) weeks after acute infarction. Seven patients died suddenly within 60 minutes of the onset of new symptoms, two died of cardiogenic shock after definite recurrent infarction, and one died after probable recurrent infarction. A patient with severe left main coronary artery stenosis became hypotensive with possible recurrent infarction before planned coronary bypass surgery. This was undertaken on an emergency basis but death occurred two days postoperatively. Another man with intractable angina and left ventricular failure died after coronary

artery bypass grafting and left ventricular aneurysm resection.

Sixteen other patients underwent coronary artery bypass graft surgery (median 2 (range 1–14) months after infarction). Nine of these had angina; in seven cases surgery was undertaken for prognostic reasons in patients with multivessel coronary disease.

PREDICTIVE VARIABLES

Twenty (27%) patients had normal submaximal exercise tests; 54 (73%) had one or more abnormal variables. Forty two (57%) patients had ST segment shift, 28 (38%) ST depression, 21 (28%) ST elevation, and seven (9%) both ST elevation and depression induced by exercise in different leads. Forty three (58%) patients did not complete five metabolic equivalents because of angina (6, 8%), fatigue or dyspnoea (9, 12%), exceeding 70% of age predicted maximum heart rate (24, 32%), ventricular arrhythmias (2, 3%) or ST depression >5 mm (2, 3%). Eighteen (24%) patients had an inadequate blood pressure response to exercise, of whom four were receiving beta blockade. Every patient who had an inadequate blood pressure response to exercise had at least one other exercise abnormality; 12 had either ST depression or elevation, four exceeded 70% of age predicted maximum heart rate, and two were limited by fatigue or dyspnoea. The two patients who had ventricular arrhythmias during exercise also had ST depression. Of the six patients who were limited by angina, five also had ST shift: ST depression in four, ST elevation in one. Of the 12 patients who were receiving beta blocking agents at the time of submaximal exercise testing six had been treated for hypertension and two for angina preceding hospital admission, and this medication was continued. Four had beta blockade instituted after hospital admission because of chest pain in the peri-infarction period. Five patients taking beta blocking agents had no exercise induced abnormality, and together with two who were limited by fatigue, had an uncomplicated follow up. The remaining five, two of whom were limited by fatigue and two by angina, had abnormal ST segment responses to exercise: four had ST depression, three ST elevation, and two both ST depression and elevation in different leads. Of these, one died after recurrent myocardial infarction, one died suddenly, and three experienced angina during follow up. None of the patients taking beta blocking agents exceeded 70% of age predicted maximum heart rate.

When compared with patients with no abnormality on exercise testing, the following variables were predictive of subsequent cardiac events (Table 1): ST elevation ($p < 0.001$); ST shift ($p < 0.001$); ST depression or angina ($p < 0.02$); ST depression ($p < 0.02$); inability to complete five metabolic equivalents

Table 1 *Likelihood of cardiac events in patients with an abnormal exercise variable compared with those with a normal exercise test*

Exercise test result	Total No of patients	Cardiac event (deaths)	No cardiac event	p value
Normal test	20	3 (1)	17	
ST depression	28	15 (5)	13	<0.02
ST elevation	21	18 (7)	3	<0.001
ST shift (depression or elevation or both)	42	27 (9)	15	<0.001
ST depression or angina	29	16 (5)	13	<0.02
<5 mets*	43	24 (7)	19	<0.01
Inadequate blood pressure response	18	10 (5)	8	<0.05

*Inability to complete 5 metabolic equivalents.

($p < 0.01$); and inadequate blood pressure response to exercise ($p < 0.05$).

When the presence or absence of specific variables was analysed, however, only ST elevation ($p < 0.001$) and ST shift ($p < 0.001$) were predictive of subsequent cardiac events (Table 2). Inability to complete five metabolic equivalents, ST depression or angina, ST depression, or inadequate blood pressure response did not statistically predict subsequent cardiac events.

Half of the patients who experienced cardiac events during the follow up period did so because of the occurrence of angina. When analysis was confined to cardiac death, left ventricular failure, or recurrent myocardial infarction the presence of exercise induced ST elevation was the only exercise test variable which retained significant predictive value ($p < 0.05$). If cardiac death alone was considered exercise induced

Table 2 *Likelihood of cardiac events in patients with abnormal exercise variables*

Exercise variable	Total No of patients	Cardiac event (deaths)	No cardiac event	p value
ST depression				
Present	28	15 (5)	13	NS
Absent	46	19 (7)	27	
ST elevation				
Present	21	18 (7)	3	<0.001
Absent	53	16 (5)	37	
ST shift				
Present	42	27 (9)	15	<0.001
Absent	32	7 (3)	25	
ST depression or angina				
Present	29	16 (5)	13	NS
Absent	45	18 (7)	27	
Exercise duration				
<5 mets*	43	24 (7)	19	NS
5 mets	31	10 (5)	21	
Inadequate blood pressure response				
Present	18	10 (5)	8	NS
Absent	56	24 (7)	32	

*Inability to complete 5 metabolic equivalents.

Table 3 *Patients with ST elevation or ST depression in lead V5 compared with the occurrence of these variables in any lead and predictive accuracy for subsequent cardiac events*

ST segment change	Total No of patients	Cardiac event (deaths)	No cardiac event	Predictive accuracy (%)
ST elevation				
Lead V5	4	4 (1)	0	
Any lead	21	18 (7)	3	74
ST depression				
Lead V5	19	9 (3)	10	53
Any lead	28	15 (5)	13	57

ST elevation was again the only exercise test variable which was of statistically significant predictive value ($p < 0.05$).

Of the 21 patients with ST elevation induced by exercise, 17 had transmural anterior infarction, and four had transmural inferior infarction. ST elevation occurred in leads with new Q waves in 20 of the 21 cases. If lead V5 alone was considered only four patients had exercise induced ST elevation compared with the 21 when 12 lead electrocardiograms were analysed. Similarly, only 19 patients had exercise induced ST depression in lead V5 compared with 28 when 12 leads were considered; the greater yield of ST depression with 12 lead recordings did not diminish predictive accuracy of this variable for subsequent cardiac events (Table 3).

When clinical variables were considered, cardiomegaly (cardiothoracic ratio greater than 0.5 on a chest radiograph before hospital discharge) was a statistical predictor of subsequent cardiac events ($p < 0.02$), but not history of previous myocardial infarction, Killip classification III or IV,¹³ nor site of infarction (Table 4). None of these variables was a

Table 4 *Clinical variables related to likelihood of subsequent cardiac events. Figures are numbers of patients*

	Cardiac event (deaths)	No cardiac event	p value
Mean age (yr)	58.5 (54.7)	53.7	NS
Previous myocardial infarction	9 (4)	3	NS
Killip class III or IV	6 (2)	3	NS
Cardiomegaly	14 (6)	6	<0.02
Site of infarction:			
Anterior	14 (7)	10	NS
Inferior	16 (4)	19	NS
Non-transmural	5 (1)	10	NS

NS, not significant.

statistically significant predictor of subsequent mortality.

Of the 52 patients who underwent gate blood pool scanning before hospital discharge, 16 with exercise induced ST elevation had a left ventricular ejection fraction 40.6 (3.1%) (mean (SEM)), which was significantly less than that of 36 patients without exercise induced ST elevation who had a left ventricular ejection fraction 52.3 (2.2%) (mean (SEM)) ($p < 0.01$).

Discussion

The role of exercise testing early after acute myocardial infarction remains imprecise. The prediction of subsequent complications by exercise induced ST depression⁵⁻⁷ or a combination of abnormal exercise variables including ST depression¹¹ has been reported. Other investigators have found that exercise induced ST depression did not predict subsequent mortality but that exercise duration⁸ or angina^{4,9} did. Variable findings may be partly explained by differences in patient selection, exercise methodology, and timing.

The extent of myocardial damage is the single most important prognostic factor after myocardial infarction. Clinical indices of prognosis¹³⁻¹⁵ are indirect assessments of this, and more recent studies have shown the prognostic importance of a low left ventricular ejection fraction.¹⁶⁻¹⁹

In the present study ST elevation, ST depression, limited exercise duration, and an inadequate blood pressure response to exercise were all predictive of subsequent cardiac events when compared with patients with a normal exercise test. When data were analysed for the presence or absence of each variable, however, only exercise induced ST elevation predicted either cardiac death or cardiac events. Only six patients experienced exercise induced angina; five of these subsequently reported angina, two of whom died. Four had ST depression and one ST elevation induced by exercise. Because of the small number this group was not analysed separately.

EXERCISE INDUCED ST ELEVATION

The significance of exercise induced ST elevation after infarction is controversial. It occurs usually in the presence of transmural anterior infarction, as in this study, and has been thought to represent wall motion abnormality rather than myocardial ischaemia^{20,21} and to suggest single vessel coronary artery disease when unaccompanied by ST depression in other leads.²² One view is that "little significance should be attached to exercise induced ST elevation shortly after infarction when such changes occur in the leads bearing new Q waves,"²³ and this exercise variable has been discounted,² excluded from

analysis,⁷ or not specified in many studies.

Our finding of a significantly lower left ventricular ejection fraction in patients with exercise induced ST elevation soon after infarction is in accordance with other investigators,^{3,4} and a recent report suggests that ST elevation in this context may predict subsequent mortality.²⁴ Corbett *et al* also found exercise induced "ST change,"²⁵ which consisted of ST elevation or depression or both, more sensitive for the prediction of death or other cardiac events than ST depression alone, but as their study utilised supine bicycle exercise it may not be directly comparable.

The finding of a lower mean left ventricular ejection fraction in patients with exercise induced ST elevation suggests that this group of "higher risk" patients might be just as easily identified by clinical variables used to indirectly assess extensive left ventricular myocardial damage. In this study, however, only nine of the 21 patients with exercise induced ST elevation had any one of history of previous myocardial infarction, cardiomegaly, or Killip classification III or IV.

SITE OF MYOCARDIAL INFARCTION

Although the site of infarction was not a statistical predictor of cardiac events, there was a trend towards increased complications with anterior infarction (14 cardiac events, including seven deaths, from 24 cases of anterior infarction, NS). Most subjects with exercise induced ST elevation (17 of 21) had anterior infarction. When analysis was confined to patients with anterior infarction, however, exercise induced ST elevation was still predictive of subsequent cardiac events (13 cardiac events including six deaths, $p < 0.02$). It therefore seems unlikely that exercise induced ST elevation is merely a marker of transmural anterior infarction, which was shown to have a worse prognosis than infarction in other sites in the Framingham study.²⁶ Other studies have not, however, shown a higher long term mortality after anterior myocardial infarction compared with infarction in other sites, although it has been suggested that the early mortality may be higher.²⁷

LEAD SYSTEMS FOR EXERCISE TESTING

Twelve lead electrocardiograms were recorded during and after exercise in this study, as has been the case in other studies.³⁻⁶ Other investigators have used a variety of lead systems including a single bipolar lead⁷ 24 lead V5 only,⁸ leads V1, V5, and V6,¹¹ leads V4, V5, V6,⁹ Frank lead system,²⁵ and 16 lead precordial mapping.²⁸ In the present study exercise induced ST elevation occurred much more frequently, and exercise induced ST depression was also more common, when 12 lead recordings were assessed than when analysis was confined to lead V5. Multiple lead recording may, therefore, be superior to single lead

systems particularly in detecting exercise induced ST elevation.

INFLUENCE OF CORONARY ARTERY SURGERY AND BETA BLOCKADE

The influence of coronary artery bypass grafting after infarction remains undefined in asymptomatic or minimally symptomatic patients¹⁸ although it seems likely that the prognosis might be improved in those with multivessel coronary disease and reasonable preservation of left ventricular function.²⁹ The seven asymptomatic patients who underwent coronary artery bypass grafting had their period of follow up terminated at the time of surgery for this reason. Eighteen patients in all underwent coronary artery bypass surgery. These included six (29%) of those with ST elevation, 10 (36%) of those with ST depression, and three (9%) of those with no ST shift; one patient undergoing coronary artery bypass surgery had both exercise induced ST elevation and depression. The two patients who died—one of whom had ST depression and the other ST elevation—were already at high risk from complicated infarctions; thus any overall benefit conferred by surgery is likely to have been almost evenly distributed to each of the groups with ST depression or elevation. Nevertheless, of the seven asymptomatic patients, four had exercise induced ST depression and none had ST elevation.

Thirty one patients received beta blockade during the follow up period. These included 20 (71%) of those with ST depression in any lead, 14 (74%) of those with ST depression in lead V5, 10 (48%) of those with ST elevation, and six (19%) of those with no ST shift on the predischARGE exercise test. Five patients in this group had both ST depression and elevation induced by exercise in different leads. Only 13 of these 31 patients, however, received beta blockade for secondary prevention of future cardiac events^{30 31} in the absence of another clinical indication for the use of such agents. This small group of 13 patients contained nine (32%) of those with ST depression in any lead, seven (37%) of those with ST depression in lead V5, three (14%) of those with ST elevation, and three (9%) of those with no ST shift induced by exercise before hospital discharge. Among the 13 were five patients, four of whom had exercise induced ST depression, who also underwent coronary artery bypass grafting. Their follow up was terminated at the time of operation. A greater proportion of the group of patients who had exercise induced ST depression, therefore, received beta blockade for either therapeutic or prophylactic reasons or had follow up curtailed because of coronary artery bypass surgery compared with the groups who had either exercise induced ST elevation or no ST shift. Despite the small numbers involved this may partly explain

the diminished predictive power of exercise induced ST depression for subsequent cardiac events in this study compared with previous investigations.⁵⁻⁷

CONCLUSIONS

Exercise induced ST elevation early after infarction was associated with an increased risk of subsequent complications and with a lower left ventricular ejection fraction in this group of patients. It has been reported that coronary artery bypass surgery may abolish exercise induced ST elevation in patients with transmural infarction and suggested, therefore, that the underlying mechanism producing this feature may be myocardial ischaemia rather than merely wall motion abnormality.²⁸ Data from the Norwegian multicentre timolol trial³⁰ indicate that those patients who had the greatest reduction in cardiac death from beta blockade were those from the high risk groups which were categorised clinically but which were likely to have included those patients with lower left ventricular ejection fractions.³² Hence, surgical and medical treatment may both have significant beneficial roles in patients who have exercise induced ST elevation early after infarction. As this sign may not persist indefinitely after infarction,³³ and because risk of subsequent cardiac events is highest in the early months after acute infarction, it may be advisable to undertake exercise testing, preferably using a multiple lead system, before hospital discharge.

This study was supported by the National Heart Foundation of New Zealand.

References

- 1 Starling MR, Crawford MH, Richards KL, O'Rourke RA. Predictive value of early postmyocardial infarction modified treadmill exercise testing in multivessel coronary artery disease detection. *Am Heart J* 1981; 102: 169-75.
- 2 Akhras F, Upward J, Stott R, Jackson G. Early exercise testing and coronary angiography after uncomplicated myocardial infarction. *Br Med J* 1982; 284: 1293-4.
- 3 Fuller CM, Raizner AE, Verani MS, *et al.* Early post-myocardial infarction treadmill stress testing. An accurate predictor of multivessel coronary disease and subsequent cardiac events. *Ann Intern Med* 1981; 94: 734-9.
- 4 Schwartz KM, Turner JD, Sheffield LT, *et al.* Limited exercise testing soon after myocardial infarction. Correlation with early coronary and left ventricular angiography. *Ann Intern Med* 1981; 94: 727-34.
- 5 Smith JW, Dennis CA, Gassman AN, *et al.* Exercise testing three weeks after myocardial infarction. *Chest* 1979; 75: 12-16.
- 6 Davidson DM, DeBusk RF. Prognostic value of a single exercise test 3 weeks after uncomplicated myocardial

- infarction. *Circulation* 1980; **61**: 236-42.
- 7 Thérout P, Waters DD, Halphen C, DeBaisieux JC, Mizgala HF. Prognostic value of exercise testing soon after myocardial infarction. *N Engl J Med* 1979; **301**: 341-5.
 - 8 Weld FM, Chu KL, Bigger JT Jr, Rolnitzky LM. Risk stratification with low-level exercise testing 2 weeks after acute myocardial infarction. *Circulation* 1981; **64**: 306-14.
 - 9 Jelinek VM, McDonald IG, Ryan WF, Ziffer RW, Clemens A, Gerloff J. Assessment of cardiac risk ten days after uncomplicated myocardial infarction. *Br Med J* 1982; **284**: 227-30.
 - 10 Patterson JA, Naughton J, Pietras RJ, Gunnar RM. Treadmill exercise in assessment of the functional capacity of patients with cardiac disease. *Am J Cardiol* 1972; **30**: 757-62.
 - 11 Starling MR, Crawford MH, Kennedy GT, O'Rourke RA. Exercise testing early after myocardial infarction: predictive value for subsequent unstable angina and death. *Am J Cardiol* 1980; **46**: 909-14.
 - 12 DeBusk RF, Kraemer HC. Management strategies based on treadmill exercise testing and clinical evaluation soon after myocardial infarction [Abstract]. *Am J Cardiol* 1982; **49**: 933.
 - 13 Killip T III, Kimball JT. Treatment of myocardial infarction in a coronary care unit: a two year experience with 250 patients. *Am J Cardiol* 1967; **20**: 457-64.
 - 14 Peel AA, Semple T, Wang I, Lancaster WM, Dall JLG. A coronary prognostic index for grading the severity of infarction. *Br Heart J* 1962; **24**: 745-60.
 - 15 Norris RM, Caughey DE, Deeming LW, Mercer CJ, Scott PJ. Coronary prognostic index for predicting survival after recovery from acute myocardial infarction. *Lancet* 1970; **ii**: 485-7.
 - 16 Taylor GJ, Humphries JO, Mellits ED, *et al.* Predictors of clinical course, coronary anatomy, and left ventricular function after recovery from acute myocardial infarction. *Circulation* 1980; **62**: 960-70.
 - 17 Sanz G, Castañer A, Betriu A, *et al.* Determinants of prognosis in survivors of myocardial infarction: a prospective clinical angiographic study. *N Engl J Med* 1982; **306**: 1065-70.
 - 18 Norris RM, Agnew TM, Brandt PWT, *et al.* Coronary surgery after recurrent myocardial infarction: progress of a trial comparing surgical with nonsurgical management for asymptomatic patients with advanced coronary disease. *Circulation* 1981; **63**: 785-92.
 - 19 Dewhurst NG, Muir AL. Prognostic value of radionuclide ventriculography after first myocardial infarction [Abstract]. *Br Heart J* 1981; **45**: 611.
 - 20 Chahine RA, Raizner AE, Ishimori T. The clinical significance of exercise-induced ST segment elevation. *Circulation* 1976; **54**: 209-13.
 - 21 Castellanet MJ, Greenberg PS, Ellestad MH. Comparison of S-T segment changes on exercise testing with angiographic findings in patients with prior myocardial infarction. *Am J Cardiol* 1978; **42**: 29-35.
 - 22 De Feyter PJ, Majid PA, Van Eenige MJ, Wardeh R, Wempe FN, Roos JP. Clinical significance of exercise-induced ST segment elevation. Correlative angiographic study in patients with ischaemic heart disease. *Br Heart J* 1981; **46**: 84-92.
 - 23 Stang JM, Lewis RP. Early exercise tests after myocardial infarction. *Ann Intern Med* 1981; **94**: 814-5.
 - 24 Hossack KF, Sivarajan ES, Almes MJ, Belanger LG, Green B, Bruce RA. Prognostic value of ST elevation during low level treadmill testing early after myocardial infarction [Abstract]. *Am J Cardiol* 1982; **49**: 932.
 - 25 Corbett JR, Dehmer GJ, Lewis SE, *et al.* The prognostic value of submaximal exercise testing with radionuclide ventriculography before hospital discharge in patients with recent myocardial infarction. *Circulation* 1981; **64**: 535-44.
 - 26 Kannel WB, Sorlie P, McNamara PM. Prognosis after initial myocardial infarction: The Framingham Study. *Am J Cardiol* 1979; **44**: 53-9.
 - 27 Wasserman AG, Bren GB, Ross AM, Richardson DW, Hutchinson RG, Rios JC. Prognostic implications of diagnostic Q waves after myocardial infarction. *Circulation* 1982; **65**: 1451-5.
 - 28 Fox KM, Jonathan A, England D, Selwyn AP. Significance of exercise induced ST segment elevation in patients with previous myocardial infarction [Abstract]. *Am J Cardiol* 1982; **49**: 933.
 - 29 European Coronary Surgery Study Group. Prospective randomised study of coronary artery bypass surgery in stable angina pectoris. *Lancet* 1980; **ii**: 491-5.
 - 30 The Norwegian Multicenter Study Group. Timolol-induced reduction in mortality and re-infarction in patients surviving acute myocardial infarction. *N Engl J Med* 1981; **304**: 801-7.
 - 31 National Heart, Lung and Blood Institute. The Beta Blocker Heart Attack Trial. *JAMA* 1981; **246**: 2073-4.
 - 32 Norris RM. Beta-adrenoreceptor blockade after acute myocardial infarction. *Aust NZ J Med* 1982; **12**: 119-24.
 - 33 Starling MR, Crawford MH, Kennedy GT, O'Rourke RA. Treadmill exercise tests predischARGE and six weeks postmyocardial infarction to detect abnormalities of known prognostic value. *Ann Intern Med* 1981; **94**: 721-7.