Br Heart J 1993;70:428–432

First myocardial infarction in patients under 60 years old: the role of exercise tests and symptoms in deciding whom to catheterise

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Abstract

***Objective*—To determine the role of exercise tests and assessment of angina in the detection of potentially threatening disease in young patients with infarcts.**

***Design*—Elective readmission of patients at a mean (SD) of 60 (30) days after acute myocardial infarction for assessment of angina, treadmill exercise tests, and cardiac catheterisation.**

***Setting*—Cardiology department of a teaching hospital.**

***Patients*—186 consecutive survivors, aged under 60 years and discharged from the coronary care unit after a first myocardial infarction.**

***Main outcome measures*—Coronary arteriography, presence of angina, result of exercise tests, and referral for revascularisation.**

***Results*—31% of patients had either two vessel disease (with proximal left anterior descending involvement), three vessel disease, or left main stem disease. 49% of all patients had angina. Of the 173 patients who had an exercise test 34% had 1 mm and 24% had 2 mm of exercise induced ST depression. Thirty percent had no angina and a negative exercise test: after a mean (SD) follow up of 16 (4) months none of this symptom free subgroup had died, had experienced a further myocardial infarction, or had been referred for revascularisation. 79% of patients with either two vessel disease (with proximal left anterior descending involvement), three vessel disease, or left main stem disease had either angina or a 1 mm ST depression during the exercise test.**

***Conclusion*—Patients without cardiac pain after myocardial infarction and without ST changes during an exercise do not need arteriography.**

(*Br Heart J* 1993;70:428–432)

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Accepted for publications 9 June 1993

After myocardial infarction it has been thought desirable to know the coronary anatomy, and through this define an individual patient's risk and suitability for revascularisation. There is, however, no established policy as to which patients should be offered coronary arteriography.

It is known that in patients with angina, the more extensive the coronary artery disease, the worse the prognosis.[1] The presence of stenosis of the left main stem with angina has a particularly poor short term survivial,[2] the actual risk increasing with the severity of the stenosis.[3] Left ventricular impairment is also a predictor of long-term outcome.[4]

In patients with stable coronary artery disease, coronary artery surgery has been shown in the short-term to improve prognosis in patients with angina and either severe disease of the proximal left anterior descending artery, three vessel disease, or disease of the left main stem.[5 6] It has been assumed that after a myocardial infarction, patients with multivessel disease have a poor prognosis, and that it is possible to improve this prognosis with surgery. Furthermore it has been suggested that an exercise test can identify those patients with multivessel disease at high risk.[7 8]

To determine the role of exercise tests and angina in the detection of multivessel disease after acute myocardial infarction, we have investigated a consecutive series of young survivors with this condition.

Patients and methods

PATIENTS

For 18 months, starting in March 1990, all admissions to the coronary care unit at Aberdeen Royal Infirmary with their first acute myocardial infarction were identified. The 191 survivors aged under 60 years were electively readmitted at a mean (SD) of 60 (30) days for an exercise test, assessment of angina, and cardiac catheterisation.

DIAGNOSIS OF INFARCTION

The diagnosis of myocardial infarction was based on the presence of two of the following criteria: the development of new Q waves or the evolution of characteristic ST-T wave changes on the electrocardiogram; a typical history of chest pain persisting for at least 30 minutes; a rise in concentration of cardiac enzymes to twice the upper limit of normal.

The site of infarction was determined from the resting electrocardiogram: in anterior infarction changes were in leads V1–6, I, and aVL, and in inferior infarction in leads II, III, and aVf.

ASSESSMENT OF ANGINA

The presence of angina was determined by asking the patient to complete a Rose questionnaire.[9] Angina was defined as exercise induced pain or discomfort affecting the sternum or left anterior chest and left arm, which resolved on stopping or slowing down, and disappeared within 10 minutes of standing still. The severity of angina was not taken into account. The questionnaire was modified slightly in that the questions relating to the presence of previous myocardial infarction and to peripheral vascular disease were omitted (figure).

EXERCISE TEST

All patients were requested not to take any cardioactive medication for 24 hours before performing the exercise test.

Exercise tests were performed on a treadmill according to the Bruce Protocol. A 12 lead electrocardiogram, blood pressure, and heart rate were recorded at rest and at three minute intervals throughout the test. After the test, data were collected every three minutes until any ST changes had resolved or the resting heart rate had approached that observed at rest, whichever was later.

Exercise was stopped if the patient developed limiting symptoms, ventricular arrhythmias, profound ST segment depression (>3 mm as well as any resting changes), or a fall in systolic blood pressure of >20 mm Hg compared with the standing, pre-exercise reading. Exercise induced ST segment depression, with or without chest pain, of >1 mm or >2 mm at 80 ms beyond the J point of the QRS complex was taken to indicate reversible ischaemia.

An exercise test not showing any additional ST segment changes was considered negative if >85% of the maximal age related predicted heart rate was achieved, or inadequate if this target heart rate was not achieved. Exercise tests were reported independently by two observers; discrepancies were settled by a third.

CARDIAC CATHERISATION

All patients underwent coronary arteriography by the Judkins technique. Multiple views of each coronary artery were taken. The catheter data were reviewed independently by two observers; discrepancies were settled by a third. A reduction of luminal diameter of >50% of the left main stem, LAD, circumflex, or right coronary arteries was regarded as indicating a significant stenosis. Significant disease of the left anterior descending coronary artery (LAD) was subdivided into proximal or distal disease. In proximal disease the lesion was at or before the origin of the first septal branch. Patients were thereby classified as having normal coronary arteries, single, two or three vessel disease, or left main stem disease. A patient identified as having significant left main stem disease was put into that group irrespective of any additional coronary artery disease. Patients were placed in only one category.

END POINTS

Follow up was for a mean (SD) of 16 (4) months. Follow up was ended by death, readmission with further myocardial infarction, or after bypass surgery or angioplasty. Onset or worsening of angina, and arrhythmias were noted.

Results

Of the 191 patients identified, four patients died suddenly and unexpectedly shortly after discharge from the first admission: one took his own discharge shortly after admission and died a week later; one had left ventricular failure; and two had an otherwise uncomplicated hospital stay. One patient committed suicide. Table 1 shows the characteristics of the remaining 186 patients who underwent investigation.

It was not possible to perform exercise tests in 13 patients: five had unstable angina; one had aortic stenosis; three refused; and four

POST MI QUESTIONNAIRE

INSTRUCTIONS: for each question (a) to (g), mark with an X next to the most appropriate statement. If your answer is NO to (a) or (b), there is no need to answer any more questions.

(a) Since discharge from hospital after your heart attack have you had any pain or discomfort in your chest?
1.YES____ 2.NO____(do not answer any more questions)

(b) Do you get this pain or discomfort when you walk uphill or hurry?
1.YES____ 2.NO____(do not answer any more questions)

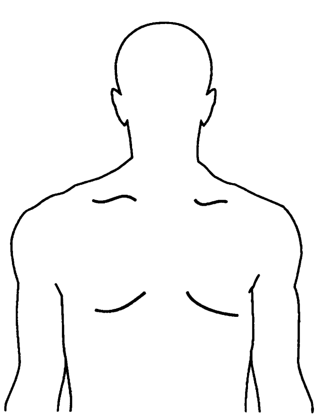
(c) Do you get it when you walk at an ordinary pace on the level?
1.YES____ 2.NO____

(d) When you get any pain or discomfort in your chest what do you do?
1.STOP____
2.SLOW DOWN____
3.CONTINUE AT THE SAME PACE____

(e) Does it go away when you stand still?
1.YES____ 2.No____

(f) How soon?
10 MINUTES OR LESS_____
MORE THAN 10 MINUTES___

(g) Where do you get this pain or discomfort?
Mark the place(s) with X on the diagram.



Modified Rose questionnaire.

Table 1 Characteristics of patients

Characteristic	Value
No	186
Men	144 (77%)
Mean (SD) age (yr)	51 (6)
Age range (yr)	35–59
Median age (yr)	53
Site of infarct:	
Anterior	90 (48%)
Inferior or posterior	96 (52%)
Received thrombolytic drug	136 (73%)

Table 2 Extent of coronary artery disease and incidence of angina

Extent CAD	No (% of total)	Angina (% of group)
0 VD	20 (11%)	6 (30%)
1 VD	78 (42%)	33 (42%)
2 VD	54 (29%)	30 (56%)
LAD + 1 VD	23 (12%)	12 (52%)
3 VD	28 (15%)	18 (64%)
LMS	6 (3%)	4 (67%)

CAD, coronary artery disease; LAD + 1VD, two vessel disease with proximal left anterior descending artery affected; LMS, stenosis of the left main stem; VD, vessel disease.

were incapable of exercise because of physical disability.

Table 2 shows the extent of coronary artery disease and presence of angina. About half of our patients had either essentially normal coronary arteries or single vessel disease. With increasing extent of coronary artery disease there was a tendency for the presence of angina to be more likely, but this did not reach significance (χ^2 test).

Table 3 shows the results of the exercise tests with either 1 or 2 mm of exercise induced ST depression for the diagnosis of ischaemia. With increasing extent of coronary artery disease a patient was more likely to have a positive exercise test ($p < 0.01$ for both 1 and 2 mm of ST depression, χ^2 test), and less likely to have a negative exercise test ($p < 0.01$ for 1 mm, $p < 0.05$ for 2 mm ST depression, χ^2 test).

When 1 mm of exercise induced ST depression was used for the diagnosis of ischaemia 35 patients were judged to have a technically inadequate test: this was due to shortness of breath in 10, failure to omit β blockers in nine, fatigue in eight, bundle branch block in three, dizziness in two, arthritis in one, claudication in one, and arrhythmia in one. When 2 mm of ST depression was used as the diagnostic criterion the number of inadequate tests were 40. In the additional five patients this was due to shortness of breath in one, exhaustion in three, and chest pain in one. The proportion of patients with an inadequate exercise test was not affected by the extent of coronary artery disease (NS, χ^2 test). This was true for either 1 or 2 mm of ST depression.

Table 4 shows the effect of combining angina and exercise tests. With increasing extent of coronary artery disease a significantly higher proportion of patients exhibited ischaemia ($p < 0.01$ for 1 mm and $p < 0.05$ for 2 mm of ST depression or angina, χ^2 test). With increasing extent of coronary artery disease there was less chance of a patient not having either angina or 1 mm of ST depression on exercise ($p < 0.05$, χ^2 test). This was not significant for the presence of either angina or 2 mm of ST depression. About 80% of patients with three vessel or left main stem disease had either a positive exercise test or angina. Table 5 shows the patients with both angina and a positive exercise test. With increasing extent of coronary artery disease a patient was more likely to have both angina and a positive exercise test ($p < 0.01$ for both 1 and 2 mm of ST depression).

The mean (SD) exercise time of those patients with a positive exercise test (1 mm ST depression) who had two vessel disease involving the proximal LAD, three vessel disease, or left main stem disease was 466 (167) seconds. This was not significantly different from the mean (SD) exercise time of 462 (157) seconds for those patients with normal coronary arteries, single vessel disease, or two vessel disease not involving the proximal LAD and who had a positive exercise test (unpaired t test). When 2 mm of ST depression was used these mean (SD) times were 471 (166) and 455 (162) seconds, which again are not significantly different (unpaired t test).

Table 6 shows the numbers of patients in each diagnostic group who were referred for revascularisation at the time of arteriography. The only patient without coronary arterial stenosis who underwent surgery had ectatic

Table 3 Results of exercise tests

Extent CAD (No)	1 mm ST depression (%) +ve	1 mm −ve	1 mm I	2 mm ST depression (%) +ve	2 mm −ve	2 mm I
OVD (18)	3 (17)	12 (66)	3 (17)	2 (11)	12 (67)	4 (22)
1VD (73)	16 (22)	39 (53)	18 (25)	10 (14)	45 (61)	18 (25)
2VD (52)	20 (39)	22 (42)	10 (19)	15 (29)	24 (46)	13 (25)
LAD + 1VD (23)	7 (30)	11 (48)	5 (22)	5 (22)	12 (52)	6 (26)
3VD (24)	15 (63)	6 (25)	3 (12)	10 (42)	11 (46)	3 (12)
LMS (6)	5 (83)	0 (0)	1 (17)	4 (67)	0 (0)	2 (33)

I, inadequate; +ve, positive; −ve, negative exercise test. Other explanations as for table 2.

Table 4 Patients with ischaemia (angina or exertional ST depression), without ischaemia, and with no angina and an inadequate exercise test

Extent CAD (No)	1 mm ST depression (%) Angina or +ve	1 mm No angina −ve	1 mm No angina I	2 mm ST depression (%) Angina or +ve	2 mm No angina −ve	2 mm No angina I
OVD (18)	8 (44)	9 (50)	1 (6)	8 (44)	9 (50)	1 (6)
IVD (75)	40 (53)	26 (35)	9 (12)	39 (52)	27 (36)	9 (12)
2VD (54)	38 (70)	12 (32)	4 (8)	37 (69)	13 (24)	4 (7)
LAD + 1VD (23)	16 (70)	4 (25)	3 (5)	15 (65)	5 (31)	3 (4)
3VD (27)	23 (85)	4 (15)	0 (0)	21 (78)	6 (22)	0 (0)
LMS (6)	5 (83)	0 (0)	1 (17)	5 (83)	0 (0)	1 (17)

Explanations as for table 3.

Table 5 Patients with angina and a positive exercise test

Extent CAD (No)	Angina + 1 mm ST depression (%)	Angina + 2 mm ST depression (%)
OVD (18)	1 (6)	0 (0)
1VD (73)	9 (12)	4 (5)
2VD (52)	12 (23)	8 (15)
LAD + 1 VD (23)	3 (13)	2 (9)
3VD (24)	10 (42)	7 (29)
LMS (5)	4 (67)	3 (50)

Explanations as for table 3.

Table 6 Patients referred for revascularisation at the time of arteriography

Extent CAD (No)	*CABG*	*PTCA*
0VD (20)	1 (5%)	0 (0%)
1VD (78)	1 (1%)	5 (6%)
2VD (54)	5 (9%)	2 (4%)
LAD + 1VD (23)	3 (13%)	0 (0%)
3VD (28)	11 (39%)	0 (0%)
LMS (6)	4 (67%)	0 (0%)

Explanations as for table 3.
CABG coronary artery bypass graft; PTCA percutaneous coronary angioplasty.

left and right coronary arteries, angina, and a positive exercise test. The patients with single vessel disease and two vessel disease (with normal proximal LAD) who underwent surgery were referred because of symptoms (three had unstable angina). The patients with two vessel disease and proximal LAD involvement, three vessel disease, and left main stem disease who did not undergo surgery were not referred because they either had little or no angina, or because they underwent successful angioplasty for unstable angina. It was of interest that one of the two with left main stem disease not referred for surgery was able to finish the Bruce protocol, although he did have ST depression of 1 mm or more from the eighth minute. Of the 23 patients with no angina but a positive exercise test (1 mm of ST depression), only three were referred for surgery.

During follow up five patients died: two immediately after by pass surgery; two on the waiting list for surgery; and one awaiting angioplasty. Those patients whose deaths were unrelated to surgery had either three vessel disease or two vessel disease with proximal LAD involvement.

Twelve patients, initially symptom free, developed angina. All were treated medically. Seven patients developed worsening angina and were referred for surgery or angioplasty. One patient had a non-fatal myocardial infarction.

None of the 55 patients without angina and with <2 mm of ST depression during the exercise test (30% of all patients) died, had a further myocardial infarction, or were referred for surgery or angioplasty. Table 7 shows the coronary arteriographic findings in these patients. Only 11% had three vessel disease and none had left main stem disease. During follow up six of this symptom free group developed angina and two have developed atrial fibrillation, one sustained, one paroxysmal.

Table 7 Findings of coronary arteriography in patients without angina and with <2 mm of ST depression during exercise test

Extent CAD	*No (%)*
0VD	9 (45)
1VD	27 (35)
2VD	13 (24)
LAD + 1VD	5 (22)
3VD	6 (21)
LMS	0 (0)

Explanations as for table 3.

Discussion

After a myocardial infarction, many cardiologists will attempt to stratify a patient's risk by a combination of assessment of symptoms and exercise tests, with the intention of performing cardiac catheterisation on those thought to be at high risk. Patients without angina (either before, or after infarction), symptomatic ventricular arryhthmias, left ventricular failure, cardiomegaly, or an abnormal modified Naughton exercise test (ST depression, abnormal blood pressure response, or angina), before discharge represent a low risk group.[10]

The Bruce protocol exercise test has been reported to have high sensitivity and specificity in identifying patients with multivessel disease who presented with a myocardial infarction,[7 8] as has the Ellestad protocol,[11] whereas the modified Naughton protocol before discharge has not.[12 13] The exercise test can also predict which patients are likely to undergo by pass surgery subsequently,[14] and those who are unlikely to die or reinfarct.[15-17]

For patients under 60 there seems to be a lower threshold for performing this investigation, perhaps on no more than emotional grounds and yet patients over 60 have the poorer long term outcome.[18] We need to know if we should be considering all younger patients for catheterisation after infarction.

We studied a young population with infarcts to assess the role of assessment of angina or exercise tests in identifying those patients with potentially threatening disease. Our study population represents 87% of patients under 60 years of age who presented with acute myocardial infarction to the Aberdeen hospitals.[19] The time to subsequent elective admission was dependent on the waiting list for cardiac catheterisation, which increased during the period of the study.

Although after a myocardial infarction it is possible with exercise tests to identify patients at high risk this is perhaps only of value if the long-term outcome can be favourably influenced. The European Coronary Surgery Study evaluated the effect of medical surgical treatment on survival in men under 65 with stable, mild to moderate angina, at least two vessel disease and good left ventricular function. After five to eight years of follow up, surgery was shown to improve survival in the total population, in patients with three vessel disease, and in those with stenosis of the proximal LAD as a component of two or three vessel disease.[6] The 12 year survival rates favoured the surgically treated patients. No specific group benefited significantly.[20]

The Coronary Artery Survival Study considered the effect of surgery *v* medical treatment in patients aged under 65, who either had mild to moderate angina or were symptom free survivors of myocardial infarction. After five years of follow up there was no significant difference in survival in either treatment group.[21] Surgery did not prevent myocardial infarction.[22] At seven years patients with three vessel disease and ejection fractions <50% had improved survival with surgery.[23] At 10 years surgery benefited patients who had an ejection fraction <50%.[24]

In a study of symptom free or mildly symptomatic patients under 60 years who have had two or more myocardial infarctions, bypass surgery compared with medical treatment did not reduce mortality, after 4·5 years of follow up.[25] At present angioplasty has not been shown to affect prognosis in coronary artery disease.

In a study of angioplasty in patients with previous myocardial infarction, occlusion of the infarct related coronary artery did not cause pain as frequently as occlusion of the non-infarct related artery. This was thought to be secondary to damage of afferent pain fibres at the time of infarction.[26] Silent ischaemia after a myocardial infarction has been shown to carry the same prognosis as symptomatic ischaemia.[27 28] Therefore, after myocardial infarction, it does not seem appropriate to restrict our investigation to only those patients with angina (49% of our study group).

We have deliberately not discussed the left ventricular function of our patients, as although this variable is important for prognosis,[29-32] it can be measured non-invasively.

In our study the total exercise time in patients with a positive exercise test was not helpful in differentiating patients with multivessel disease from those with either normal coronary arteries, single vessel disease, or two vessel disease not involving the proximal LAD.

We have found that most of our patients had either angina or a positive exercise test (69% for 1 mm ST and 67% for 2 mm ST depression). This does not include the six patients without angina who did not have an exercise test, nor the 15 patients without angina who had an inadequate exercise test, one of whom had stenosis of the left main stem; his exercise test was inadequate because of left bundle branch block.

Although it might seem desirable to know the coronary anatomy of all young patients with myocardial infarction, this knowledge does not appear to have affected our management. We have found that of those 55 patients without angina and with a negative exercise test (with 2 mm of ST depression for the diagnosis of ischaemia), which is 30% of all patients, none has died, suffered a further myocardial infarction, or has been referred for revascularisation. About one third of these patients had multivessel disease.

Therefore, not every young infarct patient requires coronary arteriography, but perhaps only those with reversible ischaemia or an inadequate exercise test (about 70% of our series), so that potentially threatening multivessel and left main stem disease can be detected. This would have significant implications for costs and waiting lists.

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