Arrhythmias and symptoms during treadmill testing three weeks after myocardial infarction in 100 patients

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Treadmill tests with continuous electrocardiographic recording were carried out 3 weeks after the acute episode began on 100 patients with myocardial infarction. Ventricular premature beats were recorded in 3 patients at rest immediately before the test, and in 19 during and/or after the test. The test led to a change of treatment for 16 patients. No severe arrhythmias or reinfarctions were induced by the test. Twenty patients developed angina pectoris. The incidence of ventricular premature beats during the test was higher in the patients with arrhythmia during the acute phase (10/37) than in those without (7/55). This difference is not statistically significant. The treadmill test proved to be a sensitive method for demonstrating a tendency to arrhythmia in patients with recent infarction. It permits observation of the patient during exercise similar to that performed during rehabilitation.

The mortality rate of patients with myocardial infarction during the first year after discharge from hospital is said to be approximately 8 per cent (Pell and D'Alonzo, 1964). Many die suddenly, probably because of ventricular arrhythmia (Lown, Kosowsky, and Klein, 1969). Mortality in patients with coronary heart disease appears to be greater in patients with ventricular premature beats than in those without (Chiang *et al.*, 1969).

A two-year follow-up of men who had suffered myocardial infarction disclosed a mortality twice as high for patients with frequent ventricular premature beats in a single electrocardiogram than for those with rare or no ventricular premature beats. The difference was significant even after correction for coronary heart disease risk factors (Lown and Wolf, 1971). The discovery of a tendency to ventricular arrhythmia soon after infarction would be a help in the choice of treatment. Ventricular arrhythmia is more likely to be detected during brief, moderately heavy exercise than during continuous ambulatory monitoring for two hours (Kosowsky *et al.*, 1971). Therefore, we arranged for patients with acute myocardial infarction to perform a standardized functional test on a treadmill, immediately before planned discharge. The test was also intended

to assist in evaluating the patient's functional state as a means of arriving at individualized programmes of management.

Subjects

The study comprises 100 consecutive exercise tests on a treadmill performed by patients with acute myocardial infarction in the period April 1970 to October 1971. There were 97 patients altogether (90 men and 7 women), 3 being examined a second time because of reinfarction. All were treated in the hospital's coronary care unit which serves a population of 180,000. The tests were performed immediately before the planned discharge from hospital, i.e. a mean of 21 days after the acute episode began. A total of 228 patients with infarction (174 men and 54 women) attended the unit during the period in question. Of these, 44 died during their stay in the hospital and 95 of the remaining 184 were older than 65 years. Nobody above this age was tested on the treadmill during the first half of the study, owing to a lack of resources, and only 16 during the second half. Of the remaining patients under 65, 8 were not tested. A lack of beds in the unit made it necessary to move 5 of these to another ward during the second week and the other 3 had complicating disorders (hemiplegia, fracture of the neck of the femur, and malignancy, respectively).

The distribution by age and sex for the 100 patients in the study is shown in Fig. 1 (the 3 patients with 2 infarction episodes are counted as 6 patients). Seventy-

Received 27 December 1972.

FIG. 1 The age and sex of the 100 patients.

FIG. 2 Maximum aspartate aminotransferase in 93 patients.

five cases were evaluated as first infarctions, 20 as second, 3 as third, and 2 as fourth. The maximum values for serum aspartate aminotransferase (IU) for 93 patients are shown in Fig. 2 (7 patients were admitted more than 3 days after the onset of symptoms). Heart volume was determined radiologically in a conventional manner

with the patient upright, using the formula of Jonsell (1939). The relative heart volume was more than 500 ml/m² body surface area in 49 men and more than 450 ml/m² in 4 women. No one had a heart volume greater than 750 ml/m².

The sites of infarction according to the electrocardiogram are shown in Table 1. A definite site could be identified in 94 patients. Of the remaining 6, 3 had had previous myocardial infarction, one displayed transient ST depression corresponding to the anterior wall as the only electrocardiographic change, one had left bundle-branch block, and one had non-specific electrocardiographic changes.

A minimum of 2 of the following 3 criteria were required for diagnosis.

- 1) Acute central chest pain, lasting more than 30 minutes.
- 2) A rise of aspartate aminotransferase with values

TABLE 1 Site of myocardial infarctions in 94 patients

Location	No.
Anteroseptal/anterolateral	50
Diaphragmatic	36
Posterior	6
Anteroseptal/anterolateral + diaphragmatic	1
Diaphragmatic + posterior	1

TABLE 2 Ventricular arrhythmias during monitoring day 1-3, during rest, and before, during, and after treadmill test

	No. of patients with ventricular premature beats				Ventricular fibrillation	Total no. of patients with ventricular arrhythmias
	≥ 5/min					
	Series					
	Unifocal	Multifocal	2-3	≥ 4		
During monitoring	11	3	24	8	1	37
During rest before treadmill test	2	1	—	—	—	3
During and after treadmill test	6	8	7	1	—	19

higher than those of alanine aminotransferase (in International Units, IU). Serum lactic dehydrogenase (IU) isozyme assay helped to confirm the diagnosis in a few cases in which the aspartate aminotransferase was only slightly raised.

3) Electrocardiographic pattern consistent with infarction. Posterior localization of the infarction was confirmed by vectorcardiogram (Frank system).

The patients were mobilized during their hospital stay with the aid of a physical therapist: the programme allowed for visits to the lavatory from the second or third day and an ambulatory regimen from the seventh to the tenth day. In the third week patients were allowed to climb stairs. Mobilization proceeded more slowly for 7 patients with serious arrhythmia and/or myocardial insufficiency.

Methods

All patients were examined before discharge from hospital, with treadmill tests at a walking speed of 0.5 m/sec. The mechanical work was derived from body weight, velocity, and the angle of inclination of the treadmill by the use of a nomogram. (Mechanical work in kpm/min = $\sin \alpha \times 60 \times a \times b$. α = angle of inclination in degrees, a = treadmill velocity in m/sec, b = body weight in kg.)

Usually the first load was 100 or 200 kpm/min (approximately 16 or 33 Watt, respectively), depending on age, sex, and clinical condition. The intention was to achieve a maximal heart rate of approximately 120 beats/min. If the heart rate after 4 to 6 minutes on the treadmill was below 120 beats/min and the patient had no distress, he was allowed to continue at a higher load.

The treadmill was a standard Collins (P2000) 1-8 NPH, fitted with an angle measuring device which permitted settings with an accuracy of $1/6^\circ$, and a calibrated speedometer with an accuracy of 0.10 m/sec. With a constant velocity and the angles used in the study oxygen consumption in a healthy subject displays an approximately linear relation to the angle of inclination and therefore to the mechanical work (Bobbert, 1960). This should also apply to a coronary patient. When comparing individuals with different body weights, however, mechanical work is a better measure of the circulatory demands imposed by exercise than the angle of inclination and treadmill velocity alone, the latter being conventional measures.

The electrocardiogram was recorded at recumbent rest for 1 minute, in a standing position before the test, and continuously during and for the first 10 minutes after exercise. Post-exercise recordings were made with the patient recumbent. During exercise, chest-head leads ($CH_1, 2, 3, 4, 5, 7$) were used with the reference electrode on the forehead. Before and after exercise, the corresponding chest-right arm leads ($CR_1, 2, 3, 4, 5, 7$) were used in addition to extremity leads.

A 6-channel direct-writing Mingograf 81 electrocardiogram (Elema-Schönander AB) was used for the recordings. The electrocardiogram was monitored continuously on an oscilloscope throughout the examination.

The functional test was stopped in the event of the following occurring: (1) angina pectoris or dyspnoea; (2) frequent ventricular premature beats; (3) heart rate exceeding 140 beats/minute.

The functional test was continuously supervised by a physician.

Results

The test was ended at a work load of 100 kpm/min in 11 patients, at 200 kpm/min in 59, at 300 kpm/min in 5, and at 400 kpm/min in 23; 1 patient continued to 500 kpm/min and another to 600 kpm/min. The average duration of exercise at the final load was five minutes. The mean maximal heart rate during the test was 118/min. Twenty patients developed angina pectoris, and 5 pronounced dyspnoea and/or fatigue. All complaints had disappeared 10 minutes after the conclusion of exercise. The incidence of ventricular premature beats during the acute stage and during the treadmill test is shown in Table 2. No severe arrhythmias or reinfarctions were induced by the test.

Ventricular premature beats (5 or more per minute or a series of at least 2) were recorded in only 3 patients at rest immediately before the test and in 19 during or within 10 minutes after exercise. Of the 3 patients with premature beats at rest, 2 were included in the 19. Of these 19 patients, 6 were on antiarrhythmic therapy.

Of the 92 patients continuously monitored during the first two to three days of the acute phase, 37 had either 5 or more ventricular premature beats a minute or a series of at least 2. Of these 37 patients, 10 also had this arrhythmia during the functional test; five of them were on antiarrhythmic therapy. Of the 55 patients without ventricular arrhythmia during the acute phase, only 7 displayed ventricular premature beats during the functional test; one of them was on antiarrhythmic treatment. Thus the incidence of ventricular premature beats during the treadmill test was higher in the patients with arrhythmia during the acute phase (10/37) than in those without (7/55). This difference is not statistically significant.

At the time of the test antiarrhythmic therapy (procainamide 0.5 g four times daily in most cases) was given to 16 of the 37 patients in the former group (43%) and only 7 of the 55 (13%) in the latter. Sixty-one patients were being treated with digitalis and/or diuretics. The test led to a change in the drug treatment of 16 patients, most frequently to the initiation of antiarrhythmic therapy (11 patients). Eight patients had their hospital stay prolonged and were retested. One patient performed 3 treadmill tests and another patient 4 before discharge.

All patients were followed up for a minimum of

three months after the onset of symptoms. During this period, 5 patients died, 4 of them suddenly and 1 after reinfarction with cardiogenic shock. Of the 4 patients who died suddenly, 2 had had ventricular premature beats during the treadmill test; in one of them the beats had been frequent and multifocal during 4 tests performed before discharge, despite the use of various antiarrhythmic drugs. The other 2 patients who died suddenly had had no arrhythmia during the treadmill test. One of them had developed angina pectoris and the test was stopped after 4 minutes at 200 kpm/min; this patient died in the shower immediately before discharge some days after the test. The other had to discontinue the test because of a high heart rate (137 beats/min at 200 kpm/min) and mild dyspnoea. Of the 5 patients who died in these 3 months, 4 had cardiomegaly and 3 had had angina pectoris during the treadmill test.

During exercise a positive T developed in the electrocardiogram in 24 patients who had an inverted T at rest. The ST segment was raised above the baseline in 44 patients by a mean of 0.18 mV in leads reflecting the infarcted area. In the patients with diaphragmatic infarction, such repolarization changes could not be recorded until after work, since extremity leads were not used during exercise. Fifty-nine patients had one or both of these electrocardiographic abnormalities. Similar abnormalities during exercise have been reported by Atterhög, Ekelund, and Kaijser (1971).

Discussion

This study shows that a tendency to arrhythmia soon after an acute myocardial infarction can be demonstrated with treadmill tests more frequently than with routine electrocardiograms at rest. Moreover, the test made it easier to determine the factors limiting the patient's work capacity. There were no

indications that the procedure described involved any risks. We could not find any published reports about the use of standardized exercise tests for the detection of arrhythmia in this early phase after myocardial infarction.

At three-month follow-up the mortality was higher in the group of patients with ventricular premature beats at the treadmill test (2/19) than in that without (2/81). To evaluate the importance of this finding we plan further studies.

Treadmill tests provide an opportunity of observing the patient during exercise similar to that to be prescribed for rehabilitation.

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