The immediate antecedents of myocardial infarction in active men

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Summary: The antecedents of myocardial infarction have been reviewed in 102 patients (117 episodes) undergoing a program of rehabilitation. The year prior to the first attack was characterized by business and social problems, with some weight gain; in the week before the attack there was added tiredness, poor general health and, in some cases, increasing anginal pain. Heavy lifting and/or unusual exercise were common immediately before or during an attack; five attacks were related to the shovelling of wet snow.

Both bed and the normal place of work were uncommon sites for an attack. More than 50% of patients had 30 minutes' warning of infarction. The relevance of these findings to a safe program of therapeutic exercise is discussed.

Résumé: *Les événements précédant immédiatement l'infarctus du myocarde des hommes actifs.*

Les auteurs ont analysé les événements qui ont précédé la survenue d'un infarctus du myocarde chez 102 malades (117 épisodes) soumis à la réadaptation. Durant l'année qui précédait la première crise cardiaque, on retrouvait la présence de difficultés sociales et de problèmes d'affaires et une certaine tendance à l'embonpoint. La semaine précédant la crise était marquée par une plus grande fatigabilité, un état de santé médiocre et, en certains cas, par une plus grande douleur angineuse. On notait souvent un violent effort (levée de lourdes charges ou exercices inaccoutumés, parfois les deux) durant la période précédant immédiatement la crise, soit durant celle-ci. Dans cinq cas, la crise était survenue chez des malades en train de pelleter une neige lourde.

Il était rare que la crise se produisit au lit et au lieu ordinaire du travail. Plus de la moitié des malades signalaient un avertissement 30 minutes avant l'infarctus. L'article fait état de ces constatations et analyse leur importance au sein d'un programme thérapeutique d'exercices physiques exempt de risques.

Physicians who establish an exercise program for the rehabilitation of the post-coronary patient are in a vulnerable position. The natural history of the disease is such that over a five-year period 20 to 25% of patients will die.[1,2] Furthermore, while the long-term effect of exercise seems beneficial, the likelihood of a recurrence of the coronary attack during vigorous physical activity is substantial.[3-5] It would therefore be of great practical value to identify the circumstances likely to produce such a recurrence, and to determine to what degree the likelihood of a favourable outcome may be influenced by the detection of premonitory symptoms.

The majority of previous relevant reports[6-13] have been based on retrospective analyses of fatal episodes. Furthermore, some[9,10,12] of these studies have failed to distinguish between young, active patients and older or even bed-ridden individuals. The present study is based upon a specific and detailed re-examination of non-fatal episodes in a group of middle-aged (30 to 60 years) active patients engaging in a program of rehabilitation following myocardial infarction.

Methods

Statistical analysis

A total of 102 male patients (117 attacks) were included in the analysis. Their clinical and physiological characteristics have been the subject of previous articles,[15,16] and it is sufficient to note here that all were referred by their physicians for a program of cardiac rehabilitation which emphasized physical conditioning. The typical patient was a middle-class executive, aged 45, seen three to six months following infarction. The characteristics of the original episode and any recurrences were evaluated by having the patient complete, anonymously, a questionnaire (largely multiple-choice items) under the supervision of one of us.*

The data of Tables I, II and IV have been subjected to a simple chi-squared analysis. In Tables I and II the hypothesis tested has been that complaints are normally distributed, with an equal proportion of patients reporting increased and decreased symptoms. For each symptom, we have noted the number of patients with increased

*Copy available upon request.

(P) and the number with decreased severity of the complaint (Q). According to our hypothesis the expected frequency is (P+Q)/2 and the discrepancy from expectation P—(P+Q)/2 or, applying Yates's correction for discontinuity, P—(P+Q)/2—0.5. The corresponding variance is given by (P+Q)/4, so that χ^2 may be calculated as

$$\chi^2 = \frac{P-(P+Q/2-0.5}{(P+Q)/4}$$

In Table IV we have tested the hypothesis that the observed frequency of coronary attacks during a specific type of activity is equal to that anticipated from the proportion of the average day devoted to the activity; again, we have applied Yates's correction to our calculation of chi-squared.

Results

1. Condition of patient prior to attack

The patients' assessments of their condition one year and one week prior to the attack are summarized in Tables I and II respectively. The predominant feature recorded was an increase of business problems. The specific nature of the problems may be illustrated by four examples:

1. "I was a stock broker. The market was falling and my clients were losing money. This made me feel badly. I was also losing money, which made me feel worse. On top of this, a problem I had with the firm came to a head and I resigned."
2. "Constant friction with the company president caused me to walk out of my job after 13 years, leaving my keys on the desk. With a mortgage and four children to support it was a rough year."
3. "An average of three hours' sleep per night for the week before the attack."
4. "I was maintaining my present job while trying to start up my own business.

A significant proportion also noted increased social and domestic problems (although sensitivity may have been increased by the primary business stress). Thirty-seven reported an increase in body weight (20 gaining more than 10 pounds over the year) and 34 felt in poor health during the week of the attack. Of the latter, 12 noted increasing chest pain on exertion and 14 also complained of extreme tiredness for some days prior to the attack. Only four noted specific (viral) infections, but a fifth patient had some periodontitis. Other complaints were of indigestion, dizziness, fainting spells and general malaise.

2. Condition of patient on the day of attack

On the day of the attack (Table III), business and social problems were still quite frequently reported, but heavy lifting and/or vigorous physical activity were also quite common events. Forty patients felt unwell prior to the attack, the complaints being similar to those listed in the previous section: chest pain (14), tiredness (13), "indigestion" (5), anxiety (3), "off-colour" (1), shortness of breath (3) and dizziness (1) were particular comments. When specifically questioned a much larger number (51) reported chest pain, but only three listed cardiac irregularities.

A substantial number of patients reported adverse weather conditions on the day of their initial attack. Fifteen noted a fall of fresh snow, 44 recalled cold weather (but only 8 of these "very cold") and 17 humid weather. Five shovelled snow for 15 minutes or longer. There was a slight excess of attacks in the final quarter of the year (30/102, of which 11 occurred in December) but this was not statistically significant.

3. Activity at the time of the attack

The activity reported at the time of the attack (Table IV) has been related to the anticipated activity patterns of the middle-aged Toronto executive.[17] Unfortunately, four of the 102 patients were unable to recall the activity at the time of their primary attack.

Information on 15 recurrences (occurring prior to being referred for enrolment in the program) has been added to this analysis. However, conclusions are essentially similar whether based on primary attacks or all episodes (Table IV). There are fewer attacks during sleep than anticipated, and an excess during the performance of "odd jobs", sport and walking. This becomes even more obvious if account is taken of several unusual activities that were reported immediately preceding relaxation or sleep. For example, four of the patients reported the following activities: lengthy portage of a canoe, driving screws into a concrete wall, starting a recalcitrant power mower and snow shovelling.

The types of activity associated with an attack were varied and included snow-shovelling (5), walking (9), running (7),† curling (2), tennis (1), baseball (1), dancing (1), sex (1), ice breaking (1) and various domestic chores

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†This is perhaps greater than the expected frequency of running in Toronto and suggests that the group as a whole may have had some bias toward physical activity.

Table I — Condition of patients in year preceding first coronary attack

	Increased	Normal	Decreased	χ^2*	P
Body weight	37	56	9	15.8	<0.001
Physical activity	23	64	15	1.3	n.s.
Business problems	71	29	2	63.3	<0.001
Social and domestic problems	31	71	0	29.0	<0.001
Financial problems	15	77	10	0.6	n.s

*Test of the hypothesis that complaints are normally distributed, that is, an equal proportion of patients reporting increased and decreased symptoms; Yates's correction applied.

Table II — Condition of patients in week preceding first coronary attack

	Increased	Normal	Decreased	χ^2*	P
General health	5	63	34	20.1	<0.001
Physical activity	19	65	18	0.0	n.s.
Business problems	56	43	3	45.8	<0.001
Social and domestic problems	21	80	1	16.4	<0.001
Financial problems	14	81	7	1.7	n.s.

*Test of the hypothesis that complaints are normally distributed, that is, an equal proportion of patients reporting increased and decreased symptoms.

Table III — Problems on the day of initial attack

Unusual annoyance	24/102
Unusual business problem	27/102
Unusual social or domestic problem	12/102
Unusual financial problem	4/102
Heavy lifting	24/100 (no reply from 2)
Vigorous physical activity	31/101 (no reply from 1)
Unwell prior to attack	40/100 (no reply from 2)
Increased chest pain	51/91 (no reply from 11)

(5). In some cases there was associated emotional stress — defending a curling championship and, in one of the walkers, visiting the house where he had spent his childhood and recalling the hard economic background from which he had emerged.

Although dining was reported at about the expected frequency, in four of the seven episodes there were comments about overeating and of entertaining.

"Other" activities were also unusual, three of the four men being in attendance at a hospital or doctor's office for treatment of an unrelated condition.

4. Nature of the attack

In general, the attack conformed to the classical textbook picture. All were verified by electrocardiographic and serum enzyme changes. Only four of the 102 patients failed to notice pain; the initial site was in the chest (60), arm (9), neck (4), or a combination of these three sites (25). Of 94 respondents 29 classed the pain as no more than mild indigestion, 29 as severe pain, 25 as very severe and 11 as unbearable; three patients lost consciousness. The duration of pain was quite varied and, perhaps because of our deliberate selection of survivors, was shorter than the classical "20 minutes or longer" in about half the cases. Of 90 respondents 11 checked "2 minutes or less"; 21, 10 minutes; 3, 20 minutes; 14, 30 minutes; and 41, longer than 60 minutes. About one half (47/81) had more than 30 minutes' warning of the attack, with premonitory symptoms as discussed above; in 20 the warning was about 2 minutes, in 9 about 30 seconds and in 13

Table IV — Activity at time of attack, relative to anticipated activity of 45-year-old Toronto executive, 117 episodes (98 primary attacks and 15 recurrences)

Primary attacks			
Activity	Observed	Anticipated	χ^2*	P
Sleep	17	32.7	10.6	0.01—0.001
Work	11	28.6	14.5	<0.001
Relaxing at home	21	16.3—20.4	1.3—0.1	n.s.
Driving	8	5.3	1.0	n.s.
Dining	7	5.3	0.3	n.s.
Personal toilet	3	4.1	0.1	n.s.
Odd jobs	10	2.0	28.7	<0.001
Sport and vigorous activity	9	2.0	21.6	<0.001
Walking	8	1.2	33.5	<0.001
Other	4	0.4	24.1	<0.001
All attacks			
Activity	Observed	Anticipated	χ^2*	P
Sleep	21	39.0	11.8	<0.001
Work	16	34.1	12.8	<0.001
Relaxing at home	24	19.5—24.4	1.0—0.0	n.s.
Driving	9	6.3	0.8	n.s.
Dining	7	6.3	0.1	n.s.
Personal toilet	3	4.9	0.4	n.s.
Odd jobs	10	2.4	21.4	<0.001
Sport and vigorous activity	14	2.4	52.4	<0.001
Walking	9	1.5	33.1	<0.001
Other	4	0.5	18.1	<0.001

*Yates's correction applied.

about 5 seconds. Of 101 respondents 86 were confident they would recognize a future attack, some three quarters of this total basing recognition upon chest and/or arm pain, and the remainder using the various symptoms already discussed.

Discussion

1. Validity of methods

We have made the assumption that there is an average level of contentment within the population and that our subjects, in describing their episodes of business and domestic stress, were indeed detailing deviations from the norm. While this assumption may be challenged on statistical grounds, it seems a reasonable one from a clinical viewpoint.

As in any clinical problem it has been necessary to accept what the patient has told us about his illness. Possibly in future studies the wife could also complete an answer sheet. Problems of observer bias have been minimized by the use of a standard questionnaire, but the views of the patients regarding their attacks may well have been coloured by interaction with others attending the rehabilitation program. Nevertheless, the responses to the formal questionnaire stand in good agreement with both appended anecdotal material and our personal knowledge of the individual, acquired over several months of rehabilitation.

More significant criticisms are the use of a selected sample (survivors of a coronary infarct attending a rehabilitation program), and, in about half the group, the short duration of chest pain (less than 20 minutes). It would seem worth while to follow up this study by examination of a random sample of post-infarct patients in an intensive care ward.

2. Circumstances of attack

Jokl[14] has stated that exercise does not cause death from coronary infarction in a normal heart, and that careful postmortem examination always discloses an antecedent congenital, infective or degenerative abnormality. In the present group of middle-aged executives it is likely that all had some degree of coronary atherosclerosis at the time of their infarction. The immediate factor triggering the coronary attack in about one third of the group seems to have been intense and unaccustomed exercise, sometimes associated with excitement. In a proportion of the remainder there was a well defined emotional shock.[18-21] In some, no clear-cut trigger could be identified. For those in whom an immediate "cause" could apparently be pinpointed, the preceding year had been far from satisfactory. Business pressures had been increased, there was often a complaint of lassitude and fatigue, and in some cases an increasing frequency of angina was reported. On the other hand, in only four patients was there any history of acute infection. We may reasonably suspect that the groundwork for the acute attack was laid by general stress to which the individual had incompletely adapted;[22] however, the nature of such a groundwork remains open to speculation. Specific biochemical changes altering blood coagulability or cardiac irritability, excessive smoking and coffee drinking, and/or general deterioration of physical condition with increased desk responsibilities, could all be involved.

3. Is exercise advisable?

The incidence of attacks during exercise is rather higher than in previous reports concerned with sudden death. Moritz and Zamcheck[7] found that the frequency of death

during strenuous activity was twice the anticipated figure. Their data were based on retrospective analysis of wartime military statistics and presumably referred to men who were younger, fitter and of lower average body weight than the present group. Adelson[12] noted that in 5% of all cases of sudden death reported to the medical examiner's office the individuals were engaged in strenuous activity, while Spain and Bradess[9] found that of the "coronary" sudden deaths reported in Westchester County, 14% of those due to atherosclerotic lesions and 16% due to thrombotic lesions were preceded by "unusual" physical activity; both figures are high relative to the normal frequency of vigorous effort in North America, particularly since very elderly and inactive patients were not excluded.

The evidence to date therefore indicates that physical exercise can precipitate myocardial infarction in an individual who has diseased coronary arteries, the danger increasing progressively with the age of the individual and the presence of other stress factors. Any discrepancy between previous reports and the present study is likely to be due to the selection imposed by (a) death and (b) accepting a rehabilitation program which emphasizes physical training; active individuals are statistically more likely to recover from the acute attack.

If exercise causes acute myocardial infarction, can it also be a safe and suitable mode of therapy? Paradoxically, the answer appears to be yes. The majority of epidemiological studies, while open to tantalizing objections, support the conclusion that prolonged inactivity increases the overall risk of myocardial infarction.[23] Further, the recurrence rate in those who have already sustained an infarction is apparently reduced by exercise therapy.[24] Exercise as a precipitant does no more than reveal a previously damaged coronary vascular tree, highly susceptible to both physical and emotional stress. Certainly the triggering exercise is sometimes excessive, but most men inevitably face excessive activity on occasion. Judicious regular exercise prepares for such emergencies and by improving overall fitness reduces the relative severity of stress in such episodes.

4. Towards a safer exercise regimen

Granted that exercise can provoke an infarct in the coronary-prone individual, how may the hazards be reduced? With regard to the exercise itself, the intensity, the isometric component and any associated emotional stimuli should be carefully regulated. Intensity should be kept within limits defined by exercise testing in the laboratory, during which test the patient is monitored for arrhythmias and ST segmental depression.[15] The emotional element of sport is hard to eliminate in the typical striving, success-oriented coronary victim. However, he should be prescribed definite and conservative goals and told to avoid competition, particularly against those who are better performers than himself.

The premonitory signs of fatigue, tiredness and increasing angina provide a strong indication for moderation of an exercise program pending detailed re-evaluation. We would agree with Huckle[6] that there can be substantial immediate warning of an attack; this point is also borne out by the discrepancy between deaths from coronary thrombosis while driving and vehicle accidents.[25] The first symptom readily recognized by the patient is anginal pain, and if either this or a recognized arrhythmia develops during exercise, efforts should be halted until the symptom passes.

Finally, the present study raises once again the dangers of unsupervised programs of physical activity. Any formal training program for the coronary-prone or post-coronary patient should be under the close supervision of a physician who has the experience and training to undertake defibrillation and external cardiac massage. It is unrealistic to prohibit all unsupervised activity, but this should be held to closely prescribed limits and, where possible, should be undertaken in the company of someone who is not himself a potential coronary victim.

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