Hypertrophic cardiomyopathy associated with sudden death during marathon racing

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SUMMARY An experienced marathon runner died suddenly during a competitive race. At necropsy, ventricular hypertrophy but no asymmetrical septal hypertrophy was found. Histological studies showed features of hypertrophic cardiomyopathy. The coronary arteries were normal. We propose that the runner died from myocardial ischaemia, precipitated by marathon running on a background of hypertrophic cardiomyopathy. Excess cardiac work, induced by marathon running in the presence of mild congenital cardiac defects, could have contributed to the development of the cardiomyopathy.

Necropsy reports on marathon runners are very uncommon. In 1961, Currens and White reported the necropsy findings of Clarence de Mar, the legendary American who had been a marathon runner for 50 years. A striking cardiovascular finding was the size of the coronary arteries which were estimated to be two to three times the normal diameter, and the paucity of coronary atherosclerosis. This finding has been cited as supportive evidence for the controversial hypothesis that marathon running influences coronary atherosclerosis (Bassler, 1977; Noakes et al., 1977). Green et al. (1976) reported the case of a marathon runner who collapsed during a race, was resuscitated, but later died. At necropsy the clinical diagnosis of myocardial infarction was confirmed but the patient was found to have normal coronary arteries. The possible cause of this unusual combination was debated (Annals of Internal Medicine, 1976) but the possibility exists that marathon running can precipitate myocardial infarction in the presence of normal coronary arteries.

We here report the findings in a 42-year-old man who died suddenly during a marathon race. At necropsy a diagnosis of hypertrophic cardiomyopathy was made. Though the patient had normal coronary arteries, we cannot exclude that he died from myocardial ischaemia, precipitated by marathon running on a background of hypertrophic cardiomyopathy.

Case report

The deceased, a 42-year-old man, was found at the age of 7 to have a cardiac murmur and was advised to restrict his physical activity. This advice was apparently ignored because he excelled in competitive sport until the age of 27, when he consulted a cardiologist for firm advice about the safety of his continuing in competitive athletics. A diagnosis of ventricular septal defect was made and he was advised to undergo cardiac catheterisation but this was not done. An electrocardiogram was normal, but slight prominence of the right ventricular outflow tract was noted on screening of the heart.

In 1965, at the age of 32, he was seen at Groote Schuur Hospital by the late Professor V. Schrire. Interrogation revealed that a grandfather had died from a heart attack at the age of 42, that the patient’s father had died suddenly shortly after exercise, and that one of his sons had suffered an attack of rheumatic fever. The patient was a ‘moderate smoker’, a habit which he subsequently stopped when he took up long distance running. On clinical examination, a grade 2-3/6 systolic murmur was heard, maximal in the 4th left interspace close to the sternum. The murmur did not radiate. As there were no other clinical findings, a diagnosis of a Roger type ventricular septal defect was made and this was considered to be of no haemodynamic significance.

In 1972, at the age of 39, he took up long distance running and in May 1973 he completed the 56 mile Comrades Marathon between Durban and Pietermaritzburg in 8½ hours. During that race he was troubled by dyspnoea and chest pain. A further attack of chest pain was precipitated by running after an emotional argument with an official.

For the following two years he continued to run regularly. In April 1974 he complained of non-
specific diarrhoea, for which no cause was found. His cardiac status as assessed by clinical examination was unchanged. In particular, he was normotensive, and we could find no change from the previous electrocardiogram.

At the age of 42 he entered a standard 26 mile marathon race on 7 February 1976. During this race he complained that he felt ill and that he wished to stop. He continued running, however, and shortly after the 20 mile mark, was found lying supine at the side of the road. There was no evidence of spontaneous respiration and all attempts at resuscitation failed.

A medico-legal necropsy was performed 48 hours later. No naked eye cause to explain the sudden death was found. In particular, there was no intracranial, intrathoracic or intra-abdominal bleeding nor was pulmonary embolism found. The lungs showed acute oedema.

The heart (Fig. 1) was submitted to us for examination 7 hours after necropsy, having been kept on ice for that time. It weighed 460 g and the left ventricular free wall was 2.4 cm thick. The hypertrophy was concentric in nature. The interventricular septum measured 1.3 cm in thickness, giving a septum to free wall ratio of 0.54. The aorta was slightly dextroposed and a sigmoid septum was present. A 2 mm diameter ventricular septal defect passed from below the right coronary cusp of the aortic valve to open on the inferior edge of the crista supraventricularis. The severe degree of myocardial hypertrophy seen in this heart was clearly disproportionate to the small ventricular septal defect.

The heart valves appeared normal. No endocardial lesions were present, apart from a small jet lesion adjacent to the right ventricular ostium of the septal defect. The coronary arteries showed no significant atherosclerosis and the great arteries were normally related.

Numerous sections from all portions of the heart were examined and most showed hypertrophied myofibres only. However, in several sections of left ventricle (septum and free wall) there were foci of myofibril disarray (Fig. 2) of the type seen in hypertrophic cardiomyopathy. The histological hypertrophic obstructive cardiomyopathy index (Van Noorden et al., 1971) applied to such areas came to over 50 per cent.

Multiple drill biopsies taken from numerous sites in the left ventricle were submitted for biochemical analysis of potassium to sodium (K+/Na+) ratios (Table). The myocardial K+/Na+ ratio starts to fall within minutes of the onset of severe ischaemia (Nayler et al., 1971) long before histological features of infarction (Rose et al., 1976) are apparent. A potassium to sodium ratio below 1.1 is considered by McVie (1970) to be diagnostic of myocardial infarction. The finding that 8 of the 14 biopsies taken in this patient were below this value seems to indicate myocardial ischaemia, but we cannot exclude the possibility that hypertrophic cardiomyopathy per se causes or predisposes to myocardial ionic imbalance.

Discussion

Ventricular hypertrophy is an accepted consequence of prolonged athletic training (Gott et al., 1968). The introduction of echocardiography has, however, disclosed that structural adaptation in the heart differs in response to different exercise types.

Athletes involved in prolonged dynamic exercise such as swimming and running increase their end-diastolic left ventricular internal dimensions without an increase in ventricular wall thickness (Morganroth et al., 1975). On the other hand, shotputters and wrestlers, involved in static exercise, develop an increased left ventricular wall thickness without a change in end-diastolic left ventricular volume. These findings have been related to the stimuli acting during the different exercises; dynamic exercise produces, like valvular incompetence, a
ratios in patient with hypertrophic 
K+/Na+ indicate myocardial infarction

*Biopsies were taken 55 hours after death by the drill biopsy method of Pool et al. (1968) and analysed for myocardial K+/Na+ ratios by the method of Jennings et al. (1957).

In each group, biopsies were numbered starting at the base of the heart and working towards the apex.

A K+/Na+ ratio above 1:1 is normal, whereas values below 1:1 indicate myocardial infarction (McVie, 1970). For a discussion on the significance of decreased myocardial K+/Na+ ratio see Rose et al. (1976) and Raiskina et al. (1977).

Table Relation between biopsy sites and myocardial K+/Na+ ratios in patient with hypertrophic cardiomyopathy

<table>
<thead>
<tr>
<th>Biopsy number*</th>
<th>K (mmol/l) fresh weight</th>
<th>Na (mmol/l) fresh weight</th>
<th>K+/Na+†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site A: Between anterior descending and circumflex coronary artery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>60.2</td>
<td>126.2</td>
<td>0.47</td>
</tr>
<tr>
<td>2</td>
<td>68.5</td>
<td>52.8</td>
<td>1.29</td>
</tr>
<tr>
<td>3</td>
<td>67.4</td>
<td>56.7</td>
<td>1.18</td>
</tr>
<tr>
<td>4</td>
<td>68.4</td>
<td>46.7</td>
<td>1.46</td>
</tr>
<tr>
<td>5</td>
<td>69.3</td>
<td>49.3</td>
<td>1.40</td>
</tr>
<tr>
<td>Site B: Posterior to circumflex coronary artery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>60.0</td>
<td>64.8</td>
<td>0.93</td>
</tr>
<tr>
<td>7</td>
<td>67.9</td>
<td>58.9</td>
<td>1.15</td>
</tr>
<tr>
<td>8</td>
<td>59.5</td>
<td>62.5</td>
<td>0.95</td>
</tr>
<tr>
<td>9</td>
<td>66.5</td>
<td>58.4</td>
<td>1.13</td>
</tr>
<tr>
<td>10</td>
<td>64.6</td>
<td>62.1</td>
<td>1.04</td>
</tr>
<tr>
<td>11</td>
<td>77.5</td>
<td>75.0</td>
<td>1.03</td>
</tr>
<tr>
<td>Site C: Septum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>71.0</td>
<td>90.6</td>
<td>0.78</td>
</tr>
<tr>
<td>13</td>
<td>72.6</td>
<td>70.3</td>
<td>1.03</td>
</tr>
<tr>
<td>14</td>
<td>80.5</td>
<td>78.7</td>
<td>1.02</td>
</tr>
</tbody>
</table>

volume overloaded heart, while during static exercise the heart must work against an increased pressure load.

In contrast to the findings in normal runners, the athlete here reported had a distinct increase in the left ventricular free wall thickness and the necropsy appearance of a small intraventricular volume; these findings would be more compatible with a pressure-overloaded heart. As the patient was normotensive (blood pressure 110/60 mmHg) and had not trained with static exercise, these would constitute unlikely explanations for the ventricular hypertrophy. In addition, the septal defect (2 mm in diameter) was clinically and pathologically too small to have caused such hypertrophy by itself.

The finding of uniform cardiac hypertrophy with the histological pattern of myofibril arrangement as seen in hypertrophic obstructive cardiomyopathy, but unassociated with disproportionate septal hypertrophy, is considered by Davies (1975) to be a not uncommon variant. We have encountered 4 such patients at necropsy in whom this abnormal myofibril arrangement was associated with sudden unexpected death and we consider this to be a further example. Knieriem et al. (1975) report a similar case which they label hypertrophic non-obstructive cardiomyopathy. As the presence or absence of left ventricular outflow obstruction, which may in any case have been present only intermittently if at all during life, cannot be determined by necropsy, the term hypertrophic cardiomyopathy more accurately describes our own findings.

The concept of hypertrophic cardiomyopathy as a genetic myocardial disease has been questioned by Bulkley et al. (1977) and Come et al. (1977) who...
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report patients with either histological or clinical evidence of hypertrophic obstructive cardiomyopathy but without asymmetrical septal hypertrophy. They suggest that haemodynamic factors may be important in the genesis of this group of conditions. We do not know whether haemodynamic factors associated with marathon running could (in the presence of mild congenital cardiac defects) have contributed to the development of the cardiomyopathy in this patient, or whether the inotropic stimulus of exercise may have caused or increased left ventricular outflow obstruction, particularly during the final race.

Suggestive evidence against a familial explanation for this athlete's cardiomyopathy was the failure to find any clinical, radiological, or echocardiographic evidence for this condition in other members of his family (1 brother, 1 sister, 2 sons, 3 nephews). The important practical point arising from this report is that the athlete chose to ignore his symptoms and to conceal these from his doctors, lest he be forced to stop running. This attitude is identical to that shown by a group of marathon runners who developed myocardial infarction (Noakes et al., 1977), all of whom, exactly like other sportsmen (Opie, 1975), had chosen to ignore warning symptoms. We stress that marathon runners should be aware that they are not immune to cardiac death and that symptoms suggestive of myocardial ischaemia must be investigated.

We are indebted to Dr E. G. J. Olsen of the National Heart Hospital, London, and Dr J. E. Edwards of St Paul, Minnesota, for reviewing the myocardial histology.

We thank Dr T. G. Armstrong of the Cardiac Unit, University of Natal, Durban; Professor J. B. Barlow and Dr A. Davidoff of the Cardiac Clinic, University of Witwatersrand, Johannesburg, and Dr Maurice Nellen, London, who investigated family members of the deceased.

This work was supported by the Medical Research Council of South Africa and the Chris Barnard Fund. T.D.N. is recipient of a Guy Elliot Research Fellowship from the University of Cape Town.

References


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Hypertrophic cardiomyopathy associated with sudden death during marathon racing.
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Br Heart J 1979 41: 624-627
doi: 10.1136/hrt.41.5.624