

# Paroxysmal ventricular tachycardia during repeated 24-hour ambulatory electrocardiographic monitoring of postmyocardial infarction patients\*

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**SUMMARY** Twenty-four hour ambulatory electrocardiographic tape recording was carried out four times within the first six months after an acute myocardial infarction in 100 consecutive patients below the age of 70 years. Sixty-four episodes of ventricular tachycardia were observed on 23 tapes recorded from 19 patients. Six episodes were accompanied by symptoms; syncope occurred twice. Ventricular tachycardia was rare during sleep, and occurred more commonly after discharge than in hospital. Forty-seven per cent of the episodes were 10 or more beats in length, and the maximum heart rate in each varied from 108 to 300/min. The heart rate immediately beforehand was 89/min  $\pm$  15 (SD), and was not constant in any individual experiencing repeated attacks. Episodes, even longer ones, were not followed by significant tachycardia. Patients with ventricular tachycardia or ventricular fibrillation in the coronary care unit were significantly more likely to develop ventricular tachycardia later ( $p < 0.05$ ), and ventricular tachycardia was more frequent after transmural than subendocardial infarction ( $p < 0.05$ ). In hospital, the group with ventricular tachycardia was significantly more likely to have a sleeping heart rate of 80/min or more ( $p < 0.05$ ). The mean prematurity index ( $RR'/QT$ ) of the first complex of each episode of ventricular tachycardia was  $1.41 \pm 0.28$  (SD) and no episode was triggered by the R of T phenomenon, which was seen 43 times. Four patients died suddenly in the six-month follow-up period; none had ventricular tachycardia, which was seen in two of the four patients who reinfarcted. The investigation shows that ventricular tachycardia occurs frequently during the first six months after a myocardial infarction, but it is usually self-limiting and asymptomatic, whether patients are or are not receiving antiarrhythmic treatment.

It is generally accepted that sudden death in patients with ischaemic heart disease results from ventricular fibrillation, and that electrical instability in the myocardium frequently precedes the fatal arrhythmia.<sup>1</sup> Arrhythmias in patients who have recently recovered from a myocardial infarction are of special interest, therefore, as these patients are prone to sudden death. Several investigations using electrocardiographic tape recordings over a period of hours during recovery from infarction showed that frequent ventricular extrasystoles, multifocal ventricular extrasystoles, and paired ventricular extrasystoles as well as ventricular tachycardia indicate a poor prognosis in this respect,<sup>2-6</sup> but another recent study did not support this.<sup>7</sup> More controversy has been added by the assertion that

ventricular tachycardia in patients discharged from hospital after acute myocardial infarction<sup>8</sup> or in those with other heart diseases<sup>9</sup> is usually self-limiting, accompanied by few symptoms, and without any serious risk of progression to ventricular fibrillation.

The objects of the present investigation were to study the incidence of ventricular tachycardia during the first six months after acute myocardial infarction, to relate this back to the acute illness in an attempt to predict patients liable to develop ventricular tachycardia later, and to determine the prognosis of this arrhythmia.

## Subjects and methods

The subjects were 100 consecutive patients, admitted after January 1978 to the coronary care unit of the Odense University Hospital, who had a

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proven acute myocardial infarction, were less than 70 years of age at the time of admission, and were discharged alive. All gave their informed consent to the investigation. Nine others complying with the above criteria were not studied; three refused, three lived too far away, two were employed in the hospital, and one suffered from catatonic schizophrenia. Each of the 100 patients underwent 24-hour electrocardiographic recordings during the later stages of their hospital stay as well as one, three, and six months after discharge.

The diagnosis of acute myocardial infarction was made using the criteria of the World Health Organization.<sup>10</sup> Continuous monitoring of the electrocardiogram in the coronary care unit used a frequency based alarm system, combined with surveillance of the oscilloscope by specially trained nurses. The electrocardiograms were continuously recorded on tape and played back in cases where difficulty in identification of arrhythmias occurred. The arrhythmias observed were recorded on a special form.

On one of the last days before discharge from hospital, as well as one, three, and six months after discharge patients were examined and their drug regimen noted. The resting 12-lead electrocardiogram was recorded and a 24-hour tape recording obtained using a Medilog tape recorder (two leads). Analysis of the 24-hour tapes was carried out by a Pathfinder High Speed Electrocardiogram Analyser at 60 times real time using the automatic analysis facility of the instrument combined with continuous surveillance of the electrocardiogram on the oscilloscope. All paired ventricular extrasystoles, R on T extrasystoles, and episodes of ventricular tachycardia were recorded on paper at normal speed for closer inspection and documentation. The total number of ventricular extrasystoles was counted using a digital counter connected with the logic output of the analyser.

Each tape was divided into four periods of six hours. The mean heart rate, the number of ventricular extrasystoles, the number of paired ventricular extrasystoles, the number of R on T ventricular extrasystoles, and the number of episodes of ventricular tachycardia were noted for each six-hour period. The heart rate immediately before and after

episodes of ventricular tachycardia was measured over three normal beats.

Ventricular tachycardia was defined as three or more consecutive ventricular extrasystoles at a rate of 100 beats/minute or more, and R on T ventricular extrasystoles as those with an RR'/QT ratio of less than one. The patients continued their usual daily activities during the period of monitoring; no change was made in their drugs.

During the follow-up period of six months, five patients died, four from sudden cardiac death with symptoms of less than one hour's duration, all before the first ambulatory monitoring, and the fifth from a cerebrovascular accident six months after the attack of myocardial infarction. One of the 100 patients moved away and did not have the final 24-hour tape recording.

#### STATISTICS

Fisher's exact test and Student's t test were used. The significance level was 5 per cent.

#### Results

In a total of 386 24-hour recordings, 64 episodes of ventricular tachycardia were observed on 23 tapes from 19 patients. The arrhythmia was self-limiting in all cases, and did not progress to ventricular fibrillation. Table 1 shows the time of relation of these episodes. A single episode was observed on 16 tapes, two on four tapes, and seven, 12, and 20 episodes, respectively, on one tape each.

The number of beats in each episode of ventricular tachycardia can be seen in Fig. 1; in 16 per cent they consisted of three beats only, and in 47 per cent of 10 or more. The mean maximum heart rate during ventricular tachycardia (Fig. 2) was  $179 \pm 35$  (SD) per minute (range 108 to 300). The mean heart rate immediately before ventricular tachycardia was  $89 \pm 15$  (Fig. 3), while the mean heart rate during the six-hour period in which it occurred was  $75 \pm 13$ . This difference is statistically significant ( $p < 0.001$ ). Two episodes occurred during sleep between midnight and 6 am, and 13 between 6 pm and 12 midnight. In two cases ventricular tachycardia was accompanied by syncope and in four by dizziness.

Table 1 *Timing of ventricular tachycardia in relation to acute myocardial infarction*

	Late hospital phase (No. = 100)	One month after AMI (No. = 96)	Three months after AMI (No. = 96)	Six months after AMI (No. = 96)
No. of tapes with ventricular tachycardia	3	8	5	7
No. of episodes of ventricular tachycardia	3	10	27	24

AMI, acute myocardial infarction. No., number of tape recordings.

Ventricular tachycardia was not followed by an increase in heart rate as compensation for a presumed drop in cardiac output; immediately beforehand the heart rate was  $89 \pm 15$ , while immediately afterwards it was  $88 \pm 12$ . This difference is not statistically significant. Longer episodes of ventricular tachycardia did not differ from shorter ones in this aspect.

Forty-three instances of R on T extrasystoles were seen in nine patients, and, of these, two had episodes of ventricular tachycardia on the same tape, but in no case was the prematurity index ( $RR'/QT$ ) of the first extrasystoles of any episode of ventricular tachycardia less than one (Fig. 4), and the mean index was  $1.41 \pm 0.28$  (range 1.00 to 2.53).

or more during sleep (midnight to 6 am) was significantly more frequent in the group with ventricular tachycardia ( $p < 0.05$ ). At this point 10 of these 19 patients were receiving digoxin and/or antiarrhythmic agents compared with 46 of the remaining 81.

At the time of recording, of the 23 tapes showing ventricular tachycardia five of the patients concerned were being treated with digoxin, three with beta-blockers, and two with both. The proportion of the remaining 363 tapes recorded while patients were taking these drugs was not significantly different. For quinidine and procainamide the figures were zero and 31 recordings, respectively. The most frequent indication for beta blockers was angina pectoris and, therefore, the doses given were higher

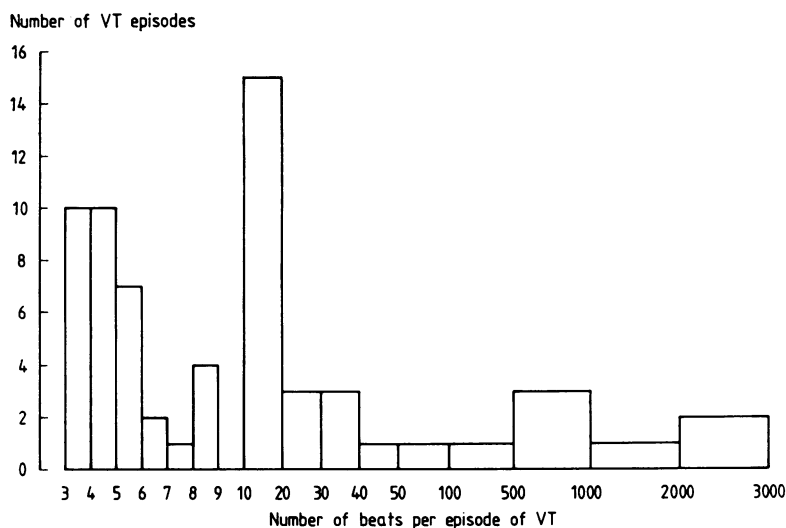


Fig. 1 The number of beats in each episode of ventricular tachycardia.

Table 2 compares the 19 patients who experienced one or more episodes of ventricular tachycardia and the 81 patients who did not. There was no significant difference in age, sex, cardiac history, or presence of risk factors. Ventricular tachycardia occurred significantly more frequently after transmural than after subendocardial infarction ( $p < 0.05$ ). It was also more frequent after inferior than after anterior infarction, but not significantly. In the coronary care unit, patients later developing ventricular tachycardia were more likely to have had ventricular extrasystoles (NS), and ventricular tachycardia, and ventricular fibrillation (both  $p < 0.05$ ). The incidence of cardiac failure (using the criteria of Killip and Kimbal)<sup>11</sup> or of massive infarction (suggested by a maximum LDH value of more than 3000 units per litre) did not differ significantly between the two groups. During the 24-hour electrocardiographic monitoring in hospital a heart rate of 80/min

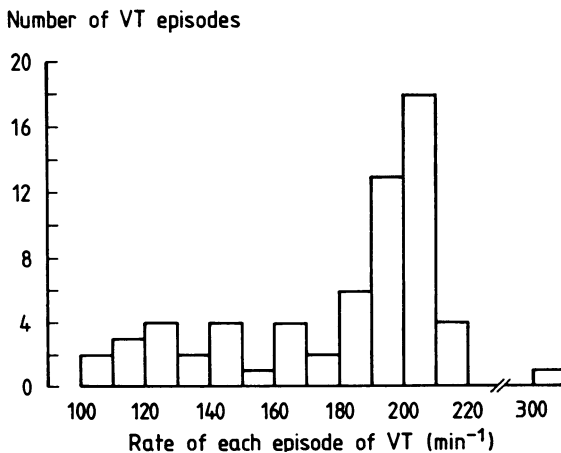


Fig. 2 The maximum heart rate of each episode of ventricular tachycardia.

than those normally used for antiarrhythmic treatment (80 to 320 mg propranolol per day); the doses of quinidine and procainamide were 1.2 to 1.6, and 3 g per day, respectively. In summary, digoxin and/or antiarrhythmic agents were being given during 10 out of 23 of the recordings showing ventricular tachycardia as compared with 182 of 363 of the remainder. These proportions are not significantly different.

Four cases of sudden cardiac death occurred during the period of follow-up of six months, all with symptoms lasting less than one hour. In the coronary care unit one of these patients had had ventricular fibrillation, one ventricular tachycardia, one paired ventricular extrasystoles, and one frequent ventricular extrasystoles. During 24-hour monitoring before discharge from hospital two had had frequent and multifocal ventricular extrasystoles and the other two isolated unifocal ventricular extrasystoles.

Four of the patients had a further myocardial infarction, and these occurred between 13 and 151 days after the original one. In the coronary care unit during the first admission one of these patients had had paired ventricular extrasystoles, two frequent ventricular extrasystoles, and the last patient isolated ventricular extrasystoles. During the 24 hours of monitoring in the hospital, two of these patients had had ventricular tachycardia, one frequent ventricular extrasystoles, and one isolated unifocal ventricular extrasystoles.

## Discussion

This study shows that ventricular tachycardia

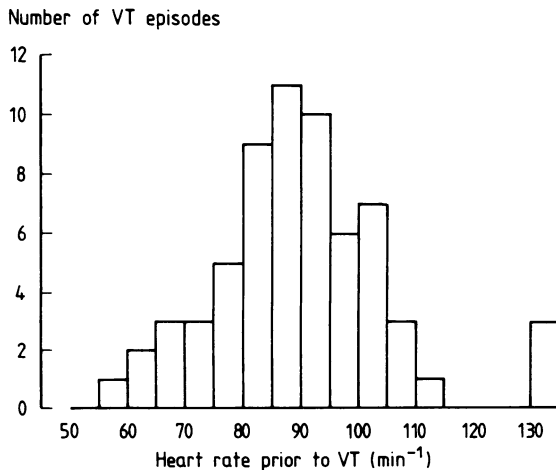


Fig. 3 The heart rate immediately before each episode of ventricular tachycardia.

occurs frequently during the first months after acute myocardial infarction. The differing incidence in previously published reports may be the result of variations in patient selection, in definition of ventricular tachycardia, in the duration of electrocardiographic monitoring and in the technique of analysis. During the later stages of the hospital

Table 2 Clinical characteristics of 100 consecutive postmyocardial infarction patients, with and without ventricular tachycardia, during 24 hours of ambulatory electrocardiographic monitoring

Clinical	Ventricular tachycardia present (No. = 19)	Ventricular tachycardia absent (No. = 81)	p value
Previous medical history			
Stable angina	5	25	
Unstable angina	5	18	
Myocardial infarction	4	18	
Heart failure	3	16	
Hypertension	4	23	
Smoking	14	47	
Age (y) (mean ± SD)	60 ± 8	58 ± 8	
Men	17	63	
Site of infarction			
Anterior	5	39	
Inferior	10	24	
Anterior + inferior	3	12	
Unknown	1	6	
Type of infarction			
Transmural	17	51	< 0.05
Data from CCU			
First systolic BT < 100 mmHg	2	6	
Killip class 2-4	14	59	
Cardiothoracic ratio ≥ 0.50	10	54	
Maximum LDH > 3000 U/l	3	12	
Ventricular extrasystoles present	18	62	
Ventricular tachycardia present	7	12	< 0.05
Ventricular fibrillation present	5	7	< 0.05
Status on discharge from hospital			
Resting electrocardiogram			
Heart rate (mean ± SD)	74 ± 13	76 ± 14	
Ventricular extrasystoles	2	11	
ST elevation ≥ 1 mm	6	36	
24-hour tape recording			
Heart rate (mean ± SD)	76 ± 11	76 ± 12	
Heart rate during sleep (mean ± SD)	71 ± 12	69 ± 11	
Heart rate > 80/min during sleep	7	11	< 0.05
Ventricular extrasystoles present	11	73	
Ventricular extrasystoles present during sleep	15	55	
Ventricular extrasystoles/h (mean > 10)	4	15	
Ventricular extrasystoles/h (mean > 1)	13	38	
Ventricular extrasystoles/h during sleep (mean > 1)	12	31	
Multifocal ventricular extrasystoles	4	19	
Paired ventricular extrasystoles	2	9	
Ventricular bigeminy	3	12	
Digoxin or antiarrhythmic treatment	10	46	

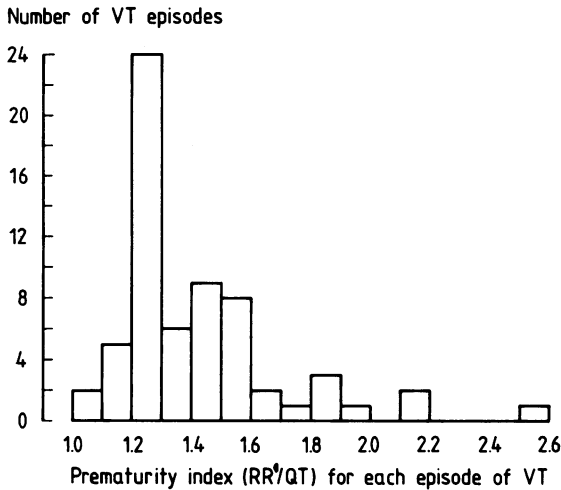


Fig. 4 The prematurity of the ventricular extrasystoles starting each episode of ventricular tachycardia.

stay ventricular tachycardia was found in 3 per cent of the patients in the present investigation, while the incidence in studies using the exercise electrocardiogram during the early stages of recovery from acute myocardial infarction is stated to be between 0.5 and 1 per cent,<sup>12 13</sup> and 1 to 6 per cent using tape recording.<sup>2-4 6</sup> Between one and six months after infarction in the present study ventricular tachycardia was observed in an additional 16 per cent of the patients during a total of 72 hours of monitoring each, but in other studies the incidence has varied from 1 to 20 per cent, single or repeated periods of monitoring for between six and 24 hours being used.<sup>2 4 6 14-16</sup> In two of these investigations in which monitoring was repeated and included the first three months after infarction, ventricular tachycardia was observed in 10 to 15 per cent of the patients.<sup>2 15</sup>

The R on T phenomenon was observed in 9 per cent of the patients but, as others have found,

ventricular tachycardia was not usually triggered by such extrasystoles.<sup>8 9</sup>

In Table 3 the present study is compared with those two others with respect to the heart rate immediately before ventricular tachycardia and the prematurity index. There is considerable agreement and this despite the fact that the investigation of Winkle *et al.*<sup>9</sup> included patients both with and without cardiac disease. However, our patients had much longer episodes of ventricular tachycardia, approximately half of these being 10 or more ventricular extrasystoles in length. The greater electrical instability of the myocardium during the first months after a myocardial infarction may account for this difference as this period was not included in the other two studies, though the longer episodes of ventricular tachycardia were in fact evenly distributed, did not occur at any special time of the day, and were not preceded by a heart rate which differed from that of the other episodes. Ventricular tachycardia occurred rarely during the night or in the evening, which is in contrast to the findings of others,<sup>17</sup> but in some studies a reduction in the number of ventricular extrasystoles during sleep has been found.<sup>18 19</sup>

The mean heart rate immediately before episodes of ventricular tachycardia was relatively rapid, and was significantly higher than the mean for the six-hour period in which they occurred. Bradycardia, therefore, did not appear to be of importance in triggering ventricular tachycardia as has been described in the acute stage of the infarction.<sup>20</sup>

Exercise studies of individual patients have shown that ventricular tachycardia occurs at the same heart rate both before and during antiarrhythmic treatment,<sup>21</sup> but this was not so with those of our patients who experienced several episodes. Thus, in a patient who had ventricular tachycardia 20 times within a single 24-hour period, the heart rate beforehand varied between 79 and 130 beats/min.

Since ventricular tachycardia tends to follow a sinus tachycardia, beta blockers may prevent

Table 3 Comparison with previous studies

Authors	Patients	No. of patients with ventricular tachycardia	No. of episodes of ventricular tachycardia	Heart rate/min before ventricular tachycardia (mean $\pm$ SD)	Peak ventricular tachycardia rate/min (mean $\pm$ SD)	No. of ventricular tachycardia with three ventricular extrasystoles (%)	Prematurity index (mean $\pm$ SD)
Winkle <i>et al.</i> <sup>9</sup>	Various heart diseases	23	94	83 $\pm$ 17	148 $\pm$ 26	49	1.36 $\pm$ 0.27
Anderson <i>et al.</i> <sup>8</sup>	Four to 48 months after acute myocardial infarction	66	199	87 $\pm$ 19	152 $\pm$ 24	47	1.49 $\pm$ 0.37
Present study	Nought to six months after acute myocardial infarction	19	64	89 $\pm$ 15	179 $\pm$ 35	18	1.41 $\pm$ 0.28



sudden cardiac death by preventing the latter, though in our study they appeared to exert no protective effect. However, ventricular tachycardia was commoner after inferior infarction, so it is possible that beta blockers exert a greater anti-arrhythmic effect in anterior infarction. This would be in agreement with the multicentre international practolol study,<sup>22</sup> but further investigation is needed on this point.

The failure of heart rate after an episode of ventricular tachycardia to increase in compensation for the reduction in cardiac output during the arrhythmia is remarkable. Even the longest lasting episodes were not followed by any significant increase. It is also remarkable that only six of 64 episodes of ventricular tachycardia produced significant symptoms.

The connection between ventricular tachycardia and fibrillation in the coronary care unit and the occurrence of ventricular tachycardia later has previously been confirmed by some,<sup>7 23</sup> but only partly by others.<sup>3 4 8</sup> The association with transmural rather than subendocardial infarction may be because the former judged by the maximum increase in serum enzymes tends to be larger, but size does not explain the higher incidence of ventricular tachycardia in inferior as compared with anterior infarctions.

The study shows that of all indices measured in the late hospital phase only the heart rate during sleep is helpful in forecasting the likelihood of ventricular tachycardia in the first six months after myocardial infarction, but it is impossible, even so, to do this with any certainty. The study also shows, in agreement with others,<sup>7 8</sup> that ventricular tachycardia does not necessarily carry a poor prognosis, is frequently self-limiting even in the absence of antiarrhythmia treatment, is not very likely to proceed to ventricular fibrillation, and rarely produces symptoms.

## References

- <sup>1</sup>Lown B, Calvert AF, Armington R, Ryan M. Monitoring for serious arrhythmias and high risk of sudden death. *Circulation* 1975; **51** and **52** Suppl III: 189-98.
- <sup>2</sup>Van Durme JP. Studie van Prognose en Behandeling van Ritmestoornissen na de akute Fase van het Myokardieinfarkt. Gent: Thesis, 1975.
- <sup>3</sup>Vismara LA, DeMaria AN, Hughes JL, Mason DT, Amsterdam EA. Evaluation of arrhythmias in the late hospital phase of acute myocardial infarction compared to coronary care unit ectopy. *Br Heart J* 1975; **37**: 598-603.
- <sup>4</sup>Moss AJ, DeCamilla JJ, Davis HP, Bayer L. Clinical significance of ventricular ectopic beats in the early posthospital phase of myocardial infarction. *Am J Cardiol* 1977; **39**: 635-40.
- <sup>5</sup>Schulze RA Jr, Strauss HW, Pitt B. Sudden death in the year following myocardial infarction. Relation to ventricular premature contractions in the late hospital phase and left ventricular ejection fraction. *Am J Med* 1977; **62**: 192-9.
- <sup>6</sup>Rehnqvist N, Lundman T, Sjögren A. Prognostic implications of ventricular arrhythmias registered before discharge and one year after acute myocardial infarction. *Acta Med Scand* 1978; **204**: 203-9.
- <sup>7</sup>de Soya N, Bennett FA, Murphy ML, Bissett JK, Kane JJ. The relationship of paroxysmal ventricular tachycardia complicating the acute phase and ventricular arrhythmia during the late hospital phase of myocardial infarction to long-term survival. *Am J Med* 1978; **64**: 377-81.
- <sup>8</sup>Anderson KP, DeCamilla J, Moss AJ. Clinical significance of ventricular tachycardia (3 beats or longer) detected during ambulatory monitoring after myocardial infarction. *Circulation* 1978; **57**: 890-7.
- <sup>9</sup>Winkle RA, Derrington DC, Schroeder JS. Characteristics of ventricular tachycardia in ambulatory patients. *Am J Cardiol* 1977; **39**: 487-92.
- <sup>10</sup>World Health Organization. *Ischaemic heart disease registers*. Report of the Fifth Working Group. The organization, Copenhagen, 1971.
- <sup>11</sup>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.
- <sup>12</sup>Ericsson M, Granath A, Ohlsén P, Södermark T, Volpe U. Arrhythmias and symptoms during treadmill testing three weeks after myocardial infarction in 100 patients. *Br Heart J* 1973; **35**: 787-90.
- <sup>13</sup>Ibsen H, Kjølner E, Styperek J, Pedersen A. Routine exercise ECG three weeks after acute myocardial infarction. *Acta Med Scand* 1975; **198**: 9.
- <sup>14</sup>Kotler MN, Tabatznik B, Mower MN, Tominga S. Prognostic significance of ventricular ectopic beats with respect to sudden death in the late postinfarction period. *Circulation* 1973; **47**: 959-66.
- <sup>15</sup>Kleiger RE, Martin TF, Miller, JP, Oliver GC. Ventricular tachycardia and ventricular extrasystoles during the late recovery phase of myocardial infarction (abstract). *Am J Cardiol* 1974; **33**: 149.
- <sup>16</sup>Ryan M, Lown B, Horn H. Comparison of ventricular ectopic activity during 24-hour monitoring and exercise testing in patients with coronary heart disease. *N Engl J Med* 1975; **292**: 224-9.
- <sup>17</sup>Vorpahl U, Blümchen G. Supraventriculäre und ventrikuläre Extrasystolen bei Patienten in der späten Postinfarktphase. *Z Kardiol* 1971; **67**: 612-20.
- <sup>18</sup>Lown B, Tykocinski M, Garfein A, Brooks P. Sleep and ventricular premature beats. *Circulation* 1973; **48**: 691-701.
- <sup>19</sup>Pickering TG, Goulding L, Cobern BA. Diurnal variations in ventricular ectopic beats and heart rate. *Cardiovasc Med* 1977; **2**: 1013-22.
- <sup>20</sup>Han J, DeTraglia J, Millet D, Moe GK. Incidence of ectopic beats as a function of basic rate in the ventricle. *Am Heart J* 1966; **72**: 632-9.
- <sup>21</sup>Talbot S, Kilpatrick D, Krikler D, Oakley CM.

Ventricular tachycardia due to cardiac ischaemia: assessment by exercise electrocardiography. *Br Med J* 1978; **2**: 733-6.

<sup>22</sup>Multicentre International Study. Improvement in prognosis of myocardial infarction by long-term beta-adreno-receptor blockade using practolol. *Br Med J* 1975; **3**: 735-40.

<sup>23</sup>Rehnqvist N. Ventricular arrhythmias prior to discharge after acute myocardial infarction. *Eur J Cardiol* 1976; **4**: 63-70.

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