Sinoatrial disease in acute myocardial infarction¹

Long-term prognosis

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Of 32 patients with acute myocardial infarction complicated by sinoatrial disease, 23 survived. All 23 had inferior infarction. During follow-up lasting 4 to 6 years only one patient developed severe chronic sinoatrial disease (sick sinus syndrome) necessitating permanent pacemaker treatment; twelve others died during this time. In 2 of them death was sudden 5 and 6 months after infarction. Atrial pacing studies in 7 of the 11 patients still alive showed no gross abnormalities. A review of 71 patients with chronic sinoatrial disease treated with a permanent pacemaker revealed only 5 with previous documented infarction.

The present data suggest that sinus node dysfunction in patients surviving acute infarction is most often only temporary as is atrioventricular block. Occasionally, however, severe chronic sinoatrial disease requiring a permanent pacemaker may develop later, and this course of events is most likely to occur in those patients who had additional complications during the acute infarct.

The incidence and course of sinoatrial disease complicating acute myocardial infarction have been reported (Rokseth and Hatle, 1971), but the long-term prognosis is not well known. Ferrer (1973) recommends that patients who have inadequacy of the sinoatrial node during acute myocardial infarction but whose nodal function recovers should be carefully followed up indefinitely. A more chronic stage probably the result of slow fibrosis may take several months or even years to become permanent and cause syncopal episodes. Meltzer and Cohen (1972) described 4 patients all of whom showed persistent obvious sinus bradycardia or prolonged episodes of sinus arrest several months after infarction: permanent pacing was required in each case. To our knowledge no systematic studies regarding the natural course have been reported. The purpose of the present paper is to report the follow-up of patients with myocardial infarction and sinoatrial disease who were seen in the acute stage between 1966 and 1970 and previously described by Rokseth and Hatle (1971).

Patients and methods

Among the 32 patients previously described all except

one had inferior infarction. Nine died during their stay in hospital. The remaining 23 patients were followed up from 4 to 6 years. There were 4 women and 19 men whose ages ranged from 40 to 82 years (mean 66). All had inferior infarction. The sinoatrial disorder was in no case related to drugs such as morphine, lignocaine, digitalis, etc. The main manifestations of sinoatrial disease during infarction were second degree sinoatrial block (intermittent cycles of twice the normal cycle length) in 7, second degree sinoatrial block of Wenckebach's type in 2, sinus arrest (here defined as a pause longer than twice the normal cycle length interrupted by an ectopic beat, excluding pauses following blocked atrial premature conduction) in 9, and slow nodal rhythm (rate 50 or less) in 5 patients. Often more than one type of sinus node dysfunction was recorded on the electrocardiogram in the same patient. Table 1 shows the total number of arrhythmias in the 23 patients. The most frequent complicating arrhythmia was atrial fibrillation which occurred in 11 patients. Atrioventricular block was seen in 8 patients and ventricular fibrillation in 1. Thirteen patients were treated with an intravenous drip of isoprenaline as occasional intravenous administration of atropine (0.5 mg) was inadequate. In 2 of them temporary pacemakers had to be used because of repeated syncope. The remaining 10 patients received no specific treatment.

On discharge 20 patients had regular sinus rhythm (rates 60 to 84) and atrial fibrillation persisted in one only. Second degree sinoatrial block of Wenckebach's type was present in 2 patients. In one of them it was later established that this rhythm had been present several

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TABLE 1 *Arrhythmias occurring while in hospital (23 patients)*

	No.
Sinoatrial block	13
Sinus arrest	9
Slow nodal rhythm	13
Atrioventricular block	8
Atrial fibrillation	11
Ventricular premature beats	2
Ventricular fibrillation	1

Note: In addition, 9 patients had periods of sinus bradycardia.

years before myocardial infarction. None had congestive heart failure on discharge but the heart size was enlarged in 10 of 19 where a chest x-ray was obtained.

Follow-up was usually carried out at intervals of 3 to 6 months and included clinical examination and electrocardiogram. In 7 patients electrophysiological studies were possible 4 to 6 years after infarction. All were men aged 61 to 71 years. The procedure was as follows. A bipolar electrode catheter was passed percutaneously through a femoral vein in 6 patients (cubital vein in the 7th) to the right atrium. Before atrial pacing a His bundle electrogram was obtained in the 6 patients where the femoral approach was possible. The catheter tip was placed against the lateral wall of the atrium and atrial pacing was performed by a Medtronic 5837 pulse generator at the following rates successively: 100, 110, 120, 130, and 140. The pacing time was 60 seconds at intervals of 60 seconds. Three patients then received atropine intravenously, 0.025 mg per kg body weight. The pacing procedure was repeated 5 to 15 minutes after atropine. Two patients received digoxin 0.125 mg twice daily. In Case 6, digoxin was discontinued 24 hours before investigation, and in Case 7 it was discontinued only on the morning of the investigation because of recent signs of congestive heart failure.

Sinus node recovery time (SRT) was measured from the beginning of the last spike of stimulation to the beginning of the first P wave after turning off the pacemaker. The corrected sinus recovery time was obtained by subtracting the average PP interval before pacing from sinus node recovery time. The recovery time as a percentage of the average cycle length before pacing was also calculated.

TABLE 2 *Electrocardiogram at follow-up*

	No. of patients	
	Later dead	Alive
Sinus rhythm	9	9
Sinoatrial block Wenckebach	1	1
Atrial fibrillation		1
Bradycardia/tachycardia	1*	
Electrocardiogram not recorded (no symptoms)	1	

*Treated with pacemaker. See text.

Clinical results at follow-up

During observation 12 patients died, 5 after 5 to 12 months, 2 after 2 years, 1 after 3 years, and 4 after 4 to 6 years. Eleven patients are still alive.

One patient developed a persistent bradytachycardia syndrome and was treated with a permanent pacemaker. Two other patients suffered rare attacks of supraventricular tachycardia. They received digoxin without known episodes of bradycardia. Angina pectoris in 4 patients was never shown to be associated with bradycardia. Recurrent infarction in 3 others was not complicated by rhythm disturbances. One patient with persistent atrial fibrillation suffered a stroke attributed to cerebral embolism. Repeat clinical examination and electrocardiogram showed a ventricular rate of 60 to 80. No patients had dizziness or syncope.

Table 2 shows the electrocardiogram at follow-up examinations. Among patients who died during the period of observation one had second degree sinoatrial block (Wenckebach) which had been present before myocardial infarction occurred, and one patient had bradycardia alternating with tachycardia. Nine patients were in normal sinus rhythm while the 12th patient died before the first control and an electrocardiogram was not recorded. Among the 11 patients still alive 9 had normal sinus rhythm.

The causes of death were cancer in 3, heart failure in 2, car accident in 1, and recurrent infarction in 1 patient. Two died of unknown causes after 2 and 5 years. Two others died suddenly at home after 5 and 6 months, respectively. No necropsy was made and the cause of death is unknown. Both had been examined during the preceding months and the electrocardiogram showed normal sinus rhythm. A third patient also died suddenly and because he was the only one who developed chronic sinoatrial disease his case history is given in some detail. He was a man aged 67. The hospital course during acute infarction had been stormy, with sinus arrest complicated by ventricular fibrillation, third degree atrioventricular block, and repeated syncope. A temporary pacemaker had to be used for 21 days. He was discharged with normal sinus rhythm (rate 68), dyspnoea on exertion, and moderate cardiomegaly. On examination 1 and 2 months afterwards his condition was unchanged. After 2 months he suffered repeated attacks of atrial tachycardia with 2:1 atrioventricular block alternating with sinus bradycardia (rate 30). His dyspnoea became worse and he was treated with a permanent pacemaker combined with digoxin 0.25 mg twice daily. No further attacks of tachycardia were recognized except during the first

TABLE 3 *Atrial pacing studies 4 to 6 years after infarction*

		Case No.						
		1	2	3	4	5	6	7
Age (y)		64	70	71	65	75	61	65
Heart rate/min		60	67	50-70*	57	73	58	84
Atrial pacing	Rate	100	120	140	140	100	140	140
	Sinus node recovery time (ms)	1200	1200	1100	1430	1050	1575	1245
	Sinus node recovery time (%)	120	130	110	140	120	150	173
	Corrected sinus node recovery time (ms)	190	300	100	380	200	540	530
<i>Effects of atropine</i>								
Heart rate/min				92	80			96
Atrial pacing	Rate			120	120			140
	Sinus node recovery time (ms)			750	900			1060
	Sinus node recovery time (%)			110	120			165
	Corrected sinus node recovery time (ms)			100	150			440

*Sinus arrhythmia.

pacemaker replacement after 2 years when the electrocardiogram showed atrial tachycardia with 2:1 atrioventricular block. His condition otherwise improved. After 4 years the electrocardiogram showed atrial fibrillation, with a ventricular rate varying between 35 and 60 and complete dissociation between the pacemaker stimuli and QRS caused by lead fracture. The breakage was repaired when a second pacemaker was installed and he remained well until death occurred suddenly 5 years after infarction. The pacemaker functioned normally. Necropsy showed extensive old myocardial infarction in the anterior and inferior wall, significant arteriosclerosis in the left coronary artery, and total arteriosclerotic occlusion of the right coronary artery. Unfortunately, a description of the sinus node with its artery was not obtained.

Electrophysiological investigations

The results of atrial pacing are seen in Table 3. Basal heart rate varied from 57 to 84. One other patient had sinus arrhythmia. The pacing rate giving maximal sinus node recovery time and maximal corrected sinus node recovery time varied from 100 to 140. Maximal sinus node recovery time was 150 per cent or above and maximal corrected sinus node recovery time was above 500 ms in cases 6 and 7, both receiving digoxin before the examination. At the time of investigation we were not aware that atropine was useful when studying sinus node function. However, heart rate increased in all three patients who received atropine, the increase being only slight in case 7. Maximal corrected sinus node recovery and sinus node recovery time did not change significantly after atropine. In all experiments sinus rhythm developed after cessation of

pacing and no prolonged secondary pause was observed. Atrioventricular conduction times were normal in all patients (the one whose His bundle electrogram was not obtained had a normal PQ time).

Comments

The mortality among the present 23 patients was 52 per cent, 4 to 6 years after discharge from hospital as a result of acute inferior myocardial infarction complicated by sinoatrial disease. The figure was not significantly different from the mortality in the same period (45%) among 587 patients with inferior infarction but without this complication. The average age in the two groups was similar (66 years). Only one of the 23 patients developed severe chronic sinoatrial disease or sick sinus syndrome (Lown, 1967; Ferrer, 1968) requiring permanent pacemaker treatment. Two other patients had second degree sinoatrial block of Wenckebach's type during the whole time in hospital for acute myocardial infarction and during the follow-up period. Some aetiology other than coronary artery disease could be involved. In one of them the rhythm disturbance had been recorded years before infarction. Both were free of symptoms. A fourth patient developed atrial fibrillation which persisted from the acute stage of infarction throughout the follow-up period. According to James (1961) and Ferrer (1974) atrial fibrillation could be a result of sinus node damage. We do not know if this was the case in our patient as no attempt at electroconversion has been made. This procedure might have resulted in sinus arrest if atrial fibrillation was the result of sinus node damage. In the remaining patients there were no symptoms or signs of sinoatrial disease. Sinus arrest cannot be

excluded in the two patients who died suddenly. However, sudden death from other arrhythmias, e.g. ventricular fibrillation, is not an uncommon event in patients with coronary artery disease.

The electrophysiological studies showed possible slight sinus dysfunction in 2 of 7 among 11 patients who were alive after 4 to 6 years: these were the only two who received digoxin before the investigation. The role of digitalis is difficult to assess. According to clinical experience sinoatrial disorders may develop during digitalis intoxication. But there was no suspicion of digitalis intoxication in our patients. Unpublished studies in our laboratory with ouabain intravenously have occasionally shown a prolongation of sinus node recovery time though Engel and Schaal (1973) showed a statistically significant reduction of sinus node recovery time after ouabain in patients with the sick sinus syndrome. Both our patients had a sinus node recovery time of 150 per cent or more. The other patients had values of 130 and 140 per cent, respectively. It is questionable whether these latter figures are pathological as there is no general agreement on normal limits. According to Ferrer (1974), the upper normal limit is 120 to 128 per cent depending on the basal heart rate. Narula, Samet, and Javier (1972) report a normal range from 115 to 159 per cent, with the longest corrected sinus node recovery time of 525 ms. Opinions also vary regarding the atropine response. Ferrer (1973) suggests that the heart rate should normally increase above 90 while Mandel, Laks, and Obayashi (1975) suggest that the increase should be above 50 per cent, with a transitional zone between 25 and 50 per cent. Gupta *et al.* (1974) accept heart rate responses above 30 per cent as normal. Dighton (1975) found that the heart rate response after atropine was a less reliable test. Before drawing conclusions from the electrophysiological studies one must be aware that no known test of sinoatrial function is wholly reliable. Nevertheless, our results do not indicate gross abnormalities.

In order to throw further light on the course of disease we have reviewed all patients, including those referred from other hospitals, receiving permanent pacemakers from 1966 to February 1975 because of severe chronic sick sinus syndrome.

Among 71 patients, 5 had previous documented myocardial infarction. All 5 developed severe sick sinus syndrome several months to one year after inferior infarction. In addition to the one already described, 2 others had sinus arrest, 1 had sinoatrial block, and 1 had prolonged sinus bradycardia during the acute stage. All had signs of extensive infarction with additional complications, such as congestive heart failure and/or prolonged hypotension. One of them had had a pulse rate of about 40 for 20 years after diphtheria and in two others electrocardiograms recorded before infarction had shown sinus bradycardia (rates 50 to 55). Nevertheless, myocardial infarction could be responsible, at least partly, for the severe chronic stage in these patients.

In order to obtain additional information on the natural course of sinoatrial disease especially during the first weeks and months after infarction serial measurements of sinus recovery time might be useful. This opportunity occurred when a bus driver aged 57 suffered acute inferior myocardial infarction in 1973. About an hour after the first symptoms he had a short bout of atrial fibrillation. Second degree 2:1 sinoatrial block developed 20 hours later, lasted a few hours, and never recurred. The course was otherwise uncomplicated, and because of his occupation specially careful follow-up was considered necessary. In addition to frequent clinical examinations atrial pacing studies were made 10 days as well as 3 and 5 and 14 months after infarction. The results are shown in Table 4. After 10 days maximal corrected sinus node recovery time was 450 ms and sinus node recovery time 150 per cent. After 3 months the corrected rate was 300 and the recovery time 130. After 5 and 14 months both figures were within limits accepted by all authors as normal.

The present material is drawn from a department with a yearly admittance of around 400 patients with acute myocardial infarction. Because sinoatrial disease is a fairly rare complication the examined group is not very large, but to our knowledge no systematic follow-up study in a larger group of patients has been reported. With this reservation our previous study (Rokseth and Hatle, 1971) and the present data suggest the following natural

TABLE 4 Repeat atrial pacing studies after infarction

Months after infarction	1	3	5½	14½
Heart rate/min	70	60	60	55
Atrial pacing				
Rate	110	120	120	120
Sinus node recovery time (ms)	1305	1300	1200	1390
Sinus node recovery time (%)	150	130	120	125
Corrected sinus node recovery time (ms)	450	300	200	300

course in patients with myocardial infarction complicated by sinoatrial disease. Inferior infarction is almost always present. Signs of sinoatrial disease often occur early, during the 3 first days after onset of chest pain, and are mostly of short duration, hours to a few days, and do usually not recur during hospital stay. Electrophysiological investigation may, however, unmask sinus node dysfunction for some time afterwards. Occasionally, sinoatrial disease may be a malignant complication lasting for weeks during acute infarction and requiring temporary pacemaker. If death occurs it is generally from other causes, such as shock and congestive heart failure. In survivors the long-term outlook as regards sinus node function is generally good. But chronic severe sick sinus syndrome requiring a permanent pacemaker may occasionally later develop especially in patients with a severe course and additional complications during acute infarction. These patients should, therefore, be carefully followed at least for a year. It should be borne in mind that sudden death may conceivably be caused by undetected sinoatrial disease, and it remains to be shown if repeat electrophysiological investigations may detect latent sinus node dysfunction preceding a severe development.

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