Long-term prognosis after cardiac pacing in atrioventricular block¹

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The long-term prognosis after cardiac pacing in atrioventricular block was assessed by a follow-up study of 48 patients in whom pacing had been introduced 5 years or more before analysis. The one-year survival rate was 81.3 per cent and the 5-year survival rate was 58.3 per cent. These figures are substantially better than the survival rate reported in patients not paced. The mortality has been higher in the older age groups. Pacing-related deaths, which should be avoidable, have diminished considerably with increasing experience. The institution of a special clinic for follow-up of these patients has been largely responsible for the improved results.

Over the past decade cardiac pacing has become the standard mode of therapy of heart block and its complications (Dack and Donoso, 1969). The increasing use of cardiac pacemakers has been encouraged by improved and simplified techniques of permanent pacing, by the development of more dependable electrodes and pulse generators, and by increasing clinical experience and follow-up data indicating a favourable effect on prognosis and improved cardiovascular performance. To date, however, there is little information on the long-term prognosis after cardiac pacing.

In 1964, we reported our experience in 4 patients treated with electrical pacing of the heart (Zion *et al.*, 1964). Since then, we have used long-term pacing in increasing numbers of patients with extended indications for pacing. However, in the majority of our patients, symptomatic atrioventricular block has been the indication.

Until the end of January 1972, there were 48 patients with atrioventricular block, in whom pacing had been introduced at least 5 years earlier. We report here an analysis of the survival rate in these 48 patients.

Subjects and methods

Between June 1963 and January 1967, 48 patients were subjected to long-term pacing. There were 28 men and 20 women, and their ages ranged from 29 to 85 years. The age distribution, by decades, is shown in Fig. 1.

All the patients had complete atrioventricular block, either continuously present, or occurring in recurrent

fashion without a preceding Wenckebach phenomenon (Mobitz Type 2 block), or alternating with various degrees of partial atrioventricular block. The indications for pacing were recurrent Adams-Stokes attacks in 44 patients, severe giddiness, with 'grey-outs' in 2 patients, intractable cardiac failure in 1 patient, and weakness with a persistently raised level of blood urea in 1 patient.

FIG. 1 Age distribution of patients.

Received 4 October 1972.

¹ Supported in part by the South African Research Council.

TABLE 1 *Aetiology of atrioventricular block*

Idiopathic	23
Ischaemic heart disease	20
Calcified mitral annulus	2
Calcific aortic stenosis	1
Cardiomyopathy	1
Postoperative	1

The aetiologies of the block are listed in Table 1.

In the first year of our experience, pacing was usually instituted via epicardial leads implanted at thoracotomy. Thereafter, the elective method of pacing was by transvenous catheter electrode positioned in the apex of the right ventricle. Only if transvenous pacing failed persistently were epicardial leads implanted. The sites of introduction of the transvenous leads were the right or left external jugular veins or, failing these, the right internal jugular vein. Elema (model 588B) transvenous pacing leads were used in these cases. The implanted units comprised Elema, Medtronic, St. Georges, De-vices, Vitatron, and Cordis pacemakers, as well as a unit of local design. Fixed rate or demand type pacing was used according to the requirements of individual cases. In 3 patients, atrial triggered pacing was instituted initially, but in 2 of these, subsequent pacing has been 'fixed rate'. One patient, the first to be paced long-term, has persistently refused an implanted unit, and has been paced for a total of 8 years and 7 months with portable external units.

Patients have been followed up at regular intervals at a special clinic, with clinical, electrocardiographic, and x-ray examination, as well as analysis of the pacing artefact on a rapid sweep oscilloscope (Type 561 A Tektronix, Inc. Portland, Oregon). The frequency of attendance has varied according to circumstances, but usually no less frequent than once every three months. Few patients have failed to attend as requested. Elective replacement of the pacing unit has been performed where these assessments have indicated impending unit failure.

Non-elective replacement of pacing units and re-positioning of displaced leads, or revision of pacing technique have been performed as required.

To assess possible improvements in early mortality in more recent experience, we have analysed the mortality experience in a further 101 patients followed for one year or longer.

Patients who died suddenly and unexpectedly at home were regarded as having died of pacing failure. While it is possible that some of these deaths were due to other causes, we were thus able to ensure that no deaths due to pacing failure were missed. In all the remaining patients who died, the causes of death were known.

Results

Deaths

Twenty of the patients have died, giving a 5-year survival of 58.3 per cent. The one-year survival rate was 81.3 per cent. The survival curve is shown in

FIG. 2 *Survival curve up to 5 years.*

Fig. 2. Of the 28 patients who have survived 5 years and longer, 11 are in the 6th year, 9 in the 7th year, 7 in the 8th year, and 1 in the 9th year.

Of the 44 patients who were paced for recurrent Adams-Stokes attacks, 26 (59.1%) have survived 5 years or longer.

Causes of death The causes of death are shown in Table 2.

It can be seen that 8 deaths were attributable to pacing failure or to operation for the introduction of long-term pacing (pacing-related deaths). Of the 6 patients who died of pacing failure, 4 had had electrocardiographic demonstration of failed pacing and died in Adams-Stokes attacks before pacing could be reinstituted. Two patients died suddenly and unexpectedly at home.

TABLE 2 *Causes of death*

Pacing failure	4 Documented electro-cardiographically	6	} Pacing-related deaths
	2 Sudden unexpected deaths		
Deaths due to thoracotomy		2	} Pacing-related deaths
Congestive heart failure		4	
Carcinoma		2	
Motor neurone disease		1	
Myocardial infarct with cardiogenic shock		1	
Pneumonia		1	
Ventricular fibrillation while pacing*		1	
Heart block†		1	
Anaemia		1	

* This patient had recurrent ventricular fibrillation, whether being paced via an external unit or not.

† This patient pulled out her transvenous lead and absconded from hospital.

The 4 patients who died of congestive heart failure were pacing steadily at the time of death. In one patient pacing had been instituted for intractable cardiac failure and complete atrioventricular block due to a congestive cardiomyopathy, with no real change in his progressive downhill course. The other 3 patients had had episodes of heart failure before pacing, which had been introduced for recurrent Adams-Stokes attacks. These attacks were controlled by pacing, which did not seem to affect the cardiac failure favourably or unfavourably.

Pacing-related deaths Of the 8 pacing-related deaths, 6 occurred in the first 2 years and the remaining 2 in the next 2 years. In the belief that increasing experience may be associated with a lower incidence of pacing-related deaths, we analysed the results in 63 consecutive patients paced from February 1967 to January 1970, allowing a follow-up of 2 years (minimum) to 4 years and 11 months (maximum). Nineteen of the patients died, and in 5 the deaths were pacing-related (1 post-thoracotomy; 1 documented failed pacing; 3 sudden unexpected deaths at home).

Thus in the group studied, 40 per cent of deaths were pacing-related, and these deaths comprised 16.7 per cent of the group, whereas in the later group 26.3 per cent of deaths were pacing-related, and these deaths comprised 7.9 per cent of the group (Fig. 3).

Deaths in relation to age The deaths in relation to the age group of the patients paced are shown in

TABLE 3 First year deaths

Year paced	Number paced	Deaths
1963	4	2 (50%)
1964	14	2 (14.3%)
1965	14	3 (21.4%)
1966	14	1 (7.1%)
1967*	2	1 (50%)

* Only January 1967 included in the series.

Fig. 4. There was one death in a patient in the 4th decade, 1 in a patient in the 5th decade, 4 in patients in the 6th decade, 5 in patients in the 7th decade, 6 in patients in the 8th decade, and 3 in patients in

TABLE 4 First year 'pacing-related' deaths

Year paced	Number paced	Deaths
1963	4	1 (25%)
1964	14	1 (7.1%)
1965	14	2 (14.3%)
1966	14	0 (0%)
1967	2	0 (0%)

the 9th decade. While the numbers are too small to allow of statistical analysis, the anticipated higher mortality in the older age group is shown.

Deaths in relation to year of pacing There were 18.7 per cent deaths in the first year, and only 23 per cent in the next 4 years (Fig. 2). The breakdown of these first year deaths in relation to the

FIG. 3 Comparison of pacing-related deaths in the group studied and in a subsequent group of 63 patients followed for at least 2 years.

FIG. 4 Deaths in relation to age groups of patients paced.

calendar years in which the patients were first paced, is shown in Table 3.

The first year deaths due to pacing failure or associated with pacing technique, in relation to the years in which the patients were first paced, are shown in Table 4.

First year deaths related to pacing were commoner in the earlier years of our experience. To assess if this trend continued, we analysed the results in a further 101 patients paced between February 1967 and January 1971 and followed up for at least one year. There were 2 pacing-related deaths in the first year of pacing among these patients (1 post-thoracotomy; 1 documented failed pacing). Thus in 1963 to 1965, 32 patients were paced and there were 4 first year deaths related to pacing (12.5%), while from 1966 to January 1971, 117 patients were paced and there were 2 first year pacing-related deaths (1.7%).

In this total of 149 patients paced for one year or longer the one-year survivors number 125 (84%).

Morbidity

The morbidity associated with long-term pacing is considerable and continued. It is not the purpose of this study to analyse the morbidity, but all but one

of the patients questioned as to whether pacing has been worth while have accepted that it has. The exception was the 83-year-old woman who pulled out her pacing electrode and absconded from hospital. The acceptance of the discomforts of long-term pacing is best exemplified by the patient who has accepted an external unit for over 8½ years.

Discussion

The natural history of complete heart block is not completely known. However, there have been several studies of the mortality experience of patients presenting in heart block and/or Adams-Stokes attacks. Rowe and White (1958) found a mean survival of 48 months after onset of heart block in patients with coronary heart disease alone, 55 months in those with coronary heart disease and hypertension, and 13 months in those with acute myocardial infarction. Somewhat surprisingly, the patients with Adams-Stokes attacks survived longer than those without such attacks.

Penton, Miller, and Levine (1956) found a mean survival time of 25.3 months for all patients, including those with acute myocardial infarction.

Johansson (1961) stressed that survival time differed according to the aetiology of the heart block

FIG. 5 Survival curves in this and in previously reported series, compared with the natural history for atrioventricular block.

and the age of the patients. In patients with coronary heart disease, but no acute myocardial infarction, the one-year survival rate was 50 per cent and the 5-year survival rate approximately 25 per cent. In a subsequent report (Johansson, 1969) this author confirmed these findings for the first year, but did not discuss longer term prognosis.

Friedberg, Donoso, and Stein (1964) analysed 100 cases of Adams-Stokes syndrome treated with various drugs as well as external pacing and defibrillation during acute attacks. They reported 35 per cent hospital deaths, with another 15 deaths within one year, giving a 50 per cent survival rate at one year. A further 5 deaths were known to have occurred between one and five years, and 20 patients were lost to follow-up. Friedberg (1966) subsequently reported that only 20 of the 100 patients survived for 4 years or longer.

Curd *et al.* (1963) in a study of 55 patients found a one-year survival rate of 60 per cent and a 2-year survival rate of approximately 46 per cent.

To ascertain for certain the effects of long-term pacing on survival rates, one would need to compare the results in a group of patients paced with a control group treated by drug therapy. Such a study has not been performed, and our results, and the general acceptance of long-term pacing would now make such a study unethical. A less certain method would be to compare the survival rate in patients paced with that in patients treated before the advent of long-term pacing. We personally do not have figures

relating to results before the availability of pacing, but it seems clear from other series that the 1-year survival rate for patients not paced is approximately 50 to 60 per cent and the 5-year survival rate is unlikely to be much more than 25 per cent (Fig. 5).

In our series, there is a 1-year survival of 81.3 per cent and a 5-year survival of 58.3 per cent. As in patients not treated with pacing (Johansson, 1961), the older age group have shown the highest mortality. Our series is too small to allow an analysis of mortality in relation to aetiology. However, most of our patients had heart block due to ischaemic heart disease, or fell into an idiopathic group. The mortality experience in these 2 groups has not differed significantly. We have no patients in this series in whom pacing was continued long-term after its introduction during the first few days after a myocardial infarction, a group in whom poor results may be expected (Johansson, 1969).

The sharp drop in the survival curve in the first year compared to the next 4 years closely resembles that found in non-paced cases (Friedberg *et al.*, 1964). In analysing the first year deaths according to the calendar year in which the patients were first paced, we were not able to find any constant pattern (Table 3). However, in analysing the first year deaths due to, or related to pacing, according to the calendar year in which the patients were first paced, we found a conspicuous drop in such deaths in the later years of our experience. This improvement was shown to be maintained in our subsequent experi-

ence with 101 patients paced, with a follow-up of at least one year. The improvement is attributable to the operation of a special follow-up clinic and the ability to detect impending pacing generator failure.

The overall incidence of pacing-related deaths has also been shown to drop with continuing experience. This, too, is largely due to the operation of the follow-up clinic, with the employment of techniques originally described by Davies and Siddons (1969). In fact, since the operation of such a clinic, pacing-related deaths have occurred virtually only in those patients failing to attend the clinic, with one post-surgical death in a patient in whom epicardial-lead pacing had to be used. It may be argued that sudden unexpected deaths at home were not necessarily pacing-related, but such deaths occurred in only 2 of the series studied, and in 3 of the subsequent series of 101 patients. If any or all of these deaths were, in fact, not pacing-related, the conclusions reached above would be equally valid.

The improved prognosis after pacing in chronic atrioventricular block has been commented upon by other workers. Cosby *et al.* (1965) reported a reduction of mortality from 60 to 80 per cent without pacing, to 10 per cent with pacing.

Lagergren *et al.* (1966) reported a 16 per cent mortality among 305 paced patients, practically all the deaths occurring within the first year. They compared this with a first year mortality of 48.5 per cent in 204 patients treated medically.

Chardack *et al.* (1965) showed a 1-year survival of approximately 80 per cent, a 2-year survival of 78 per cent, and a 5-year survival of 50 per cent.

Sowton and Flores (1971), reporting on a follow-up of 1 to 6 years, mentioned a mortality of approximately 7 per cent per year for the first 6 years.

Johansson (1969) showed a 1-year survival of over 80 per cent for patients treated with pacemakers as compared to a 60 per cent survival in medically treated cases.

The survival rates for paced cases (as for unpaced cases) are remarkably similar in most published series. Our survival rates for paced patients are comparable to those reported by other workers (Fig. 5).

The deaths not related to pacing have been due to various natural causes, and it is reasonable to assume that pacing has not affected this death rate in either direction. We believe, therefore, that with modern methods of pacing, mortality due to the effects of heart block *per se* may, with adequate patient co-

operation, be reduced to almost zero. The morbidity of long-term pacing is considerable but the rewards are great and patient acceptance of this morbidity is excellent.

We thank Dr. H. M. Salmon, Medical Superintendent, Johannesburg General Hospital, for permission to publish.

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