Results of Pacemaker Implantation

YOSHIFUMI SAKURAI,* EIICHIRO AOKI,*
YOSHIMI TAKEUCHI** AND TERUAKI KOIKE**

THE treatment of different arrhythmias by the use of implantable cardiac pacemakers has been developed in these 16 years since the first pacemaker implantation was reported by Chardack et al.¹⁻⁴ 1960, so that the indications of the treatment have been extended from bradyarrhythmias to tachyarrhythmias. Also, the pacemaker implantation technique has been comparatively eased irrespective of the type of lead to be used, be it endocardial or myocardial.

With the increase in the number of patients with implanted pacemakers, new different problems concerning the management of the patients have been encountered not in the pacemaker implantation technique but in the long-term follow-up of these patients; difficult problems such as

pacing troubles and pacemaker failures have frequently occurred, and how to overcome these difficulties is becoming the major problem in the patient management. Since the main purpose of the treatment with pacemakers is patients' return to the social activity, the patient care system must be complete to eliminate these difficult problems.

In addition to our paper appeared on the Japanese Circulation Journal Vol. 38, 1974,⁵ this paper will give the results of the treatment in 115 cases experienced from October 1966 to February 1977.

METHODS OF STUDY

The study was made on 115 patients to inves-

TABLE I CASES & RESULTS OF PACEMAKER IMPLANTATION
(Oct 1, 1966—Feb. 28, 1977)

Year	Cases	Replacement	Death
1966	1	0	0
1967	2	0	0
1968	2	0	0
1969	5	1	2
1970	5	5	1
1971	10	8	0
1972	11	9	2
1973	19	19	1
1974	17	17	0
1975	17	16	1
1976	21	26	0
1977	5	8	0
Total	115	109	7 (6.0%)

Oct. 1, 1966—Nov. 30, 1973; Niigata University Hospital
Dec. 1, 1973—Feb. 28, 1977; Niigata City Hospital

Dept. of 2nd Surg. Niigata City Hospital, Niigata, Japan

Dept. of 2nd Surg. Niigata University School of Medicine, Niigata, Japan

TABLE II TYPES OF ELECTRODE

Type	Cases
<i>Myocardial Electrode</i>	73 (63.5%)
<i>Unipolar Myocardial Electrode</i>	1
<i>Bipolar Myocardial Electrode</i> (7 cases unipolar use)	72
<i>Endocardial Electrode</i>	42 (36.5%)
<i>Unipolar Endocardial Electrode</i>	13
<i>Bipolar Endocardial Electrode</i>	29
<i>Total</i>	115
<i>Bipolar Electrode</i>	94 (81.7%)
<i>Unipolar Electrode</i>	21 (18.3%)
<i>Total</i>	115

TABLE III TYPES OF ARRHYTHMIA

Type	Cases
<i>Complete A-V Block</i>	56 (48.7%)
<i>Incomplete A-V Block</i>	24 (20.0%)
<i>Sinus Arrhythmia</i>	14 (12.2%)
<i>Sinus Arrest, S-A Block</i>	
<i>Sick Sinus Syndrome</i>	14 (12.2%)
<i>Surgical Heart Block</i>	3 (2.6%)
<i>Atrial Fibrillation</i>	4 (3.4%)
<i>Total</i>	115

TABLE IV CASES OF DEATH

Case	Period	Arrhythmia	Cause of death
1. 92y M	48 m	A-V Block	Senile decay
2. 41y M	18 m	A-V Block	Sudden, unknown
3. 74y F	12 m	Sinus arrest	D. M.
4. 76y M	14 m	A-V Block	Sudden, unknown
5. 50y F	13 m	A-V Block	Sudden, unknown
6. 5y M	14 m	A-V Block	Sudden, unknown
7. 70y F	10 m	S.S.S.	Heart Insuff.

Fig.1. Simple acoustic coupling transmitter.

Fig.2. Telephone transmission ECG from patients' home.

TABLE V RESULTS OF PACEMAKER IMPLANTATION
(Condition of post op.)

Year	Cases	A	B	C	D	E	Death
1966	1	1					
1967	2	1	1				
1968	2	2					
1969	5	1	2				2
1970	5	1	1		1	1	1
1971	10	4	5		1		
1972	11	5	3		1		2
1973	19	6	9		3		1
1974	17	7	7		3		
1975	17	6	7	1	2		1
1976	21	8	6	1	6		
1977	5	1	1		1	2	
Total	115	43	42	2	18	3	7

A: Return to work, B: Return to housework, C: Child, D: Retired, E: Rest

TABLE VI FAILURE AND COMPLICATION

Pacemaker Failure (Electronics, Battery, Leakage, Connecting)	5/224 (2.2%)
Electrode Failure (Myocardial 673, Endocardial 156)	7/115 (6.0%)
Pacing Failure (Abnormal Stimulation Threshold)	1/224 (0.4%)
Sensing Failure (Undersensing 1, Oversensing 5)	6/224 (2.6%)
Interference	3/224 (1.3%)
Skin Necrosis	3/224 (1.3%)
Infection	3/224 (1.3%)
Muscle Twitching	1/224 (0.4%)
Electrode Dislodgment	5/ 42 (11.9%)
Perforation	0/ 42

tigate year-to-year variations, types of electrodes, types of arrhythmias, patients returning to the social activity and postimplantation complications.

RESULTS AND DISCUSSION

Year-to-year variations of pacemaker implantations:

Table I shows that the number of cases have a tendency to increase from 1973. All the cases after December 1, 1973 were experienced at Niigata City Hospital. In 115 patients, 109 pulse generator replacements were performed, and a total of 224 pulse generators were used.

The longest pacing was ten years and five months, for which the initial implantation was performed October, 1966.

Age distribution at the initial implantation was from 1 to 88 years. Except the cases of surgical block, most of the patients were noticed

TABLE VII RESULTS OF PACEMAKER IMPLANTATION

	<i>All cases</i>	<i>Over 4Y</i>	<i>Under 4Y</i>
<i>Perfect</i>	85 (73.9%)	26 (74.2%)	59 (73.8%)
<i>Moderate</i>	20 (17.4%)	3 (8.6%)	17 (21.2%)
<i>Rest</i>	3 (2.7%)	1 (2.9%)	2 (2.5%)
<i>Death</i>	7 (6.0%)	5 (14.3%)	2 (2.5%)
<i>Total</i>	115	35	80
<i>No trouble</i>	62 (57.4%)	14 (46.6%)	48 (61.5%)
<i>Some trouble</i>	46 (42.6%)	16 (53.4%)	30 (38.5%)
<i>Total</i>	108	30	78

Perfect: Return to work & house work, Moderate: Child & Retired

to be in old ages.

There were 7 death cases, the details of which are discussed later. New lithium pulse generators⁹ were introduced into Japan in 1976, and since then, replacements of pulse generators are expected to have a tendency to decrease. However, mercury pulse generators were used in most of our cases, this decreasing tendency was not yet noticed.

Types of electrodes:

At present time, lithium powered ventricular-inhibited demand pulse generators are used in most cases, and there is a very little chance to select other types pulse generators. However, still there remains some problems as to types of electrodes (endocardial or myocardial) and types of pacing (unipolar or bipolar).

As listed in Table II, out of 115 patients, myocardial electrodes were used in 73 patients (63.5%), and endocardial electrodes, in 42 patients (36.5%). This may be different from the general tendency.

However, our clinical cases experienced after 1976 reveal that the applications of endocardial electrodes are increasing in number.

Although both unipolar pacing or bipolar pacing has its own advantage or disadvantage, bipolar pacing was used in 94 patients (81.7%), and unipolar pacing, in 21 patients (18.3%). This tendency as to the selection of unipolar or bipolar still remains, though it might be partly because of the liking of author.

Types of arrhythmias:

Table III shows the incidence of various arrhythmias seen in patients; A-V block (including surgical block) in 83 patients (71.3%), sinus ar-

rythmias in 14 patients (12.2%) sick sinus syndrome in 14 patients (12.2%), and atrial fibrillation in 4 patients. Adams-Stokes Syndrome was noted in all patients.

In patients with sick sinus syndrome, pacing was used to maintain the necessary minimum pacing rate for the prevention of occurrence of paroxysm in bradyarrhythmia and also to improve the preventive effect of tachycardia by therapeutic agents.

Recently, it is reported that such problems as pacing failure and sensing failure are increasing in number. One of the reasons may be due to the fact that the application of pacing has recently extended to sick sinus syndrome.

Investigation on death cases:

Cause of death was ascertain only 3 cases, another 4 cases not make sure. Case 1, 3, 7 was recognized senile decay, DM, and heart failure. Another 4 cases was sudden death.

5 cases were recognized complete A-V block, 1 case sinus arrhythmia, and 1 case sick sinus syndrome. We have suppose to high possibility of pacing failure, because all sudden death cases was complete A-V block.

We have been used telephone transmission system⁷ (pacemaker clinic by telephone transmission) that acoustic coupling transmitter and direct wired receiver. Simple acoustic coupling transmitter was shown in Fig. 1. Fig. 2 was shown telephone transmission ECG from patients' home.

Patients' return to the social activity:

To investigate the results of patients' return to the social activity, all the patients are classified into five groups as follows;

A: Return to pre. operative work.

B: Return to house work. C: Children.
D: Retired. E: Rest.

As listed in Table V, out of 115 patients, 85 patients (73.8%)—43 in group A and 42 in group B— could be regarded as complete return to the social activity. 20 patients—2 in group C and 18 group D— did not have any inconvenience in daily life, though they did not have any particular work. Out of 3 patients in group E, 2 with heart failure and 1 with cerebral infarction were being hospitalized.

Therefore, excluding 10 patients —3 in group E and 7 in death cases, 105 patients (91.2%) out of 115 were able to return to the social activity in some way.

However, the above figure merely shows the general recovery condition. The troubles with pacemakers and pacing and sending failures were actually noted in these favorable cases, though most these disorders temporally observed. Such disorders were frequently repeated or overlapped in particular cases.

Getting the chance to return to the social activity is the practice purpose of pacemaker implantation in 115 cases of this series. Parsonnet et al.⁸ reported that survival rate 5 years following pacemaker implantation was 60 to 70%, but our cases survival rate 5 years was 88%.

Complications:

The details on the disorders concerning pacemakers or sensing and pacing problems were omitted for want of paper's space.

Table VI shows that more troubles were found in electrodes than in pulse generators. The troubles with pulse generators were rather very limited. Especially, wire breakage was frequently noted in myocardial electrodes. However, the investigation of the electrode used in the longest pacing case at the time of last pulse generator replacement reveals that this electrode was still in good condition after the use of approximately 10 years and that its resistance including load was 500 ohms and the stimulation threshold was 2.4 μ J.

Most of pacing or sensing failures experienced with the recent pulse generators seems to be due to their narrow pulse width, which will reduce the amount of output energy.

After October 1975, whenever any implantation or replacement of pulse generator was performed by us, the measurements of both stimulation threshold and sensing threshold were made by the use of a pacing system analyzer. As to the stimulation threshold, from the threshold current

and the threshold voltage measured simultaneously, the value in micro joules was obtained.

None of troubles in pacing were found in 62 patients out of 108 (57.4%). In the remaining 42 patients (42.6%), some kind of disorder including the occurrence of extrasystoles, be it slight or serious, was noted. The fact means that the follow-up in pacing of great importance.

Both patients' return to the social activity and pacing troubles were classified into over-4-years group and less-4-years group. Though the number of cases in each group is different, VII shows that the cases falling into both A and B groups were seen in 74.2% of over-4-years group, in 73.8% of less-4-years group, and 73.8% of the total cases. Very little difference in each figure was noticed.

As to the troubles in pacing during treatment period, trouble-free pacing was noticed in 46.6% of over-4-years group, in 61.5% of less-4-years group, and in 57.4% of the total cases.

This means that the possibility of trouble occurrence will be increased with the length of pacing period.

CONCLUSION AND SUMMARY

As shown in the summary of our clinical cases, considerable much pacing trouble and early death were noted. This will advocate the necessity of selecting the indications for pacing, and the importance of patient care systems. With the increase of pacemaker implantation cases, these attitude toward the management of patients will become surely indispensable.

REFERENCES

1. CHARDACH, W. M., GAGE, A. A., & GREATBACH, W.: A transistorized, self-contained, implantable pacemaker for the long-term correction of complete heart block. *Surgery* 48: 634, 1960.
2. GLENN, W. W., MAURO, A., LONGO, E., LOVITTES, P. H., & MARCHAY, F. J.: Remote stimulation of the heart by radio-frequency transmission. Clinical application to a patient with Stokes-Adams Syndrome. *New Eng. J. Med.* 261: 948, 1959.
3. ABRAMS, L. D., HUDSON, W. A., & LIGHTWOOD, R.: A surgical approach to the management of heart block using an inductive coupled artificial cardiac pacemaker. *J. Lancet* 1: 1272.
4. LAMBERG, L., CASTELLANOSA, Jr., & BERKOVITZ, B. V.: Pacemaking on demand in A-V block. *JAMA* 191: 12, 1965.
5. SAKURAI, Y., TAKEUCHI, Y., & ASANO, K.: Indications and results of pacemaker implantation. *Jap. Circul. J.* 38: 121, 1974.
6. FURMAN, S., ESCHER, J. J. W., & SOLOMON,

- N.: Transvenous pacing of the heart. *Amer. Heart J.* 71: 408, 1966.
7. SAKURAI, Y., AOKI, E., TERASHIMA, M., ASANO, K., TAKEUCHI, Y., & HATTORI, J.: Pacemaker clinic by telephone transmission. *Jap. Artificial Organ.* 4: 357, 1975.
 8. PARSONNET, V.: A decade of permanent pacing of the heart. *Clin.* 2: 182, 1970.
 9. PARSONETT, V., FURMAN, S., & SMYTH, N. P. D.: Implantable cardiac pacemakers: Status report and resource guideline. *The Amer. Journal of Cardiology.* 34: Oct 1, 1974.