AUDIT

Permanent pacemaker use after cardiac transplantation: completing the audit cycle

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Abstract

***Objective*—To determine the effects of delaying permanent pacemaker implantation in cardiac transplant recipients from less than three weeks to three weeks or more post transplantation—a change prompted by an earlier audit.**

***Design*—Retrospective review of resting 12 lead electrocardiograms and prospective 24 hour ambulatory electrocardiograms. Comparison of pacemaker usage before (period 1) and after (period 2) the policy change in November 1990.**

***Setting*—Outpatient department, supraregional cardiopulmonary transplant unit.**

***Patients*—All 30 consecutive orthotopic cardiac transplant recipients who received a permanent pacemaker within one month of transplantation between May 1985 and August 1995.**

***Main outcome measures*—Presence of pacing on the 12 lead electrocardiogram and during 24 hour ambulatory electrocardiogram monitoring (pacemaker programmed to 50 beats per minute).**

Results—16/152 (10·5%) cardiac transplant recipients received permanent pacemakers in period 1 compared with 14/180 (7·8%) in period 2 (P = NS). Evidence of pacing was seen on 12 lead electrocardiograms at three months in 37·5% recipients in period 1 compared with 78·6% in period 2 (P = 0·03). At six months pacemaker usage had declined to 18·8% in period 1 and 35·7% in period 2 and at three years to 13·3% in period 1 and 40% in period 2 (P = NS for both). 21% patients in period 1 paced on ambulatory 24 hour monitoring compared with 38·5% in period 2 (P = NS).

***Conclusions*—Delaying permanent pacemaker implantation to three weeks or more after cardiac transplantation reduced the proportion of permanent pacemaker implantations, slightly but not significantly. There was a significant increase in permanent pacemaker usage at three months post transplantation with trends towards increased usage at later times, suggesting more appropriate selection of patients for permanent pacing.**

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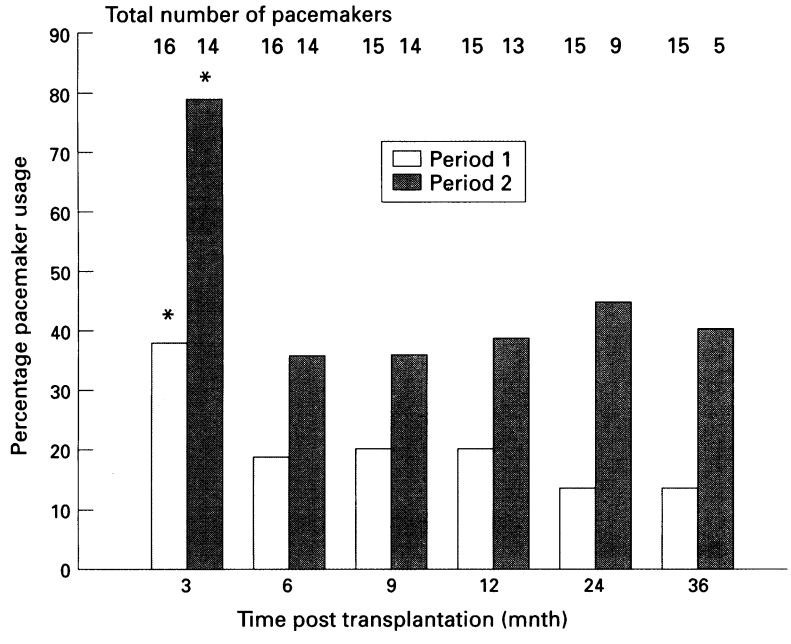
Early reports of bradycardic deaths among asymptomatic cardiac transplant recipients with sinus node dysfunction,[1] led to a high rate of permanent pacemaker implantation after orthotopic cardiac transplantation.[2–6] Permanent pacemakers are implanted in cardiac transplant recipients because of sinus node dysfunction, atrioventricular block, and, less commonly, nodal bradycardias.[2–7] Bradycardia occurs in 64% of recipients in the first few weeks after cardiac transplantation[7] but often resolves.[8 9] If such bradycardias persist permanent pacemaker implantation may be required. Permanent pacemaker implantation rates range from 4% to 29% in different transplant centres.[2–6] Differences in the criteria for permanent pacing as well as differences in incidence of bradyarrhythmias may account for this variation.

The optimal time for permanent pacemaker implantation is not known. In our centre, before November 1990, permanent pacemakers were implanted between days eight and 21 after transplantation if the resting heart rate was below 70 beats per minute. However, a review of our practice showed that in the long term permanent pacemaker usage was low.[6 9] Only 37·5% transplant recipients with permanent pacemakers continued to pace at three months and 18·8% by one year.[9] No long-term pacing was seen in those recipients who had permanent pacemakers implanted before day 16 post transplantation.[6] In the light of this, we changed our policy to delay implantation to day 21 after transplantation to allow spontaneous recovery of sinus and atrioventricular node function. We reviewed subsequent permanent pacemaker usage in April 1996.

Methods

Orthotopic cardiac transplantation is performed at our centre using the standard atrial anastomosis technique described by Lower *et al.*[10] Temporary epicardial atrial and ventricular pacing wires are attached at the time of transplantation. Temporary pacing is used to main-



*Permanent pacemaker usage in periods 1 and 2 at specified times after cardiac transplantation. *P = 0·03.*

tain a resting heart rate of at least 70 beats per minute in the first three weeks, with an infusion of isoprenaline used postoperatively as required. Permanent pacemakers are inserted if the resting heart rate is below 70 beats per minute at a specified time after transplantation (see below).

We undertook a review of all adult patients permanently paced after cardiac transplantation at our centre from November 1990 to the end of August 1995 and we have compared the results with that of a similar audit previously performed[9] in order to assess the effects of the policy change resulting from the first audit.[6 9]

The two different policy periods were identified as periods 1 and 2:

Period 1 (May 1985 to November 1990) Permanent pacemaker implantation between days 8 and 20 after cardiac transplantation

Period 2 (December 1990 to August 1995) Permanent pacemaker implantation on or after day 21 after cardiac transplantation

The indication for permanent pacing, type of permanent pacemaker implanted, and time of implantation were noted for each recipient. The number of days that all cardiac transplant recipients in period 2 who survived more than 14 days required temporary epicardial pacing was noted. The number of patients spared permanent pacemaker implantation in period 2 because of the policy change was taken as those patients paced via temporary epicardial wires at day 16 who did not subsequently receive a permanent pacemaker.

For both periods, a retrospective review of routine outpatient 12 lead electrocardiograms was performed for evidence of pacing at rest, at three, six, nine, 12, 24, and 36 months after cardiac transplantation. Prospective 24 hour ambulatory pacemaker usage was determined either by interrogation of the permanent pacemaker or by inspection of a 24 hour electrocardiogram tape, with the pacemaker programmed to 50 beats per minute.

We compared the results for the two time periods by Fisher's Exact Test using Statgraphics version 2·6.

Results

Three hundred and thirty five adult orthotopic cardiac transplants were performed at our centre between May 1985 and the end of August 1995. Thirty three (9·9%) received permanent pacemakers. Three patients had permanent pacemakers implanted after the first month: one in period 1 at three months for late sinus node dysfunction (died at four months of infection and renal failure), and two in period 2 at three years and three years five months for atrioventricular block induced by right ventricular endomyocardial biopsy. These three recipients were excluded from the study and subsequent statistical analysis.

Of the 152 cardiac transplant recipients in period 1, 16 (10·5%) had permanent pacemakers implanted compared with 14 of 180 (7·8%) in period 2 (P = NS). Nine (56%) permanent pacemakers inserted in period 1 were for sinus node dysfunction, compared with 10 (71%) in period 2 (P = NS). In period 1, seven (44%) pacemakers were for atrioventricular block compared with four (29%) in period 2 (P = NS).

Of the 14 patients who had a permanent pacemaker implanted in period 2, the proposed policy was not followed in four: in two, premature failure of temporary pacing leads occurred, in one the need for permanent pacing was established at an early stage because of surgical problems at the time of donor heart retrieval, and in one patient implantation occurred at day 20 post-transplantation because it was more convenient.

An additional seven of 166 (4·2%) patients required temporary epicardial pacing for more than 16 days post-transplantation in period 2 and therefore would potentially have undergone permanent pacemaker implantation if the policy in period 1 had continued. They all had sinus node dysfunction. These patients have not required permanent pacemaker implantation at a later stage and have remained well.

Evidence of pacing on routine 12 lead electrocardiograms and on 24 hour recording for each recipient in periods 1 and 2 are given in the table together with time of implantation, reason for implantation, and type of permanent pacemaker implanted. Evidence of pacing on 12 lead electrocardiograms for the two groups at three, six, nine, 12, 24, and 36 months post-transplantation is shown and compared in the figure. Significantly more recipients of permanent pacemakers were using them at three months in period 2 than in period 1 (78·6% *v* 37·5%, P = 0·03). Permanent pacemaker usage declined with time in both periods with only about half the patients using their permanent pacemaker at three months still using it at six months and after. However, permanent pacemaker usage

Permanent pacemaker implantation in periods 1 and 2

Number	Implantation day after operation	Mode	Indication	Pacemaker usage from 12 lead ECGs: Months after operation 3	6	9	12	24	36	Pacemaker usage from 24 hour ambulatory recording	Comments
				Period 1							
1	18	VVI	SND	−	−	−	−	−	−	−	
2	14	VVI	SND	−	−	−	−	−	−	+	Paced at night
3	8	VVI	AVB	−	−	−	−	−	−	−	
4	9	VVI	SND	+	−	−	−	−	−	ND	
5	15	VVI	AVB	−	−	−	−	−	−	−	
6	19	DDD	SND	+	+	+	+	+	+	+	†
7	9	VVI	AVB	+	−						Died at 7 months
8	17	VVI	SND	−	−	−	−	−	−	−	
9	16	VVIR	SND	−	+	−	−	−	−	−	
10	9	VVIR	AVB	+	−	−	−	−	−	−	
11	15	VVIR	AVB	−	−	−	−	−	−	−	
12	20	VVIR	SND	+	−	+	+	+	+	+	
13	10	DDDR	SND	+	+	+	+	−	−	−	
*14	90	VVIR	SND								
15	12	VVIR	AVB	−	−	−	−	−	−	−	
16	14	VVIR	SND	−	−	−	−	−	−	−	
17	15	VVIR	AVB	−	−	−	−	−	−	−	
				Period 2							
18	28	AAIR	SND	+	+	+	+	+	+	+	
19	25	AAIR	SND	−	−	−	−	−	−	−	
20	21	DDDR	AVB	+	+	+	+	+	+	+	
21	26	AAIR	SND	+	−	−	−	−	−	−	
22	21	DDDR	SND	+	−	−	−	−	−	−	
23	24	AAIR	SND	−	−	−	−				Died at 19 months
24	33	AAIR	SND	+	−	−	−	−		−	
*25	1257	VVI	AVB								Biopsy-induced AVB
*26	1085	VVI	AVB								Biopsy-induced AVB
27	19	AAIR	SND	+	+	+	+	+		+	
28	13	DDDR	AVB	+	+	+	+	+		+	
29	20	DDDR	AVB	+	−	−	−	−		−	
30	19	AAIR	SND	−	−	−	−			−	
31	34	DDD	SND	+	−	−	−			−	
32	29	AAIR	SND	+	−	−	+			−	
33	22	VVIR	AVB	+	+	+				+	

AVB, atrioventricular block; ND, not in prospective study; SND, sinus node dysfunction; +, electrocardiographic evidence of pacing; −, no electrocardiographic evidence of pacing.
*Excluded from analysis.
†Upgraded from VVI because of pacemaker syndrome.

at all intervals in period 2 is about twice that of period 1.

Three of 14 (21%) recipients in period 1 had evidence of pacing on 24 hour electrocardiogram recording compared with five of 13 (38·5%) in period 2 (P = NS) (table). There has been no significant decrease in the number of patients with sinus node dysfunction pacing long-term on 24 hour electrocardiograms (38% *v* 25%, period 1 *v* period 2) but significantly more recipients with atrioventricular block paced long-term in period 2 (0% *v* 75%, period 1 *v* period 2, P = 0·03) (table).

Discussion

Review of our permanent pacemaker implantation policy and practice in November 1990 showed that long-term pacing was often unnecessary after cardiac transplantation.[6,9] By three months after cardiac transplantation, sinus node dysfunction had improved in 56% and atrioventricular block in 71% permanent pacemaker recipients, as evidenced by lack of pacing on resting 12 lead electrocardiograms.[9] Also no patient who had a permanent pacemaker inserted before the sixteenth day after cardiac transplantation continued to pace in the long term.[6] On the basis of this, we empirically deferred permanent pacing until day 21 post transplantation to allow for spontaneous resolution of sinus node dysfunction and atrioventricular block. We expected that a delay in permanent pacemaker implantation would allow better selection of patients, thereby avoiding permanent pacemaker implantation in some patients who would have required short-term pacing only and thus increasing the proportion of patients who demonstrated long-term pacing.

This change in permanent pacemaker implantation policy has resulted in a slight but statistically insignificant fall in the incidence of permanent pacing (10·5% to 7·8%). Seven patients have been spared permanent pacemaker implantation as a result of the policy change. They have therefore been spared the potential morbidity and mortality of pacemaker complications. The change in policy has also resulted in a statistically significant increase in permanent pacemaker usage at three months and a trend to increased usage up to one year post transplantation (for which follow up data are almost complete).

Despite an increase in pacemaker usage with the change in policy, we are still not selecting those patients who require long-term pacing, because permanent pacemaker usage as shown on 12 lead electrocardiograms halves between three and six months and thereafter remains constant. In particular, we have shown that selection of those patients with sinus node dysfunction likely to pace long-term, as shown by 24 hour ambulatory recordings, has not improved significantly. We have previously shown that sinus node function improves with time after cardiac transplantation.[8] Electrophysiological indices of sinus

node function return to normal by six weeks.[8] Sinus node function therefore may not improve rapidly enough to avoid permanent pacemaker implantation in many who will no longer require pacing at three or six months post transplantation. In that study, we also found that the presence of temporary pacing during 24 hour Holter monitoring two and three weeks after transplantation, with pacing set at 50 beats per minute on demand, predicted permanent pacing requirements.[8] This observation was, however, based on two patients only. An abnormal corrected maximal sinus node recovery time at three weeks after transplantation predicted subsequent pacing but this observation was based on one patient only.[8] Both these observations were made after the permanent pacemaker policy change in 1990 and so could not be applied prospectively.

It may be easier to select patients with atrioventricular block who will require long term pacing. Significantly more patients with atrioventricular block paced long-term in period 2 than in period 1, suggesting that delaying permanent pacemaker implantation had allowed sufficient time for those who were likely to recover atrioventricular nodal conduction to do so and thereby selecting those with chronic atrioventricular block. However, those demonstrated to have been spared permanent pacemaker implantation all had sinus node dysfunction, suggesting that those with temporary atrioventricular block may have already recovered by day 16.

LIMITATIONS OF THE STUDY

The patients included in this study were identified retrospectively.

Patients spared permanent pacemaker implantation were assumed to be those requiring temporary epicardial pacing at day 16 post transplantation. Patients may have been temporarily paced to a higher heart rate despite a resting heart rate of 70 beats per minute to achieve a greater cardiac output in conditions such as in renal impairment or fluid overload.

Although 12 lead electrocardiograms were available for all included study patients at the defined times after cardiac transplantation, the ambulatory 24 hour recordings were performed at variable times between three and 65 months in period 1 and nine to 37 months in period 2. Follow up was incomplete in period 2 in terms of 12 lead electrocardiograms for time periods of 12 months onwards after transplantation because patients have not yet reached these time periods. Longer follow up was available for period 1.

CONCLUSIONS

Deferring permanent pacemaker implantation led to an insignificant reduction in pacemaker implantation. The audit based policy change significantly increased usage at three months, which suggests better selection. However, the fact that only 36%, or less than half of those using their pacemakers at three months, use their pacemaker at six months suggests that selection is still poor and that refinements are still needed.

Delaying implantation may allow recovery of temporary atrioventricular block. It is more difficult to select patients with sinus node dysfunction who need permanent pacing. Delayed implantation had no significant impact on the long-term pacing requirements of those with sinus node dysfunction.

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