

# Pacemaker dependency after pacemaker implantation

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## Abstract

**Background:** *Pacemaker dependency (PD) can be defined as the risk of serious injury or death from sudden pacemaker failure, an event more dangerous than progressive rate decrease. The aim of this study was to evaluate the incidence of PD during long-term follow-up after pacing system implantation.*

**Methods and Results:** *The study included 3638 patients (mean age  $65.3 \pm 10.2$  years). Indications for pacing were sick sinus syndrome (SSS) in 1315 patients, atrioventricular block (AVB) in 1482, AVB and SSS in 478 and atrial fibrillation (AF) with bradycardia in 363 patients. The mean follow-up was  $4.8 \pm 1.8$  years. Pacemaker dependency was defined as the absence of an intrinsic rhythm of 30 beats/min during back-up pacing and after switching off the pacemaker. If any significant symptoms of bradycardia developed or if the underlying rhythm did not appear (asystole  $> 5$  s) the pacing was restarted. Pacemaker dependency was observed in 76 (2.1%) of the 3638 patients. In this subgroup pacing indications were SSS in 8 (0.6%) of 1315 patients, AVB in 52 (3.5%) of 1482, SSS and AVB in 15 (3.1%) of 478 and AF with bradycardia in 1 (0.3%) of 363. Patients with AVB had a significantly higher incidence of PD than patients with SSS or AF ( $p < 0.001$ ,  $p < 0.005$ , respectively). A total of 139 patients suffered from myocardial infarction and 106 patients had a temporary pacing prior to pacemaker implantation. The majority of these patients were pacemaker dependent ( $p < 0.001$ ).*

**Conclusions:** *In our study PD occurred very rarely, being found in 2.1% of all patients. Patients with AVB have a significantly higher incidence of PD than patients with SSS or AF. Temporary pacing prior to pacemaker implantation and previous myocardial infarction indicate patients at risk of PD development. (Cardiol J 2007; 14: 83–86)*

**Key words:** pacemaker dependency, escape rhythm, sick sinus syndrome, atrioventricular block, atrial fibrillation

## Introduction

During long-term follow-up a considerable number of permanent pacemaker patients show a spontaneous heart rhythm faster than the basic rate of the pacemakers. However, in approximately 40% of patients continuous pacemaker-induced rhythm is observed at consecutive follow-up examinations.

These pacemaker-dependent patients, who have no intrinsic or escape rhythm, may develop

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complications (syncope, serious injury or even sudden death) under conditions of electromagnetic interference, lead dysfunction or battery depletion.

During the original pacemaker implantation it is often difficult to assess the reliability of the escape rhythm and thus to predict the development of pacemaker dependency during long-term follow-up [1–9].

The purpose of the present study was to examine pacemaker dependency (PD) in paced patients during long-term follow-up and to evaluate the difference between patients with and without escape rhythm as well as to define clinical factors that can predict a higher incidence of PD.

### Methods

A total of 3638 consecutive paced patients were enrolled in the present study (1709 men, 1929 women). Only patients in whom the pacemaker could be programmed and turned off were selected. The mean age of the population at examination was  $65.3 \pm 10.2$  years (range 23–95 years). The patients had undergone pacemaker implantation at the Department of Electrocardiology from 17 years down to 1 year before the study (mean follow-up was  $4.8 \pm 1.8$  years between 1998 and 2005). The study was a retrospective one. The indication for permanent pacing was syncope or symptomatic bradycardia caused by atrioventricular block (AVB) in 1482 patients, sick sinus syndrome (SSS) in 1315, AVB and SSS in 478 and atrial fibrillation (AF) in 363 patients. A total of 2046 patients had coronary artery disease (CAD), 1615 had arterial hypertension (AH) and 725 patients had heart failure (HF). The other 462 patients had no structural heart disease. Myocardial infarction was suffered by 139 patients and 106 patients had temporary pacing prior to pacemaker implantation. In all, 1455 patients had DDD pacing, 156 had VDD pacing, 1845 had VVI pacing and 182 patients had AAI pacing. Patients were excluded if they had undergone AV junctional radiofrequency ablation or if they had had a pacemaker implanted

because of bradyarrhythmia within 6 months of acute myocardial infarction or cardiac surgery and these patients will be analysed in a subsequent study. Our patients were treated with  $\beta$ -adrenergic blockers and other anti-arrhythmic drugs. The drugs were used chronically or intermittently. The sex distribution, mean age and mean duration of follow-up for each group are shown in Table 1.

After giving their informed consent, these patients were placed in a supine position and monitored continuously while the pacemaker (DDD and VDD  $\rightarrow$  VVI) was programmed with the pacing rate decreased by 10 beats/min every 2 min down to the lowest programmable rate (30 beats/min), which was continued for 30 s. Afterwards the pacemaker was switched off. If any significant symptoms of bradycardia developed or if the underlying rhythm did not appear, producing a ventricular asystole longer than 5 s [8], the pacing was restarted. In this event, the patient was defined as pacemaker-dependent. The examination was performed by a cardiologist, technician and specially trained nurse.

An ECG was recorded with a standard recorder at a paper speed of 25 mm/s and an amplification of 1 mV/cm. A defibrillator and resuscitation equipment were on hand for immediate use. There were no serious or life-threatening complications in the study group.

The  $\chi^2$  test was used to evaluate the effect of sex, aetiology, coronary artery disease, artery hypertension, heart failure, myocardial infarction and temporary pacing on pacemaker dependency. The difference between patients with and without escape rhythm was evaluated by using an independent t-test. A p value of 0.05 or less was considered significant.

### Results

Table 1 shows the sex distribution, mean age, and mean duration of follow-up among patients with AVB in relation to those with SSS, AVB and SSS and AF with bradycardia.

**Table 1.** Sex distribution, age and follow-up duration in relation to pacing indication. Groups and overall population (n = 3638).

| Pacing indication | AVB<br>(N = 1482) | SSS<br>(N = 1315) | SSS and AVB<br>(N = 478) | AF/bradytachycardia<br>(N = 363) | All patients<br>(N = 3638) |
|-------------------|-------------------|-------------------|--------------------------|----------------------------------|----------------------------|
| Men/women         | 637/845           | 740/575           | 225/253                  | 107/256                          | 1709/1929                  |
| Age (years)       | $67.8 \pm 9.8$    | $65.8 \pm 10.2$   | $66.4 \pm 11.0$          | $60.9 \pm 9.4$                   | $65.3 \pm 10.2$            |
| Follow-up (years) | $4.5 \pm 1.4$     | $4.9 \pm 1.8$     | $4.7 \pm 1.7$            | $4.9 \pm 2.3$                    | $4.8 \pm 1.8$              |

SSS — sick sinus syndrome; AVB — atrioventricular block; AF — atrial fibrillation

**Table 2.** Number (%) of patients with pacemaker dependency according to pacing indication.

| Pacing indication        | Pacemaker dependency |
|--------------------------|----------------------|
| AVB (N = 1482)           | 52 (3.5%)            |
| SSS (N = 1315)           | 8 (0.6%)             |
| SSS and AVB (N = 478)    | 15 (3.1%)            |
| AF/bradycardia (N = 363) | 1 (0.3%)             |

See Table 1 for explanation of abbreviations. SSS vs. AF/bradycardia:  $p = \text{NS}$ ; AVB vs. SSS:  $p < 0.001$ ; SSS vs. SSS and AVB:  $p < 0.001$ ; AVB vs. AF/bradycardia:  $p < 0.001$ ; SSS and AVB vs. AF/bradycardia:  $p < 0.005$

Of 3638 pacemaker patients 3562 (97.9%) patients presented intrinsic or escape rhythms at rates  $> 30$  beats/min and 76 (2.1%) developed PD with no intrinsic rhythm. Among the four indications for permanent pacemaker implantation were rates of PD development of 52 (3.5%) of 1482 patients with AVB, 8 (0.6%) of 1315 with SSS, 15 (3.1%) of 478 with SSS and AVB, and 1 (0.3%) of 363 patients with AF and bradycardia (Table 2).

There were no statistically significant differences in sex, age, prevalence of CAD, AH, HF or mean follow-up duration among the various pacing indication groups and pacemaker-dependent and non-dependent patients.

The incidence of PD was significantly higher among patients with AVB than patients with SSS and AF ( $p < 0.001$  and  $p < 0.005$  respectively).

As shown in Table 3, AVB and SSS patients who had had temporary pacing before pacemaker implantation or who had undergone myocardial infarction had a significantly higher incidence of PD ( $p < 0.001$ ).

## Discussion

The definition of PD has long been a source of controversy and confusion. Duncan-Fraser et al. [1]

**Table 3.** Comparison between temporary pacing and myocardial infarction with and without escape rhythm.

| Group of patients             | Temporary pacing | Old myocardial infarction |
|-------------------------------|------------------|---------------------------|
| Overall<br>— 3638 (100%)      | 106 (2.9%)       | 139 (3.8%)                |
| With escape<br>— 3562 (97.9%) | 48 (1.3%)        | 95 (2.6%)                 |
| Without escape<br>— 76 (2.1%) | 58 (76.3%)*      | 44 (57.8%)*               |

\* $p < 0.001$  between two values

reported their experience from June 1983 onwards, performing routine standardised dependency risk scoring on an active clinical population of 1800 patients with some 25 models of pacemakers from 5 different manufactures. A patient was classified as 1+ when an intrinsic rhythm exceeded the paced rate of 70 beats/min, as 2+ when an intrinsic rhythm was visible with rate slowing or competition, as 3+ when there was no spontaneous escape or an escape rate between 30 and 50 beats/min and as 4+ when there was no spontaneous escape or an escape rate  $< 30$  beats/min. They reported that dependency risk scoring is a useful parameter of assessment in any paced patient and provides reliable and safe timing for pulse generator replacement. They further concluded that knowledge of a patient's dependency status has allowed them to set realistic surveillance schedules, to improve patient flow within the clinic, to utilise physician time to best advantage and to funnel highly dependent patients to a programming room with resuscitation equipment.

In the study published by Behrens et al. [9] four classes of PD are distinguished (class I — 5 s of asystole, class II — 2–5 s of asystole with escape by complete heart block, class III — escape by lesser degrees of AVB, ventricular ectopy with sinus bradycardia equal to or below 30 beats/min, class IV — escape by sinus rhythm of 40 beats/min or more). Classes III and IV were deemed non-dependent.

After implantation of a permanent pacemaker, the escape rhythm may be suppressed and when pacing is stopped a significant percentage of the patients fail to develop an effective escape rhythm [2, 3, 5, 7]. This effect depends on the pacing rate and duration [5]. The pacemaker-dependent patients may, with a sudden loss of pacing, be at significant risk of developing syncope, serious injury or even sudden death [2, 3, 5, 7].

The 2.1% of PD after pacemaker implantation in our study was relatively low compared to the incidence observed in previous studies, ranging between 5% and 30% [2, 3, 7]. The difference may be attributed to variation between studies in the definition of PD. The definition of Staessen et al. [2] includes the absence of any ventricular escape rhythm within 4 s of successful pacemaker inhibition and irregular ventricular escape rhythms with pauses of 4 s or more. The other definition of PD, that of Glikson et al. [4], is an underlying rhythm below 50 beats/min. Nagatomo et al. [7] defined PD as the absence of an escape rhythm for at least 30 s after gradual slowing of the pacing rate to 30 beats/min without turning off the pacemaker.

Our definition, based on the absence of an escape or intrinsic rhythm for 30 s during temporary back-up pacing at a rate of 30 beats/min and after switching off the pacemaker, identified the highest risk pacemaker-dependent patients who suffer Stokes-Adams attacks, serious injuries or sudden death if pacing suddenly fails. Therefore a gradual slowing of the pacing rate and afterwards the cessation of pacing used in the present study seems to be the best method for evaluating PD [7]. It may indicate accidental serious pacing failure and reflect the number of patients prone to asystole or severe bradycardia.

As observed in previous works [2, 3, 7], the patients in the present study with AVB had a higher incidence of pacemaker dependency during follow-up than patients with SSS or AF. The main finding of our study is that the patients with temporary pacing prior to pacemaker implantation and with previous myocardial infarction showed a higher frequency of pacemaker dependency. Knowledge of the absence of spontaneous ventricular activity in a pacemaker patient has important clinical implications. Malfunction of the pacemaker system should be detected early in these patients and this can be achieved by increasing follow-up frequency [2, 3, 7].

It has been clearly established in the past (likewise as in our study) that there were no differences in age, sex, baseline heart disease (CAD, AH, HF) or previous coronary artery surgery between patients with and without escape rhythm [2–4, 6–8]. However, Rosenheck et al. [3, 5] underlined that patients without a reliable escape rhythm have a longer history of conduction disorder, a slower intraventricular conduction (a paced QRS wider than 180 ms), and are frequently treated with anti-arrhythmic agents. In our retrospective study we did not analyse drug administration and so were unable to assess the potential influence of pharmacotherapy on PD. However Nagatomo et al. [7] show no correlation between drug administration and the presence or absence of an intrinsic rhythm during long-term follow-up. The incidence of pacemaker or electrode malfunction was found in 1.3% and 6% patients respectively [1]. These patients are at high risk if PD does occur.

## Conclusions

In our study the prevalence of PD was relatively low (2.1%). The incidence of PD after device implantation was dependent on the pacing indication and was more common in patients with AVB than in patients with SSS or AF. Temporary pacing prior to pacemaker implantation and previous myocardial infarction indicate patients at risk of developing pacemaker dependency.

## References

1. Duncan-Fraser J, Cameron DA, Radvansky E, Goldman B. Dependency risk score: usefulness during a pulse generator recall. In: Gomez FP (ed.) *Cardiac pacing, electrophysiology, tachyarrhythmias*. Futura Media Services, Mount Kisco, New York, 1985: 1130–1133.
2. Staessen J, Ector H, De Geest H. The underlying heart rhythm in patients with an artificial cardiac pacemaker. *PACE*, 1982; 5: 801–807.
3. Rosenheck S, Bondy C, Weiss AT et al. Comparison between patients with and without reliable ventricular escape rhythm in the presence of long standing complete atrioventricular block. *PACE*, 1993; 16: 272–276.
4. Glikson M, Dearani JA, Hyberger LK, Schaff HV, Hammil SC, Hayes DL. Indications, effectiveness, and long-term dependency in permanent pacing after cardiac surgery. *Am J Cardiol*, 1997; 80: 1309–1313.
5. Rosenheck S, Bondy C, Weiss AT, Gotsman MS. The effect of overdrive pacing rate and duration on ventricular escape rhythms in patients with chronic complete atrioventricular block. *PACE*, 1994; 17: 213–221.
6. Fedman S, Glikson M, Kaplinsky E. Pacemaker dependency after coronary artery bypass. *PACE*, 1992; 15: 2037–2040.
7. Nagatomo T, Abe H, Kikuchi K, Nakashima Y. New onset of pacemaker dependency after permanent pacemaker implantation. *PACE*, 2004; 27: 475–479.
8. Deharo JC, Mansourati J, Graux P et al. Long-term pacemaker dependency after radiofrequency ablation of the atrioventricular junction. *Am. Heart J*, 1997; 133: 580–584.
9. Behrens M, Klementowicz P, Andrews C, Ausubel K, Furman S. Pacemaker dependency following cessation of pacing. *PACE*, 1985; 8: 288 (abstract).