

# Retrospective analysis of reasons for failure of DDD pacemaker implantation in patients operated on between 1993 and 2005

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## Abstract

**Background:** *During implantation of a DDD pacemaker the following difficulties may be encountered: venous anomalies (the absence of vessels of adequate calibre or difficulty in subclavian vein puncture), arrhythmias during implantation (episodes of atrial flutter/fibrillation while the atrial leads are being positioned), lack of mechanical stability of the electrode in the heart chamber and inability to achieve an acceptable pacing and sensing threshold during implantation. The purpose of the study was to analyse retrospectively the reasons for DDD pacemaker failure in patients operated on between 1993 and 2005.*

**Methods:** *We reviewed retrospectively all implantation data from 1988 to 2005 to identify patients with primary failure of DDD pacemaker implantation. Further analysis included patients who had received a DDD pacemaker between 1993 and 2005, when this type of pacemaker made up between 9 and 40% of all pacemaker implantations. We implanted 7469 pacemakers, including 1958 (26.2%) dual-chamber pacemakers, in 783 patients with atrioventricular block (AVB), 392 with sick sinus syndrome (SSS), 450 with AVB ± SSS and 333 with tachy-brady syndrome (TBS). The mean age of the patients was  $65.5 \pm 17.3$  years. DDD pacing was unsuccessful in 108 (1.4%) patients, including 32 with AVB, 22 with SSS, 16 with SSS ± AVB and 38 with TBS. The mean age of these patients was  $78.5 \pm 19.4$  years.*

**Results:** *The reasons for failed implantation were venous anomalies in 12%, an arrhythmia episode in 27.8%, a high pacing threshold in the atrium in 17.6%, low atrial potential amplitude in 25.9% and lack of mechanical stability of the electrode in 16.7% of patients. The difficulties were encountered in elderly patients ( $p < 0.01$ ), most frequently in patients with SSS and TBS (71). Between 2004 and 2005 venous anomalies and a high pacing threshold were the main causes of failure.*

**Conclusions:** *Currently the main difficulties encountered during pacemaker implantation are venous anomalies and a high pacing threshold. Arrhythmia episodes, low atrial potential*

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*amplitude and lack of mechanical stability are of minor importance. Elderly patients with sick sinus syndrome and tachy-brady syndrome have the highest failure rate. (Cardiol J 2007; 14: 155–159)*

**Key words: arrhythmia episode, high pacing threshold, low atrial potential amplitude, lack of mechanical stability, venous anomalies, DDD pacing**

## Introduction

In most cases permanent pacing is performed with an endocavitary electrode. The electrodes are inserted via the veins of the upper thorax and neck [1–6] and, exceptionally, via the femoral vein (in patients with superior vena cava syndrome) [7].

Exposure of the cephalic vein in the brachiothoracic groove is regarded as equivalent to subclavian venipuncture technique [2–5]. When these two main access sites are not available, it is recommended to use the veins lying between the pectoral muscles or superficial jugular veins, side branches of the internal jugular vein (the inferior thyroid vein or transverse vein of the neck), the internal jugular vein itself and, finally, venipuncture or exposure of the internal jugular vein [7].

Implantation of a dual-chamber pacemaker involves placement of a ventricular electrode followed by an atrial electrode inserted via the same or another vein. Appropriate fixation of the atrial electrode (similar to the ventricular electrode) is configured by a slight elevation of up to 0.2 mV of the AV segment in the endocardial lead. Where there is difficulty in placing atrial (ventricular) electrodes, it is preferable to use active fixation electrodes [2].

To sum up, during implantation of a DDD pacemaker the following difficulties may be encountered:

- venous anomalies (absence of vessels of adequate calibre or difficulty in subclavian vein puncture);
- arrhythmias during implantation (episodes of atrial flutter/fibrillation while the atrial leads are being positioned);
- lack of mechanical stability of the electrode in the heart chamber;
- inability to achieve an acceptable pacing and sensing threshold during implantation (mainly in the atrium).

These difficulties may be the reason for changing the primary decision regarding DDD pacemaker implantation. The purpose of the study was to analyse retrospectively the reasons for DDD pacemaker failures in patients operated on between 1993 and 2005. A review of the available literature shows that there are no publications dealing extensively

with this problem. There are, however, separate reports of electrode insertion during atrial flutter/fibrillation and at low atrial potential amplitude.

## Methods

According to the guidelines for electrotherapy of the heart [1], apart from achieving appropriate electrode placement, it is necessary to optimise sensing and pacing parameters and to achieve at least the threshold values of:

- ventricular potential amplitude > 4 mV;
- rate of rise of ventricular potential > 0.5 V/s;
- atrial potential amplitude > 2 mV;
- rate of rise of atrial potential > 0.2 V/s;
- pacing threshold < 1.0 V/0.5 ms [1].

Not all episodes of supraventricular arrhythmia were the cause of a change in pacing mode. Cardiac arrhythmia that did not resolve spontaneously and was resistant to anti-arrhythmic drugs forced us to abandon implantation of a DDD pacemaker. Cardioversion was not performed during the procedure.

Mechanical stability of the electrode was confirmed during the Valsalva manoeuvre and while the patient was coughing. The myocardial pacing threshold was checked during these manoeuvres.

In patients with venous anomalies (cephalic vein, other tributaries of the subclavian vein and difficulty in puncture of the latter) we made an attempt to implant the pacemaker on the contralateral side. In most cases the procedure was successful. The implantation procedure was always performed by the most experienced operator. Contrast medium was injected to a peripheral vein to visualise abnormalities. Occlusion of the subclavian vein and absence of a tributary of adequate calibre were the most frequent anomalies.

Passive fixation electrodes were applied and in the event of mechanical instability the screw-in type was used. Atrial electrodes were placed in the right atrial appendage, whereas, until 2004 ventricular electrodes were placed at the right ventricular apex. A pacing threshold in the atrium above 2 V was regarded as unacceptably high.

We retrospectively reviewed all implantation data from 1988 to 2005 to identify patients with primary failure of DDD pacemaker implantation.

**Table 1.** The number of pacemaker implantations in consecutive years.

Years	No. of all implantation/ /no. of DDD pacemakers
1993	465/43 (9%)
1994	469/88 (18%)
1995	465/81 (17%)
1996	506/103 (20%)
1997	524/132 (25%)
1998	500/131 (26%)
1999	479/135 (28%)
2000	532/103 (19%)
2001	587/131 (22%)
2002	707/174 (24%)
2003	806/271 (33%)
2004	646/264 (40%)
2005	783/302 (38%)

These patients finally received a VVI pacemaker. As the number of DDD pacemakers implanted between 1988 and 1992 was too small (below 8%), further analysis included patients who had received a DDD pacemaker between 1993 and 2005, when this type of pacemaker made up between 9 and 40% of all pacemaker implantations. At this time we implanted 7469 pacemakers, including 1958 (26.2%) dual-chamber pacemakers, in 783 patients with atrioventricular block (AVB), 392 with sick sinus syndrome (SSS), 450 with AVB ± SSS and 333 with tachy-brady syndrome (TBS). The mean age of the patients was 65.5 ± 17.3 years. DDD pacing was unsuccessful in 108 (1.4%) patients, including 32 with AVB, 22 with SSS, 16 with SSS ± AVB and 38 with TBS (Table 1). The mean age of the patients at the time of implantation was 78.5 ± 19.4 years (16–94) and 3361 (45%) were men. DDD pacing was unsuccessful in 108 (1.4%) patients, including

32 with AVB, 22 with SSS, 16 with SSS ± AVB and 38 with TBS. The mean age of these patients was 78.5 ± 19.4 years and there were 46 men (43%).

**Statistical analysis**

Data are expressed as mean ± 1 standard deviation and as a percentage. Student’s t-test was used for analysis. A p value below 0.05 was considered significant.

**Results**

The reasons for abandoning implantation of DDD pacemakers were venous anomalies in 13 (12%), an episode of atrial flutter/fibrillation during the procedure in 30 (27.8%), a high pacing threshold in the atrium in 19 (17.6%), low atrial potential amplitude in 28 (25.9%) and lack of mechanical stability of the electrode in 18 (16.7%) patients (Table 2).

We were most frequently forced to abandon the implantation of a DDD pacemaker in SSS and TBS (71 cases) as a result of an arrhythmia episode, low amplitude and lack of mechanical stability (Table 3).

Between 1993 and 2003 excessively low atrial potential amplitude and arrhythmia episodes (atrial flutter/fibrillation) during the procedure were the main causes of failure. Of note is the decrease in the rate of unsuccessful insertion of atrial electrodes with increasing experience and technological progress in electrodes and pacemakers and between 2004 and 2005 the absence of failure as a result of arrhythmia episodes, low atrial potential amplitude and inappropriate mechanical stability of the electrode. Only single cases of venous anomaly and a high pacing threshold were encountered. Patients in whom the primary procedure was abandoned were older than those with successful implantation of a DDD pacemaker (p < 0.01).

**Table 2.** Reasons for failure of DDD pacemaker implantation in consecutive years.

Reasons for failure of DDD pacemaker implantation	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Venous anomalies 13 (12%)	0	1	2	1	0	1	1	2	1	3	0	0	1
Episode of atrial flutter or fibrillation 30 (27.8%)	1	1	3	5	3	5	4	5	1	0	2	0	0
High pacing threshold 19 (17.6%)	2	2	1	0	0	1	0	2	2	0	1	5	3
Low atrial potential amplitude 28 (25.9%)	4	2	11	2	2	2	1	1	2	1	0	0	0
Lack of mechanical stability 18 (16.7%)	3	4	5	2	1	1	1	1	0	0	0	0	0

**Table 3.** Reasons for failure of DDD pacemaker implantation according to indication. Patients with indications to pacemaker implantation (N = 108).

Reasons for failure of DDD pacemaker implantation	AVB (n = 32)	SSS (n = 22)	SSS + AVB (n = 16)	TBS (n = 38)
Venous anomalies — 13	4	3	4	2
Episode of atrial flutter or fibrillation — 30	2	7	5	16
High pacing threshold — 19	5	4	5	5
Low atrial potential amplitude — 28	4	8	4	12
Lack of mechanical stability — 18	1	5	3	9

AVB — atrioventricular block, SSS — sick sinus syndrome, SSS + AVB — double node disease, TBS — tachy-brady syndrome

Unfortunately it is not possible to provide fluoroscopy times during the implantation of DDD pacemakers in consecutive years. It is now 10 minutes on average; prior to 1998 it was much longer, at about 25 minutes.

### Discussion

On 4 October 1984 the first dual-chamber pacemaker (multiprogrammable Medtronic Symbios 7006) was implanted in a 57-year-old man with second-degree AVB and transiently third-degree AVB with Morgani-Adams-Stokes syndrome. We used the original bipolar electrodes (a straight ventricular electrode and a J-shaped atrial electrode). The ventricular electrode was fixed as usual at the right ventricular apex. The atrial electrode was inserted via venipuncture of the subclavian vein under fluoroscopic control and fixed in the right atrial appendage. By the end of 1985, probably for financial reasons, only three more dual-chamber pacemakers had been implanted [8]. In 1993 the number of implanted DDD pacemakers began to increase steadily (> 9%) and as a result later analysis included patients who had received a DDD pacemaker between 1993 and 2005. A total of 7469 pacemakers were implanted, of which 26.2% were dual-chamber pacemakers. In 2006 dual-chamber pacemakers made up 49% of all implantations.

In 108 patients selected for dual-chamber pacing the procedure was abandoned and VVI pacing was used. These patients were older (78.5 years), probably with greater myocardial injury and 55% of them had SSS and TBS. The reasons for failure were low atrial potential amplitude (< 2 mV), an arrhythmia episode (atrial flutter/fibrillation) during manipulation of the atrial electrode, lack of mechanical stability and a high atrial pacing threshold (> 2 V). The first three causes were most frequently encountered in patients with SSS and TBS.

The rate of failure decreased with increasing experience and progress in pacemaker technology [9–11]. In 1997 the introduction of bipolar active fixation electrodes (screw-in endocavitary electrodes) and multiprogrammable pacemakers with special anti-tachycardia features and atrial sensitivity programmed to 0.1 mV allowed for better mechanical stability of the electrode and implantation at low atrial potential amplitude (< 2 mV). Furthermore, atrial flutter/fibrillation during insertion of the atrial electrodes is no longer a significant problem. According to Kindermann et al. [12], in the event of unexpected arrhythmia atrial electrodes should be placed in locations with potential amplitudes above 1.0 mV [13–15]. This is a useful approach to achieving sufficient atrial sensing after restoration of sinus rhythm and the only remaining problems between 2004 and 2005 were venous anomalies and a high pacing threshold.

The high rate of arrhythmias (27.8%) during the procedure was found mainly in patients with the TBS. Several investigators [12, 13, 16] report rates ranging from 1 to 5.5%, but mainly in patients with pure SSS, in whom, under normal conditions, the rate of arrhythmias is much lower. Anomalies of the cephalic vein (absent vein or hypoplasia) occur in about 10% of patients undergoing pacemaker implantation (about 0.6% in the present study) and, according to Wiegand et al. [17], in about 2% of patients undergoing pacemaker implantation it was impossible to achieve correct electrical parameters (in 2.4% in the present study).

Despite the limitations of the present study related to its retrospective character some important conclusions can be drawn.

### Conclusions

1. Currently the main reasons for abandoning implantation of dual-chamber pacemakers are

venous anomalies and a high pacing threshold (> 2 V). Low atrial potential amplitude, arrhythmia episodes and lack of mechanical stability are of minor importance.

2. Elderly patients with sick sinus syndrome and tachy-brady syndrome have the highest failure rate.

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