

# Long-term follow-up of patients with AAI pacemakers for sick sinus syndrome: system upgrades and changes in Wenckebach block point behaviour

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## Summary

**Aims:** Though indicated in guidelines, AAI<sup>1</sup> pacemakers are scarcely used in patients with sick sinus syndrome (SSS) due to fear of AV block during follow-up, necessitating device upgrade. The Wenckebach block point (WBP) is often used to determine AV nodal conduction at implant. Our aims were therefore to determine the upgrade rate of AAI pacemakers over time and to study both the stability of WBP over time and its usefulness as a predictor for upgrades.

**Methods:** In this single-centre study, patients with AAI pacemakers were followed regarding need for upgrade and predictors were explored. An AAI system was implanted in patients with SSS without evidence of conduction delay in the His-Purkinje system. WBP was measured at implant and at every follow-up visit. Changes in WBP during long-term follow-up were studied in patients with complete data.

**Results:** We included 140 patients, 87 patients (62%) were female and age at implantation was  $74 \pm 13$  years. Mean follow-up was  $3.6 \pm 3.3$  years. Intraoperative WBP was  $134 \pm 16$  bpm, for patients with complete follow-up it was  $129 \pm 18$  bpm. Mean WBP remained stable during long-term follow-up within a range of 120 to 140 bpm. No changes in WBP behaviour were seen with increasing age. System upgrade was performed in 8 patients (5.7%) mainly due to higher degree AV block. The annual upgrade rate was 1.6%. None of intraoperative WBP, age at implant, presence of atrial fibrillation at implant and gender were predictive for future upgrade.

**Conclusion:** AAI pacemakers evince a very reasonable long-term performance in patients with SSS, with very few patients needing an upgrade. WBP is stable

during long-term follow-up and well into old age. No predictors for the development of higher-degree AV block were found. Thus AAI pacemakers may be considered more frequently in patients with SSS and without signs of atrioventricular conduction disease.

**Key words:** sick sinus syndrome; Wenckebach block point; AAI pacemaker; atrial single chamber pacemaker; system upgrade

According to current guidelines [1, 2] AAI pacemakers are indicated for SSS. Several studies have shown that AAI pacemakers are sufficient to treat these bradyarrhythmias [1, 3, 4] and that additional ventricular pacing may even be detrimental [3, 5]. AAI pacemakers have various advantages in comparison with DDD<sup>2</sup> pacemakers: they are cheaper, due to lower hardware costs and lower expenditures at implantation and during follow-up [6–9], and thus their cost-effectiveness is good [8]. In addition to these economic benefits they are easier and less time-consuming to implant and the implantation involves fewer complications. Lead failure, for example, is half as frequent in AAI compared to DDD pacemakers [6], yet this remains a largely theoretical advantage as the vast majority of cardiologists continue to implant DDD pacemakers for fear of future AV nodal disease. However, large studies have shown that these concerns are mainly unfounded, as the overall upgrade rate is  $<2\%$  [4, 7, 10] or about 0.6% per year of follow-up [11]. In spite of these favourable data, AAI systems are generally underused. In Switzerland, for

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- 1 AAI Pacemaker with atrial sensing, atrial pacing and inhibition mode
- 2 DDD Pacemaker with atrial and ventricular sensing, atrial and ventricular pacing and inhibition as well as triggered mode.

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example, in 2008, 30% of all pacemakers were implanted for SSS, but in only 1.3% was an AAI system chosen [12].

The WBP is frequently used for determination of intact AV conduction and thus for selection of the pacing mode in SSS. Some guidelines [2] call for an intraoperative WBP of >120 bpm in the absence of a prolonged PR interval and of a narrow QRS complex (without specifying these prerequisites in detail). Current ACC/AHA/HRS guidelines [1] are relatively vague, suggesting “evidence for impaired AV conduction or concern over future development of AV block” as the rationale for choosing a DDD system. Data on long-term behaviour of WBP in SSS patients is scarce and limited by imprecise attribution to different heart rates tested.

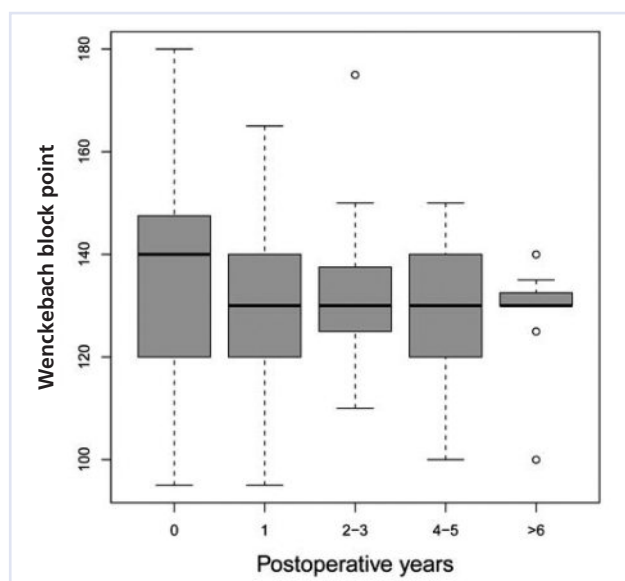
Against this background, the aims of this study were: a) to determine whether WBP decreases with age or with the number of postoperative years, b) to determine the need for system upgrade to a DDD pacemaker and c) to define predictors for system upgrades.

## Methods

We collected data in all patients who received an AAI pacemaker between 1992 and 2006 at the University Hospital of Basel, Switzerland. Indication for an AAI pacemaker in our hospital is a “pure” SSS without evidence of conduction delay in the His-Purkinje system (i.e., no PR interval prolongation, no complete left or right bundle branch block, no left anterior/posterior fascicular block). In addition, during implantation testing the WBP must be >120 bpm to ascertain whether an AAI system is appropriate. The highest WBP tested

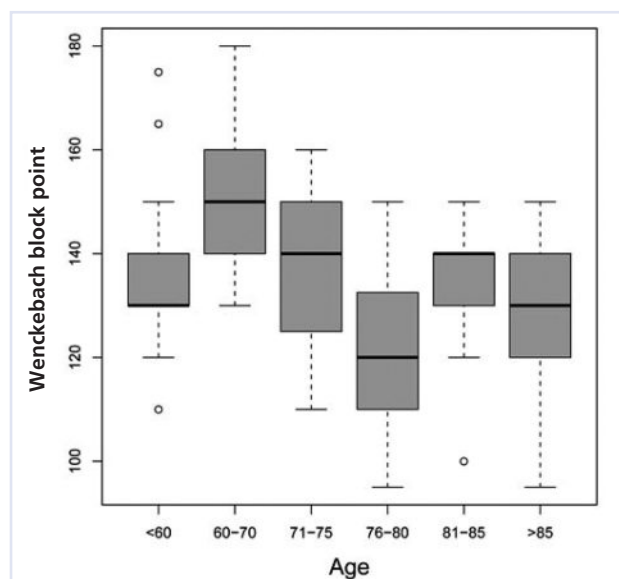
**Figure 1**

Distribution of Wenckebach block points in specific groups according to number of postoperative years. Box represents the middle 50% of all data in that specific group, the black line is the median.



**Figure 2**

Distribution of Wenckebach block points in specific groups according to patients age at implantation. Box represents the middle 50% of all data in that age-group, the black line is the median.



was 180 bpm. Patients with SSS who did not meet these criteria received a DDD system and therefore are not included in the present study.

The symptoms leading to pacemaker implantation were recorded, together with WBP behaviour and system upgrades. WBP behaviour was determined at each visit. Normally follow-up was performed annually, except for the first follow-up which was performed 3 months after implantation. We collected all available data from the date of implant until the beginning of 2008. We included all patients with regard to indication, upgrade-rate and death ( $n = 140$ ). However, for the WBP measurements we included only patients with sufficient follow-up data ( $n = 39$ ). 86 patients were excluded due to incomplete follow-up data and 15 patients in whom the medical history could not be traced. Follow-up was performed either at Basel University Hospital or at several private practices in the Basel area.

We used Microsoft Excel XP™, the internet based program GraphPad QuickCals (2002–2005 by GraphPad Software, Inc; <http://graphpad.com/quickcalcs/>) and program R: A Language and Environment for Statistical Computing, Version 2.8.1 (R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria, 2009) to generate the box plots (fig. 1 and 2); “±” is used to indicate one standard deviation.

## Results

Between 1992 and 2006, 140 patients received an AAI pacemaker, accounting for 6.5% of all pacemakers implanted during this period. 87 patients (62%) were fe-

male and age at implantation was  $74 \pm 13$  years (range 19–94).

The symptoms necessitating implantation were syncope (39%), dizziness (29%), bradycardia (21%), and others (11%). 24 patients (17%) died during follow-up. Mean follow-up of all patients was  $3.6 \pm 3.4$  years. Follow-up time of the 39 patients with complete WBP data was  $3.0 \pm 2.6$  years. Intraoperative WBP was  $134 \pm 16$  bpm, and for patients with complete follow-up it was  $129 \pm 18$  bpm. The mean WBP remained stable during long-term follow-up within a range of 120–140 bpm (see fig. 1). While the mean value for patients with complete follow-up for all controls was  $124 \pm 21$  bpm, the mean value of the last available WBP measurement was  $137 \pm 24$  bpm. No changes in WBP behaviour were seen with increasing age (fig. 3).

**Table 1**

Indications and symptoms in 8 patients who underwent system upgrades.

Reason	Symptoms	New device mode	<i>p</i>
Paroxysmal AVB III	Dyspnoea NYHA III	DDD	<i>p</i>
Persistent AVB II type 2	Dyspnoea NYHA II	VVI (advanced age)	0,8513
WBP 80 bpm	None, upgrade at time of battery depletion	DDD	0,3740
Paroxysmal AVB III	Syncope	DDD	0,5270
Paroxysmal AVB II type 1	Dyspnoea NYHA II	DDD	<i>p</i>
Persistent AVB II type 2	Presyncope	DDD	0,1175
Paroxysmal AF and AV nodal ablation	Dizziness	DDD	0,0474
Paroxysmal AF and AV nodal ablation	Multiple symptoms, not all related to AF	DDD	0,3168

DDD = pacemaker with atrial and ventricular sensing, atrial and ventricular pacing and inhibition as well as triggered mode; VVI = pacemaker with ventricular sensing, ventricular pacing and inhibition mode.

## Discussion

### Main findings

Three main findings emerged from our study. Wenckebach block point behaviour in pacemaker patients with sick sinus syndrome is stable during long-term follow-up and well into old age. AAI pacemakers exhibit a very reasonable long-term performance for this arrhythmia, as only a small minority of patients needed a system upgrade. None of our four parameters studied at the time of implant was predictive for the development of higher-degree AV Block. Therefore, AAI pacemakers should be used more frequently in patients with sick sinus syndrome and no signs of atrioventricular conduction disease.

VVI<sup>3</sup> pacemakers may not be a good alternative, having been shown [3] to be associated with lower survival rate, more thromboembolic complications, a higher incidence of heart failure and a higher risk of

System upgrade was performed in 8 patients (5.7%), chiefly due to higher degree AV block (see table 1). These patients were aged  $73.8 \pm 8.2$  years at the time of system upgrade and had been fitted with an AAI pacemaker  $3.4 \pm 2.4$  years earlier. Seven patients were upgraded to a DDD pacemaker, two of the seven also received AV-node ablation; the eighth patient received a VVI pacemaker. The annual upgrade rate was 1.6%.

None of intraoperative WBP, age at implant, presence of atrial fibrillation at implant or gender were predictive for future upgrade.

atrial fibrillation. In CTOPP (Canadian Trial Of Physiological Pacing), however, there was only a trend towards a benefit of DDD pacing for the prevention of stroke or death due to cardiovascular causes [13]. DDD pacemakers may have certain detrimental effects in comparison to atrial pacing: DDD pacing increases left atrial diameter and can also cause decreased left ventricular fractional shortening [14]. In patients with impaired left ventricular function right ventricular pacing may even cause heart failure [5, 15]. However, by the use of specific algorithms incorporated into contemporary pacemakers that prolong AV time, unnecessary right ventricular pacing can be eliminated in the majority of patients.

### Wenckebach block point behaviour over time

In our study we have been able to show that WBP is stable during long-term follow-up and well into old age. Thus, there should be no reason not to implant an AAI system even in elderly patients who otherwise fulfill the usual criteria (see below). Twenty years ago, Santini et al. [16] already reported long-term results in patients with SSS. In this study a WBP of  $>140$  bpm at

<sup>3</sup> VVI Pacemaker with ventricular sensing, ventricular pacing and inhibition mode

implant for an AAI system was required. During a mean follow-up of 5 years, WBP dropped to 100–140 bpm in 7% and to <100 bpm in another 2%, whereas 5% of the study population developed a higher-degree AV block. This resulted in an upgrade rate of 6%. Similar results were shown in a randomised trial comparing AAI to VVI pacing [10]. The WBP remained stable, i.e., >120 bpm in 80%, and dropped to 100–120 bpm in 18%.

### Upgrade rate

Our upgrade rate of 1.6% per year is in line with other studies. The reported upgrade rates were approximately 1% per year (range 0.6% to 1.7% [8, 10, 16–18]). Whether this rate is acceptable or justifies a DDD system in ALL patients is surely debatable. The most recent data concerning cost-effectiveness of AAI pacemakers were published 12 years ago and may no longer be valid [8].

### Predictors for occurrence of AV block during follow-up

Due to the unacceptable upgrade rate, left bundle branch block and bifascicular block are considered to be contraindications for an AAI system. Similarly to our results, age at implant [6], gender [6], a single fascicular block [9, 10] and a history of atrial fibrillation [6, 9] have not been shown to be predictors for future upgrades. Right bundle branch block (RBBB) was considered by Andersen [3] to be a contraindication for an AAI system, as the risk of future higher degree AV block is considerable. Two of the 4 patients who needed an upgrade in his trial did indeed present with RBBB at implant. In a recent large observational study, however, RBBB was not predictive [17]. The question whether a low WBP might be a predictor for future AV block is discussed controversially. We have shown that in our patient population this was clearly not the case. In contrast, Masumoto et al. [6] demonstrated that a WBP at implant of <120 bpm was their sole predictor. Notably, the mean age of their patients was 63 years as compared to 74 years in our population. Adachi et al. [17] showed that the AV block risk is low, even with an intraoperative WBP between 100 and 129 bpm. During a mean 9 years' follow-up only 2/35 patients required an upgrade, compared to 2/67 with a WBP >130 bpm at implant (*p*-value n.s.). This is in agreement with Haywood et al. [19], who found that a WBP over 120/min did not correlate with a lower AV block rate, as well as with Andersen et al. [10], who found that a low intraoperative WBP was a poor predictor for future AV block. Unfortunately, in two of these studies [17, 18] the WBP was measured only once – intraoperatively. A major limitation of all these studies is a certain bias in patient selection. To receive an AAI pacemaker a patient had to have a WBP above a defined level, thus excluding upfront patients with a “low” WBP. When finally

analysing the patient outcome and looking for predictors of upgrade, the WBP was found to be non-predictive.

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