

Clinical Safety and Efficacy of Single-Chamber Atrial Pacing in Sick Sinus Syndrome: Long-Term Follow-Up

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Introduction and objectives. Although atrial pacing is a more physiological mode of stimulation in sinus node dysfunction, the pacing modes most often are used DDD and VVI. The aim of our study was to demonstrate that AAI/AAIR pacing is effective and safe by analyzing the complications and mortality of this pacing mode in a long-term follow-up study.

Patients and method. Between 1982 and 2000 definitive AAI-mode pacemakers were implanted for sinus node dysfunction in mode AAI in 160 patients. We analyzed the clinical characteristics, evolution, and complications of the AAI pacing mode during a follow-up of 5.4 ± 4.5 years.

Results. The sample was made up of 104 women and 56 men with an average age of 72 ± 12 years. During follow-up, it was necessary to change the pacing mode for symptomatic bradycardia in 11 patients (annual incidence 1.2%), which was caused by second or third-degree atrioventricular block in 7 patients (annual incidence 0.8%), and chronic atrial fibrillation with bradycardia in 4 patients (annual incidence 0.4%). During follow-up, atrial arrhythmias occurred in 32 patients (annual incidence 3.7%), stroke in 4 patients (annual incidence 0.4%), and 27 patients (annual incidence 3.1%) died.

Conclusions. The AAI/AAIR pacing mode was safe and effective in sinus node dysfunction, with a low percentage of pacing changes required for progression to atrioventricular block, low incidence of atrial arrhythmias, stroke and low mortality during long term follow-up.

Key words: Pacemaker. Sinoatrial node. Prognosis.

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Seguridad y eficacia clínica de la estimulación con el modo AAI en la disfunción del nodo sinusal: seguimiento a largo plazo

Introducción y objetivos. Aunque el modo de estimulación auricular es el más fisiológico en la disfunción del nodo sinusal, la estimulación en modo DDD y VVI son las empleadas mayoritariamente. El objetivo de nuestro estudio es demostrar que una estimulación en modo AAI/AAIR es eficaz y segura; para ello hemos analizado las complicaciones y la mortalidad de este modo de estimulación en una evolución a largo plazo.

Pacientes y método. Entre 1982 y 2000 se implantó un marcapasos definitivo por DNS sintomática en modo AAI a 160 pacientes. Se ha realizado un análisis de las características clínicas, de la evolución y complicaciones del modo de estimulación AAI durante un seguimiento medio de $5,4 \pm 4,5$ años.

Resultados. La muestra estudiada está compuesta de 104 mujeres y 56 varones, con una edad media de 72 ± 12 años. En el seguimiento fue preciso cambiar el modo de estimulación por bradicardia sintomática en 11 pacientes (1,2% anual), bloqueo auriculoventricular de segundo a tercer grado en 7 pacientes (0,8% anual) y fibrilación auricular crónica con frecuencias lentas en 4 enfermos (0,4% anual). Se presentaron arritmias auriculares en 32 pacientes (3,7% anual), accidentes cerebrovasculares (ACV) en 4 pacientes (0,4% anual) y 27 enfermos (3,1% anual) fallecieron durante el seguimiento.

Conclusiones. El modo de estimulación AAI en la disfunción del nodo sinusal es seguro y eficaz, con un bajo porcentaje de cambios de estimulación por progresión a bloqueo auriculoventricular, baja incidencia de arritmias auriculares, ACV y una baja mortalidad durante el seguimiento a largo plazo.

Palabras clave: Marcapasos. Nodo sinoauricular. Pronóstico.

INTRODUCTION

In patients with sinus node dysfunction (SND), the superiority of using AAI/AAIR pacing vs VVI/VVIR pacing has been shown in various retrospective and prospective studies, with a lower incidence of thromboembolism, acute cerebrovascular

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Received 22 March 2002.
Accepted for publication 6 July 2002.

ABBREVIATIONS

SND: sinus node dysfunction.
 AF: atrial fibrillation.
 AV: atrioventricular.
 ACVA: acute cerebrovascular accident.
 AVB: atrioventricular block.
 AAI: atrial pacing.

accidents (ACVA), atrial fibrillation (AF), cardiac insufficiency, and death.¹⁻⁴ In spite of this, in recent years the number of patients who are candidates for AAI pacing who receive this type of stimulation is low (5% to 10% of patients vs 30% to 40% of patients who received DDD pacing and 50% of patients who received VVI pacing),^{5,6} as the tendency is to implant a 2-chamber stimulation pacemaker. Those who defend the two-chamber stimulation mode argue against AAI-AAR pacing because of the problems resulting from a possible progression to an atrioventricular block (AVB) that would require a change in stimulation mode,^{7,8} hemodynamic changes in the consequent pacemaker syndrome due to the development of first degree AVB, or a second degree block of the Wenckebach type with high frequency in AAIR mode⁹ and the development of AF with symptomatic bradycardia or rapid frequencies that require ablation of the atrioventricular node.¹⁰

The advantages of two-chamber pacemakers are not in question; however, until the present, the superiority of the DDD/DDDR mode over the AAI/AAIR mode in symptomatic SND has not been shown; even the recommendations of the Trabajo de Marcapasos (Pacemaker Work) group of the Sociedad Española de Cardiología (Spanish Society of Cardiology) and the guidelines of American College of Cardiology/American Heart Association (ACC/AHA) indicate that the treatment of choice is atrial stimulation in patients with normal AV conduction without the risk of the future appearance of AVB.^{6,11}

Given all this, we believe that the single-chamber atrial stimulation mode is the best choice for patients with SND who do not have atrioventricular or intra-ventricular disturbances, and who have no Wenckebach-type block with frequencies lower than 120.

The aim of our study is to perform a retrospective analysis of the patients who have had a definitive AAI/AAIR pacemaker implanted who have symptomatic SND, and to evaluate the rate of mortality and complications (progression to second and third degree AVB, the need for a change in stimulation, chronic AF or rapid AF that requires ablation of the AV node, ACVA) at long-term follow-up to show the efficacy

and security of this stimulation mode.

PATIENTS AND METHOD

Between 1980 and 2000, periodic follow-up was performed on patients who are wearing a definitive pacemaker that was implanted to treat symptomatic sick chest syndrome (362 patients); of these, 160 (44.1%) had an AAI/AAIR stimulation mode; 169 (46.6%) a VVI/VVIR mode, and 33 (9.1%), a DDD/DDDR mode.

With the exception of the early years of treatment, in which exclusively VVI mode pacemakers were implanted, after the development of atrial stimulation in 1982, AAI mode pacemakers began to be implanted in all patients with symptomatic SND who did not have associated first, second, or third degree AVB; who did not present with a left branch block or a biphasic block; and who had a Wenckebach point higher than 120 at the time of implantation. The right branch block started to be considered a contraindicated after the studies published by Andersen et al.^{2,3}

We performed a retrospective analysis of all the patients in the sample and we evaluated the clinical characteristics (age, sex, cardiopathy, type of SND) and the parameters during the implantation (threshold of atrial detection and capture). During follow-up, we evaluated the complications resulting from the electrodes (problems with detection and displacement), the development of paroxysmal or chronic AF, the appearance of ACVA, development of second or third degree AVB, the need for a change in stimulation mode, and death.

RESULTS

Of all patients with AAI mode stimulation, 56 (35%) were men (35%) and 104 (65%) were women, with a mean age at the time of implantation of 72 years±12 years. With regard to the electrocardiographic

TABLE 1. Clinical characteristics of patients wearing AAI/AAIR pacemakers

Clinical characteristics	
Mean age	72±12 years
Men	35%
Women	65%
Implant approach	
Cephalic	77%
Subclavian	23%
Type of sinus node dysfunction	
Sinus failure or sinoatrial block	53%
Bradycardia-tachycardia syndrome	47%
Etiology	
Degenerative	83%
Others	17%

presentation of the SND, the most frequent was sinus failure or sinoatrial block in 84 patients (53%) and bradycardia-tachycardia in 76 patients (47%). The most common etiology was degenerative in nature, with a total of 138 patients (86%). Implantation was performed primarily by the cephalic approach (78%) and the remainder (22%) by the subclavian approach (Table 1). Bipolar electrodes were used in 77% of the cases. In nearly all cases, a straight fixed passive electrode was used, along with a guide curve for implantation in the opening of the right atrium. At the moment of implantation, the mean amplitude of the atrial electrogram was 2.3 ± 2 mV, with a mean atrial capture threshold of 0.48 ± 0.38 V.

Mean follow-up of all patients was 5.4 ± 4.5 years (range, 1-20 years), performed systematically 1 week, 45 days, and 6 months after implantation and then annually. The incidence of detection-related problems was low; excluding the patients who developed chronic AF, dysfunction due to infra-detection appeared in 5 patients (0.5% annually); symptomatic over-detection (inhibition and syncope) occurred in only 2 patients and in all cases was corrected by reprogramming the sensitivity. The dislocation or displacement of atrial electrodes occurred in 7 patients (0.7% annually). Complications related to the implant approach were unusual, and occurred in only one case of thrombosis of the humeral vein (a case of subclavian approach).

A change in the stimulation mode to DDD/DDDR or VVI/VVIR was required in 11 patients (1.2% annually), 7 of them (0.8% annually) as a result of progression from second to third degree AVB, in 3 patients because of the development of chronic AF with slow frequencies, and in 1 patient due to elective ablation of the AV node in a patient who presented with paroxysmal symptomatic AF that could not be controlled with pharmacological treatment.

We observed, during the follow-up period, AF in 32 patients (3.7% annually), with episodes of paroxysmal AF in 18 patients (2% annually) two of whom progressed to chronic AF and 16 to chronic AF (1.8% annually). ACV was observed in 4 patients (0.4% annually).

If we add the patients who required a change in stimulation to those who developed chronic AF, 83% of patients who had an AAI/AAIR pacemaker implanted continued with that stimulation mode at 5 years following initial implantation.

During the follow-up period 27 patients died (3.1% annually), although we could not identify the cause of death in the majority of these patients because information concerning the death was obtained by telephone (Table 2).

DISCUSSION

Various studies have shown that physiological sti-

TABLE 2. Complications during follow-up and annual incidence of same

Complications during follow-up	Mean annual incidence rate, %
Dislocation	0.7
Change in stimulation mode to VVI/VVIR or DDD/DDDR	1.2
Atrial fibrillation	3.7
Second to third degree AVB	0.7
ACVA	0.4
Death from any cause	3.1

ACVA indicates acute cerebrovascular accident; AVB, atrioventricular block.

mulation (atrial and 2-chamber stimulation) improves hemodynamic patterns in comparison with ventricular stimulation (VVI/VVIR) alone.^{12,13} In addition, it has been shown that VVI mode produces a greater number of complications in the short and long term than other forms of cardiac stimulation: atrial arrhythmias, ACVA, cardiac insufficiency, pacemaker syndrome, and death.^{1,2,14-16} Nevertheless, there is still controversy about whether the most effective stimulation mode in SND is the 2-chamber or the isolated atrial mode.^{17,18} In our country, Goicolea et al¹⁹ have already confirmed the safety and stability of atrial stimulation of SND in a series of 45 patients.

If we analyze all the objections presented against atrial stimulation alone, we find that these have been refuted by various studies.

Problems with atrial electrodes

One of the problems with the single chamber atrial mode is the detection and dislocation faults caused by atrial electrodes.²⁰ Nevertheless, technological improvement of the electrodes and the advent of active fixed electrodes have significantly decreased these problems. In our study group, we did not observe detection problems in any patients that required a change in stimulation, and the displacements that required relocation were few (0.7% annually).

Atrial fibrillation and acute cerebrovascular accident

The presence of paroxysmal atrial fibrillation or flutter should not be a contraindication for the implantation of an AAI/AAIR mode pacemaker. Some of these arrhythmias are related to the presence of bradycardia or vagal hypertonia, and they later disappear with atrial stimulation. Comparative studies of AAIR vs DDDR in SND have determined that atrial stimulation alone reduces the incidence of atrial arrhythmias.¹

Atrial arrhythmias that present in SND may be rela-

ted to various factors such as the nosological entity itself (bradycardia-tachycardia syndrome), the advanced age of the patients (who generally present more frequently with chronic AF), and associated illnesses. It has been shown that atrial stimulation prevents recurrences,²¹ although in some patients the rapid atrial arrhythmias continued to recur and ended by establishing permanent AF.²² In our study, the incidence of chronic or paroxysmal AF was 3.7% annually, similar to that found in other published series.²

The fact that AF occurs does not mean that anti-bradycardia stimulation is required nor that ablation of the atrioventricular node must necessarily be performed if the mean ventricular frequency can be controlled with medication. In a very few cases, it is necessary to change the stimulation mode because of the presentation of chronic AF with slow frequencies,^{3,23} including in those patients who present with a bradycardia-tachycardia syndrome and who require antiarrhythmia drugs to prevent recurrences or to stop atrioventricular conduction.²⁴ Nevertheless, in a recent study the researchers concluded that the subgroup of patients with bradycardia-tachycardia syndrome would be the patients that might benefit from the DDDR mode because of the incidence of second and third degree AVB that presented during stimulation following exercise.²⁵ In exceptional cases, there is the need to perform nodal ablation because of rapid frequencies.^{3,23-25} In follow-up of our patients, only 1 required AV node ablation.

The incidence of ACVA in the patients analyzed was 0.4% (probably a result of younger mean age of our sample population), less than the incidence of ACVA in the series of Anderson et al,² which was around 2% annually.

First degree or Wenckebach-type AV block

Another of the arguments used in favor using DDD is the probability of developing a pacemaker syndrome secondary to a Wenckebach-type AVBV with high frequencies, primarily if there is a Wenckebach point of less than 120 during the implantation.²⁶⁻²⁹ Although we did not analyze this data, it has already been shown that the PQ interval following atrial stimulation at frequencies greater than 100 beats/minute did not result in significant changes during follow-up, and the incidence of a pacemaker syndrome resulting from a first degree or a Wenckebach-type AVB with elevated frequencies requiring a change in stimulation during follow-up was rare.^{3,24}

Second and third degree AV block

The occurrence of an advanced AVB requiring the placement of a new electrode for ventricular stimulation has been an argument for using two-chamber sti-

mulation,^{7,8,10,30} although various studies have shown a low incidence of AVB during follow-up, less than 1%;^{3,7,31-35} even in these cases, the only predictors of second and third degree AVB are disturbances of intra-ventricular conduction (branch block and biphasic block),^{3,31} and atrial stimulation should only be avoided in those patients with the aforementioned intra-ventricular conduction disturbances.⁷

The incidence of AVB was 0.6% annually in the AAI mode stimulation group in the prospective study by Andersen et al,³ which shows that atrial stimulation is safe for the treatment of SND. In our sample population, it was necessary to change the stimulation mode to DDD because of the occurrence of second or third degree AVB or AF with symptomatic bradycardia in 1.2% of patients annually, data that is more in line with recent observational study that reviewed 339 consecutive patients who had an AAI mode pacemaker implanted for symptomatic SND and in whom they observed a 1.7% annual incidence of stimulation change resulting from AVB or AF with symptomatic bradycardia.²⁴

Mortality

With respect to mortality, Lemke et al³⁶ studied the survival rate of 100 people with SND and atrial stimulation; the survival rate at 5 years was 85%, which was no different from that observed in a comparable population. Brand et al³¹ studied 213 patients with atrial stimulation for 5 years, and the mortality rate was 89%, without differences from the control group. In our patients, the mortality rate at 5 years was 16% (3.1% annually), similar to that observed in the previously-noted studies and with an incidence rate somewhat lower than that found in the study by Andersen et al² and the PASE study.³⁷ This discrepancy may be explained by the fact that, in both studies, the mean age was 76 years, which was higher than that in our study (72 years).

Disadvantages of DDD

DDD-mode pacemakers have some disadvantages: the implantation technique presents the risk of more complications; a longer implantation time; follow-up is more laborious; and the time elapsed before elective replacement is shorter due to battery depletion, which increases the number of replacements and the probability of infection, the deleterious effects of ventricular stimulation, and the higher cost of the devices.

Recently, 2 published prospective studies (PASE, CTOPP) have not been able to demonstrate the superiority of DDDR mode over VVIR mode in terms of mortality, AF, and ACVA in the subgroup of patients with SND,^{16,36} which points to the possibility that the physiological effect is lost with DDD stimulation and that ventricular stimulation is detrimental, changing

systolic and diastolic function, as well as myocardial perfusion, when the atrium and apex of the right ventricle are stimulated sequentially;³⁸⁻⁴² AAI stimulation has been shown to have beneficial effects by preserving AV synchronicity.²³ As a result, we deduce that the DDD/DDDR mode has still not shown to be beneficial in SND, and the AAI/AAIR has been shown to be beneficial in prospective studies.^{2,43}

Disadvantages of atrial stimulation alone

It must be noted that single-chamber atrial stimulation can present the disadvantages noted, such as the possibility of developing a pacemaker syndrome with stimulation at frequencies elevated by first degree or Wenckebach-type AVB, the risk of presenting high grade AVB, and the need for antiarrhythmia drugs for the control of cardiac frequency during the episodes of rapid atrial arrhythmias that can be caused by AVB. As a result, it can be deduced that the selection of patients who are candidates for AAI/AAIR-mode pacemakers must be made carefully, but also it is certain that the implantation of a new ventricular electrode to convert the atrial mode to a 2-chamber mode is a simple, faster technique.

A prospective study is in progress that compares AAI with DDD in SND that will clarify the ideal stimulation mode for this disorder.⁴⁴

CONCLUSIONS

The low incidence of progression to AVB, the rare requirement of a change in the stimulation mode, the exceptional need for ventricular stimulation, the preservation of synchronicity and the lesser incidence of atrial arrhythmias and embolism make AAI/AAIR the optimal stimulation mode for the treatment of symptomatic sinusoidal dysfunction. Therefore, in the absence of AVB of various degrees, both spontaneous and drug-induced, and branch blocks or biphasic blocks, the AAI/AAIR stimulation mode should be considered as the safest and most efficacious form of treatment for these patients.

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