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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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...
ABBR EVIATION S
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 AAIIR 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>
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<th>TABLE 1. Clinical characteristics of patients wearing AAI/AAIR pacemakers</th>
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<tr>
<td>Men</td>
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<td>Women</td>
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<td>Implant approach</td>
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<td>Type of sinus node dysfunction</td>
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<td>Sinus failure or sinoatrial block</td>
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<td>Bradycardia-tachycardia syndrome</td>
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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). ACVA 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 stimulation (atrial and 2-chamber stimulation) improves hemodynamic patterns in comparison with ventricular stimulation (VVI/VVIR) alone. 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. Nevertheless, there is still controversy about whether the most effective stimulation mode in SND is the 2-chamber or the isolated atrial mode. In our country, Goicolea et al 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. 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.

Atrial arrhythmias that present in SND may be rela-
Mortality

With respect to mortality, Lemke et al. 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 al. 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 al. and the PASE study. 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, 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. AAI stimulation has been shown to have beneficial effects by preserving AV synchrony. 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.

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.

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 sinusoid 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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