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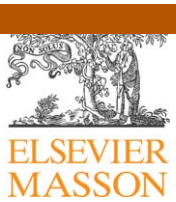

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CLINICAL RESEARCH

Outcome of patients aged over 75 years who received a pacemaker to treat sinus node dysfunction

Devenir des patients de plus de 75 ans ayant bénéficié d'un stimulateur cardiaque pour une dysfonction sinusale

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KEYWORDS
Sinus node dysfunction;
Dual-chamber pacemaker;
Elderly patients

Summary
Background. — The prognosis for patients aged over 75 years who receive a pacemaker in the context of sinus node dysfunction is unclear.
Aims. — We sought to evaluate the incidences of atrial fibrillation, heart failure and death in such patients, and the role of the pacing mode in their prognosis.
Methods. — This was a retrospective study of 102 patients aged over 75 years (mean 82.2 ± 4.4 years) who received a pacemaker in the context of sinus node dysfunction.
Results. — During the follow-up period (mean 806 days), 36 patients (35.3%) experienced heart failure, 47 patients (46.1%) had an episode of paroxysmal atrial fibrillation, 19 patients (18.6%) progressed to chronic atrial fibrillation and 29 (28.4%) died, the fatal event being sudden death or of cardiac origin in almost half of these patients (44.8%). Patients assigned to dual-chamber minimal ventricular pacing showed significantly lower rates of heart failure episodes ($P = 0.023$) and all-cause mortality ($P < 0.001$) than those assigned to conventional dual-chamber pacing. In contrast, the two groups did not differ with regard to either paroxysmal or chronic atrial fibrillation.

Abbreviations: AF, Atrial fibrillation; HF, Heart failure; LVEF, Left ventricular ejection fraction; VKA, Vitamin K antagonist.

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Conclusion. — In patients aged over 75 years, the use of dual-chamber pacemakers incorporating an algorithm minimizing ventricular pacing for sinus node dysfunction seems to decrease the number of heart failure episodes and mortality. On the basis of this finding, the implantation of such devices seems justifiable, even in this age group.

MOTS CLÉS
Dysfonction sinusale ;
Stimulateur cardiaque double chambre ;
Patients âgés

Résumé
Contexte. — Le pronostic des patients de plus de 75 ans qui ont bénéficié d'un stimulateur cardiaque pour une dysfonction sinusale est mal connu.
Objectif. — Le but de cette étude a été d'évaluer dans cette population, les incidences de la fibrillation auriculaire, de l'insuffisance cardiaque et de la mortalité ainsi que l'influence du mode de stimulation sur le pronostic.
Méthodes. — Il s'agit d'une étude rétrospective sur 102 patients de plus de 75 ans porteurs d'un pacemaker pour une dysfonction sinusale.
Résultats. — Au cours du suivi (806 jours en moyenne), 36 patients (35,3 %) ont présenté une décompensation cardiaque, 47 patients (46,1 %) un épisode de fibrillation atriale paroxystique, 19 patients (18,6 %) sont passés en fibrillation atriale chronique et 29 (28,4 %) sont décédés dont près de la moitié (44,8 %) de mort subite ou de cause cardiaque. Dans le groupe de patients porteurs d'un stimulateur double chambre avec un algorithme minimisant la stimulation ventriculaire, nous avons observé un taux moindre de décompensations cardiaques ($p = 0,023$) et une plus faible mortalité totale ($p < 0,001$) que dans le groupe de patients ayant un stimulateur DDD standard. En revanche, il n'y a pas eu de différences entre les deux groupes en termes de fibrillation auriculaire paroxystique ou chronique.
Conclusion. — Les stimulateurs cardiaques double chambre avec un algorithme minimisant la stimulation ventriculaire semblent diminuer le nombre d'épisodes de décompensation cardiaque et les décès chez les patients de plus de 75 ans atteints de dysfonction sinusale. Cela justifie donc leur implantation même à cet âge.

Background

Sinus node dysfunction is one of the main indications for pacemaker implantation. However, the prognosis for patients who receive a pacemaker for this reason, in terms of mortality and occurrence of atrial fibrillation (AF) or heart failure (HF), has not been clearly established in the oldest age group.

Large-scale randomized trials, such as MOST [1] and CTOPP [2], did not really demonstrate a great superiority of dual-chamber pacemakers over single-chamber devices. It has been shown that dual-chamber pacemakers can be deleterious compared with single-chamber ventricular pacemakers when the ventricular stimulation rate is high (MOST [1], DAVID [3]). New algorithms were developed in order to limit the ventricular stimulation rate. The SAVE PACe [4] study showed a benefit of dual-chamber minimal ventricular pacing over conventional dual-chamber pacing in terms of persistent AF.

Few patients aged over 75 years were included in these trials. However, the population aged over 75 years corresponds with more than 50% of pacemaker first implantations [5], and this population is expected to increase threefold within the next 40 years [6]. It therefore seemed worthwhile to analyse the outcome of patients aged over 75 years who had received a pacemaker in the context of sinus node dysfunction, either alone or already associated with paroxystic supraventricular arrhythmia.

Methods

This single-centre, retrospective study, conducted in the Cardiology Department of the Medical, Surgical and Obstetrical Centre in Schiltigheim, France, included all consecutive patients aged over 75 years on the day of pacemaker implantation and referred for initial implantation of a pacemaker in the context of sinus node dysfunction between 1 January 2001 and 31 October 2006. Patients with second- or third-degree atrioventricular block and those who had undergone implantation of a single-chamber ventricular pacemaker were excluded.

The patient's medical history, clinical characteristics, pacemaker settings and left ventricular ejection fraction (LVEF) at the start of follow-up were extracted from the initial hospitalization report. The clinical events occurring during follow-up were recorded on questionnaires sent to each patient's cardiologist. The questionnaires were completed with the help of the patient's primary care physician and the reports from the centre in which the pacemaker had been implanted.

The pacing algorithms considered to be algorithms minimizing ventricular stimulation rate were MVP® (Medtronic Inc. Minneapolis, MN, USA) and SafeR® (Sorin Group, Milan, Italy).

The primary endpoints defined before the start of the study were mortality, episodes of HF, incidences of paroxysmal and chronic AF and occurrence of embolic complications. All episodes of HF were taken into account,

Table 1 Patient demographics and clinical characteristics.

Characteristic	
Men	33 (32.4)
Women	69 (67.6)
Age (years)	82.2 ± 4.4
Sinus node dysfunction without history of AF	45 (44.1)
Sinus node dysfunction with history of paroxysmal AF	57 (55.9)
LVEF at inclusion (%)	59.3 ± 10.9
Ischaemic cardiopathy	20 (19.6)
Non-obstructive cardiomyopathy	4 (3.9)
Valvular disease	20 (19.6)
Left ventricular hypertrophy	36 (35.3)
Other cardiopathy	3 (2.9)
No known cardiopathy	37 (36.3)
History of hypertension	80 (78.4)
History of heart failure	16 (15.7)
History of stroke	17 (16.7)
Diabetes	26 (25.5)
$CHADS_2$ score ≥ 2	86 (84.3)
Signs of heart failure at implantation (Killip class ≥ 2)	26 (25.5)

AF: atrial fibrillation; $CHADS_2$: congestive heart failure, hypertension, age >75 years, diabetes and prior stroke/transient ischaemic attack; LVEF: left ventricular ejection fraction; SD: standard deviation.
Data are mean ± standard deviation or number (%).

irrespective of whether they needed hospitalization or only ambulatory treatment adjustment for worsening HF. The causes of death were classified as sudden death, death of cardiac origin or other cause.

Statistical analysis

All analyses were performed according to the ''intention-to-treat'' principle. Qualitative variables were analysed using the Chi^2 test or Fisher's exact test when the number of patients concerned was small (<5 for the theoretical population). Student's *t* test or a unifactorial analysis of variance was used to compare continuous variables. Data not corresponding to a normal distribution (atrial and ventricular stimulation rates and LVEF) were analysed using a non-parametric test (Mann-Whitney test). Statistical significance was concluded at $P < 0.05$ (95% confidence interval).

Results

Between 1 January 2001 and 31 October 2006, 102 medical files met all inclusion criteria and these patients were included in the study; their clinical characteristics at the time of pacemaker implantation are summarized in Table 1.

Table 2 Pacemaker characteristics and pacing mode at the time of implantation.

Pacemaker characteristic/ pacing mode	Number of patients (%)
Conventional DDD pacing	71 (69.6)
Dual-chamber minimal ventricular pacing	27 (26.5)
AAI pacing	3 (2.9)
VVI pacing	1 (1.0)
Atrial lead positioned into the right atrial appendage	98 (96.1)
Right ventricular lead positioned at the right ventricular apex	95 (96)
Rate-responsive pacing mode activated	60 (58.9)

Pacemaker specificities and setting modes are summarized in Table 2 .

Follow-up

No patient was lost to follow-up. The mean duration of clinical follow-up was 806 days (i.e. approximately 2.2 years), the minimum follow-up being 38 days and the maximum 2043 days.

The pacemaker variables at the end of follow-up are summarized in Table 3. Events that occurred during the follow-up period are summarized in Table 4 .

Fifty-three patients (51.9%) had at least one episode of AF (paroxysmal or chronic) and five patients had no pacemaker interrogation with a programmer during follow-up. During the follow-up period, one patient benefited from a dual-chamber to triple-chamber pacemaker upgrade due to HF.

Table 3 Pacemaker variables at the end of follow-up.

Pacemaker variable	
Mean duration of pacemaker follow-up between implantation and last assessment (days)	670.6
Conventional DDD pacing	57 (55.9)
Dual-chamber minimal ventricular pacing	28 (27.5)
DDI	2 (2)
AAI	5 (4.9)
VDD	1 (1)
VVI	9 (8.8)
Mean (median) percentage of atrial stimulation before any progression to chronic AF	68.4 (85)
Mean (median) percentage of ventricular stimulation before any progression to chronic AF	56.3 (82.2)

AF: atrial fibrillation.
Data are number (%) unless otherwise indicated.

Table 4 Events during follow-up.

Event	
Paroxysmal AF not progressing to chronic AF	34 (33.3)
Paroxysmal AF whether or not progressing to chronic AF	47 (46.1)
Chronic AF whether or not preceded by paroxysmal AF	19 (18.6)
Mean (median) time to progression to chronic AF (days)	535 (391)
External electrical cardioversion	0 (0)
Episodes of heart failure	36 (35.3)
Cerebral embolism	5 (4.9)
Other systemic embolism	1 (1)
High-degree atrioventricular block	14 (13.7)
Deaths	29 (28.4)
Sudden death	5 (17.2)
Death of cardiac origin	8 (27.6)
Death from other cause	16 (55.2)
Mean (median) time to death after pacemaker implantation (days)	598 (557)
Complete resolution of symptoms after pacemaker implantation	74 (72.5)
Partial resolution of symptoms after pacemaker implantation	21 (20.6)
No resolution of symptoms after pacemaker implantation	7 (6.9)

AF: atrial fibrillation.
Data are number (%), unless otherwise indicated.

Among the 38 patients in whom the Holter pacemaker recordings could be determined unequivocally, 24 had their mode of care changed on the basis of these recordings (anticoagulant treatment initiation, antiarrhythmic drug replacement or initiation).

Chronic atrial fibrillation

Patients progressing to chronic AF ($n = 19$) had a higher HF incidence ($P = 0.022$). Neither the mode of pacing at the time of pacemaker implantation nor the activation of algorithms designed to prevent AF had a significant impact on the incidence of chronic AF. All of these patients were treated with vitamin K antagonists (VKAs) at the end of the follow-up period.

Paroxysmal atrial fibrillation

Patients experiencing one or more episodes of documented paroxysmal AF during follow-up ($n = 47$) had more frequently a history of AF before implantation ($P = 0.022$) and cardiopathy of any kind of aetiology ($P = 0.037$) at the time of pacemaker implantation. A greater proportion of patients in this group experienced one or more episodes of HF ($P = 0.024$); they also progressed more frequently to chronic AF ($P = 0.03$). In contrast, there were neither more deaths nor more thromboembolic events in this group. The pacing mode did not affect the incidence of paroxysmal AF. With regard to patients who experienced an episode of paroxysmal AF but did not progress to chronic AF, 67.6% received at least transient treatment with VKA during follow-up and 52.9% were still being treated with VKAs at the end of follow-up. None of the treatments ongoing at the time of implantation or during follow-up (in particular angiotensin-converting enzyme inhibitors and angiotensin II receptor blockers) were associated with a statistically significant decrease in the number of paroxysmal AF episodes.

Stroke

Six patients (5.9%) experienced either cerebral or systemic embolism during follow-up. All of these patients had a $CHADS_2$ score ≥ 2 [7]. Four of these patients presented documented AF during follow-up, of whom two were not receiving anticoagulant treatment.

Heart failure

Patients experiencing HF during follow-up ($n = 36$) had a significantly lower LVEF at inclusion (mean 52.58 vs 62.97%, $P < 0.001$) and had more frequently ischaemic cardiac disease than another aetiology of cardiopathy ($P = 0.002$). These patients were classified more often in Killip class $\geq$II at the time of pacemaker implantation and were receiving beta-blocker treatment more often at this time. Conventional DDD mode [8] pacemaker programming at the time of implantation was a factor favouring HF ($P = 0.026$), whereas dual-chamber minimal ventricular pacing was a factor protecting against this event ($P = 0.033$). The ventricular stimulation rate was significantly higher in patients presenting episodes of HF (mean 67.6%; median 96.7%) than in those not experiencing this event (mean 50.6%, median 56.6%) ($P = 0.044$). Patients presenting HF episodes during follow-up also had more episodes of paroxysmal AF ($P = 0.024$) and chronic AF ($P = 0.022$), and had a higher mortality ($P < 0.001$).

Mortality

The patients who died during follow-up ($n = 29$) were significantly older ($P = 0.033$) and had more frequently an LVEF $\leq$50% ($P = 0.029$) than those who survived. The pacemakers of patients who died were more often conventional dual-chamber pacemakers ($P = 0.022$) and less often dual-chamber minimal ventricular pacing pacemakers ($P = 0.005$). The ventricular stimulation rate was significantly higher among patients who died (mean 78.4%, median 98%) than among those who remained alive (mean 49.4%; median 51%) ($P = 0.039$). This group also experienced more episodes of HF ($P < 0.001$). In contrast, the rates of paroxysmal and chronic AF did not differ between the two groups.

Comparison of patients assigned to conventional dual-chamber pacing and to dual-chamber minimal ventricular pacing

As the development of pacemakers incorporating an algorithm minimizing ventricular pacing occurred relatively recently, the duration of follow-up of patients who received this type of device was significantly shorter than that of

Table 5 Comparison of patients assigned to dual-chamber minimal ventricular pacing and to conventional dual-chamber pacing with a follow-up duration of <1000 days.

	Dual-chamber minimal ventricular pacing ($n = 27$)	Conventional DDD pacing mode with a follow-up of <1000 days ($n = 42$)	*P*	Relative risk (confidence interval)
Mean duration of follow-up (days)	480.6	567.4	0.215	
Men[a]	7 (25.9)	18 (42.9)	0.153	
Mean age ± SD (years)	82.1 ± 3.6	83.2 ± 5.0	0.390	
Sinus node dysfunction without history of AF[a]	10 (37.0)	23 (54.8)	0.150	
Sinus node dysfunction with history of paroxysmal AF[a]	17 (63.0)	19 (45.2)	0.150	
Mean LVEF at inclusion (%)	61.8, with 3 patients (11.1%) having an LVEF ≤50%	57.8, with 13 patients (31.0%) having an LVEF ≤50%	0.0670.057	
First-degree atrioventricular block[a]	7 (25.9)	16 (38.1)	0.295	
Medication[a]				
Anticoagulant	14 (51.9)	14 (33.3)	0.126	
Amiodarone	10 (37.0)	9 (21.4)	0.157	
Flecainide	1 (3.7)	1 (2.4)	0.749	
Propafenone	1 (3.7)	0 (0)	0.214	
Sotalol	0 (0)	1 (2.4)	0.419	
Other betablockers	9 (33.3)	10 (23.8)	0.387	
Digoxin	0 (0)	4 (9.5)	0.098	
Verapamil or diltiazem	0 (0)	2 (4.8)	0.250	
ACE inhibitors or ARBs	15 (55.6)	23 (54.8)	0.948	
Mean (median) ventricular stimulation rate before possible chronic AF (%)	25.1 (2.5)	62.8 (86.0)	0.004	
Patients with ventricular stimulation rate < 40% (%)	72.7	30.0	0.002	
Episodes of heart failure[a]	5 (18.5)	19 (45.2)	0.023	2.23 (1.03—5.15)
Paroxysmal AF whether or not followed by chronic AF[a]	12 (44.4)	16 (38.1)	0.600	
Chronic AF[a]	4 (14.8)	7 (16.7)	0.838	
Systemic or cerebral embolism[a]	1 (3.7)	3 (7.1)	0.551	
Deaths[a]	2 (7.4)	22 (52.4)	<0.001	4.86 (1.24—19.07)
Sudden death	0 (0)	3 (7.1)		
Sudden death, no. (%)				
Death of cardiac origin	0 (0)	7 (16.7)		
Death of cardiac origin				
Death from other causes	2 (7.4)	12 (28.6)		
Death from other cause, no. (%)				

ACE: angiotensin-converting enzyme; AF: atrial fibrillation; ARB: angiotensin receptor blocker; LVEF: left ventricular ejection fraction; SD: standard deviation.
[a] Data are number (%).

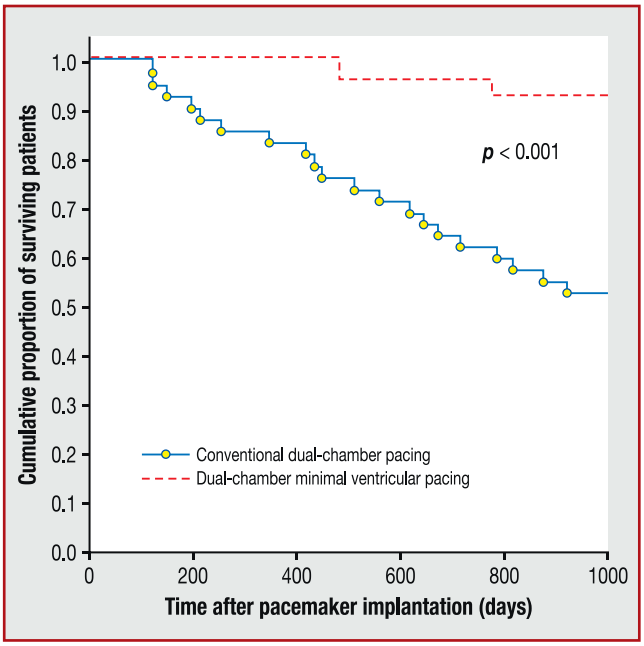

Figure 1. Survival as a function of time according to pacing mode in patients with a follow-up of less than 1000 days.

those equipped with a conventional dual-chamber pacemaker (480.6 days vs 919.9 days, $P < 0.001$). In order to compare these two groups of patients, we perfomed an analysis including only patients with a follow-up duration of less than 1000 days. The main results of this analysis are summarized in Table 5, and Figs. 1 and 2.

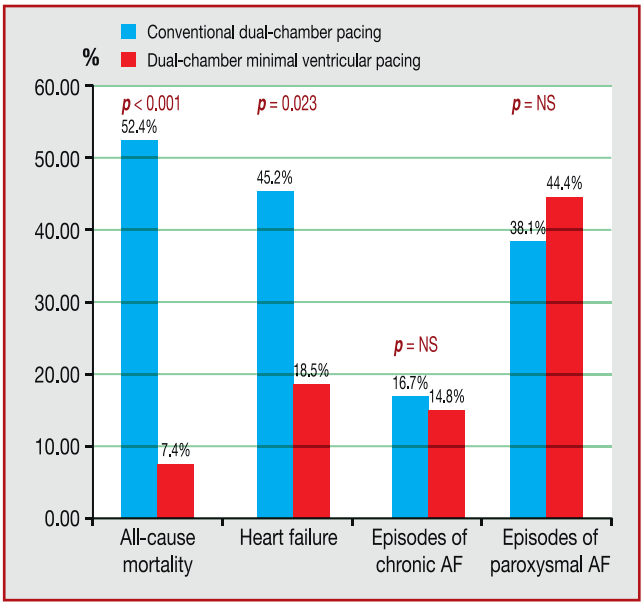

Figure 2. All-cause mortality and episodes of heart failure, chronic AF and paroxysmal AF according to pacing mode among patients with a follow-up of less than 1000 days. AF: atrial fibrillation; NS: not significant.

Discussion

The population studied was composed of very old patients, with a mean (±standard deviation) age of 82.2 (±4.4) years; 67 patients (65.7%) were older than 80 years. To our knowledge, this is the oldest population ever studied in trials concerning patients with sinus node dysfunction.

Symptoms

Seven patients (6.9%) showed no resolution of their symptoms and 21 patients (20.6%) achieved only partial symptom resolution after pacemaker implantation. The symptoms of sinus node dysfunction are not specific to this pathology. Disorders such as vasovagal syncope and neurovestibular disorders, which also occur very frequently among patients of this age, can have similar symptoms. The multiple comorbidities of elderly patients complicate the symptomatic sinus node dysfunction diagnosis.

Atrioventricular blocks

Among patients having sinus node dysfunction, the annual incidence of high-degree atrioventricular block has been estimated to be 0.6 to 1.9% [9–12]. The European Society of Cardiology [13] recommends the use of a single-chamber atrial pacemaker (Class I indication, level of evidence C) in patients with sinus node dysfunction alone (i.e. not associated with arrhythmia or a conduction disorder). In our study, the rate of high-degree atrioventricular block was estimated to be 13.7% during a mean follow-up of 2.2 years, corresponding to an annual incidence of 6.2%. Our incidence was higher than those previously described [9–12], probably because our patient population was older than those in these trials but also because we did not perform atrial-pacing tests to evaluate atrioventricular conduction before inclusion, unlike the studies from which these low atrioventricular block incidences are extracted.

Atrial fibrillation

The annual incidence of chronic AF during follow-up in our study (8.5%) was higher than those reported in other trials: 7.7% in MOST [1]; 3.25% in CTOPP [2]; and 6.1% in SAVE PACe [4]. This increase in chronic AF incidence with age should be taken into account when choosing the pacing mode and the type of pacemaker to be implanted.

The age of a patient is generally recognized to be a risk factor for progression to chronic AF [14,15]. However, in our study, mean age did not differ significantly between patients who progressed to chronic AF and those who did not. The same applied to patients who experienced paroxysmal AF compared with those who did not. This may be explained by the difficulty of detecting an age difference between two groups of patients within a population comprising exclusively elderly patients, with a mean age of 82.2 years and a narrow standard deviation (±4.4). Surprisingly, no electrical cardioversion was reported to treat persistent AF, despite the high prevalence of HF; this may be explained by a preferred rate-control strategy in elderly patients.

Among the patients who experienced an episode of paroxysmal AF without subsequently progressing to chronic AF,

only 67.6% had received at least transient treatment with VKAs and only 52.9% were still receiving VKAs at the end of follow-up, despite 82.4% of these patients having (had) a $CHADS_2$ score ≥ 2 [7] at inclusion. In contrast, all patients who developed chronic AF received at least transient treatment with VKAs, despite the risk of stroke being considered equivalent in these two types of AF in all recommendations [16].

No particular pacing mode programmed at the time of implantation (and at the end of follow-up) was significantly associated with an increase or decrease in the risk of paroxysmal or chronic AF. Several studies have shown a difference in the incidence of chronic AF according to the pacing mode [1,2,10] but all of these trials compared the VVI mode with other pacing modes. The SAVE PACe trial [4] revealed a 40% decrease in the relative risk of developing chronic AF in patients assigned to dual-chamber minimal pacing compared with those assigned to conventional dual-chamber pacing. But in terms of absolute risk, the decrease was only 2.8% per year, indicating that 36 patients needed to be treated to prevent one case of chronic AF per year. This difference in progression to chronic AF in the SAVE PACe trial [4] was attributed to a lower ventricular stimulation rate in the group of patients whose pacemakers incorporated an algorithm minimizing ventricular pacing (median 9.1% vs 99% in the other group). In our study, the median ventricular rate in the group with a pacemaker incorporating such an algorithm was 2.5% (before any progression to chronic AF) compared with a median of 95.5% in the group of patients whose pacemaker did not include this algorithm ($P < 0.001$). On this basis, we may conclude that this algorithm remains an effective means of reducing the ventricular stimulation rate in patients aged over 75 years, although the incidence of AF (paroxysmal and chronic) was not affected by the pacing mode to a statistically significant extent in our study (at least within the implemented follow-up period).

Heart failure

During follow-up, 36 patients (35.3%) experienced HF, corresponding to an annual incidence of 16%. Among these patients, we noted higher event rates for both chronic AF ($P = 0.022$) and paroxysmal AF ($P = 0.024$). This finding is consistent with the results of the SAVE PACe trial [4], in which patients who presented persistent AF had a higher rate of hospitalizations for HF ($P = 0.03$).

In the MOST trial [17], in the group of patients with a dual-chamber pacemaker, a ventricular stimulation rate above 40% was correlated with a relative risk of hospitalization for HF 2.6-fold higher than that in patients with a ventricular stimulation rate below 40%. Similarly, in our study, the ventricular stimulation rate was significantly lower ($P = 0.044$) in patients who did not experience any episode of HF (mean 50.6%; median 56.6%) than in the group of patients presenting HF, irrespective of whether or not this event necessitated hospitalization (mean 67.6%; median 96.7%). As already mentioned, the ventricular stimulation rate was significantly reduced by algorithms minimizing ventricular pacing. It is, therefore, logical that the group of patients experiencing HF included fewer patients assigned to dual-chamber minimal ventricular pacing ($P = 0.03$) and more patients assigned to conventional dual-chamber pacing.

As pacemakers with algorithms minimizing ventricular stimulation have been developed only recently, the patients with this type of pacemaker had a shorter follow-up compared with other patients ($P < 0.001$). But as the side-effects of right ventricular stimulation often develop slowly (in the MOST trial, for example, the risk of HF due to ventricular pacing was mainly evident from 5 years of follow-up onwards [18]), a significant difference in duration of follow-up would have created bias in our study. That is why we analysed a subgroup of patients with a follow-up period of less than 1000 days. In this substudy, with a comparable follow-up period ($P = 0.21$), the incidence of HF was still significantly lower in the group of patients assigned to dual-chamber minimal ventricular pacing than in patients assigned to conventional dual-chamber pacing ($P = 0.023$).

The relative risk of HF in patients with a conventional DDD pacemaker, compared with in those with a pacemaker incorporating an algorithm minimizing ventricular stimulation, was estimated to be 2.23 (confidence interval 1.03—5.15). In the SAVE PACe trial [4], no such difference was observed, but the mean age of the patients was lower (72.3 years in SAVE PACe vs 82.7 years in our study). It may, therefore, be postulated that the older the patient, the lower the tolerance of right ventricular stimulation, probably due to a greater decrease in left ventricular compliance in older patients.

Mortality

In our study, 29 patients (28.4%) died, corresponding to an annual mortality rate of 12.9%, with a mean time to death of 598 days post-implantation. In a substudy of MOST [19], the 3-year mortality of patients aged over 75 years was 23.5%. In our study, 17.2% of deaths were sudden deaths, 27.6% were of cardiac origin and 55.2% were due to other causes. These proportions are fairly similar to those reported in MOST [19].

Among patients with a follow-up of less than 1000 days, comparison of those assigned to conventional dual-chamber pacing with those assigned to dual-chamber minimal ventricular pacing revealed a lower mortality in the latter group ($P < 0.001$). The relative risk of death between these two groups was estimated to be 4.86 (confidence interval 1.24—19.07). This indicated that death can occur relatively soon after implantation in the group of patients receiving a conventional DDD pacemaker, as the difference between the groups was statistically significant despite the limited duration of follow-up. No such difference was observed in the SAVE PACe trial [4], but as mentioned earlier, the mean age of the patients was lower (72.3 years in SAVE PACe vs 82.7 years in our study), which may partly explain this difference.

Study limitations

This was a retrospective, observational study. At inclusion, 27 patients had a pacemaker in which the algorithm minimizing ventricular pacing was activated, whereas 71 patients had a conventional DDD pacemaker. It is conceivable that the choice of a pacemaker incorporating an algorithm minimizing ventricular stimulation might have been made on the basis of the patient's general state of health. This could partly explain the difference in non-

cardiac mortality between the two groups (even if the groups characteristics were not statistically different at inclusion).

The duration of our study (like that of most trials focusing on this topic) was relatively short (mean follow-up 806 days). Yet the time elapsing between pacemaker implantation and the development of complications related to this procedure, such as HF, embolic complications or progression to chronic AF, is often lengthy. Such relatively long delays in the onset of complications may be considered to be fully acceptable in patients aged over 75 years, but do not necessarily apply to this patient population; in our study, even a shorter follow-up was sufficient to reveal statistically significant differences in the incidences of HF episodes and mortality. The complications of right ventricular stimulation seem to occur faster in elderly patients than in younger patients.

Conclusion

Mortality and morbidity are both high among patients who receive a pacemaker in the context of sinus node dysfunction. Dual-chamber pacemakers incorporating an algorithm minimizing ventricular stimulation appear to reduce the number of HF episodes and deaths in patients aged over 75 years with sinus node dysfunction. This finding warrants the implantation of such devices, even in patients of this age group.

Conflicts of interest statement

None.

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