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Abstract:

Background: The rate of pacemaker (PM) implantations is constantly growing. Since life expectancy of the population is projected to increase, a large number of nonagenarian patients will need PM implantation. We aimed at analyzing short and long-term outcomes after PM implantation in nonagenarians.

Methods: Patients aged ≥90 yo referred for PM implantation from 2004 to 2017 were included. The primary clinical endpoint was total mortality. Secondary endpoints included procedure-related and in-hospital complications.

Results: 172 patients were included (92.6±2.1 yo, from 90.0 to 101.4 yo). Procedure duration was 50.0±19.7 min. Most of the patients had VVI devices implanted (143 pts, 83,1%) and mean hospital stay was 3.5±1.5 days. Nine patients (5.2%) had short-term device-related complications and 29 patients (16.8%) had post-procedural complications, non-related to the implantation, including four leading to patients' death. During a follow-up of 22.5 months (IQR: 7.3-38.0), 94 patients (54.7%) died. Survival rates were 82.9% (95% CI: 76.0-88.0), 73.7% (95% CI: 65.7-80.1) and 37.5% (95% CI: 27.5-47.5) after 1, 2 and 5 years, respectively. The Charlson comorbidity index was a predictive factor of procedural complications (odds ratio = 1.33; 95% CI: 1.05-1.69, p=0.02) while having a complication (hazard ratio = 4.04; 95% CI: 1.79-9.11, p=0.001) and atrial fibrillation (hazard ratio = 1.63; 95% CI: (1.02-2.63), p= 0.043) were predictors of post-implantation death.

Conclusion: PM implantation in nonagenarians is safe, with a low risk of procedural complications, but many comorbidities-related complications can occur. Caution should be taken in this old and frail population since complications significantly impact patients' survival.

Keywords: Pacemaker; Nonagenarian; Complications

List of abbreviations:

AF: Atrial fibrillation

AV: Atrio-ventricular

CCI: Charlson comorbidity index

CI: Confidence interval

CRT: Cardiac resynchronization therapy

CRT-P: Cardiac resynchronization therapy-Pacemaker

OR: Odds ratio

HR: Hazard ratio

Introduction

The implantation rate of pacemakers (PM) is increasing significantly each year in Europe, reaching 933 pacemakers per million inhabitants. [1] This increase is due in part to the ageing of the population, which causes an increased risk to develop atrioventricular (AV) block and sinus node dysfunction, but also related to the expansion of cardiac resynchronization therapy (CRT) indications or His ablation for heart rate control in patients with atrial fibrillation (AF). The mean age at device implantation is currently 80.2, 77 and 75.5 years old for single chamber, dual chamber and CRT-devices, respectively[2]. In 2015, life-expectancy at birth in Europe was 80.5 years for the general population, reaching 83.3 and 77.9 years for women and men, respectively.[3] Over the past 50 years, it has increased by about 10 years. By 2060, life expectancy is projected to be 89.1 and 84.6 years for female and male, respectively,[4] and the number of patients aged 80 and more is expected to double. Currently, only few studies specifically reported the long-term outcome of PM implantation in elderly patients. Mandawat et al evaluated the short-term mortality and complications of PM implantation in elderly patients, reporting 1.87% and 6.31% mortality and complications rates in nonagenarians, respectively. [5] Also, Udo et al studied outcome of PM recipients aged > 80 and reported a cumulative 5-year survival of around 50% after implantation, with a 18.1% complication rate. [6] More recently, Loirat et al described short and long term outcomes of pacemaker replacement in nonagenarians, reporting AF and non-physiological pacing as predictors of mortality. [7]

However, no studies specifically evaluated the short and long-term outcomes of PM primo-implantation in nonagenarian. Therefore, in the present study, we aimed at analyzing the procedural characteristics, survival rate and causes of deaths in nonagenarians.

Methods

Study population and data collection

Consecutive patients aged > 90 yo referred to our tertiary centre for device implantation from January 2004 to December 2017 were retrospectively enrolled. The study was approved by local ethical committee and all patients gave their informed consent to participate.

Clinical information was obtained from patients' medical records, which included patient demographics, medical history and medication use. "Physiological pacing" was defined as the implantation of a dual chamber PM or CRT in patients in sinus rhythm and single chamber PM for patients in atrial fibrillation, while "non-physiological pacing" was defined as the implantation of a VVI chamber device in patients in sinus rhythm. The Charlson comorbidity index (CCI), a validated score to assess patients' comorbidities, was evaluated using dedicated scales available online. [8,9] Various CCI have been proposed, depending on the number of variables included. We decided, as previously performed by Mandawat et al in their study about elderly pacemaker recipients, to use the one not including age, since all our patients were > 90 yo. [5]

Procedural characteristics of the device implantation were recorded, including indication of pacing, the type of PM implanted, the hospital length stay, and the procedural complications. Procedural complications included lead-related re-interventions for displacement or dysfunction, hematoma requiring re-intervention, pneumothorax requiring drainage, hemothorax, pericardial effusion due to cardiac perforation, and pacemaker-related systemic infections or endocarditis.

Follow-up and outcomes

Clinical follow-up data were obtained from clinical visits, or telephone interviews of patients or their families, general practitioners or nurses. The primary clinical endpoint was total mortality over the follow-up period.

Causes of death were obtained through hospital discharge notes, inquiries made with the family, the general practitioner or nursing homes, and classified using the *International Statistical Classification of Diseases and Related Health Problems* classification (ICD-10), as cardiovascular cause (I00-I99), pulmonary cause (J00-J99), digestive cause (K00-K93), neoplasic cause (C00-D48), renal cause (N00-N99), due to a multiple organ dysfunction (R65-10) or from an unknown origin (R99). Deaths were classified as unknown when no specific cause could be identified. Patients lost to follow-up were censored as alive the day of the last visit. Secondary endpoints included procedure-related and in-hospital complications.

Statistical analyses

Data are summarized as frequencies and percentages for categorical variables. Quantitative variables are expressed as mean ± standard deviation or median (inter quartile range (IQR)) for non-normally distributed variables. Qualitative data were compared using Fisher exact test, while quantitative data were compared using Mann and Whitney test. Survival curves were estimated using Kaplan-Meier method, with log-rank tests for comparisons. The prognostic relevance of different characteristics on long-term survival was assessed in univariate and multivariate fashion using Cox's proportional hazards regression analysis. All the values with a $p \leq 0.2$ in univariate analysis were used for multivariate analysis. All tests were 2 sided at the 0.05 significance level. All statistical analyses were carried out with the SPSS for Windows, version 16.0 (SPSS Inc., Chicago, Illinois, USA).

Results

Study population

From January 2004 to December 2017, 172 nonagenarian patients were referred for PM implantation. Patients' characteristics are described in Table 1. The median age of patients included was 91.9 years (IQR 90.9-93.7; from 90.0 to 101.4 yo) at the time of PM implantation, and 67 (39.8%) were male. A total of 45 patients (26.2%) were living in nursing homes at the time of implantation and the median CCI was 2.0 (1.0-3.5).

The main indication for implantation was high degree AV block (144 patients, 83.7%). The other indications were sinus node dysfunction, sick-sinus syndrome, high rate AF with AV junction ablation, carotid sinus hypersensitivity and CRT for heart failure.

Procedural characteristics and short-term outcome

Procedures were short, lasting for a median time of 50.0 (IQR 35.0-60.0) minutes, and all were performed with local anesthesia using mild sedation. Median hospital stay was 3.5 days (IQR 2.0-7.0, from 1 to 30 days). Most of the patients had single chamber PM implanted (143 patients, 83.1%) and pacing was considered as "physiologic" only for 58 (33.7%), since most of the patients were in sinus rhythm on time of implantation (136 patients, 79.1%) and devices implanted mostly VVI pacemakers (83.1%).

To note, at the time of device implantation, many of the patients were under antithrombotic therapy with anticoagulant, antiplatelet therapies or both (25.0%, 47.7% and 4,7% respectively), and the median number of drugs taken by the patients was 5.0 (3.0-7.0).

Regarding the complications of the procedure (Table 2), four patients had a pocket hematoma, none of them requiring a surgical revision. Three patients had a lead displacement requiring a redo intervention, and one got a pneumothorax. One patient had a hemothorax needing a surgical drainage and a prolonged hospitalization (24 days).

Twenty-six patients (16.2%) had post-procedural complications, non-related to the implantation (Table 2): 9 patients had congestive heart failure (8.0%) regressive after medical therapy, but leading to one death. The other complications were transient confusion for 2 patients, pneumonia for 2 patients, and renal failure for one patient. A 97 years old woman had a femoral fracture after a fall following PM implantation and one patient in AF had an embolic stroke. For all these patients, the complication extended the duration of hospital stay to 6.5 days (IQR 3.0-9.0, $p<0.001$). There was a significant difference in CCI between nonagenarians with or without procedure complication (Table 1). Indeed, as shown in Figure 1, panel A, the higher the CCI, the higher the risk of per- or post-procedural complications. Furthermore, the CCI was found to be the only predictor of post-implantation complications (Table 3) in multivariate analysis (odds ratio (OR) = 1.33; 95% confidence interval (CI): (1.05-1.69) per 1 unit increase, $p= 0.02$).

Four nonagenarians (2.3%) died before leaving hospital: two patients of severe geriatric cachexia, one of a myocardial infarction and one of a cerebral hemorrhage.

Long-term follow-up

The median time of follow-up was 22.5 months (IQR 7.1- 37.1). Twelve patients (6.7%) were lost of follow-up, and censored as alive the day of the last visit.

During the follow-up, 94 patients died (54.7%), and one patient was still alive after more than 9 years of follow-up. Causes of death are described in Table 2. The median time of survival was 22.5 months (95% CI 7.3-38 months). The survival at 1, 2 and 5 years were 82.9% (95% CI: 76.0-88.0%), 73.7% (95% CI: 65.7-80.1%) and 37.5% (95% CI: 27.5-47.5%), respectively. Seventeen patients (18.1%) died from a cardiovascular cause, mainly due to heart failure (14 patients, among which pacing was considered “physiologic” in only 6). Despite inquiries made with the general practitioner or medical service in case of patients

living in nursing homes, 52 deaths remained of unknown cause (55.3%). To note, one patient with an aortic mechanic valve had an endocarditis (*Streptococcus gallolyticus*) 3 months after the implantation of the PM, leading to patients' death few weeks later.

Predictors of mortality

Predictors for all-cause mortality in univariate and multivariate analysis are shown in Table 3. In univariate analysis, there was an increased mortality risk depending on a history of AF (Hazard Ratio (HR) = 1.80; 95%CI: 1.17-2.77, p= 0.08), on the presence of an ischemic or a valvular cardiomyopathy (HR = 2.48, 95% CI: 1.18-5.24 p= 0.0.17 and HR = 2.13, 95% CI: 1.07-4.26, p= 0.032) and on complications after PM procedure (HR = 2.17, 95% CI: 1.31-3.61, p= 0.003). Moreover in univariate analysis, the number of medications (HR = 1.12, 95% CI: 1.03-1.22, p= 0.01) per each additional treatment, the CCI (HR = 1.19 per unit increase, 95% CI: 1.06-1.33, p= 0.003) and AF (HR = 1.80, 95% CI: 1.17-2.77, p = 0.008) were significant predictors of mortality.

In multivariate analysis, a complication during hospitalization (OR = 4.04, 95% CI: 1.79-9.11, p = 0.001) and a history of AF (OR = 1.63, 95% CI: 1.02-2.63, p = 0.043) were the only predictive factors of mortality. Neither the other comorbidities nor CCI were predictors of mortality. Kaplan-Meier survival curves depending on the occurrence of complications are shown in the figure, panel B.

Discussion

Main results

The main findings of this study are the following: 1) PM implantation in nonagenarians is a straightforward procedure in patients > 90 yo, but carries a significant risk of peri-procedural and post-procedural complications; 2) Many comorbidities can affect post-operative period

and prolong the hospitalization; 3) The CCI is a predictive factor of post-operative complications 4) Post-operative complications and AF are predictors of mortality.

Nonagenarians in the general population

The percentage of nonagenarians is expected to increase in next decades, and according to the American Social Security Administration, one out of every four 65-year-olds today will live past age 90, and one out of 10 will live past 95. [10] In the United States, the number of nonagenarians has increased from approximately 230,000 in 1960 to approximately 1.8 million in 2010, and in the five biggest countries in the European Union (Germany, France, the United Kingdom, Italy, Spain) the number has increased from approximately 250.000 to 1.6 million. [11] This frail population is at high risk of symptomatic high degree AV block and sinus node dysfunction requiring PM implantation.

Safety of the procedure

Many short-term complications are described after PM implantation like hematoma, device-related infection, lead dislodgment, device extrusion or pericardial effusion. [6] They affect approximately up to 9.5% of device recipients. [12] Kirkfeldt et al analyzed all procedure of electronic device implantations in Denmark regardless of age. Lead related re-intervention was the most common complication (2.4%). [12] In elderly patients (> 80 yo), the risk of any lead-related re-intervention was lower than for patients between 60 and 79 yo (1% vs 3.1%, $p< 0.001$).Similarly, Udo et al reported a significant 9.8% and 6.9% rate of complications in octagenarians, mostly lead-related, within 2 months and during long-term follow-up, respectively. [6] Similarly, very elderly patients did not seem to have more complications than younger patients in other studies. [12,13] On the contrary, Ozcan et al demonstrated that the complication rate for elderly patients who had a permanent PM implantation was statistically

lower than in patients who were < 70 yo. [14] However, in the largest epidemiologic study published so far about PM implantations, in the nonagenarians subgroup, including more than 12 000 patients from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample administrative database, Mandawat et al demonstrated a 1.87% and 6.31% mortality and complication rates, respectively, modestly but significantly more than in septuagenarians and octogenarians. These frail patients also had a significantly longer hospital stay than younger patients, whose cost was estimated to be more than $41 000. Severe comorbidities and older age were strong predictors of mortality. [5] Various parameters may explain the higher rate of complications observed in elderly patients, including tortuous venous anatomy making lead placement sometimes challenging. [15] This may explain the higher rate of pneumothorax observed in the PASE trial in patients aged > 75 years. [16] Elderly patients also have a thinner right ventricular wall, increasing the risk of cardiac perforation. Ventricular lead should be carefully placed to reduce this risk. In our study, 5.2% had early complications. No hematoma requiring re-intervention was noted during the follow-up period. Three patients had a lead displacement requiring a redo intervention and one had a hemothorax needing a surgical drainage and a prolonged hospitalization. Twenty-six patients (15.1%) had post-procedural complications, non-related to the implantation. This important rate of complications was related to nonagenarians' fragility, directly correlated to the CCI. As described, nearly 50% of the nonagenarians with a CCI between 6 and 8 had post procedural complication. For all these patients, the complication extended the duration of hospital stay.

Long-term survival

Among the study population, 92 patients (54.7%) died, mainly from unknown or cardiovascular causes, and survival rates were 82.9%, 73.7% and 37.5% after 1, 2 and 5 years, respectively, and median time of survival was 22.5 (95%CI: 7.1- 37.1 months). These survival

rates are quite similar to what has been previously described by Udo et al. in a population of octogenarians and nonagenarians implanted with PMs (86, 75 and 49% after 1, 2 and 5 years),[5] In a prospective community-based study, Formiga et al found that better cognitive status and lesser comorbidities (evaluated by the CCI) were the best predictors to identify which nonagenarians will die after a 5-year follow-up period. [17] In our study univariable analysis showed that CCI, number of medication, AF and complications during hospitalization are predictors of mortality. In multivariable analysis, the CCI was the only predictive factor of post procedure complications. AF and complications were significant predictive factors of mortality for nonagenarians.

Pacing mode in nonagenarians

The optimal pacing mode has been, for a while, a matter of debate. In 2005, the United Kingdom Pacing and Cardiovascular Events (UKPACE) study showed that in elderly (> 75 yo) patients with high degree AV block, the pacing mode (VVI or DDD) did not influence the rate of deaths from all causes and the incidence of cardiovascular events.[18] Healey et al. published a meta-analysis about pacing modes to analyze whether an atrial-based pacing mode was associated with better long-term outcomes in device recipients, including UKPACE[18] and 4 large studies (CTOPP,[19] MOST,[20] PASE[21] and the Danish trial[22, 23]). The authors showed that compared with ventricular pacing, the use of atrial-based pacing does not improve survival or reduce heart failure or cardiovascular death. Jahangir et al [24] describe that in very elderly patients (≥ 80 years), the mode of pacing was not found to be a predictor of all-cause mortality. However, these results were contradicted by Krzemień-Wolska et al in a recent paper [25] that showed that DDD mode pacing decreased mortality among patients aged >80 years in long-term follow-up, and by Loirat et al. that found that non-physiological pacing was a predictor of mortality in nonagenarians scheduled

for PM replacement, [7] In our study, only 58 patients (33.7%) had a physiological stimulation, but there was no significant difference in terms of mortality between non-physiological stimulation in univariate analysis neither in multivariate analysis.

Limitations

We acknowledge some limitations in our study. Our analysis was performed as a retrospective review of a cohort of patients, with the inherent limitations of such studies (i.e. some patients were lost of follow-up). Due to the retrospective nature of the study, only in-hospital complications could be carefully collected and described. Out-of-hospital complications, except device-related endocarditis in 1 patient, could not be gathered and detailed in the manuscript. Furthermore, the limited number of patients may not allow a precise determination of predictive factors of mortality.

As stated above, some patients developed heart failure during the study period. However, none of them were scheduled for CRT-P implantation, and all were treated medically. Although this attitude is questionable, patients were considered too frail and/or too elderly to undergo a left ventricular lead implantation, and so, we cannot draw conclusions about device upgrade in nonagenarians. Moreover, a potential deleterious effect of right ventricular pacing on left ventricular function cannot be excluded in these patients. The pacing burden was not collected in our study, so we cannot incriminate with certainty the pacing as the cause of heart failure development.

The rate of VVI, DDD or other device type was similar among groups (p=0.926). One would probably expect higher risk of complications in patients with more than one single lead implanted, but our study was probably underpowered to show such effect.

Lastly, despite inquiries made with the general practitioner or medical service in case of nursing homes, 52 (55.3%) deaths remained from unknown cause, patients for whom the devices were not interrogated post-mortem.

Conclusion

PM implantation in nonagenarians is a straightforward procedure, but carries a significant risk of complications occurring during the hospitalization. Many comorbidities-related complications can occur in this old and frail population, that eventually major the risk of mortality.

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Table Legends

Table 1. Characteristics and comparison between nonagenarians with and without complication during hospitalization. AF: Atrial fibrillation; AV: Atrio-ventricular; CRT-P: Cardiac resynchronization therapy-pacemaker.

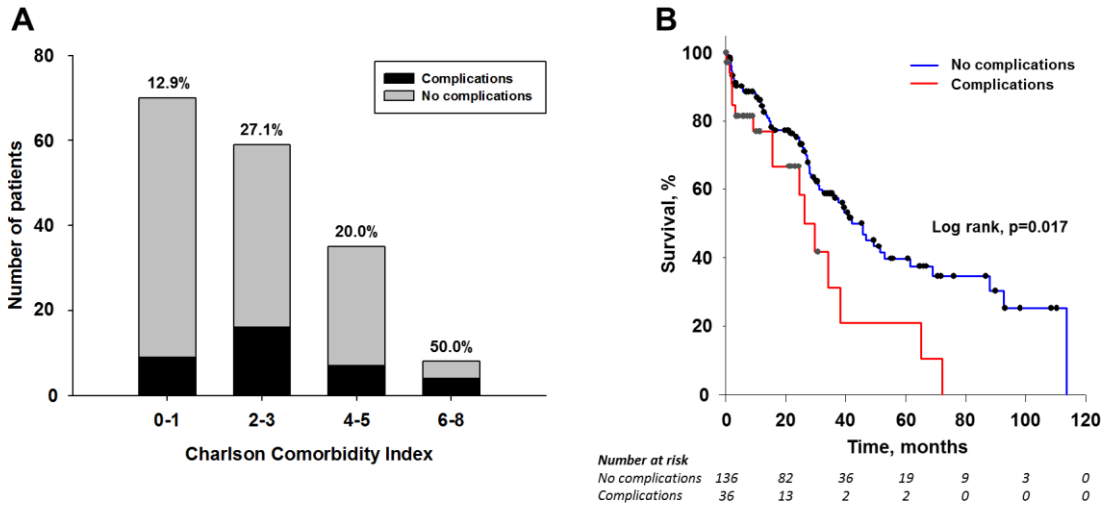
Table 2. Procedure and in-hospital related complications, mortality and causes of death during the follow-up

Table 3. Cox regression for all-cause mortality and logistic regression for all-cause complications in pacemaker recipients above 90 years of age.

HR= Hazard ratio ; OR= Odds ratio *Per each additional treatment, reference : 1; ** Per 1 unit increase ; † Per 1g/dL increase

Figure Legends

Figure 1. Complication rate depending of Charlson comorbidy index (panel A) and Kaplan Meier survival curve depending of the occurrence of a per- or post-procedural complication (panel B)



	General population N=172	No complication N=136	Complication N=36	p
Age (years)	91.9 (90.9-93.7)	92.1 (90.9-94.1)	91.5 (90.9-93.4)	0.584
Male. n (%)	67(39.0%)	54 (39.7%)	13 (36.1%)	0.593
Patients living in nursing home. n (%)	45 (26.2%)	36 (26.5%)	9 (25.0%)	0.972
Body mass index, (kg/m²)	23.0 (21.1-25.9)	23.1 (21.1-25.8)	22.4 (20.8-26.0)	0.693
Indication of implantation. n (%)				
High degree AV block	144 (83.7%)	114 (82.8%)	30 (83.3%)	
Sinus node dysfunction	14 (8.1%)	10 (7.4%)	4 (11.1%)	
Sick-sinus syndrome	8 (4.7%)	7 (5.2%)	1 (2.8%)	0.923
High rate AF with AV junction ablation	4 (2.3%)	3 (2.2%)	1 (2.3%)	
Carotid sinus hypersensitivity	1 (0.6%)	`1 (0.74%)	0 (0%)	
CRT-P for heart failure	1 (0.6%)	1 (0.74%)	0 (0%)	
Type of PM. n (%)				
Single chamber VVI	143 (83.1%)	112 (82.4%)	31 (86.1%)	
Dual chamber DDD	26 (15.1%)	21 (15.4%)	5 (13.9%)	0.926
Single chamber AAI	1 (0.6%)	1 (0.7%)	0 (0%)	
VDD	1 (0.6%)	1 (0.7%)	0 (0%)	
CRT-P	1 (0.6%)	1 (0.7%)	0 (0%)	
Physiologic stimulation. n (%)	58 (33.7%)	47 (34.6%)	11 (30.6%)	0.800
Subclavian puncture. n (%)	61 (35.5%)	51 (37.5%)	10 (27.8%)	0.374
Duration of procedure (minutes)	50.0 (35.0-60.0)	49.0 (35.0-60.0)	50.0 (38.5-70.0)	0.202
Mean hospital stay (days)	3.5 (2.0-7.0)	3.0 (2.0-6.0)	6.5 (3.0-9.0)	<0.001
Heart rhythm at the time of implantation. n (%)				
Sinus rhythm	136 (79.1%)	107 (78.7%)	29 (80.6%)	0.987
AF	36 (20.9%)	29 (21,3%)	7 (19.4%)	
Cardiomyopathy. n (%)				
Valvular	35 (20.3%)	28 (20.6%)	7 (19.4%)	
Ischemic	31 (18.0%)	23 (16.9%)	8 (22.2%)	
Hypertrophic	14 (8.1%)	11 (8.1%)	3 (8.3%)	0.931
Primary dilated	8 (4.7%)	7 (5.2%)	1 (2.8%)	
Tachycardia-induced cardiomyopathy	1 (0.6%)	1 (0.7%)	0 (0.0%)	
Pulmonary hypertension	1 (0.6%)	1 (0.7%)	0 (0.0%)	
Unknown (no TTE performed)	48 (27.9%)	35 (25.7%)	13 (36.1%)	
Comorbities. n (%)				
History of AF	58 (33.7%)	45 (33.1%)	13 (36.1%)	0.870
Diabetes Mellitus	17 (9.9%)	13 (9.6%)	4 (11.1%)	0.971
Hypertension	107 (62.2%)	84 (61.8%)	23 (63.9%)	0.968
History of stroke	29 (16.9%)	22 (16.2%)	7 (19.4%)	0.829
Heart failure	56 (32.6%)	42 (30.9%)	14 (38.9%)	0.477
Valvular disease	43 (25.0%)	34 (25.0%)	9 (25.0%)	0.829
Coronary artery disease	41 (23.8%)	32 (23.5%)	9 (25.0%)	0.971
Cardiac surgery	15 (8.7%)	10 (7.4%)	5 (13.9%)	0.366
Median Charlson comorbidity index	2.0 (1.0-3.5)	2.0 (1.0-3.0)	3.0 (1.5-4.0)	
Charlson comorbidity index				
0	33 (19.2%)	33 (24.3%)	0 (0%)	
1	37 (21.5%)	28 (20.6%)	11 (29.7%)	
2	25 (14.5%)	22 (16.2%)	3 (8.1%)	
3	34 (19.8%)	21 (15.4%)	13 (35.1%)	0.003
4	21 (12.2%)	17 (12.5%)	4 (10.8%)	
5	14 (8.1%)	11 (8.1%)	3 (8.1%)	
6	1 (0.5%)	1 (0.7%)	0 (0%)	
7	6 (1.7%)	3 (2.2%)	3 (8.1%)	
8	1 (0.5%)	0 (0%)	0 (0%)	
Treatments. n (%)				
No antithrombotic treatment	55 (32.0%)	45 (33.1%)	10 (27.8%)	0.713
Anticoagulants	43 (25.0%)	32 (23.5%)	11 (30.6%)	
Antiplatlet agents	82 (47.7%)	65 (47.8%)	17 (47.2%)	
Association AC and AP agent	8 (4.7%)	6 (4.4%)	2 (5.6%)	
Number of medications	5.0 (3.0-7.0)	5.0 (3.0-7.0)	6.5 (4.5-8.0)	0.02
Blood work				
Hémoglobin level (g/dl)	12.2 (11.3-13.0)	12.2±1.4	11.8±1.7	0.166
Creatinin level (µmol/l)	102.5 (80.0-132.0)	101.0 (81.0-131.5)	111.0 (73.8-143.8)	0.543

Table 1. Characteristics and comparison between nonagenarians with and without complication during hospitalization. AF: Atrial fibrillation; AV: Atrio-ventricular; CRT-P: Cardiac resynchronization therapy-pacemaker.

Complications/ Number of patients. n (%)	36 (20.9%)
Procedure-related :	
Lead displacement	3 (8.3%)
Hematoma	3 (8.3%)
Pericardial effusion	2 (5.6%)
Hemothorax	1 (2.8%)
Pneumothorax	0 (0%)
In-hospital	
Congestive heart failure	9 (25.6%)
Transient confusion	3 (8.3%)
Stroke	2 (5.6%)
Acute myocardial infarction	1 (2.8%)
Fall	1 (2.8%)
Pneumonia	4 (11.1%)
Urinary tract infection	1 (2.8%)
Renal failure	4 (11.1%)
Geriatric cachexia	1 (2.8%)
Delayed :	
Endocarditis	1 (2.8%)
Deaths/ Number of patients. n (%)	94 (54.7%)
Causes of deaths	
Unknown	52 (55.3%)
Cardiac	17 (18.1%)
Pulmonary	5 (5.3%)
Digestive	3 (3.2%)
Stroke	7 (7.5%)
Severe infection	4 (4.3%)
Neoplasia	2 (2.1%)
Multiple organ dysfunction syndrome	1 (1.1%)
Renal failure	1 (1.1%)
Geriatric cachexia	1 (1.1%)

Table 2. Procedure and in-hospital related complications, mortality and causes of death during the follow-up

Cox regression for mortality	**Univariate HR (95% CI)**	**p**	**Multivariable HR (95% CI)**	**p**
Male sex	1.37 (0.90-2.08)	0.14	0.96 (0.60-1.55)	0.87
Physiological pacing	1.55 (0.995-2.44)	0.052	1.12 (0.67-1.87)	0.67
Cardiomyopathy		0.09		0.27
Ischemic	2.48 (1.18-5.24)	0.017	2.09 (0.94-4.66)	0.07
Valvular	2.13 (1.07-4.26)	0.032	1.94 (0.93-4.04)	0.08
Other	1.79 (0.96-3.35)	0.069	1.68 (0.88-3.20)	0.12
Atrial fibrillation	1.80 (1.17-2.77)	0.008	1.63 (1.02-2.63)	0.043
Prior stroke	1.53 (0.92-2.54)	0.10	1.40 (0.78-2.51)	0.26
Complication during index hospitalization	2.17 (1.31-3.61)	0.003	4.04 (1.79-9.11)	0.001
Number of medications	1.12 (1.03-1.22)*	0.01	1.06 (0.97-1.16)*	0.24
Charlson score	1.19 (1.06-1.33)**	0.003	1.08 (0.95-1.24) **	0.24
Time*complications interaction	-	-	0.96 (0.92-1.002)	0.059
Logistic regression for complications	**Univariate OR (95% CI)**	**p**	**Multivariable OR (95% CI)**	**p**
Number of medications	1.17 (1.02-1.34)*	0.022	1.10 (0.94-1.29)*	0.22
Charlson score	1.35 (1.11-1.64)**	0.003	1.33 (1.05-1.69)**	0.02
Hemoglobin on admission	0.84 (0.65-1.09)†	0.19	0.95 (0.71-1.27)†	0.72
Sub-clavian approach	0.55 (0.24-1.25)	0.15	0.55 (0.22-1.36)	0.20

Table 3. Cox regression for all-cause mortality and logistic regression for all-cause complications in pacemaker recipients above 90 years of age.

HR= Hazard ratio ; OR= Odds ratio *Per each additional treatment, reference : 1; ** Per 1 unit increase ; † Per 1g/dL increase