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SERMENT D'HIPPOCRATE

En présence des Maîtres de cette Faculté,
de mes chers condisciples
et selon la tradition d'Hippocrate,
je promets et je jure d'être fidèle aux lois de l'honneur
et de la probité dans l'exercice de la Médecine.

Je donnerai mes soins gratuits à l'indigent,
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Electrophysiological study of patients implanted with TAVI and their clinical outcomes: a retrospective study in the population of CHRU of Tours in 2018 and 2019

ABSTRACT

Introduction: Aortic stenosis is frequent and responsible of high morbidity/mortality. Transcatheter aortic valve implantation (TAVI) has emerged as an alternative to surgery. New onset of atrio-ventricular conduction disturbance remains the major concern of our daily practice. In our center, we had an approach based on electrophysiological study (EPS) since 2018 which is similar to the new 2021 ESC recommendations. **Our objective was to describe electrographic and EPS factors of our population and to evaluate the risk stratification strategy based on EPS in our cohort on hard clinical outcomes** (death, heart failure and ischemic stroke).

Methods: This retrospective cohort study was based on the database all patients implanted with TAVI from 2018 and 2019 in the CHRU of Tours.

Results: Of 209 patients included in the cohort, 92 had EPS leading to discharge without PPM, 53 had EPS leading to permanent pacemaker (PPM) implantation and 64 had early PPM implantation without needing EPS. Mean follow-up was 488.2±342.0 days.

In comparison to patients with EPS leading to discharge, patients with early PPM implantation without EPS had significant longer PR interval (208.64 ± 49.7ms vs. 185.57 ± 38.3ms, p=0.003), wider QRS (118.49 ± 28.9ms vs. 103.57 ± 21.6ms, p = 0.0003), and right bundle branch block (RBBB) associated to left anterior fascicular block (LAFB) (18.8% vs. 3.3%, p=0.001).

First degree AV block (AVB1) was more frequent in the EPS leading to PPM implantation group compared to EPS leading to discharge group (79.2% vs. 57.6%, p=0.01). They had wider QRS (160.87 ± 21.5ms vs. 146.10 ± 24.3ms, p=0.0003), more frequent left bundle branch block (LBBB) (94.2% vs. 73.6%, p=0.002) and also had more sinus node disease (9.4% vs. 1.1%, p=0.01).

Coherently with our protocol, patients with EPS leading to discharge had a shorter HV interval (60.67±8.2 vs 84.17±14.8 ms, p<0.0001) and had no intra or infra hisian block compared to patients with EPS leading to PPM implantation. They also had shorter AH interval (143.08±53.1 vs 164.43±51.8 ms, p=0.03), thinner His (25.21±5 vs 31.4±10.8 ms, p=0.001), higher his amplitude (0.096±0.006mV vs 0.077±0.04mV) and higher rate of Wenckebach block (146.3±30.2 vs 131.27±26.1 bpm). Patients with PPM without EPS had

more paced QRS on ECG during follow-up compared to patients with EPS leading to PPM implantation (38 out of 64 patients - 59% vs. 11 out of 53 patients – 21% respectively, p<0.0001).

In multivariable analysis, we did not find any predictor of ventricular pacing, HV interval > 70ms even appeared protective for ventricular pacing (HR=0.043, IC95%=0.002-0.929, p=0.045).

Death and ischemic stroke were statistically not different between the groups.

Patients with PPM without EPS had significantly more hospitalization for heart failure (23.4% vs. 5.4%, p 0.001 with an HR of 1.78, IC95%=1.06-2.97, p=0.028 and had a significantly lower LEVF (57.5 ± 9.4% vs. 60.2 ± 10.3%, p=0.01) compared to patients with EPS leading to discharge.

No differences regarding heart failure was seen between EPS leading to PPM and EPS leading to PPM

Conclusion: **No interesting predictors of ventricular pacing was found in our study. However, EPS seemed to be safe to stratify atrioventricular conduction disorders with similar outcome regarding death in the three groups. Only three patients in the EPS leading to discharge without PPM group had a PPM during the follow-up for atrioventricular conduction disorders. Interestingly, patients implanted with a PPM without EPS had a worse prognosis regarding heart failure and had lower LVEF. They had had higher pacing rates, and this should be explored in other large studies**.

Keywords. TAVI, Conduction disease, electrophysiological study, Pacemaker.

ABBREVIATIONS

AH Atrial- His interval

AF Atrial fibrillation

AIJR Accelerated idiojunctionnal rhythm

ARP Absolut refractory period

ASA Acetyl salicylic acid

AV Atrioventricular

AVB Atrioventricular block

AVR Aortic valve replacement

AWP Anterograde Wenckebach point

BBB Bundle branch block

b.p.m. Beats per minute

CABG Coronary artery bypass graft

CD Conduction disorders

CI Confidence interval

CRT Cardiac resynchronization therapy

CRT-D Defibrillator with cardiac resynchronization therapy

CRT-P Cardiac resynchronization therapy-pacemaker

DDD Dual-chamber, atrioventricular pacing

ECG Electrocardiogram/electrocardiographic

EPS Electrophysiological study

HAVB High atrioventricular block

HF Heart failure

HR Hazard ratio

HV His–ventricular interval (time from the beginning of the H deflection to the earliest onset of ventricular depolarization recorded in any lead, electrophysiology study of the heart)

ICD Implantable cardioverter-defibrillator

LAFB Left anterior fascicular block

LBBB Left bundle branch block

LPFB Left posterior fascicular block

LVEF Left ventricular ejection fraction

MI Myocardial infarction

NOAC Non-vitamin K antagonist oral anticoagulant

NYHA New York Heart Association

OAC Oral anticoagulant

OR Odds ratio

PASP Pulmonary artery systolic pressure

PCI Percutaneous coronary intervention

PPM Permanent pacemaker

RBBB Right bundle branch block

RRP Relative refractory period

SND Sinus node dysfunction

SR Sinus rhythm

SVT Supraventricular tachycardia

STEMI ST elevation with myocardial infarction

STS Society of thoracic surgeons

TAVI Transcatheter aortic valve implantation

TPM Temporary pacemaker

VKA Vitamin K antagonist

VT Ventricular tachycardia

INTRODUCTION

Aortic stenosis (AS) is the most frequent acquired valvular disease in the elderly and is responsible for high morbidity and mortality if left untreated.[1–3] [4] Historically, the main treatment was the surgical approach.[5] However, 30% of patients could not be operated due to their comorbidities.[6,7] In 2002, transcatheter aortic valve implantation (TAVI) emerged as an alternative to surgery for these patients.[8] It was firstly used in surgical high-risk patients[9,10] and due to the constant amelioration of this approach, indications were extended to intermediate-risk patients.[11,12] Transcatheter technique indications have gradually increased in recent years.[13,14]

Despite improvements in technique,[15–17] new onset of atrioventricular (AV) conduction disturbance and associated morbimortality[18–24] remains one of the major concern of our daily practice, even with the new generation of prosthesis.[25] Rates of permanent pacemaker implantation (PPM) after TAVI range between 3.4% and 25.9% in randomized trials and large registries.[26,10,27,13,14,28] It represents a real challenge, especially in younger population with lower surgical risk. [29]

These conduction disorders (CD) are explained by the proximity of the aortic ring and the conduction pathway.[30–34] However, identifying patients at risk is challenging. Some factors determining severity of conduction system disturbance after TAVI has been well identified: Electrocardiographic (ECG) characteristics such as right bundle branch block (RBB),[35] PR- interval prolongation[36] and left anterior fascicular block (LAFB);[36] Patient's factors such as: Older age,[37] male sex[4] and larger body mass index;[37] anatomical considerations such as: severe mitral calcification,[38] LV outflow tracts calcifications,[39] membranous septum length,[33] Porcelain aorta[40] and higher mean aortic valve gradient;[4] and at last procedural factors such as: self-expandable valve,[36] deeper valve implantation,[41] larger ratio between prosthesis diameter versus annulus or outflow tract diameter,[42] balloon post dilatation[4] and TAVI valve in valve.[40]

Recently, European society of cardiology established recommendations for management of conduction abnormalities after TAVI.[43] We had a similar approach based on electrophysiological study (EPS) over the past years in our center. Patients with conduction abnormalities after TAVI underwent the same protocol. Persistent high degree atrioventricular block (AVB) underwent permanent pacemaker implantation within the 48 hours after TAVI. Transient high degree AVB underwent EPS after 5 days of ECG monitoring. Persistent left Bundle branch block (LBBB) or any CD after 5 days underwent EPS. During EPS, if His-ventricular (HV) interval was 70ms or more or if intra or infra hisian block was seen, a PPM

was implanted, if not patient was discharged. If no conduction abnormalities were observed of if CD disappeared, patients still underwent 3 days of ECG monitoring before discharge.

Our objective was to describe electrographic and EPS factors of our population and to evaluate risk stratification strategy based on EPS in our historical cohort.

METHODS

Data sources

We created a database from the patients treated with TAVI between 2018 and 2019 with the help of manuscript/computer medical data; ECG/EPS data and survey data.

EPS data were collected and reinterpreted by an electrophysiologist physician.

Outcome's parameters were collected by using computer medical data; medical survey was sent to general cardiologist to collect data from out-hospital care.

The study was driven retrospectively, patients were not involved in its conduct, and there was no impact on their care. Thus, their consent was not needed.

Study population

We included all patients over 18 years old from January 1, 2018, to December 31, 2019, who underwent a TAVI in the CHRU of Tours.

Patients with previous pacing systems (PPM, implantable cardioverter-defibrillator, and cardiac resynchronization therapy) were not included.

Patients were excluded if they died before PPM or EPS, or if the monitoring was not in accordance with service protocol or if they were transferred to another center before end of monitoring.

At last, patients who had no conduction abnormalities or CD appearance within the 3 days of ECG monitoring were not included.

So, we collected and analyzed a cohort which was divided in 3 different groups:

PPM without EPS, EPS leading to PPM and EPS leading to discharge without PPM.

Data collection

Baseline characteristics as general, cardiovascular, and extra cardiovascular data were collected. Type of valve, echocardiographic and peri operatory conditions were already described. We also interpreted ECG at the first day and during the monitoring. We analyzed the kinetics of cardiac disorders abnormalities as the first CD apparition, their regression and apparition of rhythm disorders. All parameters were interpreted by electrophysiologist physicians.

At last, we analyzed the outcomes: it included need PPM, ventricular pacing on ECG, death and heart failure.

Statistical analyses.

Qualitative variables are described using counts and percentages and continuous quantitative variables as means ± standard deviation. Comparisons between groups were made using chi-square tests for comparing categorical variables and the Student t test or non-parametric Kruskal Wallis test where appropriate for continuous variables.

To identify independent characteristics associated with PPM implantation and ventricular pacing, a proportional hazard model was used. Baseline characteristics were pooled into a multivariate Cox model. The results were expressed as hazard ratios risk (HR) and 95% confidence intervals (CI). The proportional hazard assumption was checked by plotting the log-rank Kaplan Meier curves. In all analyses, a p value <0.05 was considered statistically significant. All analyses were performed using the software STATA®.

RESULTS

EPS leading to discharge, EPS leading to PPM implantation and PPM without EPS at baseline (Tables 1, 2 and 3; and Figure 1)

550 patients underwent TAVI in 2018 and 2019. We excluded 83 patients with previous PPM or implantable cardiac defibrillator, 4 patients died during the hospitalization, 19 patients had a monitoring which was not in accordance with our service protocol, 34 patients were transferred to another centre before end of monitoring and 201 patients presented no conduction abnormalities within 3 days of ECG monitoring. Thus, 209 patients (38% of all patients) were included in our cohort and underwent our monitoring protocol for atrioventricular conduction disorders.

92 patients (44, 02%) had an EPS leading to discharge without PPM, 53 patients had an EPS leading to PPM implantation (25, 36%) and 64 patients had an early PPM implantation after persistent high degree AVB without needing EPS (30, 62%). (**Figure 1**) In total, 117 patients (21% of all patients) underwent a PPM implantation.

Baseline characteristics of patients from the three groups are described in **Table 1**. Mean age was 82 years old, 48.8% of patients were male. There were no significant differences between the three groups except for patients with EPS leading to PPM implantation which had more lung disease (26.4% vs. 12% for patients with EPS leading to discharge, p=0.03).

Few had previous surgical AVR (4 patients) or previous TAVI (1 patient).

Mean Euroscore II was 4.3 and mean STS score was 4.08.

Baseline valvular characteristics of patients are described in **Table 2**. Patients with EPS leading to discharge had a significant smaller size of prosthesis when an Edwards SAPIENS 3® or EVOLUT R® was implanted. Other characteristics were not significantly different between the 2 groups. Aortic calcification was the main aetiology (95%), however 6 patients had bicuspid valve and 5 patients had a degenerescence of bioprothesis.

The echocardiography parameters shown cardiac hypertrophy (13.5±3 mm); severe AS parameters; preserved LEVF (59.2±10.4 %); a dilated left atria (46.7±16.7 ml/m2), no significant associated valve's disease, a good right ventricular function (83.7%) and a pulmonary hypertension (38.37±14.6).

Most of the implanted valves were Evolut Pro® (47%) and Edwards Sapiens 3® (32.5%). Pre and post valve expansion represented 15% of TAVI. Mean Gradient was 10.35±6.6 mmHg. There were few paravalvular leaks (mean leak grade was 0.94±0.8) and pericardial effusion (5.3%).

Importantly, Hospitalization length was not different between the 3 groups (7.48±3.6 days).

Baseline ECG characteristics of patients are described in **Table 3**. In comparison to patients with EPS leading to discharge, patients with early PPM implantation without EPS had significant longer PR interval (208.64 ± 49.7ms vs. 185.57 ± 38.3ms, p=0.003), wider QRS (118.49 ± 28.9ms vs. 103.57 ± 21.6ms, p = 0.0003), and RBBB associated to LAFB (18.8% vs. 3.3%, p=0.001). Other baseline characteristics were not different between the 3 groups.

CD apparition and regression among patients with EPS (Table 4 and 5)

First degree AV block (AVB1) was more frequent in the EPS leading to PPM implantation group compared to EPS leading to discharge group (79.2% vs. 57.6%, p=0.01). They had longer maximum PR interval (274.5 ± 67.8ms vs. 227.42 ± 51.4ms, p<0.0001), they had wider QRS (160.87 ± 21.5ms vs. 146.10 ± 24.3ms, p=0.0003), more frequent LBBB (94.2% vs. 73.6%, p=0.002) and had more sinus node disease (9.4% vs. 1.1%, p=0.01).

These conduction disorders (First degree AV block and LBBB) appeared at day 0 post TAVI.

Rhythm disorders were not different between the two groups, especially there were no difference regarding Accelerated idiojunctional rhythm (3.8% vs. 2.2%, p=0.57)

Conduction disorder regression and the delay for its regression were not significantly different between the two groups (**Table 5**). Interestingly AVB1 regression was seen after 2.44 ± 1.9 days in 15.1% of patients with EPS leading to discharge and after 4 ± 4.2 days in 4.7% of patients with EPS leading to PPM implantation. LBBB regression was seen after 2.45 ± 1.7 days in 16.4% of patients with EPS leading to discharge and after 1.4 ± 0.9 days in 10% of patients with EPS leading to PPM implantation.

EPS Characteristics (Table 6)

Mean delay of 4.5 days was similar between EPS leading to discharge vs PPM implantation.

There were significant differences concerning EPS parameters:

Patients with EPS leading to discharge had a shorter HV interval (60.67±8.2 vs 84.17±14.8 ms, p<0.0001) and had no intra or infra hisian block (0% vs. 11.3%, p=0.001) compared to patients with EPS leading to PPM implantation. This is of course coherent with our protocol.

They also had shorter atrial-his (AH) interval (143.08±53.1 vs 164.43±51.8 ms, p=0.03), thinner His (25.21±5 vs 31.4±10.8 ms, p=0.001), higher his amplitude (0.096±0.006mV vs 0.077±0.04mV) and higher rate of Wenckebach block (AWP) (146.3±30.2 vs 131.27±26.1 bpm).

There were no difference atrioventricular refractory periods between the two groups.

PPM Characteristics (Table 7)

Patients with PPM implantation without EPS were implanted earlier than patients with EPS leading to PPM (4.8±1.5 vs 3.3±1.8 days, p<0.0001).

Approximately 75% of implanted PPM were dual chambers. Patient with an EPS had more leadless pacemaker (5.7% vs 0%, p=0.01). There were very few chronic resynchronisation therapy (CRT) (i.e 2 patients in the PPM without EPS group).

2 pneumothorax, 3 hematoma and 3 lead displacements were associated to PPM implantation in the total population.

PPM implantation at baseline and follow-up (Tables 9)

Following our protocol, 92 patients had an EPS leading to discharge. Among these patients, 6 had a PPM during the follow-up. We described their characteristics in **Table 12**). Among these patients, only 3 had a PPM implantation for atrioventricular conduction disorders (One had syncope with the apparition of infra-hisian block and two had symptomatic high degree AV block). PPM implantation occurred 403, 161 and 38 days after discharge for each patient. Two patients had an Evolut Pro® and one had an Edwards Sapiens 3®. They all had before discharge an HV interval < 60ms without intra of infra hisian block. They had a His amplitude >0.08mV and his width was ≤30ms.

Accordingly, to our protocol, HV interval > 70ms was a strong predictor of PPM implantation (HR=13.704, IC95%=4.773-39.522, p<0.0001 in the multivariable analysis). We also found in our multivariable analysis that Sapiens XT® was at risk of PPM implantation (HR=14.410, IC95%=1.442-144.043, p=0.023) and that apparition of LBBB after TAVI was surprisingly protective for PPM implantation (HR=0.346, IC95%=0.162-0.740, p=0.006)

In univariate analysis, RBBB before TAVI with or without LAFB, His duration >30ms and His amplitude ≤0.08mV were risk factors when QRS width before TAVI < 120ms and LBBB apparition were protective (**Table 9**).

Clinical outcomes

Mean follow-up was 488.2±342.0 days (median: 525 days, IQR: 163-748 days).

*Ventricular pacing (**Tables 10**)*

We observe that patients with PPM without EPS had more paced QRS on ECG during follow-up compared to patients with EPS leading to PPM implantation (38 out of 64 patients - 59% vs. 11 out of 53 patients – 21% respectively, p<0.0001).

Data on percentage of ventricular pacing on PPM interrogation, when available showed a higher rate of pacing in patients with PPM without EPS (65.9 ± 43.2% vs. 14.9 ± 26%, p<0.0001). Those data were available in only 23 patients of patients with EPS leading to PPM implantation and in 18 patients of patients with PPM without EPS.

In multivariable analysis, we did not find any predictor of ventricular pacing, HV interval > 70ms even appeared protective for ventricular pacing (HR=0.043, IC95%=0.002-0.929, p=0.045).

In univariate analysis, apparition of LBBB and a higher Wenckebach point were protective for ventricular pacing when RBBB before TAVI, His amplitude <0.08mV, High degree AVB and third degree AVB apparition were risk Factor for ventricular pacing (**Table 11**).

*Death, heart failure, ischemic stroke during follow-up (**Table 8**)*

In our cohort, 31 patients died (14.8%), 28 patients had heart failure (13.4%), 5 had an ischemic stroke (2.4%) and 2 needed PPM upgrading to CRT (1.6%) during follow-up. Mean left ventricular ejection fraction (LVEF) was 58.1± 10.0%.

Death was statistically not different between the groups (HR=0.794, 95%CI=0.292-2.160, p=0.651 for group with EPS leading to discharge vs. EPS leading PPM and HR=1.290, IC95%=0.807-2.062, p=0.287 for patients with EPS leading to discharge vs. PPM without EPS). This was illustrated in the **Figure 2**.

Patients with PPM without EPS had significantly more hospitalization for heart failure (23.4% vs. 5.4%, p 0.001 with an HR of 1.78, IC95%=1.06-2.97, p=0.028 and had a significantly lower LEVF (57.5 ± 9.4% vs. 60.2 ± 10.3%, p=0.01) compared to patients with EPS leading to discharge.

No differences regarding heart failure were seen between EPS leading to PPM and EPS leading to PPM (HR= 1.95, IC95%=0.74-5.04, p=0.18) as illustrated on **Figure 3**.

There were no significant differences between the three groups for ischemic stroke during follow-up.

DISCUSSION

Using a local database, we performed an overview of epidemiology of conduction diseases needing EPS and/or PPM implantation in our TAVI population and their outcomes.

Population characteristics

We observed that half of the patient implanting with TAVI had experiment an EPS or a PPM implantation.

We can observe that patients were 82 years old, half were male.

Most of them have cardiovascular risk factor. ¼ were hospitalised for cardiac heart failure during the previous years.

Few had previous surgical AVR or TAVI.

There were co-morbidities as kidney disease, anaemia.

AS calcification stays as the main indication of TAVI, although bicuspid valves and aortic valve degeneracies can be found.

Thus, our cohort is relevant with population described in literature.[44]

It's relevant to say there only one case of cardiac amyloidosis in our population which contrast with literature. It probably shows an under diagnostic of these disease.[45]

Evolut PRO®, Evolut R® and Edwards Sapiens 3® were the most implanted valve, their implantations depending on several parameters.[46]

Difference ECG

At the basis ECG, it's relevant to observe that ¾ of patients had QRS <120ms.

We can also observe that population with EPS leading to discharge and EPS leading to PPM were similar.

At contrary, Patients implanted without PPM presented longer PR and QRS, Less QRS <120ms, and more conduction disease which is relevant with literature

It's interesting to observe there were no statistical difference affecting LLBB and LAFB pre-existing TAVI.

We observe that patients with EPS leading to discharge had thinner PR and QRS at the first day.

There were less AVB, thinner interval PR max and QRS max.

There was less LBBB, and delay of temporary pacemaker (TPM) was longer.

There were less sinus node dysfunction (SND) and more atrial fibrillation (AF).

It's important to note that LBBB is an important proportion in each group which demonstrate his presence is not a unique parameter to decide PPM implantation, even it didn't regress.[47]
It's important to note that TPM was involved with few complications.
TPM removal is an interesting parameter between EPS leading to discharge and PPM without EPS. It's concordant with the fact that HAVB not regressing within the 48h represent an indication of PPM implantation.[48]

Difference EPS

We can see statistical difference with these parameters: AH interval, HV interval, His width, intra or infra hisian Block, higher his amplitude and lower AWP.
The nature of EPS parameters is relevant with literature.[49,50]

Outcomes

We have an overview > 1 years about our population.
We observe that 14.8% of the patients have died during follow up which is similar to the data from the literature.[51]
It's important to note that patient implanted with PPM with or without EPS, suffered much for heart failure hospitalization.[18]

PPM implantation

We observe some factors associated with PPM implantation:
Preoperative RBBB, preoperative RBBB + LAFB, HV > 70ms, His width and His amplitude, Sapiens XT® implantation are Risk Factor of PPM implantation.
It surprising to see that LBBB appeared as a protective factor; it can be explained by the design of our study.
Unfortunately, mostly of the parameters didn't reach statistical result in multivariate analysis.
Only 3 patients have been implanted for AVB after an EPS without PPM, which demonstrate that EPS can be safe to stratify risk of PPM implantation.

Ventricular Pacing

We observed that Patients implanted with PPM without EPS are much more stimulated that patient with EPS.
It's pondered with the fact that we didn't have the information about all the ventricular pacing of patient implanted with PPM.

We observe some factors associated with Ventricular pacing: preoperative RBBB, HV>70ms, His amplitude, HAVB and AVB 3 apparition are risk Factor.

It surprising to see that, in univariate analysis: LBBB and AWP>130 ms are protective for ventricular pacing. In multivariate analysis, HV >70 ms seems protective.

Unfortunately, mostly of the parameters didn't reach statistical result in multivariate analysis.

Thus, there's no interesting predictors of ventricular pacing were found despite some interesting parameters in univariate analysis.

It's concordant with literature which reports some's patients restore their atrioventricular conduction during follow up.[52,53]

There's still no strong factor to predict ventricular pacing and atrioventricular recovery, despite some factor that can be interesting.[54,4]

Morbimortality

We can observe that outcome regarding death is similar in the three groups.

It can demonstrate that EPS seem to be safe to stratify risk of atrioventricular conduction disorders.

We can note that patients implanted with a PPM without EPS had a worse prognosis regarding heart failure and had lower LVEF.

It can be explained by a higher rate of ventricular pacing. This high level of pacing could develop at last a pacing induced cardiomyopathy.[55]

It's one of the explications of the suspicion of over mortality of patient implanted with PPM after TAVI. [19,20]

The poorer evolution of LEVF after PPM implantation can explained such an observation.[18,56,57]

These results are supported by study showing that patients with factors associated to ventricular pacing develop more heart failure.[52,35,58]

However, some study suggests a reduction of mortality with patient implanted with PPM, that may be explained by of the lower sudden death at 1 years.[18]

It will be interesting to determine the factors associated with the development of these cardiomyopathy to develop strategy of early CRT implantation.[59–61]

Limitation

A main limitation of this study was inherent to its retrospective observational nature.

Another important limitation concerns our population where we excluded patients presenting no conduction abnormalities within 3 days of ECG monitoring.

Moreover, Events included were mainly in our hospital, we had few data on extra-hospital diagnoses.

Our study is based on a population based on year 2018-2019 and so, there's few data on new valve and the extended indications of TAVI.

Finally, data about ventricular pacing were small and is another limitation of our study.

CONCLUSION

No interesting predictors of ventricular pacing were found in our study.

However, EPS seemed to be safe to stratify risk of atrioventricular conduction disorders with similar outcome regarding death in the three groups. Only three patients in the EPS leading to discharge without PPM group had a PPM during the follow-up for atrioventricular conduction disorders. Interestingly, patients implanted with a PPM without EPS had a worse prognosis regarding heart failure and had lower LVEF. They had had higher pacing rates, and this should be explored in other large studies.

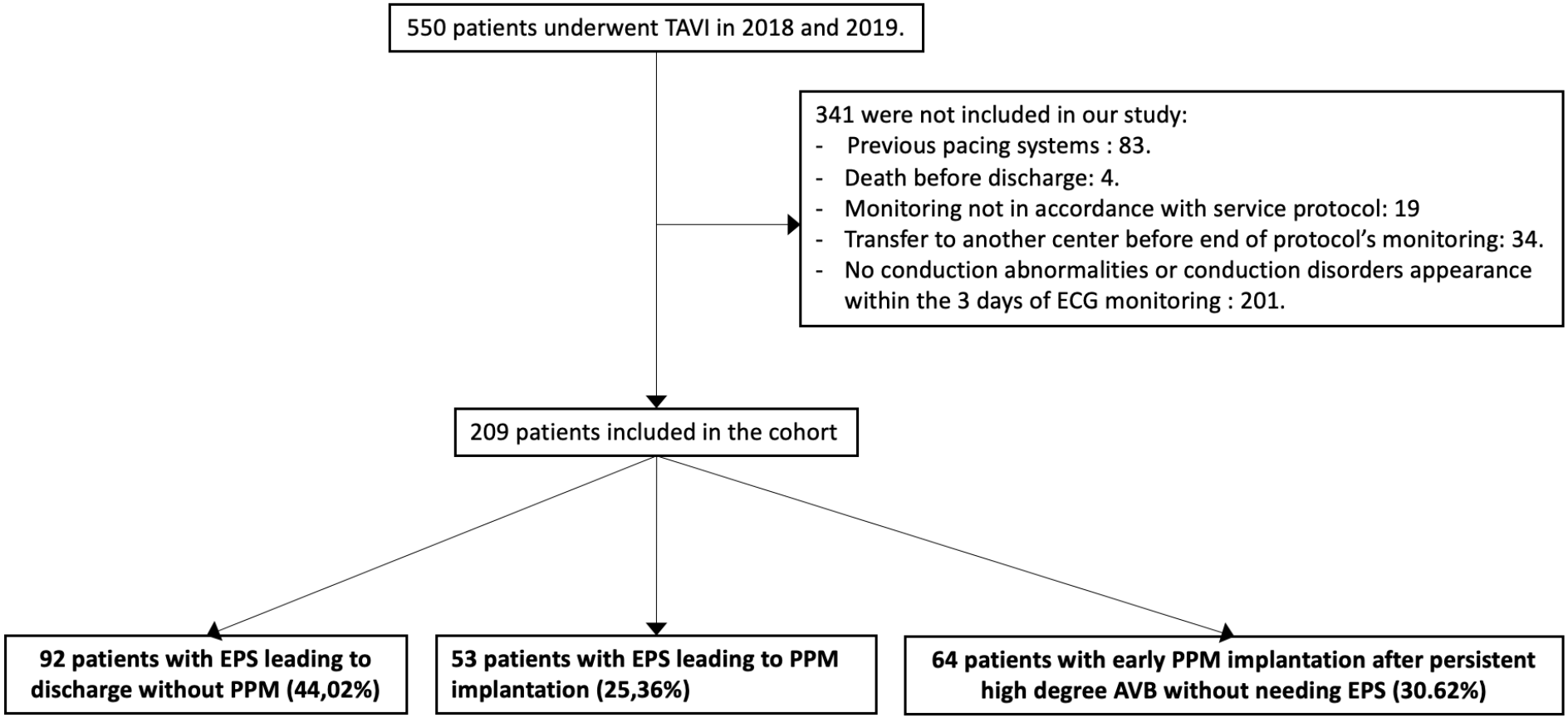

Figure 1 - Flow chart of the study patients.

Table 1- Baseline clinical characteristics of patients

Variables	EPS leading to discharge n= 92	EPS leading to PPM implantation n= 53	PPM without EPS n= 64	Total N= 209	p Value EPS leading to PPM implantation vs. EPS leading to discharge	p Value PPM without EPS vs. EPS leading to discharge
Age, years	82.6 ± 6.2	82.3 ± 6.7	83.2 ± 6.3	82.7 ± 6.3	0.75	0.61
Gender (male), n (%)	40 (43.5%)	30 (56.6%)	32 (50%)	102 (48.8%)	0.13	0.42
Body mass index	27.8 ± 5.7	29.0 ± 5.5	27.7 ± 4.3	28.1 ± 5.3	0.2	0.9
Risk Factor, n (%)						
Hypertension	77 (83.7%)	47 (88.7%)	53 (82.8%)	177 (84.7%)	0.42	0.89
Dyslipidaemia	52 (56.5%)	36 (67.9%)	44 (68.8%)	132 (63.2%)	0.18	0.12
Diabetes mellitus	39 (42.4%)	22 (41.5%)	22 (34.4%)	83 (39.7%)	0.92	0.32
Acute Smoking	4 (4.3%)	1 (1.9%)	1 (1.6%)	6 (2.9%)	0.44	0.33
Obstructive sleep apnoea	4 (4.3%)	8 (15.1%)	5 (7.8%)	17 (8.1%)	0.02	0.36
Vascular disease	52 (56.5%)	33 (63.5%)	45 (70.3%)	130 (62.2%)	0.42	0.08
Coronary artery disease, n (%)						
STEMI	6 (6.5%)	2 (3.8%)	6 (9.4%)	14 (6.7%)	0.49	0.51
Percutaneous intervention	12 (13.0 %)	8 (15.1%)	10 (15.6%)	30 (14.3 %)	0.73	0.65
Bypass Graft	4 (4.3%)	4 (7.5%)	2 (3.1%)	10 (4.8%)	0.42	0.7
Hospitalization for heart failure < 1 year, n (%)	24 (26.1%)	12 (22.6%)	16 (25%)	52 (24.9%)	0.65	0.88
Dyspnea, NYHA	2.29 ± 0.86	2.55 ± 0.8	2.40 ± 0.8	2.39 ± 0.83	0.09	0.42
Nt-ProBNP	2918.4 ± 5965.4	2763.5 ± 2615.1	2971.66 ± 4106.0	3479.0 ± 8396.4	0.9	0.34
Cardiac amyloidosis, n (%)	0 (0%)	1 (1.9%)	0 (0%)	1 (0.5%)	0.19	-
Atrial Fibrillation/Flutter/Atrial tachycardia, n (%)	32 (34.8%)	15 (28.3%)	21 (32.8%)	68 (32.5%)	0.43	0.8
Surgical AVR, n (%)	3 (3.3%)	0 (0%)	1 (1.6%)	4 (1.9%)	0.19	0.51
TAVI, n (%)	1 (1.1%)	0 (0%)	0 (0%)	1 (0.5%)	0.45	0.4
Stroke, n (%)						
Ischemic stroke	9 (9.8%)	9 (17.0%)	10 (15.6%)	28 (13.4%)	0.21	0.28
Intracranial Bleeding	1 (1.1%)	1 (1.9%)	1 (1.6%)	3 (1.4%)	0,69	0.8
Extra cardiovascular comorbidities, n (%)						
Renal disease	39 (42.4%)	24 (45.3%)	33 (51.6%)	96 (45.9%)	0.74	0.26
Cockcroft	53.93 ± 25.1	55.95 ± 22.1	51.08 ± 23.1	53.59 ± 23.7	0.63	0.48
Liver disease	3 (3.3%)	2 (3.8%)	4 (6.3%)	9 (4.3%)	0.87	0.38
Lung Disease	11 (12.0%)	14 (26.4%)	9 (14.1%)	34 (16.3%)	0.03	0.7
Inflammatory Disease	5 (5.4%)	3 (5.7%)	5 (7.8%)	13 (6.2%)	0.95	0.55
Cancer within preceding 5 years	10 (10.9%)	2 (3.8%)	5 (7.8%)	17 (8.1%)	0.14	0.53
Anaemia	46 (50%)	23 (43.4%)	25 (39.1%)	94 (44.98%)	0.45	0.18
Thyroid disease	17 (18.5%)	7 (13.2%)	13 (20.3%)	37 (17.70%)	0.41	0.78
Alcohol-related diagnoses	3 (3.3%)	3 (5.7%)	2 (3.1%)	8 (3.83%)	0.49	0.96
Treatments, n (%)						
Amiodarone	16 (17.4%)	8 (15.1%)	9 (14.1%)	33 (15.8%)	0.72	0.58
Beta Blocker	46 (50%)	26 (49.1%)	30 (46.9%)	102 (48.8%)	0.91	0.7
Calcium channel inhibitor	6 (6.5%)	1 (1.9%)	5 (7.8%)	12 (5.7%)	0.21	0.76
Others Anti Arrhythmic	6 (6.5%)	2 (3.8%)	6 (9.4%)	14 (6.7%)	0.49	0.51
ASA	51 (55.4%)	29 (54.7%)	32 (50%)	112 (53.6%)	0.93	0.51
Clopidogrel	20 (21.7%)	15 (28.3%)	15 (23.4%)	50 (23.9%)	0.38	0.8
Ticagrelor	3 (3.3%)	0 (0%)	3 (4.7%)	6 (2.9%)	0.19	0.65
Vitamin K antagonist	12 (13.0%)	3 (5.7%)	8 (12.5%)	23 (11.0%)	0.16	0.92
NOAC	25 (27.2%)	12 (22.6%)	11 (17.2%)	48 (23.0%)	0.55	0.15
Euroscore II	5.03 ± 4.5	3.98 ± 4.2	3.61 ± 2.1	4.30 ± 3.8	0.34	0.11
STS Score	4.59 ± 2.3	3.19 ± 2.0	4.75 ± 3.6	4.08 ± 2.7	0.1	0.89
PCI before TAVI, n (%)	28 (30.4%)	12 (22.6%)	16 (25.0%)	56 (26.8%)	0.32	0.46

EPS: Electrophysiological study, PPM: Permanent pacemaker, STEMI: ST elevation with myocardial infarction, NYHA: New-York Heart Association, AVR: Aortic valve replacement, TAVI: Trans aortic valve replacement, ASA: Acetyl Salicylic Acid, NOAC: Non-vitamin K antagonist oral anticoagulant, STS: Society of thoracic surgeons, PCI: Percutaneous intervention.

Table 2- Baseline valvular characteristics of patients

Variables	EPS leading to discharge n= 92	EPS leading to PPM implantation n= 53	PPM without EPS n= 64	Total N= 209	p Value EPS leading to PPM implantation vs. EPS leading to discharge	p Value PPM without EPS vs. EPS leading to discharge
Type of valulopathy, n (%)						
Aortic Stenosis	92 (100%)	53 (100%)	64 (100%)	209 (100%)	-	-
Aortic Insufficiency	27 (29.3%)	18 (34.0%)	22 (34.4%)	67 (32.1%)	0.57	0.51
Aortic disease	27 (29.3%)	19 (35.8%)	23 (35.9%)	69 (33.0%)	0.42	0.39
Type of valve, n (%)						
Calcification	85 (92.4%)	51 (96.2%)	63 (98.4%)	199 (95.2%)	0.36	0.09
Bicuspid	3 (3.3%)	2 (3.8%)	1 (1.6%)	6 (2.9%)	0.87	0.51
Bioprothesis degeneracies	4 (4.3%)	0 (0%)	1 (1.6%)	5 (2.4%)	0.13	0.33
Echography parameters						
Thickness, mm	13.80 ± 2.9	13.52 ± 3.2	13.13 ± 2.9	13.50 ± 3.0	0.67	0.26
Maximal velocity, m/s	4.25 ± 0.7	4.35 ± 0.8	4.32 ± 0.5	4.30 ± 0.7	0.48	0.5
Mean Gradient, mmHg	49.15 ± 11.2	51.15 ± 17.4	48.98 ± 12.8	49.61 ± 13.4	0.41	0.93
Index valve area, cm/m2	0.45± 0.1	0.44 ± 0.1	0.47 ± 0.2	0.45 ± 0.2	0.76	0.51
Grade of insufficiency	1.17 ± 0.8	1.22 ± 0.9	1.19 ± 1.0	1.19 ± 0.9	0.79	0.93
LVEF, %	60.34 ±9.8	57.76 ± 12.0	58.70 ± 9.9	59.2± 10.4	0.17	0.33
Atrial Index Volume, ml/m2	48.19 ± 18.6	44.64 ± 15.3	46.53 ± 15.6	46.70 ± 16.7	0.39	0.66
Mitral Insufficiency	1.12 ± 0.7	0.93 ± 0.8	1.21 ± 0.7	1.10 ± 0.8	0.19	0.49
Mean A-V Gradient, mmHg	3.56 ± 1.3	3.08 ± 1.7	5.63 ± 2.9	3.86 ± 2.0	0.4	0.02
Tricuspid Insufficiency	0.92 ± 0.6	2.25 ± 8.0	0.86 ± 0.6	1.24 ± 4.1	0.25	0.65
Good Right ventricular	75 (81.5%)	45 (84.9%)	55 (85.9%)	175 (83.7%)	0.05	0.06
Function n (%)						
PASP, mmHg	38.82 ± 15.1	35.52 ± 13.8	39.85 ± 14.6	38.37 ± 14.6	0.33	0.74
Type of Valve						
Acurate Neo®, n (%)	2 (2.2%)	0 (0%)	1 (1.6%)	3 (1.4%)	0.28	0.79
Edwards Sapiens 3®, n (%)	28 (30.4%)	17 (32.1%)	23 (35.9%)	68 (32.5%)	0.84	0.47
Size	25.36 ± 1.9	26.88 ± 2.3	26.65 ± 2.2	26.18 ± 2.2	0.02	0.03
Sapiens XT®, n (%)	0 (0%)	1 (1.9%)	0 (0%)	1 (0.5%)	0.19	-
Evolut R®, n (%)	18 (19.6%)	6 (11.3%)	11 (17.2%)	35 (16.7%)	0.2	0.71
Size	25 ± 6.9	31.83 ± 3.5	29.91 ± 4.2	27.64 ± 6.3	0.03	0.04
Evolut Pro®, n (%)	42 (45.7%)	29 (54.7%)	29 (45.31%)	100 (47.8%)	0.3	0.97
Size	26.84 ± 4.7	27.76 ± 1.5	27.66 ± 1.9	27.34 ± 3.4	0.32	0.38
Valve Pro®, n (%)	2 (2.2%)	0 (0%)	0 (0%)	2 (1.0%)	0.29	0.24
Per op, n (%)						
Pre-Valve expansion	11 (12.0%)	9 (17.0%)	8 (12.5%)	28 (13.4%)	0.4	0.92
Post-Valve expansion	16 (17.4%)	10 (18.9%)	11 (17.2%)	37 (17.7%)	0.82	0.97
Post TAVI						
Mean gradient, mmHG	10.58 ± 5.4	9.43 ± 4.8	10.78 ± 9.1	10.35 ± 6.6	0.21	0.87
Leak, mean grade (0 to 4)	0.90 ± 0.8	0.96 ± 0.8	0.97 ± 0.8	0.94 ± 0.8	0.66	0.61
Pericardial Effusion, n (%)	4 (4.3%)	3 (5.7%)	4 (6.3%)	11 (5.3%)	0.72	0.6
Hospitalization length, Days	7.65 ± 4.0	7.72 ± 2.5	7.03 ± 3.8	7.48 ± 3.6	0.92	0.33

EPS: electrophysiological study, PPM: Permanent pacemaker, LVEF: Left ventricular ejection function, A-V: Atrio-Ventricular, PASP: Pulmonary artery systolic pressure.

Table 3- Baseline ECG characteristics of patients

Variables	EPS leading to discharge n= 92	EPS leading to PPM implantation n= 53	PPM without EPS n= 64	Total N= 209	p Value EPS leading to PPM implantation vs. EPS leading to discharge	p Value PPM without EPS vs. EPS leading to discharge
ECG Parameters						
Frequency, bpm	70.7 ± 15.3	70.6 ± 13.3	69.0 ± 13.4	70.1 ± 14.2	0.97	0.48
SR	77 (83.7%)	48 (90.6%)	56 (87.5%)	181 (86.6%)	0.25	0.51
AF	15(16.3%)	5 (9.4%)	7 (10.9%)	27 (12.9%)	0.25	0.35
PR, ms	185.57 ± 38.3	195.15 ± 42.9	208.64 ± 49.7	195.3 ± 41.1	0.2	0.003
QRS, ms	103.57 ± 21.6	106,26 ± 24.2	118.49 ± 28.9	108.67 ± 25.4	0.44	0.0003
QRS <120ms	74 (80.4%)	43 (81.1%)	35 (54.7%)	152 (72.7%)	0.92	0.0005
QT, ms	453.09 ± 35.4	447.92 ± 26.2	458.16 ± 36.4	453.34 ± 33.7	0.36	0.39
AVB1, n (%)	27 (29.3%)	21 (39.6%)	29 (45.3%)	77 (36.8%)	0.21	0.04
RBBB, n (%)	4 (4.4%)	0 (0%)	9 (14.1%)	13 (6.2%)	0.12	0.03
RBBB+LPFB, n (%)	0 (0%)	0 (0%)	1 (1.6%)	1 (0.5%)	-	0.23
RBBB+LAFB, n (%)	3 (3.3%)	2 (3.8%)	12 (18.8%)	17 (8.1%)	0.87	0.001
LAF, n (%)	15 (16.3%)	11 (20.8%)	9 (14.1%)	35 (16.7%)	0.5	0.7
LPF, n (%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-	-
LBBB, n (%)	8 (8.7%)	5 (9.4%)	5 (7.8%)	18 (8.6%)	0.88	0.85
SND, n (%)	0 (0%)	1 (1.9%)	0 (0%)	1 (0.5%)	0.19	-

ECG: Electrocardiogram/electrocardiographic, EPS: Electrophysiological study, PPM: Permanent pacemaker, SR: Sinus rate, AF : Atrial fibrillation, AVB: Atrioventricular block, RBBB: Right bundle branch block, LPFB: Left posterior fascicular block, LAFB: Left anterior fascicular block, LBBBB: left bundle branch block, SND: Sinus node dysfunction.

Table 4- CD apparition among patients with EPS

Variables	EPS leading to discharge n= 92	EPS leading to PPM implantation n= 53	p Value EPS leading to PPM implantation vs. EPS leading to discharge
ECG - The first day			
Frequency, bpm	66.7 ± 16.6	68.4 ± 18.4	0.58
SR, n (%)	78 (84.8%)	48 (90.6%)	0.32
AF, n (%)	14 (15.2%)	5 (9.4%)	0.32
Ventricular Pacing, n (%)	2 (2.2%)	1 (1.9%)	0.91
PR, ms	196.68 ± 40.2	211.78 ± 50.1	0.07
QRS, ms	136.3 ± 26.5	144.27 ± 22.6	0.07
QRS <120ms, n (%)	25 (27.2%)	9 (17.0%)	0.17
QT, ms	490.07 ± 45.1	499.06 ± 38.3	0.23
CD Apparition			
AVB 1, n (%)	53 (57.6%)	42 (79.2%)	0.01
Delay, Day	0.70 ± 1.1	0.83 ± 1.4	0.6
PR enlargement, n (%)	49 (53.3%)	36 (67.9%)	0.09
PR max, ms	227.42 ± 51.4	274.5 ± 67.8	<0.0001
QRS enlargement, n (%)	31 (33.7%)	23 (43.4%)	0.25
QRS max, ms	146.10 ± 24.3	160.87 ± 21.5	0.0003
RBBB, n (%)	7 (7.6%)	2 (3.8%)	0.36
Delay, Day	0.43 ± 0.8	6	-
RBBB+LAFB, n (%)	4 (4.3%)	4 (7.5%)	0.42
Delay, Day	0 ± 0	1 ± 1.4	0.21
LAFB, n (%)	9 (9.8%)	3 (5.7%)	0.39
Delay, Day	0.11 ± 0.3	0 ± 0	0.59
LBBB, n (%)	67 (73.6%)	50 (94.2%)	0.002
Delay, Day	0.46 ± 1.2	0.35 ± 0.9	0.57
AVB 2/1, n (%)	2 (2.2%)	1 (1.9%)	0.91
Delay, Day	1.5 ± 0.7	1	-
AVB 2 Mobitz 1, n (%)	6 (6.5%)	2 (3.8%)	0.49
Delay, Day	1.83 ± 1.2	3 ± 1.4	0.28
AVB 2 Mobitz 2, n (%)	1 (1.1%)	2 (3.8%)	0.28
Delay, Day	4	2 ± 1.4	-
HAVB, n (%)	4 (4.3%)	5 (9.4%)	0.22
Delay, Day	1.25 ± 1.9	1.8 ± 1.3	0.62
AVB 3, n (%)	3 (3.3%)	2 (3.8%)	0.87
Delay, Day	0.33 ± 0.6	1 ± 1.4	0.5
SND, n (%)	1 (1.1%)	5 (9.4%)	0.01
Delay, Day	1	0.2 ± 0.4	-
Rhythm temporary support			
Temporary pacemaker, n (%)	11 (12.0%)	5 (9.4%)	0.64
TPM delay, Day	0 ± 0	1.6 ± 2.6	0.05
TPM Length, Day	2.73 ± 1.5	3.2 ± 1.9	0.6
Complications, n (%)	0 (0%)	0 (0%)	-
Rhythm Disorder, n (%)			
AIJR	2 (2.2%)	2 (3.8%)	0.57
AF	23 (25%)	7 (13.1%)	0.09
Other SVT	3 (3.3%)	3 (5.7%)	0.49
VT	3 (3.3%)	2 (3.8%)	0.87

CD: Conduction disease, EPS: Electrophysiological study, PPM: Permanent pacemaker, ECG: Electrocardiogram/electrocardiographic, SR: Sinus rhythm, AF: Atrial fibrillation, AVB: Atrioventricular Block, RBBB: Right Bundle Branch Block, LPF: Left posterior Fascicular, LAFB: Left anterior fascicular block, LBBBB: left Bundle Branch Block, HAVB: Hight atrioventricular block, SND: Sinus Node Dysfunction, TPM: Temporary pacemaker, AIJR: Accelerated idio-junctionnal rhythm, SVT: Supraventricular tachycardia, VT: Ventricular tachycardia.

Table 5 - CD regression among patients with EPS

Variables	EPS leading to discharge	EPS leading to PPM implantation	p Value EPS leading to PPM implantation vs. EPS leading to discharge
CD regression (among patients with CD appearance)			
AVB 1, n (%)	8 (15.1%)	2 (4.7%)	0.26
Delay, Day	2.44 ± 1.9	4 ± 4.2	0.4
RBBB, n (%)	2 (28.6%)	1 (50%)	0.91
Delay, Day	2 ± 1.1	7	-
LAFB, n (%)	1 (11.1%)	2 (66.7%)	0.28
Delay, Day	2	4 ± 0	-
LBBB n (%)	11 (16.4%)	5 (10%)	0.64
Delay, Day	2.45 ± 1.7	1.4 ± 0.9	0.23
AVB 2/1, n (%)	1 (50%)	1 (100%)	0.69
Delay, Day	2	1	-
AVB 2 M1, n (%)	3 (50%)	1 (50%)	0.62
Delay, Day	2.67 ± 2.3	3	-
AVB 2 M2, n (%)	1 (100%)	2 (100%)	0.28
Delay, Day	5	2 ± 1.4	-
HAVB, n (%)	4 (100%)	4 (80%)	0.42
Delay, Day	1.75 ±2.2	1.4 ± 1.1	0.77
AVB 3, n (%)	3 (100%)	2 (100%)	0.87
Delay, Day	0.67 ± 0.6	1 ± 1	0.64
SND, n (%)	1 (100%)	2 (40%)	0.28
Delay, Day	2	0.5 ± 0.7	-
TPM removal, n (%)	9 (81.8%)	1 (20%)	0.07
Delay TPM removal, Day	1.56 ± 1.4	0	-

CD: Conduction disease, EPS: Electrophysiological study, PPM: Permanent pacemaker, AVB: Atrioventricular Block, RBBB: Right Bundle Branch Block, LAFB: Left Anterior Fascicular block, LBBBB: left Bundle Branch Block, HAVB: High atrioventricular block, SND: Sinus Node Dysfunction, TPM: Temporary pacemaker.

Table 6- EPS Characteristics

Variables	EPS leading to discharge n= 92	EPS leading to PPM implantation n= 53	p Value EPS leading to PPM implantation vs. EPS leading to discharge
EPS			
Delay, Day	4.60 ± 1.7	4.47 ± 1.4	0.64
AH interval, ms	143.08 ± 53.1	164.43 ± 51.8	0.03
HV, ms	60.67 ± 8.2	84.17 ± 14.8	<0.0001
His width, ms	25.21 ± 5.0	31.40 ± 10.8	<0.0001
Intra or infra hisian block, n (%)	0 (0%)	6 (11.3%)	0.001
His amplitude, mV	0.096 ± 0.06	0.077 ± 0.04	0.04
ARP, ms	348.27 ± 99.8	367.5 ± 86.3	0.39
RRP, ms	359.22 ± 102.6	385.71 ± 87.3	0.25
AWP, bpm	146.30 ± 30.2	131.27 ± 26.1	0.01

EPS: Electrophysiological study, PPM: Permanent pacemaker, AH: Atrial- His interval, HV: His-Ventricular interval, ARP: Absolut refractory period, RRP: Relative refractory period, AWP: Anterograde Wenckebach point.

Table 7- PPM Characteristics

Variables	EPS leading to PPM implantation n= 53	PPM without EPS n= 64	p Value EPS leading to PPM implantation vs. PPM without EPS
PPM implantation			
Delay, Day	4.8 ± 1.5	3.3 ± 1.8	<0.0001
Medtronic®, n (%)	17 (32.1%)	16 (25.0%)	0.4
Boston®, n (%)	5 (9.4%)	10 (15.6%)	0.32
Sorin®, n (%)	10 (18.9%)	14 (21.9%)	0.69
SJM®, n (%)	11 (20.8%)	12 (18.8%)	0.79
Biotronik®, n (%)	10 (18.9%)	12 (18.8%)	0.95
Single Chamber, n (%)	8 (15.1%)	14 (21.9%)	0.35
Dual Chamber, n (%)	40 (75.5%)	49 (76.6%)	0.9
CRT, n (%)	0 (0%)	2 (3.1%)	0.2
Leadless, n (%)	5 (9.4%)	0 (0%)	0.01
Still with temporary pacemaker, n (%)	4 (7.5%)	35 (54.7%)	<0.0001
Pneumothorax, n (%)	2 (3.8%)	0 (0%)	0.12
Lead displacement, n (%)	0 (0 %)	3 (4.7%)	0.11
Hematoma, n (%)	3 (5.7%)	0 (0%)	0.05
Pericardial effusion, n (%)	0 (0%)	0 (0%)	-

PPM: Permanent pacemaker, EPS: Electrophysiological study, CRT: cardiac resynchronization therapy.

Table 8- Outcomes during follow-up of EPS leading to discharge and EPS leading to PPM implantation

Variables	EPS leading to discharge *n=92*	EPS leading to PPM implantation n= 53	PPM without EPS n= 64	p value EPS leading to PPM implantation vs. EPS leading to discharge	P value PPM without EPS vs. EPS leading to discharge	P value PPM without EPS vs. EPS leading to PPM implantation
Death, n (%)	10 (10.9%)	7 (13.2%)	14 (21.9%)	0.68	0.06	0.23
Hospitalization for heart failure, n (%)	5 (5.4%)	8 (15.1%)	15 (23.4%)	0.05	0.001	0.26
LVEF, %	60.2 ± 10.3	57.5 ± 9.4	55.6 ± 9.7	0.13	0.01	0.29
Ischemic stroke, n (%)	2 (2.2%)	0 (0%)	3 (4.7%)	0.28	0.38	0.11
PPM upgrading, n (%)	-	1 (1.9%)	1 (1.6%)	-	-	0.9

EPS: Electrophysiological study, PPM: Permanent pacemaker, LVEF: Left ventricular ejection fraction.

Table 9 - Cox regression analysis for PPM implantation at baseline and during follow-up

	Univariate analysis		Multivariable analysis	
Covariate	**HR (95% CI)**	**P-Value**	**HR (95% CI)**	**P-Value**
Pneumological Disease	1.565 (0.876-2.799)	0.131	1.287 (0.610-2.716)	0.508
Good Right ventricular Function	0.878 (0.475-1.625)	0.680	1.118 (0.501-2.496)	0.785
Calcification	1.147 (0.362-3.636)	0.816	1.203 (0.334-4.328)	0.777
Acurate Neo®	2.369 (0.325-17.257)	0.395	3.864 (0.473-31.563)	0.207
Edwards Sapiens 3®	0.852 (0.531-1.367)	0.507	0.793 (0.450-01.397)	0.421
Sapiens XT®	0.936 (0.130-6.747)	0.948	14.410 (1.442-144.043)	0.023
Evolut R®	1.248 (0.672-2.314)	0.485	1.023 (0.474-0.208)	0.954
Preoperative QRS < 120ms	0.458 (0.284-0.739)	0.001	0.565 (0.229-1.394)	0.215
Preoperative AVB1	0.966 (0.619-1.505)	0.877	0.725 (0.414-1.268)	0.259
Preoperative RBBB	2.461 (1.062-5.702)	0.036	0.389 (0.113-1.336)	0.134
Preoperative RBBB + LAFB	2.522 (1.286-4.947)	0.007	0.677 (0.224-2.040)	0.488
AVB1 apparition	0.711 (0.459-1.103)	0.128	0.705 (0.404-1.230)	0.218
LBBB apparition	0.348 (0.219-0.552)	<0.0001	0.346 (0.162-0.740)	0.006
SND apparition	-	-	1.487 (0.501-4.411)	0.475
HV >70ms	11.899 (5.199-27.231)	<0.0001	13.704 (4.773-39.522)	<0.001
His witdth	3.876 (2.144-7.009)	<0.0001	1.110 (0.486-2.534)	0.805
Intra or Infra Hisian block			2.530 (0.581-11.019)	0.216
His amplitude	2.055 (1.233-3.423)	0.006	1.679 (0.816-3.458)	0.159
AWP	0.801 (0.463-1.386)	0.429	1.314 (0.622-2.777)	0.474

PPM: Permanent pacemaker, EPS: Electrophysiological study, HR: Hazard ratio, AVB: Atrioventricular Block, RBBB: Right Bundle Branch Block, LAFB: Left Anterior Fascicular block, LBBBB: left Bundle Branch Block, SND: Sinus Node Dysfunction, HV: His ventricular period, AWP: Anterograde Wenckebach point.

Table 10 - Paced QRS on ECG and ventricular pacing on ECG at follow-up of EPS leading to PPM implantation and PPM without EPS:

	EPS leading to PPM implantation *n=53*	PPM without EPS n=64	p value
Paced QRS on ECG, n (%)	*11 (21%)*	38 (59%)	<0.0001

	EPS leading to PPM implantation *n=23*	PPM without EPS n=18	p value
Ventricular pacing, n (%)	*14.9 ± 26.0%*	65.9 ± 43.2%	<0.0001

PPM: Permanent pacemaker, EPS: Electrophysiological study,

Table 11 - Cox regression analysis for ventricular pacing on ECG at follow-up

	Univariate analysis		Multivariable analysis	
Covariate	**HR (95% CI)**	**P-Value**	**HR (95% CI)**	**P-Value**
Pneumological Disease	0.546 (0.212-1.407)	0.211	1.293 (0.421-3.972)	0.654
Good Right ventricular Function	2.058 (0.729-5.809)	0.173	1.661 (0.474-5.821)	0.428
Calcification	1.714 (0.229-12.830)	0.599	0.703 (0.060-8.201)	0.779
Acurate Neo®	3.630 (0.482-27.312)	0.210	1.596 (0.168-15.164)	0.684
Edwards Sapiens 3®	1.060 (0.563-1.997)	0.856	1.355 (0.530-3.461)	0.526
Evolut R®	1.398 (0.606-3.222)	0.432	1.314 (0.407-4.241)	0.648
Preoperative QRS < 120ms	0.542 (0.292-1.006)	0.052	1.299 (0.377-4.476)	0.678
PreoperativeAVB1	1.241 (0.658-2.344)	0.504	2.071 (0.731-5.863)	0.170
Preoperative RBBB	2.800 (1.074-7.298)	0.035	3.000 (0.665-13.526)	0.153
Preoperative RBBB + LAFB	1.809 (0.753-4.347)	0.185	2.168 (0.489-9.623)	0.309
AVB1 apparition	0.590 (0.310-1.123)	0.108	0.704 (0.230-2.154)	0.539
LBBB apparition	0.506 (0.272-0.941)	0.031	1.572 (0.418-5.916)	0.503
SND Apparition	0.700 (1.167-2.930)	0.626	0.494 (0.269-9.059)	0.635
HV >70 ms	0.284 (0.067-1.208)	0.088	0.043 (0.002-0.929)	0.045
His witdth	3.094 (0.940-10.183)	0.063	1.677 (0.333-8.445)	0.531
Intra or infra hisian block	0.508 (0.069-3.721)	0.505	0.574 (0.040-8.147)	0.682
His amplitude	3.132 (1.111-8.831)	0.031	1.804 (0.368-8.830)	0.467
HAVB apparition	2.148 (1.118-4.126)	0.022	0.398 (0.043-3.668)	0.416
AVB 3 apparition	3.412 (1.799-6.473)	<0.001	7.096 (0.642-78.467)	0.110
Pause	0.997 (0.351-2.834)	0.996	0.843 (0.186-3.821)	0.825
AVB2 Mobitz2 apparition	0.205 (0.027-1.543)	0.124	-	-
AWP>130 bpm	0.247 (0.075-0.807)	0.021	-	-

ECG: Electrocardiogram/electrocardiographic, HR: Hazard ratio, AVB: Atrioventricular Block, RBBB: Right Bundle Branch Block, LAFB: Left Anterior Fascicular block, LBBBB: left Bundle Branch Block, HV: His ventricular period, HAVB: High atrioventricular block, AWP: Anterograde Wenckebach point.

Table 12- Characteristic of patients with EPS leading to discharge which will have a PPM implantation.

Variables / Patients	1	2	3	4	5	6
Age, years	76	82	78	81	69	79
Gender (male), n (%)	0	1	0	1	0	0
Coronary artery disease	0	1	0	1	0	1
AF/Flutter/Atrial tachy	0	1	1	0	0	1
Renal disease	1	0	0	0	0	0
Euroscore II	7.11	6.94	-	1.22	-	2.71
Type of valulopathy,	AS +AI	AS + AI	AS	AS	AS	AS
Type of valve	Calcification	Calcification	Calcification	Calcification	Calcification	Calcification
Type of Valve	Evolut Pro®	Evolut Pro®	Evolut Pro®	Evolut Pro®	Ed. Sapiens 3®	Evolut Pro®
Size	26	29	29	29	26	26
Pre-Valve expansion	0	0	0	0	0	0
Post-Valve expansion	0	0	0	0	0	0
ECG Parameters	-	LAFB	LAFB	AVB1	-	-
Rythm	SR	SR	AF	SR	SR	SR
PR, ms	163		-	235	158	156
QRS, ms	93		97	108	86	102
QRS <120ms	1	1	1	1	1	1
ECG - the first day	AVB1+LBBB	LBBB	LBBB	AVB1	AVB1+LBBB	LBBB
Rythm	SR	SR	AF	SR	SR	SR
PR the fisrt day	234	-	-	261	225	175
QRS the fisrt day	154	150	141	116	128	156
QRS <120ms	0	0	0	1	0	0
CD Apparition	-	-	-	SND (1)	-	AVB1 (1)
Delay, Day (n)	-	-	-	LBBB (2)	-	-
	-	-	-	AVB2 M1 (3)	-	-
PR enlargement	0	0	0	1	0	1
PR max, ms	234	-	-	261	225	280
QRS enlargement	0	0	0	1	0	0
QRS max, ms	154	-	145	125	133	156

TPM						
TPM delay, Day	0	0	0	0	1	0
TPM Length, Day	-	-	-	-	0	-
Rhythm Disorder,	-	-	-	-	4	-
	0	1	1	0	0	0
CD regression						
Delay, Day	AVB1(1)	-	-	SND (2)	AVB1 (1)	-
TPM removal, n (%)	-	-	-	LBBB (5)	-	-
Delay TPM removal	-	-	-	-	-	-
	-	-	-	-	-	-
EPS						
Delay, Day						
AH, ms	5	4	3	5	3	2
HV, ms	138	118	-	170	66	174
His width, ms	60	58	62	58	56	58
Intra or infra block	24	24	36	28	30	28
His amplitude	0	0	0	0	0	0
ARP, ms	0.034	0.06	0.038	0.181	0.298	0.103
RRP, ms	460	540	-	-	260	570
AWP, bpm	480	560	-	-	280	-
	111	98	-	100	161	98
PPM implantation delay						
Indication	473	438	649	403	161	38
	Syncopa SD	- SD	- ANV Ablation	Syncope Infra hisian block during EPS	Syncopa HAVB	- HAVB
EPS						
	0	0	0	1	-	0

EPS: Electrophysiological study, PPM: Permanent pace maker, AF: Atrial fibrillation , AS: Aortic stenosis, AI: aortic insufficiency, AVB: Atrioventricular block, RBBB: Right bundle branch block, LAFB: Left anterior fascicular block, LBBB: Left bundle branch block, SR: Sinus rhythm, CD: Conduction disease, SND: Sinus Node disease, TPM: Temporary pace maker, AH :Atrial- His interval, HV: His-Ventricular interval, ARP: Absolut refractory period, RRP: Relative refractory period, AWP: Anterograde Wenckebach point, SD: Sinus dysfunction HAVB: High atrioventricular block , AVN : Atrioventricular node

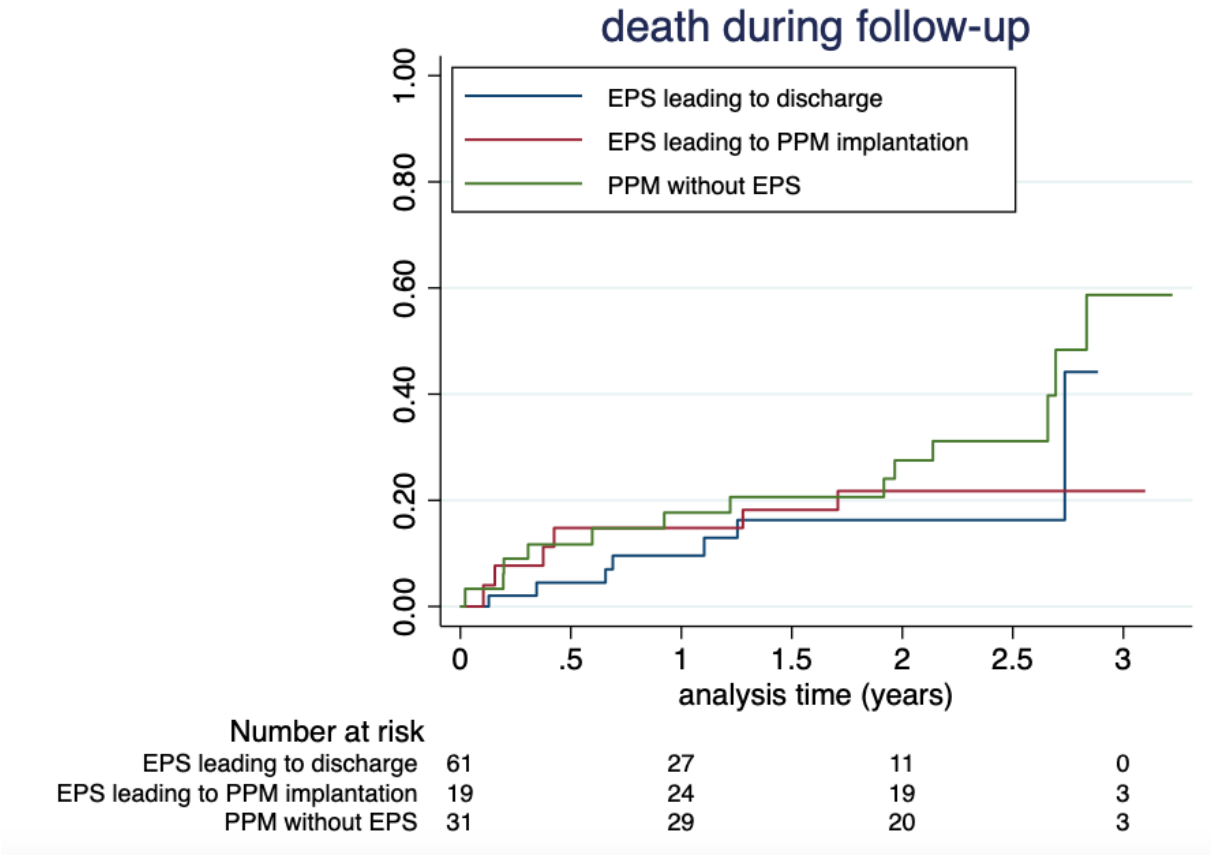

Figure 2 - Kaplan-Meier of event free curves for all-cause death in patients with EPS leading to discharge, EPS leading to PPM implantation and PPM without EPS at baseline.

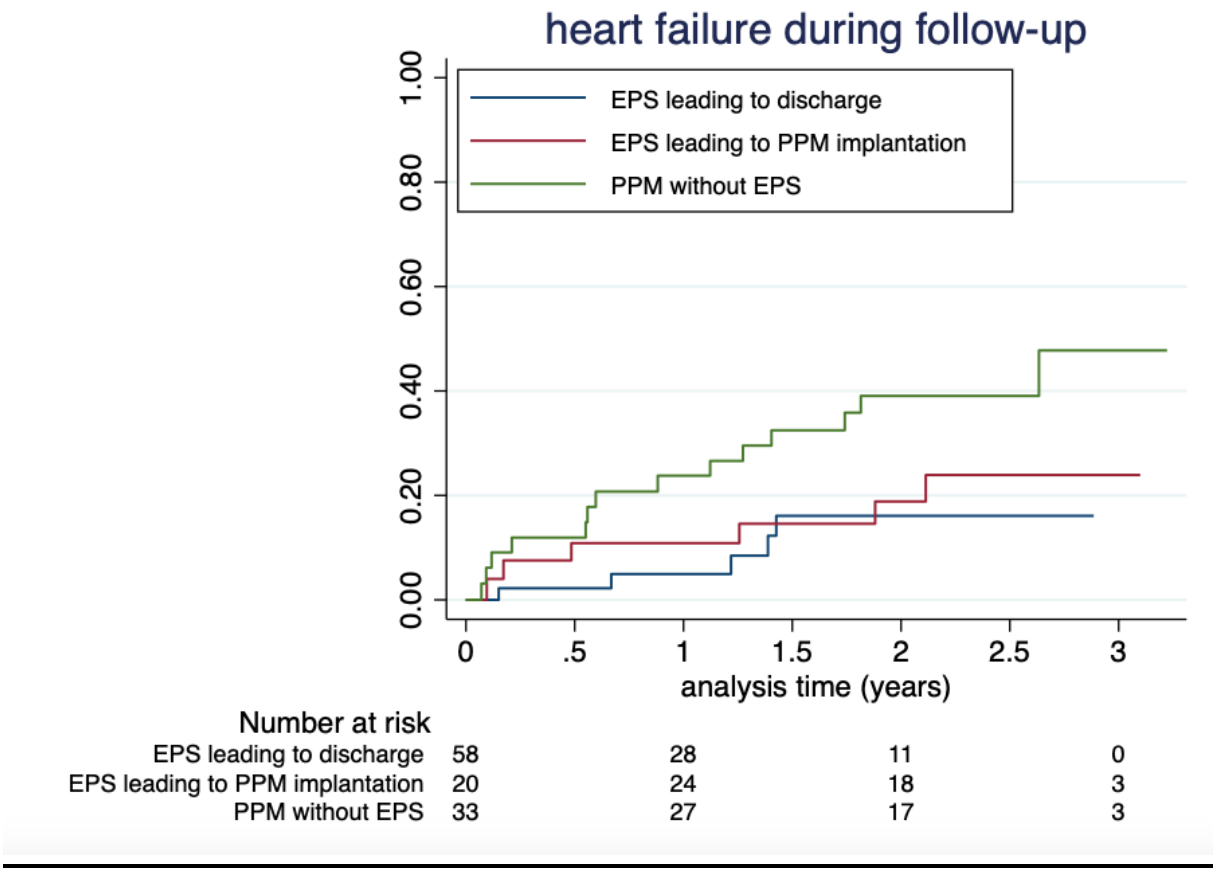

Figure 3 - Kaplan-Meier of event free curves for hospitalization for Heart Failure in patients with EPS leading to discharge, EPS leading to PPM implantation and PPM without EPS at baseline.

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Résumé :

Introduction. Notre objectif est de décrire les facteurs électrocardiographiques (ECG) et electrophysiologiques (EEP) de notre population de patient implanté par voie percutanée aortique (TAVI) afin d'évaluer la stratification du risque basée sur l'EEP.

Méthodes. Cette cohorte rétrospective porte sur les patients implantés d'un TAVI de 2018 à 2019 au CHRU de Tours.

Résultats. Sur 209 patients, 92 ont eu une EEP sans pacemaker (PM), 53 ont eu une EEP suivie d'un PM et 64 ont eu une implantation de PM sans EEP. Le suivi moyen était de 488,2jours. Par rapport aux patients avec une EEP sans PM, les patients implantés sans EEP présentaient un intervalle PR plus long, un QRS plus large et un bloc de branche droit associé à un Hémi bloc antérieure gauche. Dans le groupe des EEP suivi d'un PM par rapport au groupe des EEP sans PM, Il y avait plus de Bloc atrio ventriculaire de type 1, des QRS plus larges, plus de Bloc de branche gauche et plus de dysfonction sinusale. Les patients avec une EEP sans PM avaient un intervalle HV plus court, pas de bloc intra ou d'infra-hissien, un intervalle AH plus court, une largeur de His plus faible, une amplitude de His plus élevée et un point de Wenckebach plus élevé. Les patients implantés sans EEP avaient plus de QRS stimulé par rapport aux patients avec une EEP suivie d'un PM. En analyse multivariée, nous n'avons trouvé aucun prédicteur de stimulation ventriculaire. Les patients atteints implanté d'un stimulateur sans EEP ont été plus nombreux à être hospitalisés pour insuffisance cardiaque et ont une Fraction d'éjection ventriculaire gauche plus faible par rapport aux patients avec une EEP sans PM.

Conclusion. Aucun prédicteur de stimulation n'a été trouvé. Cependant, l'EEP semble être sûr pour stratifier les troubles de la conduction avec un résultat similaire concernant le décès. Nous notons que les patients implantés sans EEP avaient un pronostic plus défavorable concernant l'insuffisance cardiaque et une fraction d'éjection plus faible.

Mots clés : TAVI, Trouble de la conduction, Exploration électrophysiologique Pacemaker.

Jury :

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