Noninvasive pacing study via pacemakers and implantable cardioverter-defibrillators for differentiating right from left atrial flutter

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BACKGROUND Patients with atrial flutter who are implanted with a pacemaker (PM) or implantable cardioverter-defibrillator (ICD) present with the opportunity to perform a noninvasive pacing study (NIPS) using the right atrial pacing lead to differentiate right from left atrial flutter.

OBJECTIVES The purpose of this study was to study the feasibility and accuracy of NIPS to distinguish right from left atrial flutter.

METHODS We enrolled consecutive patients scheduled for an electrophysiological study or ablation procedure who were in atrial flutter and who were implanted with a PM or ICD with a functional atrial lead in the right atrial appendage. Flutter tachycardia cycle lengths (TCLs) and postpacing intervals (PPIs) were measured noninvasively via the device during the procedure.

RESULTS A total of 48 (67%) patients were studied. Right atrial flutter was present in 32 patients (of whom 29 had typical cavotricuspid isthmus-dependent flutter) and 16 (33%) patients had left atrial flutter. A PPI-TCL interval of >100 ms was 100% specific and 81% sensitive to identify left atrial flutter, with an overall accuracy of 94% and a c statistic of 0.94 (95% confidence interval 0.87–1.00). A PPI-TCL interval of ≤ 100 ms had a positive predictive value of 86% for diagnosing typical flutter.

CONCLUSION NIPS via PMs and ICDs with a PPI-TCL interval of >100 ms can reliably identify left atrial flutter (although we have only validated this cutoff for leads implanted in the right atrial appendage). This simple maneuver may allow planning for left-sided access and may avoid an unnecessary invasive electrophysiological study if left atrial flutter ablation is not to be considered.

KEYWORDS Pacemaker; Implantable cardioverter-defibrillator; Atrial flutter; Electrophysiological study; Noninvasive pacing study

ABBREVIATIONS **CS** = coronary sinus; **CTI** = cavotricuspid isthmus; **ECG** = electrocardiogram; **EPS** = electrophysiological study; **ICD** = implantable cardioverter-defibrillator; **NIPS** = noninvasive pacing study; **PM** = pacemaker; **PPI** = postpacing interval; **ROC** = receiver operating characteristic; **TCL** = tachycardia cycle length

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Introduction

Atrial arrhythmias are prevalent in patients with pacemakers (PMs) and implantable cardioverter-defibrillators (ICDs). About 1 in 4 of these patients will have evidence of atrial fibrillation and/or flutter diagnosed by the device. Diagnosis of typical atrial flutter is of particular relevance, as radiofrequency ablation of the cavotricuspid isthmus (CTI) has a high success rate (96% recurrence-free survival at 1 year[1]) with few complications, making it first-line therapy according to current guidelines[2] even in elderly patients. In contrast, atypical flutter may be a complex arrhythmia with a variety of circuits that often include the left atrium and are considerably more challenging to treat by radiofrequency catheter ablation, with lower success and higher complication rates. It is therefore important to distinguish typical CTI-dependent flutter from atypical flutter. Analysis of flutter morphology on the surface electrocardiogram (ECG) is useful, but approximately 15%–20% of CTI-dependent flutter has an atypical morphology, and conversely up to 25% of atypical flutter has a "pseudo-typical" morphology.[3] Definite diagnosis requires an invasive electrophysiological (EP) study with entrainment maneuvers. The presence of a right atrial lead in PMs and ICDs offers the opportunity to perform a noninvasive pacing study (NIPS) with measurement of postpacing intervals (PPIs) and may therefore assist in diagnosis, but this strategy has never been studied before. Our objectives were to evaluate

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the feasibility of NIPS and its accuracy to distinguish right from left atrial flutter.

Methods

Study population

We included consecutive patients referred for an EP study or catheter ablation who were implanted with a PM or ICD with a functioning right atrial lead and who presented with atrial flutter with a regular cycle length (<20-ms variation). Patients were recruited from the University Hospital of Geneva, Geneva, Switzerland, and the Hôpital de la Tour, Meyrin, Switzerland, over a 5-year period (from November 2009 to December 2014). The study was approved by the institutional ethics committee, and all patients gave informed consent.

Invasive EP study

Fasting patients had femoral venous puncture to introduce one or several diagnostic multipolar catheters in the right atrium (and a radiofrequency ablation catheter if ablation was to be undertaken). TCLs were measured on a Bard EP Lab bay (Bard Electrophysiology, Lowell, MA) and a diagnostic catheter was placed in the lateral right atrium. Pacing was performed with bursts 20 ms shorter than the TCL, and PPIs were measured using digital callipers. Entrainment mapping was performed from the CTI, coronary sinus (CS), and other sites according to the requirements of the procedure. Typical CTI-dependent flutter was diagnosed when the PPI-TCL interval at the CTI was ≤40 ms, the activation sequence was compatible with counterclockwise or clockwise flutter, and the arrhythmia was terminated by radiofrequency ablation of the CTI. Atypical atrial flutter was diagnosed in all other instances. The circuit was localized to the left or right atrium by entrainment and activation sequence mapping in the atria and CS. Patients with right atrial flutter had a PPI-TCL interval of <50 ms in the right atrium,[4] with PPIs longer in the CS or left atrium than in the right atrium. Patients with left atrial flutter had PPIs that were shorter in the left atrium or CS than in the right atrium or had a "distal to proximal" or "chevron" atrial activation sequence in the CS.[5]

NIPS

A NIPS was performed via the programmer of the PM or ICD at the beginning of the intervention. All the PMs/ICDs had a dedicated electrophysiological program that allowed burst pacing at a programmable cycle length. In Boston Scientific devices, temporary pacing was used instead, as the electrograms disappear at the end of the burst sequence, making measurement of the PPI impossible. The TCL of the flutter was measured on the programmer screen using digital callipers when available or otherwise manually on the real-time telemetry tracing printed at 50 mm/s. Burst pacing was delivered by the right atrial lead at TCL −20 ms, and acceleration of the atrial cycle confirmed by simultaneous analysis of the diagnostic EP catheter. The PPI was measured using digital callipers on the programmer (if available) or manually on the printed real-time telemetry tracing. The maneuver was repeated a second time to evaluate reproducibility of the measurement, and the mean PPI-TCL value was used for data analysis.

Statistical analysis

The data showed a non-Gaussian distribution according to Shapiro-Wilk and Kolmogorov-Smirnov tests and histogram analysis. Data are expressed as median and interquartile range. Test-retest reproducibility of the measurements was evaluated using the Bland-Altmann method. Correlation between TCLs measured on the EP bay and the PM/ICD was calculated by using Spearman correlation. Differences between groups were evaluated with the Kruskall-Wallis test. Receiver operating characteristic (ROC) analysis was based on nonparametric data distribution. The analyses were performed with SPSS version 22 (IBM Corp, Armonk, NY). A P value of $<.05$ was considered statistically significant.

Results

A total of 48 patients were included (Table 1). Right atrial flutter was diagnosed in 32 (67%) patients (of whom 29 had typical CTI-dependent flutter), and 16 (33%) patients had left atrial flutter. The atrial lead was implanted in the right atrial appendage in all patients.

TCL and PPI measurements

There was an excellent correlation between the measurement of the TCL by the diagnostic catheter/EP bay and the implanted device/programmer ($r = 0.98$; $P < .001$; Figure 1). Right atrial capture by the pacing lead during NIPS was visible on the real-time electrograms in 43 of 49 (88%) patients (Figure 2) and unclear in the remaining patients (but confirmed by the simultaneous analysis of the EP bay). Reproducibility of the repeated PPIs measured by the implanted devices was 5 ± 17 ms.

Right atrial vs left atrial flutter

There were no significant differences in TCL between right atrial flutter and left atrial flutter: 260 ms (232–309 ms) vs 257 ms (229–330 ms), respectively ($P = .97$). The results of NIPS by the implanted device are presented in Figure 3. The PPI-TCL interval was significantly shorter with right atrial flutter than with left atrial flutter: 34 ms (19–56 ms) vs 171 ms (114–236 ms), respectively ($P < .001$). A PPI-TCL interval of >100 ms was observed in 13 patients (27%) and was 100% specific and 81% sensitive to identify left atrial flutter, with an overall accuracy of 94%. Using a cutoff of 50 ms, the specificity was 78%, sensitivity 94%, and accuracy 83%. ROC analysis yielded a c statistic of 0.94 (95% confidence interval 0.87–1.00; $P < .001$; Figure 4).

Typical CTI-dependent flutter vs atypical flutter

There were no significant differences in TCL between typical and atypical flutter measured by the implanted device: 260 ms (230–313 ms) vs 260 ms (234–300 ms) ($P = .90$). All