Incidence of paroxysmal atrial tachycardias in patients treated with cardiac resynchronization therapy and continuously monitored by device diagnostics


1Hôpital Pontchaillou CHU, University of Rennes, Rennes, France; 2Ospedale Di Careggi, University of Florence, Florence, Italy; 3Institut Klinické A Experimentální, Medicíny, Prague, Czech Republic; 4Centre Chirurgical Du Val D’Or, Saint Cloud, France; 5Klinicki Centar Srbiye, Belgrade, Republic of Serbia; 6Nouvelles Cliniques Nantaises, Nantes, France; 7St Peter’s Hospital, Chertsey, Surrey, UK; 8University Medical Center Groningen, Groningen, The Netherlands; 9University Hospital, Aachen, Germany; and 10Medtronic SQDM, Arnhem, The Netherlands

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Aims

Little is known about the incidence of paroxysmal atrial tachycardias (PAT) in patients with heart failure (HF). The availability of cardiac resynchronization therapy (CRT) devices with extended diagnostics for AT enables continuous monitoring of PAT episodes. The aim of the study was to assess the incidence over time of PAT in HF patients treated with CRT.

Methods and results

Consecutive patients in NYHA functional class III or IV despite optimal drug therapy, QRS duration ≥130 ms, left ventricular ejection fraction ≤35%, and left ventricular end-diastolic dimension ≥55 mm were eligible for enrolment. Patients with permanent or persistent atrial fibrillation (AF) were not included in the study. The first follow-up examination was performed 2 weeks after implantation, to optimize atrial sensing and CRT. Subsequent follow-up examinations were carried out 15 and 28 weeks after implantation, to collect the telemetric data. A total of 173 patients (67 ± 11 years, M 116) were enrolled. Complete arrhythmia monitoring data were available from 120 patients over a mean follow-up of 183 ± 23 days. Atrial tachycardia episodes were detected through telemetry in 25 of 120 patients (21%) during at least one follow-up examination. Atrial tachycardia episodes were recorded in 29 and 17% (P = NS) of patients with and without previous history of AF, respectively.

Conclusion

More than 20% of the overall HF patient population treated with CRT suffer PAT episodes. Paroxysmal atrial tachycardia may interfere with response to CRT. Therefore, telemetric data may be relevant to drive the appropriate therapy in each patient.

Keywords

CRT • Heart failure • Paroxysmal atrial tachycardia • Biventricular pacing • Atrial fibrillation • Pacemaker

Introduction

Atrial fibrillation (AF) is the most common sustained arrhythmia in patients with chronic heart failure.1 In congestive heart failure (CHF), AF is a common co-morbidity and either condition may predispose the other. The prevalence of AF increases with more advanced HF to ~40–50% of patients in New York Heart Association (NYHA) functional class IV.2 Overall, 15–30% of patients with HF present with AF, if the permanent, persistent, and paroxysmal forms are pooled.

Little is known about the incidence of paroxysmal atrial tachycardias (PAT) in HF patients. Although persistent and permanent
forms of AF can be objectively diagnosed through a 12-lead electrocardiogram (ECG). PAT (including PAF) is mainly diagnosed through symptoms or occasionally detected by means of ECG during follow-up. Many studies have shown the low reliability of symptoms in monitoring AF and the high prevalence of asymptomatic episodes, which may be as dangerous as symptomatic ones, especially with regard to stroke and the possibility of triggering an acute HF attack. Atrial tachycardia may hamper adequate biventricular pacing in turn interfering with response to cardiac resynchronization therapy (CRT). In addition, standard 24 or 48 h Holter monitoring is of limited utility in detecting paroxysmal forms of the arrhythmias. For all these reasons, it is very difficult to estimate the prevalence and incidence of PAF, both in the general population and in HF patients.

The availability of CRT devices with extended atrial arrhythmia monitoring capabilities enables detailed and continuous monitoring of AF episodes in this population of HF patients. In the Congestive Heart Failure, Arrhythmia Monitoring and Pacing (CHAMP) study, device-based atrial arrhythmia diagnostics was used to monitor PAT in patients treated with CRT. The aim of the study was to assess the incidence over time of PAT in CRT patients.

Methods

Study population

Consecutive patients with severe CHF indicated for CRT were enrolled for this multi-centre prospective study. Since this investigation was aimed at characterizing PAT, patients with permanent atrial tachyarhythmia were excluded; an atrial tachyarrhythmia was defined as permanent if cardioversion was not considered or if the arrhythmia recurred within 24 h after an attempted cardioversion. An AT episode was defined as paroxysmal if it spontaneously terminated within 7 days after the onset, as detected by the implanted device; otherwise, it was defined as persistent. Patients were eligible for enrolment, if they were in NYHA functional class III or IV despite optimal drug therapy, had a QRS duration $\geq 130$ ms, a left ventricular ejection fraction (LVEF) $\leq 35\%$, and a left ventricular end-diastolic dimension (LVEDD) $\geq 55$ mm. These parameters were recorded during baseline assessment within 4 weeks prior to scheduled implantation of the CRT device. Patients with unstable angina, acute myocardial infarction, coronary artery revascularization or angioplasty or cardiovascular accident or transient ischaemic attack with permanent disability within 3 months prior to enrolment were not included in the study. In addition, patients on, or anticipated to require, intravenous inotropic drug therapy, patients with severe primary pulmonary disease, a supine systolic blood pressure $>170$ mmHg, renal insufficiency (serum creatinine level $>250$ $\mu$mol/L) or with untreated hyperthyroidism were excluded from participation. Patients with other implanted devices, including ICDs, were not included in the study.

Cardiac resynchronization therapy device and programming

Enrolled patients received a CRT8000 pacemaker (Vitatron B.V., Arnhem, The Netherlands) capable of delivering atrial-based, bi-ventricular pacing. This device has extended atrial tachyarrhythmia monitoring capabilities, including recording of the number of and duration of AT episodes, the total duration of AT and 12 AT onsets. The AT detection feature was programmed to detect an AT episode, if the atrial rhythm exceeded 200 b.p.m. for at least 10 consecutive ventricular beats. Specific attention was paid to optimizing the atrial sensing and blanking of the device, in order to prevent false AT detections due to atrial oversensing or undersensing. To minimize the probability of far-field R-wave sensing, a bipolar atrial lead with a short tip-to-ring distance (\(\leq 12\) mm) was implanted in the right atrial appendage. Biventricular pacing was delivered simultaneously in the right and left ventricles. Atrioventricular (AV) delay was optimized through echocardiography according to the procedure routinely applied in each hospital. All pacing therapies for AF prevention were set to OFF to avoid any interference with the natural history of AF. Basic rate was programmed at 60 b.p.m. Mode-switching was set to ON, to avoid atrial tracking during PAT.

Study protocol

The first follow-up examination was performed 2 weeks after implantation, to optimize atrial sensing and programming of the AV delay. Subsequent follow-up examinations were carried out 15 and 28 weeks after implantation. During the 15- and 28-week examinations, the devices were interrogated to obtain the arrhythmia monitoring data collected in the period prior to the examination and comprising the primary data of interest. At the baseline and the 15- and 28-week examinations, the QRS duration and NYHA functional class were determined. Furthermore, quality of life was assessed at the baseline and 15 and 28 weeks after implantation by means of the Minnesota Living with Heart Failure questionnaire and the AF Symptom Frequency and Severity checklist.

Ventricular and atrial remodelling was monitored by echocardiographic assessment of LVEF, LVEDD, and left atrial diameter (LAD) in accordance with echo guidelines. Mechanical asynchrony was assessed by means of the interventricular mechanical delay (IVMD) evaluated as the delay between the onset of pulmonary flow and aortic flow. Patients were defined as responders to CRT if their NYHA class improved by at least one level during follow-up, if they were alive at the end of the study and if they had not undergone hospitalization for HF during the study period.

Data analysis

All AT episodes recorded by the implanted devices were reviewed by two independent reviewers to assess the validity of the device-based data. In the event of any disagreement between the reviewers, a third independent reviewer made a final decision.

Owing to the explorative nature of this study, the data collected were evaluated in terms of descriptive statistics. For patients with device-detected AT recurrences, mean $\pm$ SD values were determined for total AT burden. QRS duration, LVEF, LVEDD, LAD, and IVMD were expressed as mean $\pm$ SD for all patients. Duration of PAT episodes was collected through telemetry at each follow-up examination: patients were classified as AT-free, if no episodes were stored in the memory of the device. If AT episodes were detected, these episodes were classified as short runs of PAT if their duration was shorter than 7 min, since the device automatically provides this classification. Episodes were defined as persistent if they lasted more than 7 days.

Two-tailed statistical comparisons of proportions of patients were performed by means of normal approximation (z-test) with 95% confidence. A $P$-value $< 0.05$ was regarded as significant.

Results

Patient population

A total of 173 patients were included in this study. Baseline characteristics and medications of these patients are provided in Table 1.
After enrolment, one patient presented with persistent AF at the baseline. Implantation of the left ventricular lead failed in 11 patients. Eleven other patients dropped out of the study owing to inappropriate delivery of bi-ventricular pacing due to left ventricular lead dislodgement (10 patients) and left ventricular pacing threshold elevation (one patient). Devices were explanted from three patients owing to infections, and three patients were lost to follow-up. In summary, a total of 29 patients (17%) dropped out of the study.

Of the 144 patients successfully implanted and with stable biventricular pacing during follow-up, nine patients (6%) died of HF deterioration.

In 15 of the remaining 135 patients, complete arrhythmia monitoring data over the entire study period were not available, owing to inappropriate programming or failure to save the device interrogation data. As a result, complete arrhythmia monitoring data from 120 patients were available. The baseline data of this subgroup are also shown in Table 1. The mean follow-up duration of the 120 patients with complete data was 183.5 ± 22.8 days.

**Device-detected atrial tachycardia**

Over the entire follow-up period, PAT was detected by the device in 25 of the 120 patients (21%) with complete arrhythmia monitoring data. On average, the number of AT episodes was 83 ± 273 in this group. At device interrogation, five patients (4%) presented with device-detected AT at both the 15- and 28-week follow-up examinations: four of these patients had a history of AF prior to enrolment.

Paroxysmal atrial tachycardia episodes were recorded in 29 and 17% (P = 0.14, NS) of patients with and without a previous history of AF, respectively (Table 2).

Atrial tachycardia episodes lasted more than 7 min in 19 of the 25 patients (76%) who had at least one arrhythmic event. The six patients (24%) with only short-lasting AT episodes (<7 min) also had few episodes: 3 ± 4 episodes, range: 1–11. Three patients had episodes lasting more than 7 days (12 episodes). In the same three patients, AT burden was >70%, showing a trend toward permanent AF.

Atrial tachycardia burden was 5 ± 71% (median: 0.11%; range: 0–90%) in the general population over the entire study period and was 16 ± 30% (median: 0.55%; range: 0–90%) in the subgroup of 25 patients who had AT episodes during the study period.

**Atrial and ventricular pacing**

The percentage of ventricular pacing was stable during the study period in the overall patient population: 97 ± 5% at the 15-week and 97 ± 7% at the 28-week follow-up examinations (P = NS). Atrioventricular synchrony, as detected by the implanted device, was 96 ± 14 and 95 ± 15%, respectively (P = NS). The percentage of atrial pacing was also fairly constant during the study: 30 ± 32% at the 15-week follow-up examination in the overall patient population and 34 ± 32% at the 28-week examination (P = NS).

In the subgroup of patients with AT episodes, the percentage of ventricular pacing was 96 ± 5% at the 15-week examination and 92 ± 14% at the 28-week examination (P = NS). A flat trend was observed in the subgroup of patients without detected AT episodes, the percentage of ventricular pacing being 97 ± 5% at both the 15-week and 28-week follow-up examinations (P = NS).

**Responders to cardiac resynchronization therapy**

In comparison with their baseline status, 105 (73%) of the 144 successfully implanted patients responded to CRT, in that their NYHA functional class improved by at least one level, they were alive at the end of the study and had not undergone any hospitalization. Nine patients (6%) died of HF deterioration during the study period and 135 completed the study.

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**Table 1** Baseline characteristics and medications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>All patients (n = 173)</th>
<th>Patients with complete device data (n = 120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>67.3 ± 11.0</td>
<td>69.7 ± 11.0</td>
</tr>
<tr>
<td>Male</td>
<td>116 (67%)</td>
<td>80 (67%)</td>
</tr>
<tr>
<td>NYHA III/IV</td>
<td>157/15</td>
<td>114/6</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>24.6 ± 6.1</td>
<td>24.9 ± 5.8</td>
</tr>
<tr>
<td>Ischaemic cardiopathy</td>
<td>48 (28%)</td>
<td>33 (28%)</td>
</tr>
<tr>
<td>QRS duration (ms)</td>
<td>170 ± 24</td>
<td>171 ± 23</td>
</tr>
<tr>
<td>Previous history of AF</td>
<td>51 (29%)</td>
<td>38 (32%)</td>
</tr>
<tr>
<td>LVEDD (mm)</td>
<td>71.9 ± 10.3</td>
<td>71.7 ± 9.4</td>
</tr>
<tr>
<td>LAD (mm)</td>
<td>46.6 ± 8.6</td>
<td>45.5 ± 8.8</td>
</tr>
<tr>
<td>IVMD (ms)</td>
<td>51 ± 34</td>
<td>51 ± 33</td>
</tr>
<tr>
<td>ACE-inhibitors</td>
<td>156 (90%)</td>
<td>108 (90%)</td>
</tr>
<tr>
<td>Beta-blockers</td>
<td>115 (66%)</td>
<td>84 (70%)</td>
</tr>
<tr>
<td>Amiodarone</td>
<td>63 (36%)</td>
<td>40 (33%)</td>
</tr>
<tr>
<td>Digoxin</td>
<td>42 (24%)</td>
<td>30 (25%)</td>
</tr>
<tr>
<td>Diuretics</td>
<td>164 (95%)</td>
<td>114 (95%)</td>
</tr>
</tbody>
</table>

**Table 2** Patients with device-detected atrial tachycardia during follow-up

<table>
<thead>
<tr>
<th>Follow-up</th>
<th>All patients (n = 120)</th>
<th>Previous AF history, n = 38 (32%)</th>
<th>No previous AF history, n = 82 (68%)</th>
<th>P-value (with vs. without previous AF history)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 weeks</td>
<td>13 (11%)</td>
<td>6 (16%)</td>
<td>7 (9%)</td>
<td>0.23</td>
</tr>
<tr>
<td>28 weeks</td>
<td>17 (14%)</td>
<td>9 (24%)</td>
<td>8 (10%)</td>
<td>0.04</td>
</tr>
<tr>
<td>Any</td>
<td>25 (21%)</td>
<td>11 (29%)</td>
<td>14 (17%)</td>
<td>0.14</td>
</tr>
</tbody>
</table>
Table 3 Data on QoL as assessed through the Minnesota Living with Heart Failure Questionnaire and Symptom Checklist

<table>
<thead>
<tr>
<th>Symptom checklist (frequency)</th>
<th>All patients (135)</th>
<th>Patients with history of AF</th>
<th>Patients without history of AF</th>
<th>Patients with detected AT</th>
<th>Patients without detected AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QoL score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All patients (135)</td>
<td>43 ± 19</td>
<td>44 ± 18</td>
<td>43 ± 20</td>
<td>33 ± 17</td>
<td>43 ± 20</td>
</tr>
<tr>
<td>Patients with history of AF</td>
<td>21 ± 9</td>
<td>21 ± 9</td>
<td>21 ± 10</td>
<td>20 ± 8</td>
<td>20 ± 10</td>
</tr>
<tr>
<td>Patients without history of AF</td>
<td>17 ± 8</td>
<td>16 ± 5</td>
<td>17 ± 8</td>
<td>16 ± 6</td>
<td>16 ± 8</td>
</tr>
<tr>
<td>Patients with detected AT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Patients without detected AT</td>
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</tbody>
</table>

Discussion

In the 135 patients who completed the study, NYHA class improved from 3.06 ± 0.24 at the baseline to 2.07 ± 0.64 (P < 0.001) at the end of the study period.

In the subgroup of patients without detected AT episodes, 24 of 119 (20%) patients did not respond to CRT. In the subgroup of patients with detected AT episodes, six of 16 (38%) patients did not respond to CRT. Although the proportions of non-responders in the two groups were considerably different, the difference was not statistically significant, probably owing to the small number of patients (P = 0.12, NS).

The data on QoL, as assessed through the Minnesota Living with Heart Failure Questionnaire and Symptom Checklist, are shown in Table 3. All data showed a statistically significant difference between the baseline and the end of the study (P ≤ 0.01), except for patients with detected AT episodes; in these latter, the lack of statistical significance was probably due to the small number of patients (P = 0.11). Comparison between subgroups did not reveal statistically significant differences.

Parameters derived from echocardiography

Left ventricular ejection fraction significantly improved in the overall patient population from the baseline to the 15- and 28-week follow-up examinations: 25 ± 6, 31 ± 10, and 33 ± 11%, respectively (P < 0.001).

A similar behaviour was observed in the LVEDD and IVMD: LVEDD was 72 ± 9 mm at the baseline and 67 ± 11 and 66 ± 12 mm at the 15- and 28-week follow-up examinations, respectively (P < 0.001 comparing baseline with each of the two follow-up examinations); IVMD was 51 ± 34 ms at the baseline and 24 ± 30 and 26 ± 30 ms at the 15- and 28-week examinations, respectively (P < 0.001 comparing baseline with each of the two follow-up examinations).

Left atrial diameter did not change during the study period, being 45 ± 9, 45 ± 8, and 44 ± 8 mm at the baseline, 15- and 28-week examinations, respectively (P = NS).

Figure 1A–D shows the trends in LVEF, IVMD, LVEDD, and LAD, respectively, from the baseline to the end of the study in the two groups of patients—with and without AT episodes detected by the implanted device—in the 120 patients with a complete set of clinical and telemetric data. No significant differences were seen between the two patient groups, and both groups showed similar improvements in LVEF, IVMD, and LVEDD on CRT. Left atrial diameter showed different trends between patients with and without AT: in patients with PAT, LAD tended to remain constant, whereas in patients without PAT there was a steady downward trend (though not statistically significant, P = 0.08 28 weeks vs. baseline).

Antithrombotic therapy

Of the 173 consecutively enrolled patients, 56 (32%) were on anticoagulation with warfarin, 48 (28%) were on aspirin, and 7 (4%) were on both aspirin and warfarin at the time of enrolment. The remaining 62 patients (36%) were not on any antithrombotic therapy. In summary, 111 patients (64%) were on antithrombotic therapy on enrolment.

At the end of the study, among the 120 patients with a complete set of telemetric data, 51 (43%) were on warfarin, 43 (36%) were on aspirin, and 12 (10%) were on both aspirin and warfarin. In summary, at the end of the study, 106 patients of 120 (88%) were on antithrombotic therapy.

At the end of the study, in the subgroup of 38 (32%) patients with a history of AT, 19 (50%) were on warfarin, 8 (21%) were on antiplatelet therapy, and 1 (2.6%) was on both. Of the 25 (21%) patients with AT detected during the study, eight (32%) were on anticoagulation and seven (28%) received antiplatelets: no patient (0%) received both.

Discussion

To the best of our knowledge, this is the first specifically designed study to prospectively assess the incidence of PAT in patients with HF by means of implanted devices equipped with diagnostic features for continuous AT detection and storage. The reliability of implantable pacemakers with AT diagnostics has been amply validated13–16 and this approach represents a unique chance to collect objective data independently of the patient’s symptoms and the history of the arrhythmia. Data on AF episodes were not comparable with the pre-enrolment period, owing to the non-comparable methods of arrhythmia monitoring: patient symptoms and office ECG vs. pacemaker diagnostics after implantation of the CRT device. In our study, 21% of the overall patient population treated with CRT suffered AT episodes: 29% of patients with a previous history of the arrhythmia and 17% of patients without history (P = NS).
Atrial tachycardia episodes detected in patients without a previous history of the arrhythmia could have been a manifestation of new-onset AF. Alternatively, these patients may have been suffering from asymptomatic or non-diagnosed episodes. In the CHARM program\cite{17,18}, the incidence of new-onset AF was 5–6% over a 3-year follow-up and was independent of the baseline EF. However, the CHARM investigators did not use implantable devices for AF monitoring and could only detect AF through symptoms or standard 24 h Holter recordings or office ECG. In addition, patients enrolled in our study had more severe HF and were in NYHA classes III and IV, whereas the CHARM program enrolled patients in NYHA classes II, III, and IV. These considerations may explain the higher percentage (17%) of patients with newly discovered AT during a shorter follow-up (28 weeks) in our study.

As the atrial pacing percentage was ~30% at each follow-up examination, its role should not be neglected in the interpretation of the data. We can hypothesize that atrial pacing may have an impact on AT recurrences; indeed, the low AT recurrence rate in patients with a history of AF (29%) is in line with studies conducted in patients with sick sinus syndrome. The percentage of patients free from AF after implantation of a dual-chamber pacemaker ranges between 20 and 40%, freedom from AF probably being due to antibradycardia pacing alone.\cite{16,19,20}

In addition, in patients treated with CRT, resynchronization therapy might also play a beneficial role in atrial mechanical remodelling and function,\cite{21} probably relayed to the improvement in haemodynamics and mechanics of the left ventricle. The tendency of LAD to decrease in patients without AT recurrences is in agreement with this hypothesis.

The large majority of CRT studies have been designed for patients in sinus rhythm, and some for patients with permanent AF.\cite{22–26} Recently, Puglisi et al.\cite{27} showed that the incidence of paroxysmal and persistent AF in patients with no history of the arrhythmia was 42.2% in a median follow-up period of 13 months and in a patient population of 410 consecutive CRT patients. This result is in line with the findings of the Care-HF study,\cite{28} in which new-onset AF was documented in 66 of 409 patients in the CRT group and in 58 of 404 patients who received medical therapy only (16 vs. 14%, \(P = 0.79\)); in the CRT group, however, AF episodes were detected only by device diagnostics in an additional 93 patients (22%) during a follow-up period longer than 2 years. The MASCOT study\cite{29} reported a 19% of patients with a history of AF at enrolment.

These data are in agreement with our findings if we consider that we followed patients up for 6 months on average. In patients with new-onset AF in the Care-HF trial,\cite{28} CRT significantly reduced the risk of all-cause mortality and all other predefined endpoints and improved LVEF and symptoms, showing that there was no interaction between AF and CRT. Similarly, in our study, the beneficial effects of CRT on NYHA class, symptoms, QoL,
and echocardiographic parameters were independent of the presence or absence of PAT.

In any case, it is reasonable to suppose that AF episodes may compromise LV systolic function and worsen CHF through poor rate control, irregularity of the ventricular response, loss of atrial transport, and loss of CRT. The predisposition of CHF to AF substantially involves two pathological mechanisms, i.e. irreversible and reversible processes. The former originates from organic changes, including atrial fibrosis, regional conduction abnormalities, and electrophysiological changes such as a shortened atrial refractory period chronically caused by CHF. The latter occurs via acutely increased atrial filling pressure and atrial dilatation. The significant impact of PAF would seem to be derived from the reversible haemodynamic or cardiac background. Monitoring PAF may permit an appropriate action to prevent an acute HF attack, such as cardioversion or rate control, to be undertaken. In addition, monitoring AF may help the patient to decide the best antithrombotic therapy in patients with HF; not only should new-onset AF be treated in order to avoid HF decompensation, but anticoagulation therapy should also be started.

In our patient population, the decision to undertake anticoagulation therapy was not strictly related to the occurrence of AF during the study; an objective report on the AF status, as is provided by implanted devices, could help the physician to make this decision on an evident and solid basis. In clinical practice, the management of anticoagulation is a considerable challenge; indeed, only half of the patients indicated for anticoagulation therapy actually receive it, while it is administered to many patients at low risk.30–32 This inconsistency is partly due to the uncertainty of objectively diagnosing and measuring PAF in terms of AF burden, number of episodes, and episode duration. Patients with less than two risk factors for stroke do not necessarily need anticoagulation even if AF is detected, but all patients with two or more risk factors should start anticoagulation as soon as AF is diagnosed.33 As HF patients, by definition, have at least one risk factor for stroke, careful evaluations should be made in this patient population when AF is diagnosed.

We classified AT episodes according to their duration, adopting a cut-off value of 7 min, as automatically provided by the histograms of the device. Similarly, Glotzer et al.34 used a cut-off value of 5 min and showed that atrial high-rate episodes predicted death and stroke in patients implanted with permanent pacemakers. In the Care-HF trial,28 a cut-off of 10 min was applied to AF data automatically collected by the implanted devices. In their investigation of the role of AF episode duration, Capucci et al.35 adopted two cut-off values to differentiate between short- and long-lasting episodes: 5 min and 24 h. Patients with AF episodes shorter than 5 min were considered AF-free. Hugl et al.36 classified as minor paroxysmal AF all episodes lasting <5 min, whereas those episodes lasting more than 5 min and more than 12 h were, respectively, considered as moderate and long-lasting paroxysmal AF episodes.

In our study, we chose a 7 min cut-off because this was close to the 5 and 10 min values reported in the literature and was automatically provided by the implanted device.

In the future, the development of new technologies, such as telecardiology and implantable devices, may provide more reliable, objective, real-time data to help physicians to monitor and manage HF patients better.

**Study limitations**

The limited number of patients, the high drop-out rate, the medium-term follow-up, and the inclusion of CRT-P only patients, according to the protocol design did not allow us to extrapolate our results on the effects of AF in HF patients, but only to provide a picture of the incidence and prevalence of AF independently of symptoms and prior history of the arrhythmia. For the same reason, we cannot analyse subgroups of patients depending on the underlying cardiomyopathy. Moreover, the limited follow-up period does not allow to extrapolate our results to the long-term development of AF.

**Conclusions**

More than 20% of the overall HF patient population treated with CRT suffer PAT episodes. Antithrombotic therapy may be appropriately administered on the basis of objective telemetric information on the arrhythmic status of the patient. Furthermore, adequate rate control during AT may improve outcome of CRT.

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