The development of AF over time in patients with permanent pacemakers: objective assessment with pacemaker diagnostics demonstrates distinct patterns of AF

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Aims
To describe the long-term patterns of atrial fibrillation (AF) in patients with permanent pacemakers.

Methods and results
A total of 2092 pacemaker Holter downloads were analysed in 323 patients with dual chamber permanent pacemakers, describing a cumulative 1031 patient-years of beat-to-beat monitoring. Four subtypes of AF were applied: (i) non-progressive low-burden PAF (NPLB-PAF, n = 120): such patients never have >1% AF burden throughout follow-up; (ii) chronic progressive PAF (CP-PAF, n = 55): AF burden increases but is never 100%; (iii) relapsing–remitting PAF (RR-PAF, n = 78): AF burden has reduced at least once by more than 2% and is never 100%; (iv) persistent AF (PersAF, n = 70): 100% AF burden for at least 28 days. Overall, mean AF burden rose 0.34% per year (P, 0.0001). After accounting for age, heart failure (HF) had a significant interaction with AF burden (P = 0.0022), but HATCH score and CVA/TIA did not. There were no differences in the frequency or duration of monitoring between the four AF subtypes. Atrial fibrillation episode frequency discriminated between subtypes (P = 0.0004). Eighteen of 70 (26%) patients with PersAF had pacemaker documented episodes of sinus rhythm (i.e. reversion to ‘paroxysmal AF’) after the onset of PersAF.

Conclusion
In this cohort, the development of AF over time appears more complex than current definitions suggest. Atrial fibrillation can remain low burden without progression, remit–relapse, or progress as described in currently accepted definitions. More frequent episodes of AF indicated a favourable subtype. Persistent AF is not inevitable, and can revert to paroxysmal AF.

Clinical Trial Registration

Keywords
Atrial fibrillation ● Permanent pacemaker

Introduction
Atrial fibrillation (AF) has conventionally been divided into paroxysmal AF, and several forms of persistent AF (persistent, long-standing persistent and permanent). However, defining AF by the duration of the longest detected episode or the clinical decision to perform DC cardioversion1 may have limitations. Further, this definition of AF subtypes allows progression to persistent AF, but never regression back to paroxysmal AF.

Published series describing the natural history of AF have depended on standard definitions.2–7 In the Euro Heart Survey, 15% of 1219 patients with initially paroxysmal AF were reclassified as having persistent AF after 1 year.8 Investigators observed clinical correlates for AF progression, and developed the HATCH score (2 points for heart failure or previous cerebrovascular event; one point for age >75, hypertension or chronic obstructive pulmonary disease) as a predictive tool for AF progression. It is in this context a schematic that in the 2010 ESC guideline on AF...
Distinct patterns of AF in patients with PPMs

What’s new?
- Patients with AF and permanent pacemakers were studied over long-term follow-up
- Persistent AF was not inevitable, and could revert to paroxysmal AF.
- AF could remain low burden without progression, remit–relapse, or progress as is described in currently accepted definitions.
- More frequent episodes of AF indicated a favourable subtype.

depicted inevitable AF progression despite antiarrhythmic drugs and AF ablation.9

Assuming that AF will deteriorate regardless of intervention has important clinical implications. Antiarrhythmic therapy might only be considered as a temporizing rather than a curative measure. Patients with ‘advanced’ AF might be offered different treatment to patients perceived to have paroxysmal AF. Even patients who have not yet developed persistent AF, but are considered at risk of doing so, may be offered different treatments. Indeed the investigators who developed the HATCH score suggested that ‘cardioversion and ablation may be avoided in patients with a high HATCH score’.8

Pacemaker AF diagnostics are considered the gold standard for AF detection,10 and are both objective and more descriptive of AF than currently employed techniques.11 We conducted a retrospective analysis of patients with AF and permanent pacemakers (PPMs) to observe patterns of AF as defined by their implanted device.

Methods

This study complies with the Declaration of Helsinki, and was approved by the appropriate national Ethics Committee and institutional review board.

It is not possible to consistently apply currently accepted definitions of AF to pacemaker-acquired data, so a new classification of AF subtypes based on pacemaker-derived AF data was prospectively defined. Boundaries between four mutually exclusive groups were selected based upon the limits of pacemaker AF diagnostic technology. A large pacemaker data set was examined, and patients were divided into groups based on these subtypes. The clinical and electrophysiological characteristics of each group were then described.

Atrial fibrillation subtypes

(1) Non-progressive low-burden paroxysmal AF (NPLB-PAF): AF burden was never >1%. This subtype was defined to select patients with the lowest AF burden.

(2) Chronic progressive paroxysmal AF (CP-PAF): AF burden was >1%, never decreased and never reached 100%.

(3) Relapsing–remitting paroxysmal AF (RR-PAF): AF burden was never 100%, and there was at least one absolute reduction in AF burden of ≥2% during the follow-up period. The cutoff of 2% absolute reduction in AF burden was selected because the lower limit of detection of AF burden for most PPMs is 1% (i.e. an apparent 1% absolute change in AF burden may not represent a true change). This subtype was defined to describe patients who had detectable reductions in AF burden during follow-up.

(4) Persistent AF (PersAF): 100% AF burden detected by their pacemaker for at least 28 days at least once during follow-up. This category was chosen to select only patients who unequivocally had persistent AF.

Data collection and analysis

All patients with a known diagnosis of AF and a dual chamber DDRP PPM equipped with full AF diagnostic capabilities were identified. All had complete retrospective analysis of all available pacemaker download data in January 2014. All available stored intracardiac electrocardiograms were extracted and checked for appropriate arrhythmia detection. If there was any evidence of inappropriate AF detection, or a pacemaker programming change occurred that had an impact on AF detection, that patient was excluded from the analysis. Otherwise, all available consecutive PPM downloads are reported. The minimum duration of monitoring for any time period for comparison was 28 days. Atrial fibrillation burden was defined as the proportion of monitored time a device detected AF. Atrial fibrillation burden data were available for all downloads and all patients had more than one AF burden recorded. AF episode frequency (number of device-detected AF episodes per year) was also analysed. AF episode frequency was defined as the number of episodes of AF detected by the device, divided by the duration of the monitoring period. Atrial fibrillation burden and AF episode frequency are different measures; it is possible to have many short AF episodes or few long episodes equating to the same AF burden.

Complete review of the medical records of all patients was undertaken by clinicians blinded to pacemaker data. Age was defined as the age at the most recent available pacemaker download. The presence of any of the following clinical comorbidities were recorded: heart failure (HF), hypertension (HTN), stroke or transient ischaemic attack (CVA/TIA), chronic obstructive pulmonary disease (COPD), thyroid disease (any history of treated hypothyroidism or hyperthyroidism), valvular disease (severe aortic or mitral disease or any valve surgery), vascular disease (coronary or peripheral vascular disease), renal disease (end-stage renal failure), cancer (any treated cancer except completely excised non-melanoma skin cancers), obstructive sleep apnoea (OSA), and previous cardiac surgery. The CHADS2, CHA2DS2-Vasc and HATCH scores were calculated for each patient. Clinical characteristics were collected at the time of the last available pacemaker download.

Based on all available pacemaker AF burden data across long-term follow up, each patient was classified as NPLB-PAF, CP-PAF, RR-PAF, or PersAF. Patients with PersAF were further analysed for AF burden data prior to and after the first detected episode of 100% AF burden.

Statistical analysis

Data analysis was performed using SPSS statistical software (version 21, IBM Corp, New York, USA), and SAS 9.3 (SAS Institute, Cary, NC, USA). The median and interquartile ranges are displayed for descriptive data. Categorical variables are reported as observed number of patients (percentage). A P-value of <0.05 was considered significant.

The relationship between AF burden and clinical characteristics was examined in a multivariable generalized mixed linear model accounting for multiple measures within a subject. A candidate set of predictive variables (HATCH score, CVA/TIA, HF, and age) were modelled with AF burden as the response variable. Non-significant candidate explanatory variables were removed using backward selection.

Data were then analysed according to four groups: NPLB-PAF, CP-PAF, RR-PAF, or PersAF. The number, mean duration of follow-up, mean number of downloads, mean and median AF burdens were compared (Table 2). Clinical comorbidities and demographics were described and compared per group (Table 3).
The relationship between AF episode frequency and AF subtype was compared accounting for multiple measures within a subject, with the denominator degrees of freedom derived from the patient stratum.

**Results**

All patients (2546) with PPMs in a single centre were screened. In total, 4095 individual device downloads were examined. A total of 323 patients with AF and the appropriate pacemaker data were identified. In the 323 patients with evaluable data, 2092 downloads are reported, of which 1838 (88%) had AF episode data available (as not all PPMs capture AF episode data). A cumulative 1031 patient-years of beat-to-beat arrhythmia data (mean 3.2 years per patient) were analysed.

In a multivariable model with HATCH, age, CVA/TIA, and HF as predictive variables, AF burden was found to increase on average by 0.34% for every 1 year increase in age ($P_{0.0001}$. After accounting for age at pacemaker download, only HF was found to have a significant interaction with AF burden ($P = 0.002$).

### Atrial fibrillation subtypes

There were 120 patients with NPLB-PAF, 55 with CP-PAF, 78 with RR-PAF, and 70 with PersAF (Figure 1). There were no significant differences between the duration or frequency of arrhythmia monitoring between the NPLB-PAF, CP-PAF, RR-PAF, or PersAF patient groups (Table 1).

The majority (52.9%) of patients had their PPMs initially implanted for sick sinus syndrome. Approximately, one-third (31.6%) had atrioventricular block (AVB) on pacemaker implant, and 13.6% had AF as a pacing indication. Six patients (1.9%) had other indications such as hypertrophic cardiomyopathy, ventricular tachyarrhythmias, or heart failure. Patients with NPLB-PAF were more likely to have had AVB as a pacing indication (Table 2).

Median atrial pacing and ventricular pacing were both 35.0%. However, there was a wide range in the proportion of atrial and ventricular pacing seen both in the population as a whole and within each subtype (Table 3).

Fourteen clinical comorbidities and three composite scores were compared (Table 4). There were no statistically significant differences

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**Table 1 Monitoring intensity and AF burden for population and subtypes**

<table>
<thead>
<tr>
<th></th>
<th>NPLB-PAF</th>
<th>CP-PAF</th>
<th>RR-PAF</th>
<th>PersAF</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>120</td>
<td>55</td>
<td>78</td>
<td>70</td>
<td>323</td>
</tr>
<tr>
<td>Median (IQR) duration of beat-to-beat pacemaker follow-up (days)</td>
<td>1213 (689–1668)</td>
<td>735 (374–1307)</td>
<td>1190 (615–1903)</td>
<td>1054 (417–1546)</td>
<td>1072 (523–1630)</td>
</tr>
<tr>
<td>Median (IQR) number of pacemaker downloads</td>
<td>5 (3–8)</td>
<td>5 (4–7)</td>
<td>7 (4–9)</td>
<td>6 (4–10)</td>
<td>6 (4–8)</td>
</tr>
<tr>
<td>Median AF burden (IQR) (%)</td>
<td>0.1 (0.0–0.3)</td>
<td>1.0 (0.1–8.1)</td>
<td>4.9 (1.0–28.0)</td>
<td>98.0 (5.1–100.0)</td>
<td>1.0 (0.0–30.4)</td>
</tr>
</tbody>
</table>

AF, atrial fibrillation; NPLB-PAF, non-progressive low-burden paroxysmal AF; CP-PAF, chronic progressive paroxysmal AF; RR-PAF, relapsing–remitting paroxysmal AF; PersAF, persistent AF.

**Table 2 Pacing indication for population and subtype**

<table>
<thead>
<tr>
<th>Pacing indication</th>
<th>NPLB-PAF</th>
<th>CP-PAF</th>
<th>RR-PAF</th>
<th>PersAF</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrioventricular block (%)</td>
<td>50 (41.7)</td>
<td>14 (25.5)</td>
<td>18 (23.1)</td>
<td>20 (28.6)</td>
<td>102 (31.6)</td>
</tr>
<tr>
<td>Sick sinus syndrome (%)</td>
<td>58 (48.3)</td>
<td>30 (54.5)</td>
<td>47 (60.3)</td>
<td>36 (51.4)</td>
<td>171 (52.9)</td>
</tr>
<tr>
<td>Atrial fibrillation (%)</td>
<td>10 (8.3)</td>
<td>8 (14.5)</td>
<td>12 (15.4)</td>
<td>14 (20.0)</td>
<td>44 (13.6)</td>
</tr>
<tr>
<td>Other (%)</td>
<td>2 (1.7)</td>
<td>3 (5.5)</td>
<td>1 (1.3)</td>
<td>0 (0.0)</td>
<td>6 (1.9)</td>
</tr>
</tbody>
</table>

AF, atrial fibrillation; NPLB-PAF, non-progressive low-burden paroxysmal AF; CP-PAF, chronic progressive paroxysmal AF; RR-PAF, relapsing–remitting paroxysmal AF; PersAF, persistent AF.

**Table 3 Atrial and ventricular pacing for population and subtype**

<table>
<thead>
<tr>
<th></th>
<th>NPLB-PAF</th>
<th>CP-PAF</th>
<th>RR-PAF</th>
<th>PersAF</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median atrial pacing (IQR) (%)</td>
<td>34.4 (9.5–74.0)</td>
<td>29.0 (4.0–75.3)</td>
<td>55.6 (21.3–88.0)</td>
<td>6.8 (0.4–52.3)</td>
<td>35.0 (6.0–77.0)</td>
</tr>
<tr>
<td>Median ventricular pacing (IQR) (%)</td>
<td>26.1 (0.5–99.0)</td>
<td>46.1 (2.0–99.3)</td>
<td>70.0 (6.0–98.5)</td>
<td>90.0 (27.0–99.5)</td>
<td>35.0 (6.0–77.0)</td>
</tr>
</tbody>
</table>

AF, atrial fibrillation; NPLB-PAF, non-progressive low burden paroxysmal AF; CP-PAF, chronic progressive paroxysmal AF; RR-PAF, relapsing–remitting paroxysmal AF; PersAF, persistent AF.
between AF subtypes except for in HF, HTN, and the HATCH score. Heart failure was significantly less prevalent in NPLB-PAF than in any other subtype ($P = 0.001$).

The AF burden and episode frequency in the 88% of downloads where AF episode data were available are presented in Table 5. Median AF burden was highest (99.8%) in PersAF, which reflects the fact that most patients who had 100% AF burden remained at that level for many years. For AF data prior to the onset of 100% AF, the median AF burden was comparable to other groups (3.5%). Atrial fibrillation episode frequency was highest in patients with RR-PAF. Overall, AF episode frequency discriminated between AF subtypes ($P = 0.0004$).

Twenty-two percent of the population was classified as PersAF. Although the majority remained in AF once persistent AF occurred, 18 of 70 (26%) had sustained reduction in AF burden (to <50%) after the onset of 100% AF (Figure 2). PPM downloads for these patients were re-examined, and all patients had proven sinus rhythm after sustained AF on intracardiac electrograms. Twelve of these 18 patients had a left atrial ablation which coincided with their decline in AF burden. However, in one patient, AF burden declined spontaneously 4 years after an AF ablation which had been assumed to have failed. In three patients, AF burden remained persistently low or non-existent on multiple PPM downloads after DC cardioversion. Finally, in 3 of 18 (17%) patients, AF burden was observed to decline spontaneously, without any antiarrhythmic therapy or intervention.

**Discussion**

Understanding of the natural history of AF requires repeated consistent and objective assessment for AF in the same individual over the long term. Previous studies have accepted very low levels of AF monitoring, with as few as a single 12-lead ECG per year being described. The Euro Heart Survey analysis for AF progression$^8$ reported 1 year follow-up for 1219 patients, which may appear comparable to the 1031 patient-years of follow-up in our study. However, we report automated arrhythmia data based on intracardiac electrograms,

![Figure 1](image-url) Proportion of population by atrial fibrillation subtype.

### Table 4 Clinical comorbidities, demographics, and composite scores for population and subtype

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>NPLB-PAF</th>
<th>CP-PAF</th>
<th>RR-PAF</th>
<th>PersAF</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>77.4</td>
<td>76.3</td>
<td>76.2</td>
<td>78.7</td>
<td>78.7</td>
<td>0.244</td>
</tr>
<tr>
<td>Gender (female), n (%)</td>
<td>154 (47.7)</td>
<td>59 (49.2)</td>
<td>29 (52.7)</td>
<td>41 (52.6)</td>
<td>25 (35.7)</td>
<td>0.143</td>
</tr>
<tr>
<td>Heart failure, n (%)</td>
<td>52 (16.1)</td>
<td>9 (7.5)</td>
<td>11 (20.0)</td>
<td>13 (16.7)</td>
<td>19 (27.1)</td>
<td>0.004*</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>147 (45.5)</td>
<td>42 (35)</td>
<td>26 (47.3)</td>
<td>43 (55.1)</td>
<td>36 (51.4)</td>
<td>0.025*</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>26 (8)</td>
<td>9 (7.5)</td>
<td>5 (9.1)</td>
<td>10 (12.8)</td>
<td>2 (2.9)</td>
<td>0.166</td>
</tr>
<tr>
<td>Stroke or TIA, n (%)</td>
<td>40 (12.4)</td>
<td>11 (9.2)</td>
<td>6 (10.9)</td>
<td>14 (17.9)</td>
<td>9 (12.9)</td>
<td>0.321</td>
</tr>
<tr>
<td>COPD, n (%)</td>
<td>17 (5.3)</td>
<td>5 (4.2)</td>
<td>3 (5.5)</td>
<td>4 (5.1)</td>
<td>5 (7.1)</td>
<td>0.851</td>
</tr>
<tr>
<td>Vascular disease, n (%)</td>
<td>90 (27.9)</td>
<td>29 (24.2)</td>
<td>17 (30.9)</td>
<td>26 (33.3)</td>
<td>18 (25.7)</td>
<td>0.495</td>
</tr>
<tr>
<td>Thyroid disease, n (%)</td>
<td>28 (8.7)</td>
<td>8 (6.7)</td>
<td>7 (12.7)</td>
<td>10 (12.8)</td>
<td>3 (4.3)</td>
<td>0.161</td>
</tr>
<tr>
<td>Cancer, n (%)</td>
<td>7 (2.2)</td>
<td>1 (0.8)</td>
<td>1 (1.8)</td>
<td>3 (3.8)</td>
<td>2 (2.9)</td>
<td>0.526</td>
</tr>
<tr>
<td>Renal failure, n (%)</td>
<td>1 (0.3)</td>
<td>1 (0.8)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>0.638</td>
</tr>
<tr>
<td>Valve disease, n (%)</td>
<td>29 (9.0)</td>
<td>11 (9.2)</td>
<td>4 (7.3)</td>
<td>9 (11.5)</td>
<td>5 (7.1)</td>
<td>0.773</td>
</tr>
<tr>
<td>Obstructive sleep apnoea, n (%)</td>
<td>1 (0.3)</td>
<td>1 (0.8)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>0.638</td>
</tr>
<tr>
<td>Cardiac surgery, n (%)</td>
<td>35 (10.8)</td>
<td>11 (9.2)</td>
<td>6 (10.9)</td>
<td>9 (11.5)</td>
<td>9 (12.9)</td>
<td>0.877</td>
</tr>
<tr>
<td>CHADS₂ score (mean)</td>
<td>1.6</td>
<td>1.3</td>
<td>1.6</td>
<td>1.9</td>
<td>1.7</td>
<td>0.067</td>
</tr>
<tr>
<td>CHA₂DS₂Vasc score (mean)</td>
<td>3.2</td>
<td>2.8</td>
<td>3.3</td>
<td>3.7</td>
<td>3.3</td>
<td>0.096</td>
</tr>
<tr>
<td>HATCH score (mean)</td>
<td>1.7</td>
<td>1.3</td>
<td>1.7</td>
<td>1.9</td>
<td>1.7</td>
<td>0.025*</td>
</tr>
</tbody>
</table>

Values presented as n (% of AF subtype) unless otherwise stated. $P$-values are for the hypothesis that there are no differences between subtypes for the relevant parameter. AF, atrial fibrillation; NPLB-PAF, non-progressive low-burden paroxysmal AF; CP-PAF, chronic progressive paroxysmal AF; RR-PAF, relapsing–remitting paroxysmal AF; PersAF, persistent AF.

*P*-value < 0.05.
and this represents significantly improved objective data for analysis. All data in this study is based on continuous beat-to-beat rather than intermittent monitoring.

The natural history of atrial fibrillation

The 2010 ESC guideline suggests that AF burden should inexorably increase over the long term, regardless of medical intervention. Our data confirm that this does occur, but only in a minority of patients. More than one-third of patients never suffered more than 1% AF burden during follow-up. Indeed many patients with conventionally defined ‘persistent’ AF had spontaneous improvement in AF burden. Even patients with very high AF burden had large reductions in AF during long-term follow-up.

Atrial fibrillation subtypes

To enhance the currently accepted definitions of AF using beat-to-beat arrhythmia assessment, we categorized AF subtypes according to long-term patterns of AF measured continuously over several years.

The single largest patient group had low-burden non-progressive paroxysmal AF (LBNP-PAF). Their mean CHA2DS2-Vasc score was 2.8, illustrating the high embolic risk for this group. All patients with LBNP-PAF in our study were appropriately anticoagulated. It is probable, however, that the majority of patients with LBNP-PAF outside this study are not. With such a low AF burden, these individuals are unlikely to have their AF detected despite being at high risk of preventable cerebrovascular disease.

The RR-PAF, seen in 1 in 6 of our cohort, appears inconsistent with the current perception of AF progression. These patients had similar comorbidities, demographics, and follow-up as those with more progressive forms of AF. The median AF burden in patients with RR-PAF was comparable to patients destined to develop persistent AF. The only distinguishing feature was that they had discrete, frequent episodes of AF. This suggests that RR-PAF has a distinctly different pattern of AF which is not equivalent to CP-PAF observed at a

Table 5  Median AF burden and episode frequency per AF subtype and prior to the onset of PersAF

<table>
<thead>
<tr>
<th></th>
<th>NPLB-PAF</th>
<th>CP-PAF</th>
<th>RR-PAF</th>
<th>PersAF</th>
<th>Prior to onset of PersAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number where AF episode frequency data available</td>
<td>116</td>
<td>53</td>
<td>75</td>
<td>70</td>
<td>34</td>
</tr>
<tr>
<td>Median AF burden (IQR) (%)</td>
<td>0.1 (0.0–0.1)</td>
<td>1.0 (0.1–4.7)</td>
<td>4.9 (0.1–28.2)</td>
<td>99.8 (4.2–100)</td>
<td>3.5 (0.1–53.4)</td>
</tr>
<tr>
<td>Median AF episode frequency per year (IQR)</td>
<td>0 (0–5)</td>
<td>30 (1–300)</td>
<td>110 (4–1108)</td>
<td>6 (2–56)</td>
<td>25 (2–160)</td>
</tr>
</tbody>
</table>

AF, atrial fibrillation; NPLB-PAF, non-progressive low burden paroxysmal AF; CP-PAF, chronic progressive paroxysmal AF; RR-PAF, relapsing–remitting paroxysmal AF; PersAF, persistent AF.

Figure 2 Atrial fibrillation burden data for 18 of 70 (26%) of patients with PersAF who had sustained reduction in AF burden after the onset of 100% AF burden. Twelve of 18 patients had AF ablation temporally associated with decline in AF burden (solid lines). Six of 18 patients had decline in AF burden not associated with AF ablation (interrupted lines). AF, atrial fibrillation; PersAF, persistent atrial fibrillation.
Hence we do not suggest that all our findings are generalizable to primary indication for permanent pacing. Both atrial and ventricular cized. It should be noted that all patients in this analysis had a Any long-term description of the time-course for AF can be criti- sim.13

Study limitations

Any long-term description of the time-course for AF can be criti- }

Atrial fibrillation subtypes and clinical comorbidities

When patients were objectively split on the basis of AF phenotypes, previously recognized predictors for AF progression could not identi- patients with persistent AF. In this cohort, the absence of heart failure appeared to increase the chance of having non-progressive low-burden paroxysmal AF. However, the most notable finding is that no comorbidity had any clinically meaningful discriminatory power to detect persistent AF.

The disjunction between this analysis and prior work may reflect the necessarily subjective data other investigators have been forced to utilize. Unfortunately, it seems that the HATCH score may be biased by the fact that if a clinician expects to find persistent AF, they are often able to diagnose it. This has implications for the use of antiarrhythmic therapies in patients perceived to have paroxysmal AF.

Atrial fibrillation subtypes in clinical practice

The AF patterns reported in this analysis describe patterns of AF over all available follow-up. Although these descriptions are useful to illustrate the true variation in the natural history of AF, they cannot necessarily be applied prospectively to individual patients.

However, these findings have clear implications in clinical practice. There appear to be important patient subsets with either a very low burden of AF, or frequent but non-sustained episodes of AF. The electrophysiological basis for these patterns must be driven by the balance between triggers to initiate AF and the substrate to maintain it. Long-term AF monitoring may indicate the AF arrhythmia mechanism, even when clinical comorbidities appear to be unhelpful predictors.13

Conclusions

Objective arrhythmia monitoring offers unique and clinically relevant insights into the natural history of AF. The currently accepted model of inevitable progression from paroxysmal to persistent AF was not reflected in our data. Our data suggest that the history of AF is more complex than the currently accepted model of progression from paroxysmal to persistent AF. Furthermore, clinical comorbidities did not correlate with AF patterns. The elderly, and patients with comorbid disease, appear no more likely to have a progressive phenotype of AF than other patients.

Expanding access to long-term arrhythmia monitoring for patients with AF may improve management and outcomes. Future efforts to characterize AF patterns require more detailed data on AF (and sinus rhythm) episode duration and frequency distribution.

Future directions

The expansion in remote home monitoring for paced patients has created a large and growing database of pacemaker arrhythmia data. These large data sets are attractive targets for a similar analysis to our own, and may provide more insight relevant to a larger population of patients. Similarly, there is great potential in analysing arrhythmia data from implantable loop recorders,20,21 which offer the best available method for long-term arrhythmia surveillance in patients who do not have an indication for PPMs.

Clinical implications

Atrial fibrillation does not always progress. Conventional descriptions conceal the true variety and complexity of AF, and fail to detect patient groups who have a favourable long-term phenotype. Clinical comorbidities are a poor predictor of AF type, and should not be used to inform patients of the likely development of their arrhythmia. High AF episode frequency appears to signify a non-progressive phenotype. Persistent AF appears to be neither inevitable nor permanent.
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Conflict of interest

none declared.

References