High pre-ablation ECG organization in long-standing persistent atrial fibrillation terminated within the left atrium

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Introduction

• Stepwise radiofrequency catheter ablation (step-CA) has become the treatment of choice for the restoration of sinus rhythm (SR) in patient (pts) with long-standing persistent atrial fibrillation (LS-pAF).
• Its success rate appears limited as the amount of additional right atrial (RA) ablation to achieve AF termination is unknown.
• Multiple organization indices (OIs) have been used to predict the outcome of step-CA, however with limited success

Our study is aimed at 1) developing innovative OIs computed from the pre-ablation ECG, 2) evaluating the predictive value of known and new OIs, and 3) identifying the site of AF-term.

Methods

Patients Characteristics and Data Acquisition

• 29 consecutive pts (table 1) underwent step-CA (figure 1).
• 1 min ECG epochs for an average duration of 19 ± 7 min per patient were used.
• Chest lead V₆ (V₆b) was placed on pts’ back within the cardiac silhouette to improve antero-posterior recordings of AF.

Signal Processing

• Cancellation of QRST waves¹ on all chest leads V₁ and V₆b. Frequency analysis on the resulting signals using an adaptive tracking scheme (see movie).

AF Organization Measurements

• Adaptive organization index (AOI): ratio between the power of the extracted adaptive components and the total power of the signal. AOI estimates the temporal cyclicity of the oscillations.
• Adaptive phase difference (APD): variance of the slope of the phase difference (PD). APD quantifies the regularity of the oscillations.
• AF cycle length (AFCL): computed as the inverse of the dominant frequency (largest peak between 3 and 15 Hz in the power spectral density estimate).
• Spectral organization index (SOI): ratio of the power under the fundamental and first harmonic peaks to the total power of the signal².

Results

Clinical Results

• AF terminated in 73% of the pts during LA ablation (left terminated pts - LT).
• 8 (27%) pts required RA ablation among which 3 pts had AF-term (right terminated pts - RT) and 5 did not (not terminated pts – NT).

Table 2: clinical characteristics for groups LT and RT/NT. Importantly, all pts displayed similar clinical characteristics, including LA volume, except for the duration of sustained AF and the left ventricular fraction ejection (LVEF).

AF Organization Measurements

Figure 3 shows that LT pts were best separated from RT/NT pts before ablation by AOI on lead V₁ and APD on lead V₆b. SOI was not significantly different between groups. Although AFCL was significantly shorter in RT/NT vs LT pts, the overlap was larger compared to AOI and APD.

Conclusion

• Adaptive measures of AF organization computed from pre-ablation ECG perform better than classical OIs for identifying pts whose AF will terminate during ablation within the LA.
• These findings are indicative of a higher baseline organization in LS-pAF terminated within the left atrium that could be used to select best candidates for step-CA.

Table 1: clinical characteristics

<table>
<thead>
<tr>
<th>Clinical characteristics</th>
<th>Study population</th>
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<tbody>
<tr>
<td>Age (y)</td>
<td>60 ± 7</td>
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<tr>
<td>Male/Female</td>
<td>27/2</td>
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<tr>
<td>AF duration (y)</td>
<td>7 ± 5</td>
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<tr>
<td>Sustained AF (month)</td>
<td>19 ± 12</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>30 ± 6</td>
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<tr>
<td>UVEF (%)</td>
<td>48 ± 11</td>
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<tr>
<td>LA volume (ml)</td>
<td>173 ± 37</td>
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</tbody>
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Table 2: clinical characteristics before ablation. Panel A: AOI measured on lead V₁. Panel B: APD and AFCL measured on lead V₆b. SOI was not significantly different. Panel C: APD and AFCL measured on lead V₆b. SOI was not significantly different.

Figure 1: step-CA ablation protocol

Figure 2: boxplots for the ECG OIs before ablation. Panel A: AOI measured on lead V₁. Panel B: APD and AFCL measured on lead V₆b. SOI was not significantly different. Panel C: APD and AFCL measured on lead V₆b. SOI was not significantly different.

Figure 3: boxplots for the ECG OIs before ablation. Panel A: AOI measured on lead V₁. Panel B: APD and AFCL measured on lead V₆b. SOI was not significantly different. Panel C: APD and AFCL measured on lead V₆b. SOI was not significantly different.