The Role of Complex Fractionated Atrial Electrograms in Atrial Fibrillation Ablation

Moving to the Beat of a Different Drum*

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As physicians bid farewell to the last century, they also witnessed the rise of catheter-based ablation and the fall of antiarrhythmic drug use for the treatment of cardiac arrhythmias. At that time, only a select few investigators truly believed that catheter-based ablation would work for treatment of atrial fibrillation (AF).

The initial attempts at catheter ablation, patterned after the Cox surgical Maze procedure, were based on the anatomical approach with empirically created multiple linear lesions in both atria. The catheter-based Maze ablation was short lived, however, because the procedure was difficult, time-consuming, and associated with significant complications. Fortunately, the breakthrough for AF ablation came after Haïssaguerre et al. (1) described pulmonary veins (PVs) as important sources of focal AF; they have since become the most important target for AF ablation.

Shortly thereafter, the ablation approach targeting the PV–left-atrial junction to disconnect any possible arrhythmogenic electrical activities of all 4 PVs (pulmonary vein isolation [PVI]) has become the cornerstone of AF ablation.

PVI including linear lesions, and CFAE ablation yielded a termination rate of 87% and outstanding long-term outcomes of 95% after 1 to 2 procedures.

Unfortunately, APVI alone is not highly effective in the majority of patients with long-lasting persistent AF. Thus, many investigators continue to search for a better technique for AF treatment for this subset. Many centers presently incorporate complex fractionated atrial electrogram (CFAE) ablation as an adjuvant to their approach (3). In particular, most electrophysiologists have adopted a hybrid approach that combines PVI, linear lesions along the roof and mitral isthmus, and CFAE ablation (4).

In this issue of the Journal, Oral et al. (5) present the finding of their randomized study that was designed to determine the benefit of CFAE ablation after APVI in patients with long-lasting AF. They found that there were no additional benefits with respect to acute termination of AF and no long-term benefits. They found that the clinical outcomes of either APVI alone or combined APVI and CFAE ablation were only 36% and 34%, respectively. Also, the additional CFAE ablation resulted in AF termination in only 9 patients (18%). Based on these observations, it appears that CFAE sites play no role in AF perpetuation and are not good target sites for ablation.

However, the findings of Oral et al. (5) differ from the other studies that employed an ablation approach that targets CFAE sites either alone or as part of the hybrid approach to APVI. Verma et al. (3) showed that after APVI, additional ablation at the CFAE sites at the anterior and septal wall of the left atrium resulted in improved outcomes in patients with persistent/permanent AF, with a high success rate of 82% compared with 72% when only APVI was performed. Similarly, Haïssaguerre et al. (4) demonstrated their sequential ablation approach after PVI including linear lesions, and CFAE ablation yielded a termination rate of 87% and outstanding long-term outcomes of 95% after 1 to 2 procedures.

Although it may be difficult to explain the differences in the results among these studies, they all underscore one important finding: additional CFAE ablation after APVI is a formidable task. As shown in Table 1, the procedure is quite lengthy, the X-ray radiation exposure is considerable, and the number of radiofrequency (RF) ablations and the number of RFs is substantial. It is probably safe to state that ablation employing a hybrid approach of APVI plus CFAE ablation with or without additional lesions involves extensive debulking of atrial tissue, like the Maze procedure. In other words, the technique has evolved almost in a full circle back to the way AF ablation was started.

On the other hand, our group started using AF ablation with the catheter-based Maze procedure more than 10 years ago, but we have since abandoned this technique in favor of AF ablation exclusively by targeting CFAE (6). Our approach has not changed over the past 8 years because it offers several advantages.

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First, as shown in Table 1, our procedure time is considerably shorter than the hybrid approaches mentioned earlier, as is the fluoroscopic time (7). Second, contrary to conventional wisdom, AF ablation at the primary CFAE target sites requires a relatively shorter RF duration time, suggesting less extensive ablation than the 3 studies described earlier, including those of Oral et al. (5); this is because we do not ablate all long-lasting AF patients with the same pre-set strategy, as if all long-lasting AF patients are homogeneous. Our end points are clear: termination of AF or elimination of all persistent low-voltage CFAE or atrial signals that have short cycle lengths (<120 ms).

Third, we achieved a very high success rate for AF termination (80%) (7)—much higher than that observed by Oral et al. (5) but similar to that of the Haïssaguerre et al. (4) study, albeit we also administered ibutilide as a diagnostic tool to help identify the sites of AF termination. Most importantly, our ablation approach gave our patients excellent long-term outcomes associated with mortality and stroke reduction. Our results bode well for CFAE as target sites for AF ablation.

But why were outcomes for CFAE ablation after APVI not improved when compared with APVI alone in the study by Oral et al. (5)? Although there is no clear answer, we believe that the following findings gleaned from the study by Oral et al. (5) may offer some explanation. First, ablations over the wide areas of PV antrums might have also eliminated much of the CFAE sites. Therefore, perhaps some of these patients had little to gain from additional CFAE ablation after APVI.

Second, the RF power that Oral et al. (5) applied around the PV antrum may not have been adequate (maximum energy of 25 W), as is evident by the fact that the majority of their patients had at least 1 PV electrical reconnection. They also observed during their repeat ablation procedures that CFAE sites were identified near 1 or more PVS in all patients. Therefore, in the study by Oral et al. (5), it is likely that RF lesions, which were created near PV ostia, were not permanent.

Likewise, we have found that during CFAE ablations, we often need to repeatedly ablate the CFAE at the PV antrum before we can completely eliminate the electrograms, even though we use power up to 45 W. Often, the arrhythmia termination sites were the same sites we had already ablated at the beginning of the session, where very low voltage fractionated potentials ≤0.06 mV were observed (7). Such areas could otherwise have been missed, rendering ablation unsuccessful.

Third, CFAE mapping requires creating a comprehensive map of the left atrium, not just creating the contour of the left atrium; this may be adequate for APVI, but not for CFAE ablation. If the map is not complete, some important CFAE sites can be missed, even if 2 h are allotted for CFAE mapping and ablation. All of these factors may result in a low acute AF termination rate and, in turn, yield a relatively lower than expected long-term success.

In any event, the study by Oral et al. (5) emphasizes how difficult it is to terminate long-lasting AF. Thus, the best AF ablation approach for long-lasting AF, which will provide the best possible outcomes, is yet to be devised. Unlike at the beginning of this century, however, we now believe that eventually we will find a successful ablation strategy that will maintain sinus rhythm for our patients, whether they have paroxysmal or long-lasting AF. Even the debate over the role of CFAE as an important AF target site is ongoing.

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REFERENCES


Key Words: atrial fibrillation • catheter ablation • electrogram.

Table 1

<table>
<thead>
<tr>
<th>Investigators (Ref. #), Ablation Technique</th>
<th>No. of Patients</th>
<th>Age (yrs)</th>
<th>Procedure/Fluoroscopic Time (min)</th>
<th>RF Time (min)</th>
<th>Acute AF Termination</th>
<th>Long-Term Success (1–2 Ablations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verma et al. (3), APVI + CFAE + linear lesions</td>
<td>40</td>
<td>56 ± 9</td>
<td>188/84</td>
<td>57 ± 12</td>
<td>NA</td>
<td>82%</td>
</tr>
<tr>
<td>Haïssaguerre et al. (4), PVI + CFAE</td>
<td>60</td>
<td>53 ± 9</td>
<td>264/84</td>
<td>NA</td>
<td>87%</td>
<td>95%</td>
</tr>
<tr>
<td>Oral et al. (5), APVI + CFAE</td>
<td>50</td>
<td>62 ± 8</td>
<td>254/59</td>
<td>54 ± 19</td>
<td>34% (with ibutilide)</td>
<td>60%</td>
</tr>
<tr>
<td>Oketani et al. (7), CFAE alone</td>
<td>410</td>
<td>64 ± 12</td>
<td>120/7.4</td>
<td>29 ± 15</td>
<td>80% (with ibutilide)</td>
<td>81%</td>
</tr>
</tbody>
</table>

*Based on the total study population and not from the subset of APVI + CFAE.

AF = atrial fibrillation; APVI = antrum pulmonary vein isolation; CFAE = complex fractionated atrial electrogram; PVI = pulmonary vein isolation; RF = radiofrequency.