Is 8-mm More Effective Than 4-mm Tip Electrode Catheter for Ablation of Typical Atrial Flutter?

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Background—The prospective, randomized study comparing 4- with 8-mm tip electrodes for radiofrequency linear ablation of typical atrial flutter is not available.

Methods and Results—A total of 104 consecutive patients with typical atrial flutter were randomly assigned to undergo radiofrequency linear ablation using a 4- (Group I, n = 54) or 8-mm tip electrode (Group II, n = 50) catheter (temperature-control model, preset 70°C). If complete bidirectional isthmus block could not be achieved after 5 pulses, the ablation catheter was changed to the other type; the maximal radiofrequency pulse number was limited to <10 pulses. Complete or incomplete isthmus conduction block was assessed by activation sequence in a multielectrode Halo catheter during low lateral right atrial and proximal coronary sinus pacing. Before shifting to the other catheter type, the 8-mm electrode catheter achieved higher complete isthmus block rate (92% versus 67%, \( P < 0.05 \)) with fewer pulses (2±1 versus 3±1, \( P < 0.05 \)), shorter procedure time (24±15 versus 31±12 minutes, \( P < 0.05 \)), and shorter fluoroscopic time (14±10 versus 23±15 minutes, \( P < 0.05 \)). After 5 failed ablation pulses, 12 (67%) of 18 patients in group I attained complete isthmus block by using an 8-mm tip catheter, but none of 4 patients in group II achieved complete block by changing to a 4-mm tip catheter.

Conclusions—The 8-mm tip electrodes are more effective than the standard 4-mm length electrodes in linear ablation for typical atrial flutter. This clinical benefit may be of particular value for some patients with broad and/or thick isthmus. (Circulation. 1999;100:768-771.)

Key Words: atrial flutter • ablation • isthmus

Typical atrial flutter (AF) has been proved to be a macroreentrant circuit in the right atrium.1-3 Radiofrequency (RF) linear ablation targeting the cavotricuspid isthmus can achieve a high success rate.4-6 Bidirectional isthmus conduction block appears to be a better ablation end point, as opposed to interruption and noninducibility of AF.7-9 Previous experimental studies have shown that an 8- to 10-mm tip electrode is superior to the standard 4-mm tip electrode in ablating effects on ventricular tissues, applying higher RF power and causing a further increase in lesion size and depth.10-12 However, a randomized study comparing 4- with 8-mm tip electrodes for linear ablation of AF was not available. Thus, this study compared the effects of ablation on typical AF using a large tip catheter (7F, 8 mm) with those of a conventional ablation catheter (7F, 4 mm) in a prospective randomized fashion among a large patient group.

Methods

Study Patients
The study included 104 consecutive patients (76 males, 28 females; mean age 63±10 years) referred to this institution for ablation of typical AF. All patients were intolerant or had recurrent AF despite a mean of 3±1 antiarrhythmic drugs before referral. Sixty-two patients had associated cardiopulmonary diseases, including hypertensive heart diseases (n = 30), coronary artery disease (n = 9), valvular heart disease (n = 8), and chronic lung disease (n = 15). Left or right atrial enlargement was considered to be present if the end-systolic midcavity mediolateral dimension exceeded 4.5 cm on 2-D and M-mode echocardiography.9

Radiofrequency Ablation
The methods of electrophysiological studies and ablation of AF in this laboratory have been described previously.6,9 All clinically documented AF was induced by programmed stimulation protocols established in most laboratories.3-8 In all patients, a deflectable duodecapolar Halo catheter (Cordis-Webster, Inc) was used to demonstrate an AF exhibiting either a
TABLE 1. Clinical Characteristics of Study Patients

<table>
<thead>
<tr>
<th></th>
<th>Group I (n=54)</th>
<th>Group II (n=50)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>62±18</td>
<td>63±18</td>
<td>NS</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>37/17</td>
<td>39/11</td>
<td>NS</td>
</tr>
<tr>
<td>SHD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAD</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>HCVD</td>
<td>16</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>VHD</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Chronic lung disease</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Clinical AF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCW</td>
<td>51</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>CW</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Symptomatic periods, y</td>
<td>2.0±0.5</td>
<td>1.8±0.7</td>
<td>NS</td>
</tr>
<tr>
<td>AF CL, ms</td>
<td>218±21</td>
<td>220±17</td>
<td>NS</td>
</tr>
<tr>
<td>Atrial enlargement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left atrium</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Right atrium</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Both atria</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Data are expressed as mean value±SD or number of patients.

SHD indicates structural heart disease; CAD, coronary artery disease; HCVD, hypertensive cardiovascular disease; VHD, valvular heart disease; AF, atrial flutter; CCW, counter-clockwise; CW, clockwise; and CL, cycle length.

TABLE 2. Results of Radiofrequency Linear Ablation

<table>
<thead>
<tr>
<th></th>
<th>Complete ICB</th>
<th>Incomplete ICB</th>
<th>RF No.</th>
<th>Procedure Time, min</th>
<th>Fluoroscopic Time, min</th>
<th>Recurrent AF</th>
<th>Af Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group I (n=54)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I A 4 mm</td>
<td>36 (67%)</td>
<td></td>
<td>3±1</td>
<td>31±12</td>
<td>23±15</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>I B 4→8 mm</td>
<td>12</td>
<td>6</td>
<td>7±2</td>
<td>60±19</td>
<td>49±12</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Group II (n=50)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II A 8 mm</td>
<td>46 (92%)*</td>
<td></td>
<td>2±1*</td>
<td>24±15*</td>
<td>14±10*</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>II B 8→4 mm</td>
<td>0</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are expressed as mean value±SD. Both groups had a follow-up time of 10±5 months. ICB indicates low right atrial isthmus conduction block; RF No., number of applications of radiofrequency current required to achieve complete isthmus conduction block; and AF, atrial fibrillation.

*P<0.05, 8 mm vs 4 mm (II A vs I A).
catheters had a higher successful ablation rate than 4-mm tip catheters (8- versus 4-mm: 92% versus 67%, \( P < 0.05 \)) with a lower mean number of application pulses (2 ± 1 versus 3 ± 1, \( P < 0.05 \)), shorter mean procedure time (24 ± 15 minutes versus 31 ± 12 minutes, \( P < 0.05 \)), and shorter mean fluoroscopic time (14 ± 10 minutes versus 23 ± 15 minutes, \( P < 0.05 \)) required for creation of complete isthmus conduction block. There were no complications related to the ablation procedure in any patient.

**Follow-Up**

During a mean follow-up of 10 ± 5 months (range, 6 to 15 months), patients with incomplete isthmus block had a significantly higher incidence of recurrent AF than those with complete isthmus block (5 of 10 versus 0 of 94, \( P < 0.0001 \)). In all 5 patients with recurrent AF, repeated electrophysiological study revealed recovery of intact isthmus conduction: 1 received amiodarone therapy and the other 4 underwent a second successful ablation session. The incidence of clinically documented atrial fibrillation at follow-up periods was 22% (23 of 104) and was not significantly different in both groups. This finding suggested that the occurrence of atrial fibrillation may not be related to the ablation-induced lesions.

**Discussion**

**Major Findings**

To our knowledge, this is the first prospective randomized study to compare the effects of large (8-mm) and conventional tip electrode (4-mm) catheters on ablation for typical AF. This study demonstrated that an 8-mm tip electrode catheter could facilitate RF linear ablation of typical AF by achieving a higher success rate with a lower pulse number, shorter procedure, and less radiation exposure time required for creation of complete bidirectional isthmus conduction block.

**Effects of a Large Tip Electrode on Radiofrequency Lesion**

Previous experimental studies have shown that increase in ablation electrode size can allow the application of higher RF power, resulting in a further increase in lesion size and depth.\(^{10-12}\) McRury et al demonstrated good correlation between electrode size and temperature with lesion size in temperature-controlled RF ablation model in canine ventricles.\(^{12}\) Langberg et al also showed that the larger electrode could couple higher power and less impedance rise to achieve the preset target temperature.\(^{11}\) In this study, the superiority of the 8-mm tip electrode might rely on a larger and deeper lesion created by 2 mechanisms.\(^{13}\) First, a larger tip electrode with a larger electrode-blood interface area, in particular under high blood flow in the cavotricuspid isthmus area, could increase the convective cooling effect and allow higher RF power delivery to the tissues at the same electrode-tissue interface temperature with resulting greater depth of direct resistive heating. Secondly, increasing electrode-tissue interface area by orienting the electrode as parallel to the tissue as possible during the dragging ablation technique could produce greater width of direct resistive heating. Thus, both increased cooling and increased electrode-tissue interface area with a large tip electrode increase volume of direct resistive heating and create a larger and deeper lesion. Langberg et al showed that thermistor-equipped elongated ablation electrodes (8-mm) coupled to high-power outputs could reproducibly produce lesions approximately 1 cm in diameter and 11 mm in depth.\(^{11}\) In this study, we used a temperature feedback power control (up to 100 W) at a target temperature of 70°C. Accordingly, the 8-mm tip electrode catheter is superior to the 4-mm tip catheter with respect to energy delivery parameters for a steady-state temperature to make a larger and deeper lesion.

Some AF cases demonstrating resistance to or difficulty with RF ablation may be due to a broader or thicker than usual isthmus or to complex isthmus architecture with resulting in adaptation of catheters. Tabuchi et al studied isthmus pathology after RF ablation for the canine AF and demonstrated the requirement of transmural damage of the atrial myocardium from the endocardium to the subepicardium for successful isthmus ablation.\(^{14}\) Therefore, using an 8-mm tip electrode catheter (supported by a long vascular sheath for a consistent good contact with endocardial surface and for making continuous lesions during steadily dragging catheter) might be of particular benefit in linear ablation of broad and/or thickened isthmus by producing adequate lesion size and depth to reduce the possibility of skin lesions (gaps) formation.

**Comparison With Previous Studies**

Feld et al used the electrophysiological approach for AF ablation and compared the efficacy between 8- and 4-mm tip catheter. They showed reductions of the mean number of energy applications (from 11 to 6 pulses) and recurrence rate (from 43% to 10%) by using 8-mm tip electrode catheters.\(^{15}\) Iesaka et al used the anatomical approach for ablation of AF by using an 8-mm tip electrode and used the electrophysiological approach for ablation of AF by using a 4-mm tip electrode. They also concluded that the 8-mm tip electrode reduced the number of energy applications (from 10 to 2.3 pulses) required for successful ablation.\(^{16}\) In these 2 studies, there were some confounding issues on validity of results with regard to different ablation approach methods (anatomic versus electrophysiological approach) and ablation end points (termination and noninducibility versus isthmus conduction block). Additionally, these studies were not randomized controlled studies. Our laboratory had reported that the anatomic approach was time-saving with respect to the procedure time and radiation exposure time compared with electrophysiologically guided focal ablation.\(^6\) Additionally, this study used a randomized prospective method to compare the efficacy of different electrode tip sizes on ablation of AF by the anatomical approach. Thus, this study adds further insight into the superiority of 8-mm tip electrode to 4-mm tip electrode for transisthmus linear ablation of typical AF.

**Clinical Implications**

This study’s results established clearly that 8-mm tip electrodes are more effective and as safe as the standard 4-mm length electrodes in transisthmus linear ablation for typical AF. This clinical benefit of the 8-mm tip catheter for AF...
ablation may be of particular value for some patients with broad and/or thick isthmus.

Acknowledgments

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References

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