Conduction Recovery After Pulmonary Vein Isolation for Atrial Fibrillation

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Background  Although pulmonary vein (PV) isolation is useful for curing atrial fibrillation (AF), its recurrence rate is still high, so the aim of the present study was to investigate the cause of recurrence after PV isolation.

Methods and Results  Eighty-five patients with paroxysmal AF underwent PV isolation and AF recurred in 48 patients after the first session. Thirty of these 48 patients who underwent a second session were evaluated. In 49 (71%) of 69 PVs ablated in 25 patients (83%), recovery of conduction was observed between the left atrium and PV. In 45 (92%) of 49 PVs, conduction recurrences were seen from the same segment or part of a segment that was ablated in the first session. However, in the other 4 PVs (8%), conduction recurrences occurred in a different segment that had not been ablated before. In the second session, the mean number of segments ablated in the PV ostium was significantly less than in the first session (2.3±5.0 vs 4.4±5.6, p<0.01). After the second session, 16 patients (53%) did not show recurrence of AF.

Conclusion  The major cause of recurrence of PV isolation was recovery of PV conduction from the same segment that had been ablated in the PV ostium. Therefore, an additional session may be necessary to increase the success rate. (*Circ J* 2005; 69: 65–68)

Key Words:  Atrial fibrillation; Catheter ablation; Electrophysiology; Pulmonary vein

Ablation for atrial fibrillation (AF) has changed from focal ablation of the pulmonary vein (PV) that was the origin of the AF to electrical isolation of where a PV enters the left atrium (LA). PV isolation has become useful for curing atrial fibrillation (AF) and improving the patient’s quality of life; however, a large percentage of patients require an additional ablation procedure. Therefore, we investigated the cause of recurrence of AF and the maintenance of conduction block across radiofrequency (RF) lesions applied at the PV ostium after PV isolation.

Methods

All patients gave their written informed consent to participate in this study. Patients were included in the study if they met the following criteria: (1) symptomatic AF; (2) drug-refractory AF; (3) age ≤ 75 years; and (4) left atrium maximal transverse diameter of the LA ≤ 50 mm.

Patient Characteristics

The study population consisted of 85 (64 men; 57±11 years) consecutive patients with drug-refractory AF who underwent PV isolation in hospital since 2000; 81 of them had paroxysmal AF and 4 had persistent AF. The patient characteristics are summarized in Table 1. Clinical arrhythmia had been present for a median of 4.8 years (range, 0.1–24 years) and was refractory to 2.4±1.7 antiarrhythmic drugs. Hypertension was documented in 20 patients and 10 had structural heart disease. The LA maximal transverse diameter was 39.0±6.3 mm and the ejection fraction was 65±10%. We studied 30 patients who underwent a second session from among 48 patients who showed recurrence after the first session of RF catheter ablation (RF-CA).

Electrophysiological Study and Catheter Ablation

The electrophysiological study was performed as described previously. A transesophageal echocardiogram was performed before each procedure. Patients who did not have a thrombus in the left atrial appendage underwent PV isolation. Five multipolar catheters were introduced. A 5F decapolar catheter (SUPREME, CSL™; ST. JUDE MEDICAL) was positioned in the coronary sinus through the right internal jugular vein. Two 5F quadripolar catheters (SUPREME, JSN™; ST. JUDE MEDICAL) were positioned at the high right atrium and His bundle region through the left femoral vein. A 7F 4-mm-tip or 8-mm-tip quadripolar ablation catheter (7F BlazerII; Boston Scientific) and a decapolar circular catheter (7F LASSO™, Biosense

### Table 1  Patient Characteristics

<table>
<thead>
<tr>
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<th>Value</th>
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<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>57±11</td>
</tr>
<tr>
<td><strong>M/F</strong></td>
<td>64/11</td>
</tr>
<tr>
<td><strong>Duration of clinical arrhythmia (years)</strong></td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>0.1–24</td>
</tr>
<tr>
<td><strong>No. of refractory antiarrhythmic drugs</strong></td>
<td>2.4±1.7</td>
</tr>
<tr>
<td><strong>Structural heart disease</strong></td>
<td>9</td>
</tr>
<tr>
<td><strong>Coronary artery disease</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Cardiomyopathy</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td>20</td>
</tr>
<tr>
<td><strong>Left atrial diameter (mm)</strong></td>
<td>39.0±6.3</td>
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<tr>
<td><strong>Ejection fraction (%)</strong></td>
<td>65±10</td>
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</tbody>
</table>

Data are mean values (±standard deviation) or number of patients.
Fig 1. A case of conduction recurrence from a segment in which radiofrequency (RF) energy was not applied at the first session, although conduction block was confirmed following the first procedure. Eleven bipolar endocardial electrograms recorded at the first and second sessions of left inferior pulmonary vein (LIPV) disconnection in one patient. (A) During the first session, PV activation potentials recorded through 6 electrode pairs of a spiral catheter (1 and 2 to 6 and 7) separated from the left atrial activation potentials during pacing from the distal coronary sinus. Pulmonary vein potential (PVP) was recorded from the antero-superior to postero-inferior of the LIPV ostia. During the first procedure, PV disconnection was achieved with RF delivery antero-superior (bipole 2–3) to the LIPV orifice. (B) Conduction recurrence was observed during the second session. The PV activation potential recorded through 4 electrode pairs of a spiral catheter (6 and 7 to 9 and 10) was separated from the left atrial activation potentials during pacing from the distal coronary sinus. PVP was recorded from the postero-inferior to the posterior of the LIPV ostia that were not treated with RF energy in the first session. In the second procedure, PV disconnection is achieved with RF delivery postero-inferior (bipole 6–7) to the LIPV orifice. The upper drawing shows the area where RF energy was delivered (solid line) and the position at which PV disconnection was achieved (star). The right panel shows a fluoroscopic right anterior oblique view during PV disconnection in the LIPV. A decapolar circular mapping catheter was positioned at the LIPV ostia.

Fig 2. Other cases of conduction recurrence from sites that did not receive radiofrequency (RF) energy in the first session. Recurrence was seen at the right superior pulmonary vein (PV) in patients 2 and 4 and in the left inferior PV in patient 3. The solid line shows where RF energy was delivered and the solid star shows where PV disconnection was achieved in the first session. The dotted line shows where RF energy was delivered and the striped star shows where PV disconnection was achieved in the second session. In 4 PVs in 4 patients, conduction recurrence was observed at a site that did not receive RF energy at the first session, although conduction block was confirmed at the first procedure. RSPV, right superior pulmonary vein.
Webster or SPIRAL S C, DAIG) were placed transeptally at the ostium of the target PVs with two 8F long sheaths (Fast-Cath, Daig and Soft Tip Sheath, Boston) advanced through the right femoral vein, for detailed mapping and ablation. Selective pulmonary venography enabled the identification of the PV ostia and assessment of the anatomy and diameter before ablation. RF-CA of the PVs was performed at the ostial sites with the earliest PV potential (PVP) around the PV ostium during sinus rhythm, coronary sinus pacing or PV distal pacing using a circular mapping catheter. We targeted all 4 PVs. However, we did not perform PV isolation for PV less than 1 cm in diameter or PV without potential. RF energy was delivered from the ablation catheter at a maximum of 30 W and 50°C for 40–60 s at each site. Heparinization was achieved with 5,000 units (U) infused intravenously just after the Brockenbrough method and each patient underwent constant infusion with 1,000 U/h until the end of the procedure. The end-point of RF ablation was the elimination of LA–PV conduction.

Clinical Follow-up
Clinical follow-up was initiated at the end of the protocol. To confirm the absence of AF, a 12-lead ECG was recorded, and 24-h Holter monitoring was also recorded at 1- or 3-month intervals during the follow-up period. Antiarrhythmic drugs were discontinued, but warfarin was continued during follow-up. Recurrence of AF was defined as the recurrence of symptoms suggestive of tachycardia and an episode of AF documented on the 12-lead ECG or sinus pacing or PV distal pacing using a circular mapping catheter. LA–PV conduction recurred in the same segments as in the first session and in 4 PVs (8%). It was in a different segment to that in the first session, including 2 LSPVs and 2 RSPVs (Figs 1, 2). Conduction recurrence did not occur in the superior segment of the LIPV or in the inferior segment of the RSPV. However, statistical difference was not seen in the distribution of conduction recurrence. Recurrence conduction was delayed for 26.5±27 ms (range, 0–85 ms) in comparison with the conduction before isolation. Unidirectional conduction recovery and delayed success were not seen in these cases. Re-ablation was successfully performed in all PVs at the site of conduction recurrence. The mean number of segments ablated in the PV ostium per one PV in the second session was significantly less than in the first session (2.3±0.5 vs 1.4±0.6; p<0.01). After the second session, 16 (53%) of 30 patients did not have recurrence of AF during 15.5±10 months follow-up.

Complications
One patient had pericardial effusion, but neither PV stenosis nor cerebral infarction was observed. The pericardial effusion disappeared spontaneously without drainage.

Discussion
The results of this study show that conduction recurrence across the LA to the PV at their ostia is a common finding in patients undergoing RF-CA for AF, as noted in previous studies. In 71% of disconnected PVs, conduction recurrence was confirmed at the second session. For this reason, RF energy delivered from the endocardial side may not be adequate at the epicardium in which an atrial muscle sleeve runs from the endocardial side, and conduction block may result from transient edema. In most of the present patients, LA–PV conduction recurred in the same segments as in the first session and AF recurred within 5 days. However, not all of the breakthroughs recovered. The recovery of LA–PV conduction after the first ablation was seen in a few segments (1.4±0.6) and these were focally re-ablated. Recurrence conduction from the LA to the PV was delayed in most cases. Therefore, some regions may not have been adequately lesioned in the first session. However, we cannot identify the locations at which ablation is insufficient if conduction block is complete at that time. Therefore, this recurrence may be caused by transient edema or inflammation. In 4 PVs (8%) in 4 patients, conduction recurred from a point that had not been treated with RF in the first session, even though conduction block was confirmed following the first procedure. The presence of functional conduction block and concealed conduction may explain this phenomenon. Therefore, complete circumferential PV isolation may be necessary to create a conduction block between the LA and PV to cure AF. The use of new devices and techniques, such as an irrigation catheter, hot balloon catheter, and cryo-ablation, may be necessary to prevent recurrence. In segmental PV isolation, additional sessions may provide the opportunity to not only repeat ablation in segments that show recurrence, but also to find other foci that were not seen in the first session.
Study Limitations
The ring catheter at the PV ostium was unstable in some cases, so the PV potentials at the PV may not have been adequately reproduced. To accurately determine the conductivity and distribution, mapping using a basket catheter, which is stable and can record PV distal potentials, may be necessary. Because this was a retrospective study, further detailed prospective examinations may be necessary.

References