Simplified Approach to Radiofrequency Catheter Ablation of Paroxysmal Supraventricular Tachycardia

Lexin Wang\textsuperscript{1,2}, Jingtian Li\textsuperscript{2}, Rongguo Yao\textsuperscript{2}, Shukai Song\textsuperscript{2}

\textsuperscript{1}School of Biomedical Sciences, Charles Sturt University, Wagga Wagga, Australia; and \textsuperscript{2}Department of Cardiology, the Affiliated Hospital of Weifang Medical College, Shandong, the People's Republic of China

\textbf{Aim.} To investigate the safety and efficacy of a simplified approach in radiofrequency catheter ablation of paroxysmal supraventricular tachycardia.

\textbf{Methods.} The study involved 239 patients (118 men and 121 women) with paroxysmal supraventricular tachycardia and normal 12-lead electrocardiographic (ECG) findings at sinus rhythm, who visited the Cardiology Department of Weifang Medical College Hospital between January 2000 and September 2003. The mean age of patients was 39.2±11.9 years. The patients were divided into two groups: one undergoing a conventional 5-catheter ablation (controls), and the other a simplified 3-catheter ablation (study group). The follow up after ablation lasted 12 months. No antiarrhythmic agents were prescribed to the patients with successful ablation.

\textbf{Results.} The conventional and the 3-catheter ablation group did not differ in ablation success (97.5% vs 98.3%, \(p=0.42\)) and recurrence of paroxysmal supraventricular tachycardia (2.5% vs 3.3%, \(p=0.23\)). The simplified approach was associated with a significantly shorter procedure duration (89.1±28.2 vs 96.1±21.2 minutes, \(p<0.01\)) and fluoroscopy time (10.7±2.6 vs 12.7±4.2 minutes, \(p<0.01\)). There were no significant differences between the two groups in the type and incidence of procedural complications and ablation success.

\textbf{Conclusions.} The simplified 3-catheter ablation approach proved to be a safe and effective method for ablation of paroxysmal supraventricular tachycardia. However, further studies including larger sample of such patients are needed to assess the clinical outcomes and cost-effectiveness of this simplified procedure.

\textbf{Key words:} catheter ablation; electrocardiography; heart conduction system; tachycardia, atrioventricular nodal reentry; tachycardia, paroxysmal; tachycardia, supraventricular

Atioventricular reentrant tachycardia and atrioventricular nodal reentrant tachycardia are the two most common forms of paroxysmal supraventricular tachycardia (1-5). The respective anatomical substrates of these two forms of tachycardia are an atrioventricular accessory pathway and atrioventricular nodal dual pathway (6-15). For paroxysmal supraventricular tachycardia, radiofrequency catheter ablation has become the first-line curative therapy, successful in over 90% of the cases and with minimal adverse effects (1-15).

Catheter ablation of atrioventricular reentrant tachycardia caused by Wolff-Parkinson-White syndrome is usually straightforward, because the location of the culprit accessory pathway can be estimated in most patients by a standard 12-lead electrocardiography (ECG). For patients with paroxysmal supraventricular tachycardia but a normal ECG at sinus rhythm, a comprehensive electrophysiological study is usually required immediately before the catheter ablation (3-5). The conventional methods of electrophysiological study and catheter ablation of paroxysmal supraventricular tachycardia involve the positioning of four diagnostic catheters in the coronary sinus, the high right atrium, the bundle of His, and the right ventricular apex, respectively (1-13). A large-tip ablation catheter is then inserted into either left or right atrioventricular annulus to map and ablate the tachycardia substrate for atrioventricular reentrant tachycardia, and in the atrioventricular node for the slow pathway for atrioventricular nodal reentrant tachycardia. We investigated the safety and efficacy of a simplified 3-catheter approach in the electrophysiological study and ablation of paroxysmal supraventricular tachycardia related to either concealed atrioventricular accessory pathway or atrioventricular nodal dual pathway.

\textbf{Patients and Methods}

\textbf{Patients}

Patients were selected among all patients visiting the Cardiology Department of Weifang Medical College Hospital between January 2000 and September 2003. Patients who had a normal
The paroxysmal supraventricular tachycardia in these patients ranged from 1-23 years (mean±SD, 7.9±5.3 years). There was no significant difference in patients' age, sex distribution, and duration of paroxysmal supraventricular tachycardia between the control and study groups. All but three of these patients had one or more tachycardia ECGs and half of them were treated with an antiarrhythmic drug before the study. Patients with a tachycardia ECG suggesting atrial tachycardia, atrial flutter or atrial fibrillation were excluded.

After obtaining an informed consent form from the patients, a detailed medical history was collected and a thorough physical examination was conducted. A standard 12-lead body surface ECG and two-dimensional echocardiography was also performed. The study was approved by the Human Ethics Committee of Weifang Medical College Hospital.

A total of 239 consecutive patients were divided, according to the order of consultation for ablation, into two groups: one to undergo a conventional 5-catheter ablation (control group), and the other to undergo a simplified 3-catheter ablation (study group). There were 118 men and 121 women, aged 39.2±11.9 years (Table 1).

### Table 1. General characteristics of the patients with paroxysmal supraventricular tachycardia undergoing radiofrequency catheter ablation

<table>
<thead>
<tr>
<th>Approach† (No. of patients, %)</th>
<th>conventional</th>
<th>simplified</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n=119)</td>
<td>(n=120)</td>
<td></td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td>57 (47.9)</td>
<td>61 (50.8)</td>
</tr>
<tr>
<td>Age (mean±SD, years)</td>
<td>39.9±13.8</td>
<td>38.7±1.14</td>
</tr>
<tr>
<td>Duration of PSVT</td>
<td>7.8±4.2</td>
<td>8.1±5.6</td>
</tr>
<tr>
<td>(mean±SD, years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. (%) of patients with AVNRT</td>
<td>49 (41.2)</td>
<td>51 (42.5)</td>
</tr>
<tr>
<td>AVRT</td>
<td>70 (58.8)</td>
<td>69 (57.5)</td>
</tr>
<tr>
<td>LVFW</td>
<td>56 (47.1)</td>
<td>53 (44.2)</td>
</tr>
<tr>
<td>LVSEPT</td>
<td>6 (5.0)</td>
<td>9 (7.5)</td>
</tr>
<tr>
<td>RVFW</td>
<td>4 (3.4)</td>
<td>3 (2.5)</td>
</tr>
<tr>
<td>RVSEPT</td>
<td>4 (3.4)</td>
<td>4 (3.3)</td>
</tr>
</tbody>
</table>

*Abbreviations: SD – standard deviation; AVNRT – atrioventricular nodal reentrant tachycardia; AVRT – atrioventricular reentrant tachycardia; LVFW – left ventricular free wall pathway; LVSEPT – left posteroseptal pathway; RVFW – right ventricular free wall pathway; RVSEPT – right posteroseptal pathway; PSVT – paroxysmal supraventricular tachycardia.
†There were no statistically significant differences between the two groups.

**Electrophysiological Examination**

All antiarrhythmic drugs were discontinued for at least five half-lives before the electrophysiological examination and catheter ablation.

In the control group, the conventional electrophysiological examination and radiofrequency catheter ablation techniques were used. These techniques were reported in detail elsewhere (11-13,16). In brief, under local anesthesia, three 6-French quadripolar electrode catheters were advanced via the right femoral vein to the right ventricular apex, His bundle, and high right atrium, respectively. A 10-electrode catheter was positioned in the coronary sinus via the left subclavian vein.

A programmed stimulation protocol, including S1S2 and incremental stimulations was performed in the right ventricular apex and the high right atrium, respectively, to examine the physiological properties of the atrioventricular node and to induce paroxysmal supraventricular tachycardia. If paroxysmal supraventricular tachycardia was not induced, intravenous isoproterenol was administered to increase the heart rate by 20-25%; programmed stimulations were then repeated in the right ventricular apex or the high right atrium.

In the study group, a simplified, 3-catheter approach was used. A 10-electrode catheter was positioned in the coronary sinus via the left subclavian vein. A 6-French quadripolar electrode catheter was positioned in the His bundle area via the right femoral vein. A 7-French, 4-mm tip ablation catheter was also introduced via the right femoral vein to the right atrium or right ventricular apex for programmed stimulation or induction of paroxysmal supraventricular tachycardia.

**Conventional 5-catheter Ablation**

A standard 7-French, 4-mm tip ablation catheter was introduced via the right femoral vein to the tricuspid annulus for the radiofrequency ablation of atrioventricular nodal reentrant tachycardia. Slow pathway ablation was always attempted by positioning the tip of the ablation catheter midway between the His bundle and the ostium of the coronary sinus (12,16). The radiofrequency energy between 25-30 W was delivered when an atrial and ventricular electrogram ratio was <0.5 (12,16).

Application of radiofrequency current was terminated if there was no junctional rhythm within 10 s of the ablation. Application was also terminated if there was no ventriculo-atrial conduction during junctional rhythm, or if there was more than 50% PR interval prolongation on the body surface ECG.

The atrioventricular nodal reentrant tachycardia ablation was considered successful if tachycardia was no longer inducible with intravenous infusion of isoproterenol, and if no more than two atrioventricular reentrant beats (echo beats) were induced by programmed stimulation.

For the ablation of right-sided atrioventricular accessory pathway, an ablation catheter was introduced via the right femoral vein to the tricuspid annulus. The radiofrequency energy was delivered to the site where the shortest ventriculo-atrial interval during right ventricular pacing was recorded by the ablation catheter (11,13). With the left-sided accessory pathways, the ablation catheter was retrogradely introduced from the right femoral artery to the mitral annulus. The techniques to localize and ablate the accessory pathways were similar to those used for the right-sided pathway ablation (11,13).

The ablation of atrioventricular reentrant tachycardia was considered successful if ventriculo-atrial conduction was decreased during right ventricular pacing, or if there was a ventriculo-atrial conduction block, and if there was no inducible atrioventricular reentrant tachycardia.

**Simplified 3-catheter Ablation**

The ablation of atrioventricular nodal reentrant tachycardia or right-sided atrioventricular accessory pathways was carried out in a similar fashion to that used in the control group, with the ablation catheter positioned in the right atrium or ventricle during the initial electrophysiological study.

With left-sided atrioventricular accessory pathway, the ablation catheter in the right heart was withdrawn and re-positioned to the left mitral annulus via the right femoral artery. The His bundle electrode catheter was advanced to the right ventricular apex for pacing and induction of atrioventricular reentrant tachycardia.

Heparin (3,000-5,000 units) was intravenously administered only in patients with arterial catheterization of more than 30 minutes. All patients were observed in hospital for 2-3 days after the ablation procedure, with a daily 12-lead ECG recording and physical examination. A 12-lead ECG and physical examination was also carried out on monthly basis in the outpatient clinic in the first two months after the hospital discharge. The follow up was then conducted every month until 12 months have elapsed.

No antiarrhythmic agents were prescribed to the patients with successful ablation.

**Statistical Analysis**

Data were expressed as means±standard deviation (SD). Differences in patients' age, duration of ablation procedure and fluoroscopy, and the number of applications of radiofrequency energy between the control and study groups were analyzed by Student t-test. Percentages were analyzed by chi-square test. P<0.05 was considered to be statistically significant. SPSS statisti-
cal software, version 11.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

Results

Electrophysiological Examination

Atriointerural nodal reentrant tachycardia was found in 49 (41.2%) control and 51 (42.5%) study patients (Table 1). Seventy (58.8%) control patients and 69 (57.5%) study group patients had a concealed atrioventricular accessory pathway. The most common location of the accessory pathways was the left ventricular free wall, followed by left postero-septum. There was no significant difference in the distribution of accessory pathways between the two groups (Table 1).

Right-sided accessory pathways were identified in 15 patients (6.3%). In these patients, an additional diagnostic electrode catheter was inserted via the femoral vein and advanced to the right atrium or ventricle to optimize the mapping of these pathways.

Catheter Ablation

Similar ablation success rate was achieved in the control and the study group (Table 2). Atriointerural nodal reentrant tachycardia was eliminated in all patients. In the control group, two right-sided and one left-sided accessory pathway could not be ablated. In the study group, ablation attempts failed to eliminate one right-sided and one left-sided pathways.

Table 2. Results of radiofrequency catheter ablation performed in paroxysmal supraventricular tachycardia

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Approach (No. of patients, %)</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall success</td>
<td>conventional (n = 119)</td>
<td>simplified (n = 120)</td>
</tr>
<tr>
<td></td>
<td>116 (97.5%)</td>
<td>118 (98.3%)</td>
</tr>
<tr>
<td>Duration of procedure</td>
<td>99.8 ± 14.2</td>
<td>89.1 ± 18.2</td>
</tr>
<tr>
<td>Fluoroscopy time (mean ± SD, min)</td>
<td>13.0 ± 3.1</td>
<td>10.7 ± 2.6</td>
</tr>
<tr>
<td>Number of RF* applications</td>
<td>6.3 ± 4.9</td>
<td>6.1 ± 4.2</td>
</tr>
<tr>
<td>Recurrence</td>
<td>3 (2.5%)</td>
<td>4 (3.3%)</td>
</tr>
</tbody>
</table>

RF* indicates radiofrequency current.

The average number of radiofrequency energy applications was similar in both groups (Table 2). The average duration of the procedure and the fluoroscopy time in the study group were shorter than those in the control group (p = 0.007 and p = 0.002 respectively).

Complications and Recurrence of Paroxysmal Supraventricular Tachycardia

Two patients in the control group and one patient in the study group who underwent a successful ablation of atrioventricular nodal reentrant tachycardia or atrioventricular reentrant tachycardia developed a mild left pneumothorax after the catheterization of left subclavian vein. The pneumothorax resolved four days after the procedure without the need for any specific medical intervention. Three patients in the control group and two patients in the study group who underwent ablation of atrioventricular nodal reentrant tachycardia also experienced first-degree atrioventricular block. There were no other clinically significant complications, such as severe bleeding of cardiac perforation in both groups.

After 5-17 (mean ± SD, 8.3 ± 4.1) months of follow up, paroxysmal supraventricular tachycardia recurred in three (2.5%) patients in the control group (left postero-septal accessory pathway in one, and atrioventricular nodal reentrant tachycardia in two patients) and in four (3.3%) patients in the study group (atriointerural nodal reentrant tachycardia in three patients, and right postero-septal accessory pathway in one). The difference in the recurrence rate of paroxysmal supraventricular tachycardia was not statistically significant between the two groups. A second ablation attempt, with conventional approach for the three control group patients, and simplified approach for the four study group patients, eliminated paroxysmal supraventricular tachycardia in all seven patients.

Discussion

The results of the present study showed that the simplified 3-catheter approach had a similar therapeutic efficacy and safety to the conventional 5-catheter technique but had the benefits of reduced procedure time and X-ray exposure of both patients and operating physicians. In approximately 90% of the paroxysmal supraventricular tachycardia patients, two diagnostic catheters and an ablation catheter was all that was required for the successful ablation of PSVT.

Our knowledge on the clinical manifestations and underlying electrophysiological features of paroxysmal supraventricular tachycardia has grown exponentially since the introduction of radiofrequency catheter ablation more than a decade ago (1-7). We now know that most forms of paroxysmal supraventricular tachycardia patients with a normal sinus rhythm ECG are due to either atrioventricular reentry related to a concealed accessory pathway, or atrioventricular nodal reentry owing to the presence of atrioventricular nodal dual pathways (1-15). A small proportion of paroxysmal supraventricular tachycardia is also due to atrial tachycardia or atrial flutter, which can be differentiated in many patients from atrioventricular reentrant tachycardia or atrioventricular nodal reentrant tachycardia by analyzing the tachycardia ECG. For these reasons, our hypothesis was that the conventional 5-catheter technique for the study and ablation of paroxysmal supraventricular tachycardia may not be necessary for every patient, and two diagnostic electrode catheters and an ablation catheter may be sufficient to complete the electrophysiological examination and ablation in a single session in some patients with paroxysmal supraventricular tachycardia.

One of the potential drawbacks of the simplified ablation approach is that in patients with multiple atrioventricular accessory pathways, or more than one tachycardia form, additional one or two diagnostic electrode catheters may be needed to optimize mapping or pacing (17). In patients with a right free wall or postero-septal accessory pathway, at least one additional electrode catheter is required to map the activation of the right atrium (17). Furthermore, in the
event of complete heart block or severe bradycardia, which may occur during atrioventricular nodal reentrant tachycardia ablation, a pre-positioned electrode catheter in the right ventricular apex may be advantageous. However, the potential shortcomings mentioned above do not seem to be clinically significant. First, the introduction of one or two additional electrode catheters was required in only about 7% of the procedures in our study. Second, the addition of electrode catheters did not increase vascular complications, such as hemorrhage, because this was taking place during the electrophysiological study phase when patients were not yet heparinized. Finally, complete heart block or severe bradycardia requiring temporary pacing occurs in only a small proportion of patients during ablation procedures (6,8). Usually, there is sufficient time for the introduction of a new pacing catheter in these circumstances. Alternatively, the His bundle catheter may be advanced to the right ventricle for urgent temporary pacing before the introduction of an additional electrode catheter.

The cost-effectiveness of the simplified ablation approach was not evaluated in the present study. With a reduced procedure time and catheter uses in up to 90% of the patients, a significant cost reduction is expected. A recent clinical observation, although not a randomized controlled study, on a modified ablation technique similar to ours estimated that the average cost saving was US$474 for a 3-catheter ablation procedure (17).

In summary, this randomized, prospective study has shown that the simplified 3-catheter technique is safe and effective in the electrophysiological study and radiofrequency ablation of paroxysmal supraventricular tachycardia related to atrioventricular accessory pathway or atrioventricular nodal dual pathways. Additional diagnostic catheters can be safely deployed during the procedure to assist the mapping and ablation in patients with right-sided accessory pathways. Further studies are required to assess the clinical outcomes and cost-effectiveness of this simplified procedure in a larger patient population.

References

Received: July 15, 2003
Accepted: January 28, 2004

Correspondence to:
Lexin Wang
School of Biomedical Sciences
Charles Sturt University
Wagga Wagga, NSW 2678, Australia
lwang@csu.edu.au