Clinical Research

A three-pulmonary vein isolation approach to treat paroxysmal atrial fibrillation

Lexin Wang, Jing Zhou

Objective To investigate the safety and efficacy of a 3-pulmonary vein (PV) isolation approach in treating paroxysmal atrial fibrillation (AF). Methods Radiofrequency catheter ablation was used to eliminate PV potential in 11 patients with frequent paroxysmal AF refractory to anti-arrhythmic agents. During sinus rhythm, PV potential was mapped in the left and right superior PVs and left inferior PV. The procedural success was defined as the elimination of PV potential in the 3 PVs. Results PV potential was identified and abolished in a total of 24 PVs, mostly in the left and right superior PV. There was no pulmonary stenosis or other complications during or after the procedures. AF recurred in one patient after an average of 12 ± 3 month follow-up. Conclusions PV potentials were present mostly in the left or right superior PV. The 3-PVs isolation approach is safe and effective in preventing drug-resistant paroxysmal AF. (J Geriatr Cardiol 2004;1:29-34.)

Key Words radiofrequency catheter ablation; atrial fibrillation; pulmonary veins; tachycardia; electrophysiology

Introduction

Atrial fibrillation (AF) is a common arrhythmia associated with significant morbidity and mortality. The incidence of AF is approximately 2-3 per 1000 people per year between the ages of 55 and 64 years. A much higher incidence of AF is found in subjects over 80 years old. In most cases, AF is due to multiple, small reentrant circuits occurring in random order in the atrium. Recent studies show that a rapidly firing focus in or close to the pulmonary veins could also be the cause of paroxysmal AF.

For many years, the surgical “MAZE” operation to compartmentalize the atria has been the only curative therapy for AF. Transcatheter linear radiofrequency ablation in the right and/or the left atrium has been used to replicate the surgical procedures in patients with paroxysmal or chronic AF. This catheter technique, however, is time consuming and associated with a high incidence of AF recurrence. Recently, radiofrequency catheter ablation of triggering foci in the pulmonary veins (PV) has been shown to eliminate paroxysmal AF initiated from these foci. The primary purpose of the study was to investigate the safety and clinical results of pulmonary vein isolation in treating drug-resistant paroxysmal AF.

Subjects and methods

Patient characteristics

Eleven consecutive patients with paroxysmal AF were selected for PV isolation. Patient characteristics were shown in Table 1. There were 7 males and 4 females with a mean age of 43. All patients had paroxysmal AF for an average of 7 years before coming for ablation. The frequency of AF before the ablation was at least fortnightly after unsuccessful anti-arrhythmic drug therapy. Two patients had controlled hypertension at the time of the ablation. The left atrial diameter and the left ventricular function measured with echocardiography were within the normal range in these patients (Table 1).

Electrophysiological study

Anti-arrhythmic drugs were discontinued for more than 5 half-lives. Under local anesthesia, quadripolar 6F catheters were placed in the coronary sinus, right atrium and right ventricular apex. Atrial transeptal catheterization was then performed, and a decapolar Lasso circular mapping catheter (Biosense Webster, CA, USA) was positioned in one of the PVs after PV angiography (Fig.1).

No attempt was made to induce ectopic beats or AF during the study. Mapping of the PV potentials was started from the left superior PV, followed by the left inferior and the right superior PV. An arrhythmogenic PV was defined on the basis of PV potential, and/or ectopic beats if present.
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Table 1. Patient characteristics

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<thead>
<tr>
<th>Patient</th>
<th>Age/Sex</th>
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LA: left atrium. EF: ejection fraction

Fig. 1. A fluoroscopic view of the position of the ring-shaped Lasso mapping catheter positioned in the right superior pulmonary vein. The distance between the pulmonary vein ostium and the catheter was approximately 18 mm. The catheter at the lower part of the Lasso catheter was the ablation catheter where a sharp pulmonary vein potential was registered by both the Lasso catheter electrode in that location and the tip of the ablation catheter.

Ablation procedure

Ablation was attempted during the sinus rhythm. The target sites were the sites where PV potentials were recorded by the Lasso catheter. The perimeter of the PV ostium was mapped with the ablation catheter to localize the ostial site showing the highest and sharpest PV potentials. The ablation sites were confined to the proximal PV, approximately within 15 mm of the ostium. No ablation was attempted in PV sites deeper than the ostial segment to avoid potential stenosis. In each patient, the PV isolation was attempted in all PVs with PV potentials.

If ectopics were present, the target sites were those with earliest activation. Sites with PV potentials were also attempted.

Radiofrequency energy was delivered at the distal electrode of the thermocouple-equipped catheter, with a target temperature of 50 °C and a power limit of 25-30 W. Each radiofrequency ablation was approximately 100 sec. PV angiography was performed at the end of each ablation to verify that the PV potency was unchanged. The end points of ablation were the elimination of PV potentials in all mapped PVs, and ectopics, if present.

Patients were discharged three days after the ablation under oral anticoagulation for three months. The procedure was considered a success when the AF episodes were totally eliminated without anti-arrhythmic drugs.

Heparin (60 units/kg, iv) was administered immediately after transseptal catheterization. It was then administered in a dose of 2000-3000 U at 1-hour intervals until the completion of the ablation procedure.

Statistics

This was a prescriptive study; therefore no statistical analysis was attempted. Data are presented as mean ± SD for continuous variables and frequencies for categorical variables.

Results

Electrophysiological studies

Frequent ectopic beats and short runs of AF (> 30 sec) were observed in 7 and 2 patients, respectively, during the electrophysiological study (Table 2). The initiation and maintenance of AF in those two patients were due to a rapidly firing focus in the left and right superior PV, respectively. Ectopic beats initiated from the left superior PV in 2, from the right superior PV in 4,
and from both right and left superior PV in 1 patient, respectively. During the ectopic beats, PV potentials preceded atrial potentials by an average of $102 \pm 21$ msec.

Ablation results

The ablation was attempted in a total of 24 PVs from which PV potentials were registered by the mapping and ablation catheter (Table 2, Fig. 2A). Ablation within the PV ostium eliminated the PV potentials in all these PVs (Fig. 2B). In the patients with ectopic beats or short runs of AF, elimination of PV potentials was accompanied by the disappearance of the ectopy and short runs of AF. The average duration of procedure and fluoroscopy time was $210 \pm 26$ min and $26 \pm 3$ min, respectively (Table 2).

There were no complications during or immediately after the ablation procedures. The angiographic diameter of the pulmonary veins where ablation was performed remained unchanged after the ablation ($23 \pm 6$ vs $22 \pm 4$ mm, $P > 0.05$).

Follow-up

Patients were discharged without anti-arrhythmic drugs. During the follow-up of 12 ± 3 months, 10 patients were symptom free. Body surface ECG and 24-hour Holter monitoring at the end of the follow-up showed no atrial ectopic beats or AF. Paroxysmal AF recurred in one (9.1%) patient 12 months after the initial successful ablation. PV angiography was not performed in the 11 patients during the follow-up, but no clinical evidence suggesting the occurrence of PV stenosis was observed.

Table 2. Electrophysiological and ablation data

<table>
<thead>
<tr>
<th>Patient</th>
<th>Ectopy</th>
<th>AF</th>
<th>Ablated PVs</th>
<th>Procedural duration (min)</th>
<th>Fluoroscopic time (min)</th>
<th>RF pulses (no.)</th>
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<tr>
<td>Mean ± SD</td>
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<td>210 ± 26</td>
<td>26 ± 3</td>
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Ectopy and AF: spontaneous ectopy and atrial fibrillation during baseline study; RSPV and LSPV: right and left superior pulmonary vein; LIPV: left inferior pulmonary vein; RF: radiofrequency.

Fig. 2A. Pulmonary vein (PV) potential from the right superior PV. The sharp tail spike on the Lasso catheter (Las1, 2, Las7, 8) shows the PV potential. CS, coronary sinus; ABL, ablation catheter.
**Discussion**

**PVs and AF**

PVs, as shown in the present study, have recently been recognized as an origin of paroxysmal AF. The muscular wall of the left atrium may extend up to a few centimeters around the PVs, forming a muscular sleeve. A longer muscular sleeve was found in the superior PVs. Animal studies have shown that sinus node-like cells, or myocardial cells with pacemaker activities, are present in the muscle sleeves that encircle the PVs.

There has been no direct evidence supporting the presence of node-like or pacemaker cells in human PVs. However, previous electrophysiological studies in patients with paroxysmal AF have demonstrated that rapidly firing foci can be identified in and around the PVs, and that ablation of the foci may lead to disappearance of AF.

Using PV potentials as a guide, Chen et al. reported that the superior PVs have a longer myocardial sleeve than the inferior PVs, whereas the left PVs have longer myocardial sleeves than the right-sided ones. In the present study, frequent ectopic beats which led to short runs of AF in some patients were found in the left and right superior PVs where PV potentials were also recorded. More importantly, ablation of PV potentials prevented paroxysmal AF in all patients who had frequent AF before the ablation. These data indicate that myocardial cells around the PV ostium play a key role in the pathogenesis of AF.

Although every PV is potentially involved in the pathogenesis of AF, most arrhythmogenic foci were found in the upper right or left pulmonary vein. In many patients, more than two arrhythmogenic foci are often identified. Our study also shows that PV potentials, an indicator of arrhythmogenic tissues, were often found in the superior PVs.

**PV isolation for AF**

The best approach of locating the ablation sites within the PVs remains controversial. A combination of anatomical isolation of PVs and electrophysiology based mapping and ablation may be the most appropriate. In patients with spontaneous or inducible ectopic beats with the PVs, the target sites should be those showing the earliest activation. Ablation should be confined to the PV ostium, and ablation at distal branches should be avoided to reduce the incidence of pulmonary stenosis. The end point of ablation is the elimination of ectopic beats.

In the present study, PV potentials, regardless of the spontaneous ectopic beats from the PVs, were used to guide PV ostium ablation or PV isolation in the two superior and the left inferior PV. The main reason for this approach is that first of all, it is the activities of muscular sleeves in the PVs that cause AF and therefore, elimination of PV potentials would destroy the arrhythmogenic tissue and prevent AF. Secondly, attempts to induce ectopic beats during the mapping may provoke prolonged AF, which may require cardioversion. The disadvantage of the PV potential guided approach is that every PV must be mapped, and PVs with PV potentials are isolated. The extensive mapping and ablation is likely to increase the duration of procedure and fluoroscopy exposure, which was approximately 3.5 hours.
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and 26 min respectively in the present study. This approach, however, appears to offer excellent medium- to long-term results. A previous study showed that the elimination of PV potentials correlated better with clinical success than the acute suppression of arrhythmias. In the present study, AF recurrence was found in only one patient after a follow-up of 12 months. We primarily targeted the superior PVs and the left inferior PV for mapping and isolation. The right inferior PV was not routinely mapped or isolated. The reason is mainly that arrhythmogenic foci were located in the superior PVs in most patients with paroxysmal AF. Furthermore, with a PV potential-guided approach that targets these 3 PVs, a clinically satisfactory result can be achieved in more than 80% of patients with paroxysmal AF.

Long-term results of PV isolation

The long-term effect of PV isolation in preventing paroxysmal AF requires further follow-up study. In patients who had almost fortnightly AF attacks before the ablation, AF recurrence was detected in only one patient 12 months after the ablation. Previous studies in larger patient samples also demonstrated that 70-85% of the patients remain free of paroxysmal AF 6-10 months after PV ablation. Recovery of local PV potentials after the initial successful ablation is associated with the recurrence of AF. Furthermore, using a large-tip (8 mm) ablation catheter appears to increase the long-term success. No immediate or long-term complications from the PV ablation have occurred in the present study. Although PV angiography or transesophageal echocardiography was not performed during the follow-up, clinically significant PV stenosis is unlikely since no such clinical symptoms suggesting these complications were observed.

Conclusions

The importance of PVs in the initiation of paroxysmal AF has clearly been demonstrated in the present study. The 3-PV isolation approach guided by PV potentials appears to be safe and effective in preventing AF attacks in the medium-term. The curative technique should be recommended to patients with paroxysmal AF resistant to anti-arrhythmic drugs.

References

