

# Observation of the efficacy of radiofrequency catheter ablation on patients with different forms of atrial fibrillation

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**Abstract. – OBJECTIVE:** To study the efficacy and safety of radiofrequency catheter ablation (RFCA) in patients with different forms of atrial fibrillation.

**PATIENTS AND METHODS:** By retrospective analysis, we summarize 720 cases, where patients diagnosed with atrial fibrillation in our hospital were treated with RFCA from February 2010 to October 2014. Among the cases, 425 were diagnosed with paroxysmal atrial fibrillation and 295 with non-paroxysmal atrial fibrillation (including persistent atrial fibrillation and permanent atrial fibrillation). All patients were followed up until June 2015 to compare and analyze the differences in operation success rates, complications and recurrence rates.

**RESULTS:** 395 cases (92.9%) of paroxysmal atrial fibrillation and 253 cases (85.8%) with non-paroxysmal atrial fibrillation were subject to surgery and followed up. The age of onset, disease course, underlying diseases, left atrial diameter and combined anti-arrhythmics of patients with paroxysmal atrial fibrillation were lower than those of patients with non-paroxysmal atrial fibrillation, and the differences were statistically significant ( $p < 0.05$ ). The success rate of the first ablation was higher than that of non-paroxysmal atrial fibrillation. Procedure time, procedure method, complications and recurrence rate of patients with paroxysmal atrial fibrillation were lower than those of non-paroxysmal atrial fibrillation group, and the differences were statistically significant ( $p < 0.05$ ). When we compared apoplexy and heart failure caused by atrial fibrillation in the two groups, the difference was not statistically significant (Apoplexy:  $p = 0.186$ ; Heart failure:  $p = 0.170$ ).

**CONCLUSIONS:** The individual ablation success rate was higher for paroxysmal atrial fibrillation, and long-term follow-up showed that the occurrence of apoplexy and heart failure was not different from the non-paroxysmal atrial fibrillation group.

*Key Words:*

Radiofrequency ablation, Paroxysmal atrial fibrillation, First ablation success rate.

## Introduction

Atrial fibrillation (AF) is a common form of arrhythmia, whose incidence increases with age<sup>1,2</sup>. In 2010, atrial fibrillation guidelines first proposed that patients with atrial fibrillation of Grade IA can be used as indications for catheter ablation in any experienced hospital (over 50 cases of ablation annually). Almost all studies<sup>3,4</sup> that compared catheter ablation and anti-arrhythmic drugs in treating atrial fibrillation found without exception that catheter ablation was more effective than drug therapy in maintaining sinus rhythm, improving quality of life and other parameters. At present, there is no long-term efficacy data following treatment by RFCA, due to the fact that the recurrence of asymptomatic atrial fibrillation after surgery may not be recognized by patients or doctors, and the recurrence risk of asymptomatic atrial fibrillation is uncertain. Therefore, there are still debates on whether patients with atrial fibrillation at risk of stroke should stop anticoagulant therapy following RFCA<sup>5,6</sup>. Moreover, there is currently little data on the long-term efficacy of RFCA on patients with atrial fibrillation combined with heart failure and other serious structural heart diseases<sup>7</sup>. Great progress has been made in the treatment of atrial fibrillation by RFCA, but there remain disputes regarding the efficiency and safety of the initial treatment<sup>8,9</sup>. Here, we summarize and analyze the

efficacy of RFCA on patients with different forms of atrial fibrillation through a single-center, relatively large sample size and fairly long-term follow-up study.

## Patients and Methods

### Patients

We retrospectively summarize 720 cases of patients diagnosed with atrial fibrillation in our hospital and treated with RFCA from February 2010 to October 2014. 425 were cases of paroxysmal atrial fibrillation and 295 cases were non-paroxysmal atrial fibrillation (including persistent atrial fibrillation and permanent atrial fibrillation).

**Diagnostic criteria:** In accordance with the atrial fibrillation diagnosis and standard classification proposed by Ganesan et al in 2016<sup>10</sup>, paroxysmal atrial fibrillation is an episode that lasts  $\leq 7$  days (usually  $< 48$ h) and is self-limiting; Persistent atrial fibrillation lasts  $> 7$  days but  $< 1$  year and heart rhythms cannot recover itself, is resistant to drug treatment, and usually requires electro cardioversion. In addition, patients with atrial fibrillation whose seizure duration lasts over 1 year are classified as permanent atrial fibrillation.

**Inclusion criteria:** (1) Diagnosed with atrial fibrillation by dynamic electrocardiogram prior to surgery; (2) Examined for absence of left atrial thrombus as determined by examination

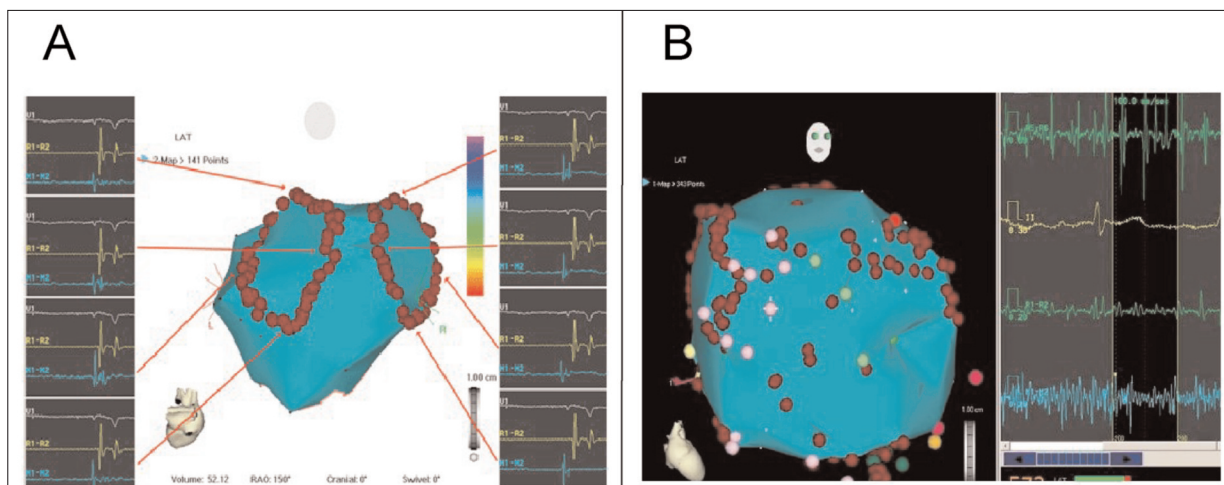
by transesophageal ultrasonography; (3) Standard treatment with anti-arrhythmia agents were ineffective or patients were unwilling to accept drug treatment; (4) Patients stopped taking anti-arrhythmia agents for at least 5 half-lives of the drug before surgery.

**Exclusion criteria:** (1) History of past treatment with RFCA; (2) Atrial fibrillation after heart surgery; (3) Inability to operate due to the use of anticoagulant therapy; (4) Cases lost in follow-up (12 cases were lost in the follow-up in the present study).

## Treatment Methods

### Paroxysmal Atrial Fibrillation

Patients underwent left atrial linear ablation surrounding the ipsilateral pulmonary veins under the guidance of the Carto 3-dimension operation system (Johnson & Johnson, Piscataway Township, NJ, USA). The ablation catheter was set at  $43^{\circ}\text{C}$  when ablating, and cold saline was persistently infused to irrigate catheters during the procedure. The output power used during the operation was 35W for the anterior wall, and 25W for the posterior wall. The time for each ablation was roughly 35 seconds. Determination of the end of radiofrequency ablation: pulmonary vein potential completely disappeared and no recurrence occurred for at least 30 minutes, or bidirectional conduction block of electronic activity between the pulmonary vein and the left atrium (Figure 1A).



**Figure 1.** Operation schematic under Carto 3-dimension system. **A**, Left atrial linear ablation surrounding the ipsilateral pulmonary veins. **B**, A combined ablation with the routine ablation of tissue surrounding the ipsilateral pulmonary vein and potential breakdown.

### **Non-paroxysmal Atrial Fibrillation**

The operating equipment used was the same as that for paroxysmal atrial fibrillation. Patients had combined ablation (with the routine ablation of tissue surrounding the ipsilateral pulmonary vein). The operating process included conventionally conducting right atrial isthmus ablation after circumferential pulmonary vein ablation (CPVA), and then conducting left atrial isthmus, apex and was the appendage ablated, breakdown potential and superior vena cava isolation in accordance with whether there were spontaneous or induced non-atrial arrhythmias. The endpoint of ablation was determined as complete preset ablation line step by step and direct current electric conversion performed on patients with atrial fibrillation that did not cease. The second ablation indication for recurrence of atrial fibrillation was conducted as detailed in methods (Figure 1B).

### **Outcomes**

Patients were followed-up until June 2015 to compare and analyze differences in parameters including sex, age, duration of atrial fibrillation, underlying diseases, average heart rate, left atrial diameter, left ventricular internal diameter, left ventricular ejection fraction, postoperative anti-arrhythmia drugs used, success rates of the first ablation, operation time, operation method, complications and recurrence rates as well as occurrence rates of stroke and heart failure caused by atrial fibrillation between the two groups.

### **Statistical Analysis**

Data were logged and processed using the SPSS 19.0 software package (SPSS Inc., Chicago, IL, USA).

Data is presented as mean  $\pm$  standard deviation. A *t*-test was adopted for comparison between groups; case number or percentage was used to show the enumeration materials,  $\chi^2$  was adopted for comparison among groups; *p* < 0.05 was taken as statistically significant.

## **Results**

### **Comparison of Characteristics Between the Two Patient Groups**

A total of 395 cases of paroxysmal atrial fibrillation (92.9%) and 263 cases of non-paroxysmal atrial fibrillation (89.2%) underwent ablation procedure and were followed up. The difference between the two groups was not statistically significant ( $\chi^2 = 3.176, p = 0.075$ ). The age of onset, disease course, underlying diseases, left atrial diameter and postoperative combined anti-arrhythmics of the paroxysmal atrial fibrillation group were significantly lower than those of the non-paroxysmal atrial fibrillation group (*p* < 0.05) (Table I).

### **Comparison of First Ablation Success Rate, Operative Time, Operative Method, Complications and Recurrence Rate**

Patients in the paroxysmal atrial fibrillation group were followed for 6-63 months (average: 38.4 $\pm$ 6.5 months), and patients in the non-paroxysmal atrial fibrillation group were followed for 6-62 months (average: 37.6 $\pm$ 7.2 months). The difference in follow-up time was not statistically significant (*t* = 0.528, *p* = 0.634). The first ablation success rate of the paroxysmal atrial fibrillation

**Table I.** The comparison of baseline materials between two groups.

Baseline material	Non-paroxysmal atrial fibrillation group (n = 395)	Non-paroxysmal atrial fibrillation group (n = 263)	t ( $\chi^2$ )	P
Male/Female	233/162	145/118	0.959	0.327
Age (year)	47.6 $\pm$ 8.3	59.3 $\pm$ 10.8	3.913	0.041
Disease course (month)	6.5 $\pm$ 1.7	15.7 $\pm$ 4.6	4.233	0.033
Rheumatic valvular disease	68	8	106.063	< 0.001
Ischemic heart disease	42	65		
Cardiomyopathy	24	46		
Average heart rate (time/minute)	93.4 $\pm$ 13.5	96.6 $\pm$ 16.7	0.364	0.417
Left atrial diameter (mm)	31.5 $\pm$ 4.1	39.8 $\pm$ 6.6	3.373	0.034
Left ventricular diameter (mm)	53.6 $\pm$ 3.3	55.1 $\pm$ 3.5	0.674	0.523
Left ventricular ejection fraction (%)	56.1 $\pm$ 5.7	52.9 $\pm$ 7.8	0.895	0.627
Usage rate of postoperative combined Antiarrhythmic agents	63 (15.9%)	225 (85.6%)	310.762	< 0.001

**Table II.** The comparison in success rate of the first ablation, operation time, operation method, complication and recurrent rate.

Items	Paroxysmal atrial fibrillation (n = 395)	Non-paroxysmal atrial fibrillation (n = 263)	t ( $\chi^2$ )	P
Success rate of the first ablation	356 (0.1)	132 (50.2)	131.416	< 0.001
Operation time (min)	65.4 ± 16.7	115.7 ± 23.4	6.345	0.019
Operation method (type)	1.1 ± 0.2	2.3 ± 0.5	5.362	0.027
Complications	51 (12.9)	79 (30.0)	29.211	< 0.001
Recurrent rate	95 (24.1)	126 (47.9)	40.288	< 0.001

tion group was higher than that of the non-paroxysmal atrial fibrillation group ( $p < 0.05$ ), while the operative time, operative method, complications (including cardiac tamponade, pulmonary edema, pneumonia, vascular complications, fatal arrhythmia, etc.) and recurrence rate were lower than those of the non-paroxysmal atrial fibrillation group, and the differences were statistically significant ( $p < 0.05$ ) (Table II).

**Comparison of Occurrence Rate of Apoplexy and Heart Failure**

We next compared the occurrence rate of stroke and heart failure caused by atrial fibrillation between the two groups, but the difference was not statistically significant for either parameter ( $p > 0.05$ ) (Table III).

**Discussion**

Since the early 1990s, rapid progress has been made in RFCA treatment. As to whether it is more effective than drug therapy in preventing mortality associated with atrial fibrillation remains to be seen. At present, there is no large sample, clinical controlled study to demonstrate this one<sup>11,12</sup>. However, it has been shown that RFCA was more effective than drug therapy in cardiac rhythm maintenance and quality of life improvement<sup>13</sup>. RFCA has been recommended as the first-line treatment for patients with symptomatic atrial fibrillation<sup>14,15</sup>. Also a multi-center, randomized controlled trial,

known as the *ThermoCool* study, published in 2010<sup>4</sup>, demonstrated this one<sup>16</sup>. Because studies on RFCA treatment in patients with different types of atrial fibrillation mostly have small sample sizes, there fewer data to be generated from follow-up because the sample number is small and therefore inefficient conclusive evidence on the effectiveness of RFCA in treating the different forms of atrial fibrillation. Through retrospectively following 395 cases of patients with paroxysmal atrial fibrillation that underwent surgery and 263 cases of non-paroxysmal atrial fibrillation (median 38 months), we can conclude that: the age of onset, disease course, underlying diseases, left atrial diameter and use of combined anti-arrhythmics after surgery in the paroxysmal atrial fibrillation group were significantly lower than that of the non-paroxysmal atrial fibrillation group. In clinical practice, the basic status (left atrial diameter, left ventricular diameter, average heart rate, and the duration of atrial fibrillation, etc.) of patients with non-paroxysmal atrial fibrillation was closely related to the result of the surgery. There are possible causes: (1) The left atrial diameter of patients with non-paroxysmal atrial fibrillation is generally increased and atrial function is decreased, which may increase postoperative recurrence rate<sup>17</sup>; (2) An enlarged atrium may lead to the enlargement of ablation scope and to avoid excessive damage, the pulmonary vein potentials originally for pulmonary vein ablation were not completely removed<sup>18</sup>; (3) Non-paroxysmal atrial fibrillation is associated with the presence of ectopic foci. While

**Table III.** Follow up and compare the occurrence rate of apoplexy and heart failure [case(%)].

	Paroxysmal atrial fibrillation group (n = 395)	Non-paroxysmal atrial fibrillation group (n = 263)	t ( $\chi^2$ )	P
Apoplexy	14	15	1.747	0.186
Heart failure	21	21	1.881	0.170
Total occurrence rate	35 (8.9)	36 (13.7)	3.822	0.051



the current elicitation method and testing indications have certain limitations, ectopic foci cannot be completely tested<sup>19</sup>. The success rate of the first ablation of the paroxysmal atrial fibrillation group was significantly higher than that of the non-paroxysmal atrial fibrillation group, while the operation time, operation method, complications and recurrence rates were significantly lower than the non-paroxysmal atrial fibrillation group. Treatment of atrial fibrillation by RFCA has a high risk of complications. The main complications include pulmonary vein stenosis, pericardial tamponade, pleural effusion, atrial arrhythmia and atrial systolic functional limitations, and the prevalence of complications between patients with different types of atrial fibrillation were different<sup>20</sup>. This study demonstrated that the prevalence of complications in the non-paroxysmal atrial fibrillation group was significantly lower, mainly because patients with non-paroxysmal atrial fibrillation were treated with combined ablation, which had a large ablation scope and larger damage scope and easily resulted in the occurrence of various complications.

Although non-paroxysmal atrial fibrillation had a lower first ablation success rate, higher recurrence rate and higher second ablation rate, the long-term follow-up found that the difference in the occurrence of apoplexy or heart failure caused by atrial fibrillation between the two groups was not statistically significant. This possibility has not yet been proposed in previous studies, and our results may provide more powerful evidence for RFCA treatment in cases of non-paroxysmal atrial fibrillation. The application of radiofrequency energy to perform circumferential pulmonary vein ablation to treat paroxysmal atrial fibrillation is recognized as an effective treatment while a limitation was that point-by-point ablation was needed to form linear lesions for pulmonary vein electrical isolation<sup>21</sup>. The STOP-AF study, presented recently at the ACC annual conference, compared and analyzed cryoplasty ablation and drug treatment in controlling THE cardiac rhythm of paroxysmal atrial fibrillation<sup>22</sup>. Cryoplasty refers to placing a balloon on the opening of the left atrial and pulmonary veins and inflating refrigerant into the balloon, thereby damaging pulmonary vein vestibulum tissue in order to achieve pulmonary vein electronic isolation. The rate of pulmonary vein electronic isolation was 98%. One-year follow-up found that the maintenance rate of sinus rhythm of the ablation group and THE drug-treatment group was 69.9%

and 7.3% respectively ( $p < 0.001$ ), which showed that cryoablation pulmonary vein isolation was more effective than anti-arrhythmic treatment. Cryoablation simplified the catheter ablation operation in pulmonary vein vestibulum, and there was almost no difference between the rate of pulmonary vein electronic isolation versus simple radiofrequency ablation. Although phrenic nerve paralysis and other adverse reactions may occur, the majority of patients can recover. Additional data from the STOP-AF study demonstrate that cryoablation is another effective ablation energy in addition to radiofrequency energy.

Although great progress has been made in the field of atrial fibrillation treatment, there are still many questions worthy of attention: is the efficacy of the new anticoagulant Apixaban as effective as Warfarin? How safe is, and what are the long-term effects of left atrial appendage occlusion and can they be applied and popularized routinely in clinical practice? What ARE the long-term efficacy and late recurrence of ablation on the development of thromboembolism? When can patients stop oral anticoagulation therapy? All these questions require further research in order to find some solutions<sup>23,24</sup>.

## Conclusions

Paroxysmal atrial fibrillation has a high individual ablation success rate, and long-term follow-up found that the prevalence of apoplexy and heart failure is not different from patients with non-paroxysmal atrial fibrillation.

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## Conflict of Interest

The Authors declare that there are no conflicts of interest.

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