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Clinical Electrophysiological Features and Radiofrequency Ablation of Patients with Atrial Fibrillation

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ABSTRACT

This study aimed to investigate electrophysiological features of radiofrequency ablation surgery in patients with the atrial fibrillation (AF). Fifty patients were included in this study and evenly divided, with 25 AF patients in the experiment group and 25 patients with arrhythmias in the control group. General clinical materials in the two groups were collected. Then, patient number of pulmonary vein antrum potential trial, intra-right atrial conduction time, intra-left atrial conduction time, interatrial conduction time, conduction time between atrium, and pulmonary veins trials were utilized to measure the efficacy of radiofrequency ablation surgery in patients with AF and clarify the relationship between AF and electrophysiological features in the atrium and pulmonary veins. Our study findings showed that conduction time interval between the atrium and pulmonary veins trial by radiofrequency ablation surgery were significantly less than those in pre-treatment AF patients. We can conclude that radiofrequency ablation surgery can effectively treat AF patients by relieving the electrophysiological dysfunction, and radiofrequency ablation can be used to prevent the development of AF.

INTRODUCTION

Atrial fibrillation (AF) is the most serious atrial electrical activity disorder. It has been associated with the regular and orderly atrial electrical activity replaced by rapid and disorderly atrial fibrillation waves [Lau 2019; Reddy 2017]. AF is characterized with common tachyarrhythmias that mainly target the pulmonary vein (PV), and it includes persistent atrial fibrillation and pulmonary vein antrum potential. Some clinical trials have pointed out that age, gender, genes, cardiomyocyte effective refractory period, myocardial conduction velocity, ectopic electrical activity in pulmonary veins and environmental determinants can be pathogenic factors. Additionally, hypertension, diabetes, myocardial infarction have been considered potential risk factors [Carlisle 2019; Marrouche 2018]. Clinically, AF can cause a series of symptoms to patients, such as severe stroke, heart failure and relative complications, and these clinical symptoms and severe complications would be life-threatening and devastating [Rukovets 2021; Hamatani 2021]. Previous clinical experiments by Leong et al. and Healey et al. [Leong 2013; Healey 2020] reported the incidence of AF in China is about 0.77%, and the incidence of AF in people older than 80 years is as high as 7.5%. With the development of surgery and techniques, circumferential pulmonary vein isolation (CPVI) and catheter ablation surgery widely have been used to treat AF patients for years, and these surgeries have helped with preventing the development of AF. In addition, a clinical study suggests that radiofrequency ablation has shown great potential in treating the AF by inhibiting the ectopic electrical activity in pulmonary veins and has been a first-line option, because radiofrequency ablation is relatively fixed, relatively clear, and the success rate is satisfactory [Yao 2018]. However, the detail effect of radiofrequency ablation in AF patients is still controversial. Some trials have reported that P radiofrequency ablation is associated with effective pulmonary vein isolation and can decrease the arrhythmia recurrence [Andrade 2019; Wazni 2021]; these previous results provide only limited information. Therefore, we should conduct further clinical studies to clear the detailed efficacy of radiofrequency ablation in minimizing ectopic electrical activity in pulmonary veins.

Previous studies have confirmed that radiofrequency ablation technology can treat AF patients by regulating ectopic electrical activity. Radiofrequency ablation, which can reduce the surgery area of the pulmonary vein and the atrial tissue near the pulmonary vein to achieve the purpose of reducing ectopic electrical activity by using microwave magnetic, and microwave magnetic can be used as an alternative technology to reduce surgical blood loss, causing revascularization, minimizing heat dissipation, and it usually obtains a complete, uniform and predictable ablation effect by providing low electrical conductivity, thermal conductivity [Izzo 2019]. A clinical trial by Narayan et al. [Narayan 2012] confirmed the success rate of radiofrequency ablation treatment in the pulmonary vein of AF patients is significantly higher those in circumferential pulmonary vein isolation in AF patients. Therefore, radiofrequency ablation technology widely has been used to treat many diseases such as AF and tumors. But it is unclear whether radiofrequency ablation contributes to treating AF patients by regulating the ectopic electrical activity. And it is

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urgent to find a safe and effective treatment method of treating AF. Interestingly, electrophysiological features can accurately reflect the characteristics of ectopic electrical activity in AF patients. Therefore, the electrophysiological features in our study were utilized to evaluate the effect of these features in treating AF patients.

Electrophysiological feature refers to the technology that stimulates the organism with various forms of energy, such as electricity, sound, and so on. We can obtain the electrical characteristics of the organism by recording and analyzing the electrical phenomena [Merchant 2020]. Electrophysiological is a specific technology of measuring AF patients; it has been clinically used for AF patients for decades in our hospital. Electrophysiological is a kind of electrical characteristic that reflects the patients, involving repetitive atrial activity changes and fractionated atrial activity changes [Marot 2021]. Left atrial myocardial tissue may extend into the pulmonary vein and participate in the development of AF. However, the detailed effect of pulmonary vein in the progress of AF is controversial. A previous clinical study by Jais et al. [Jais 2002] confirmed that radiofrequency ablation in the pulmonary veins of patients can interfere with electrophysiological.

In our study, electrophysiological in AF patients is detected to investigate the detailed efficacy of radiofrequency ablation in the pulmonary veins in AF patients.

MATERIALS AND METHODS

Patients: Twenty-five patients with AF from our hospital, from January 2020 to December 2021, were included in this clinical study as the experiment group. During the same period, 25 patients with arrhythmias also were enrolled in this trial as the control group. The patients for the clinical study were willing to be treated by radiofrequency ablation surgery. All study protocol were prospectively reviewed and approved by the Use Committee of our hospital, and written informed consent forms from all patients were obtained.

Inclusion criteria: For patients in the control group, patients had no history of AF, and patients had left accessory pathways combined with paroxysmal supraventricular tachycardia confirmed by preoperative and intraoperative electrophysiological examinations. For patients in the experiment group, patients were diagnosed with AF by preoperative and intraoperative electrophysiological examinations, according to Heart Rhythm Society and European Society of Cardiology.

Patients in the control group and experiment group had no history of radiofrequency ablation surgery and agreed to receive the radiofrequency ablation surgery. All patients were required to record detailed clinical material and electrophysiological examination.

Exclusion criteria: Patients had radiofrequency ablation surgery performed; those with significant cardiac structural abnormalities, such as rheumatic heart disease, pulmonary heart disease, cardiomyopathy, and congenital heart disease; patients who disappeared during follow up.

Trial design: All patients in the control and experiment groups had radiofrequency ablation surgery carried out. Preoperative preparation of all patients was conducted. First, all patients stopped taking antiarrhythmic drugs for at least five half-lives, and blood routine, coagulation function, thyroid function, liver and kidney function indicators and other relative indexes were detected. For patients with atrial fibrillation,

Figure 1. 3D reconstruction images between the control group and experiment group by polyconductive physiological recorder.

transesophageal echocardiography or left atrium enhanced CT examination were used to rule out complicated intracardiac thrombosis, and then anticoagulation therapy was maintained until the day of surgery. After a septal puncture, a radio frequency ablation instrument (Biosense Webster, Inc.) was utilized to perform the radiofrequency ablation surgery. The ablation catheter was sent into the left atrium along the atrial septal puncture sheath and connected to the three-dimensional mapping and ablation system. The pre-transmission V wave was the target, and the temperature was controlled at 60°C, and the power value was set at 30-60W. An effective target should block the atrioventricular bypass of the catheter partial discharge within 3 seconds, and it should be confirmed that the left accessory pathways remained blocked until the end of the operation. After radiofrequency ablation surgery, electrophysiological features in the control group and experiment group were tested using a polyconductive physiological recorder (Prucka Cardio Lab4000, CE Corp, USA). Briefly, the electrocardiogram lead and intracardiac filtering range were set at a value of 30-500 Hz, and multi-lead synchronous recording was performed. The screen speed was set at a value of 50-200 mm/s, and the gain was set a value of 0.1-0.2 mv/cm. The negative pole was connected to the distal end of the pacing catheter. Intra-right atrial conduction time, intra-left atrial conduction time, interatrial conduction time, time interval Bidirectional conduction time between atrium and pulmonary veins trial were recorded. 3D reconstruction images for AF and arrhythmias patients are presented in Figure 1. (Figure 1)

General clinical material: All patients in this study were required to collect the relative clinical material, including gender, age, atrial fibrillation history, left atrial anteroposterior diameter, and left ventricular dilatation. This material was recorded and analyzed.

Patient number of pulmonary vein antrum potential trial: When the ring electrode was located at the pulmonary vein opening, the time interval started from the local A-wave transition to the end of the pulmonary vein potential. We measured the PVAP in the vestibule of each pulmonary vein in control group and experiment group using a polyconductive Physiological Recorder.

Intra-right atrial conduction time test: In this study, the right atrial conduction time refers to the time interval from the P wave in standard lead II to the A wave in the CS electrode proximal in sinus rhythm. Intra-right atrial conduction times in all patients were measured.

Intra-left atrial conduction time test: The right atrial conduction time refers to the time interval from the A wave in the CS proximal electrode and the A wave in the CS distal electrode in sinus rhythm. Intra-left atrial conduction times in all patients were measured.

Interatrial conduction time test: Interatrial conduction time test in our study is defined as the interval time from the P wave in standard lead II to the A wave in the CS distal electrode in sinus rhythm. Interatrial conduction time in all patients was measured.

Conduction time interval between atrium and pulmonary veins trial: Time interval of conduction time between the atrium and pulmonary veins trial refers to the premature stimulation performed in the CS electrode and the ring electrodes were located distal to the corresponding pulmonary veins, the interval time from the signal in premature stimulation in CS electrode to the signal in the corresponding pulmonary veins. Time interval of conduction time between the atrium and pulmonary veins trial in all patients were measured.

Statistical analysis: SPSS 20.0 statistical software was used for statistical analysis. Measurement data are expressed by mean ± standard deviation (x±s); t test was used to compare the difference between two groups. Count data are expressed by percentage, and Chi-square test was used to compare the difference between pre-treatment groups and post-treatment groups. $P < 0.05$ showed the difference was significant.

RESULTS

The general material of patients in control group and experiment group: For all patients, general clinical material, including gender, age, atrial fibrillation history, left atrial anteroposterior diameter, and left ventricular dilatation were recorded. (Table 1) A total of 50 patients were enrolled (27 males and 23 females). Patients in the control group had a mean age of 49.8±8.6 years, and patients in the experiment group had a mean age of 50.3±10.5 years. Atrial fibrillation history in the control group and experiment group were 0 and 27.5±13.6 months; the difference between them was significant ($P < 0.05$). Gender, left atrial anteroposterior diameter, and left ventricular dilatation between the control and experiment groups were not significant.

Number of patients, pulmonary vein antrum potential trial: Pulmonary vein antrum potential in the pulmonary vein ostia in the control and experiment groups – patients are

Table 1. Baseline data in the control and experiment groups

Group	Age (year)	Gender (M/F)	Atrial fibrillation history (month)	Left atrial anteroposterior diameter (mm)	Left ventricular dilatation (mm)
Control group ($N = 25$)	49.8±8.6	12/13	0	36.2±6.4	50.1±6.1
Experiment group ($N = 25$)	50.3±10.5	14/11	27.5±13.6*	39.2±8.8	51.6±5.5

*$P < 0.05$ vs. control group

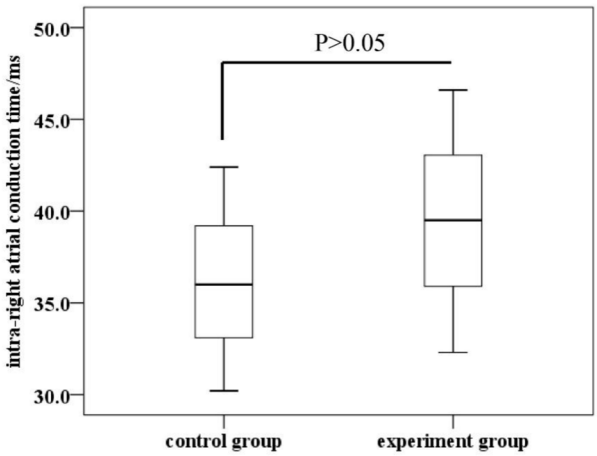

Figure 2. Intra-right atrial conduction time in the control group and experiment group are measured by polyconductive physiological recorder and the value depicted in Figure 1. P > 0.05 vs. control group.

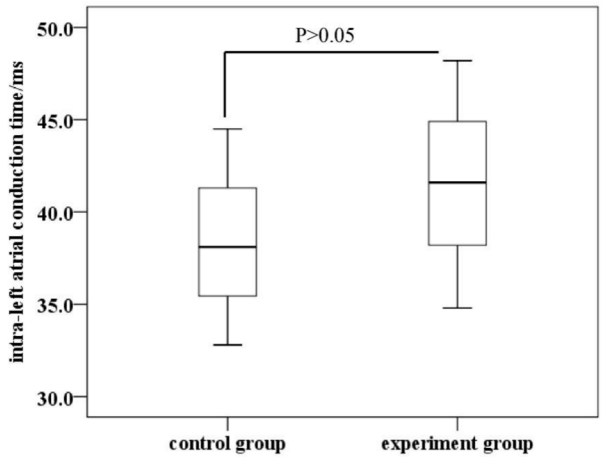

Figure 3. Intra-left atrial conduction time in the control group and experiment group are measured by polyconductive physiological recorder and the value depicted in Figure 2. P > 0.05 vs. control group.

Table 2. Number of patients with pulmonary vein antrum potential

Variable	Control group	Experiment group	*P*
Number of patients (%)	5/25 (20%)	17/25 (68%)	<0.05

Table 3. Interval of conduction time between atrium and pulmonary veins trial

Variable	Control group	Experiment group
Pre-treatment	127.6±25.8	150.2±32.5
Post-treatment	121.4±24.6	124.3±21.8
P	>0.05	<0.05*

*$P < 0.05$ vs. control group

measured by polyconductive physiological recorder. (Table 2) Number of patients in the control and experiment groups are 5/25 (20%) and 17/25 (68%), respectively. Chi-square test showed the difference between the two groups is significant.

Comparison of intra-right atrial conduction time: Intra-right atrial conduction time in the control group and experiment group also were tested. (Figure 2) Compared with the control group, the value of intra-right atrial conduction time in the experiment group was not significant ($P > 0.05$).

Comparison of intra-left atrial conduction time: Intra-left atrial conduction time in the control group and experiment group also was tested. The result is shown in Figure 3. (Figure 3) Compared with the control group, the value of intra-left atrial conduction time in the experiment group was not significant ($P > 0.05$).

Comparison of interatrial conduction time: Interatrial conduction time in the control group and experiment group were tested, and the result is shown in Figure 4. (Figure 4) Compared with the control group, the value of interatrial conduction time in the experiment group was not significant ($P > 0.05$).

Comparison of conduction time interval between the atrium and pulmonary veins: The time interval of conduction time between the atrium and pulmonary veins trial in the control group and experiment group by polyconductive physiological recorder are shown in Table 3. (Table 3) Compared with time interval of conduction time between the atrium and pulmonary veins trial in pre-treatment in the experiment group, that in post-treatment was significantly decreased ($P < 0.05$). However, time interval of conduction time between the atrium and pulmonary veins trial between pre-treatment in the control group and post-treatment in the control group was not significantly different. Radiofrequency ablation treatment in patients with AF produces a marked decrease.

DISCUSSION

The pathogenesis of atrial fibrillation still is not unclear. Currently, previous trials have confirmed that age, gender, genes, and cardiomyocyte effective refractory period are involved in the development of AF. Pulmonary vein antrum potential trial in pulmonary vein ostia in AF patients also has a close relationship with the development of AF. Children with OSAHS also increase the complexity of OSAHS. However, its detailed effect still is controversial. It was reported by Khaykin et al. [Khaykin 2009] that abnormal pulmonary vein antrum potential trial can accelerate the progress of AF by increasing the time interval of conduction time between the atrium and pulmonary veins, but this study provided limited information. Previous clinical studies have proven that radiofrequency ablation surgery has exhibited potential treatment

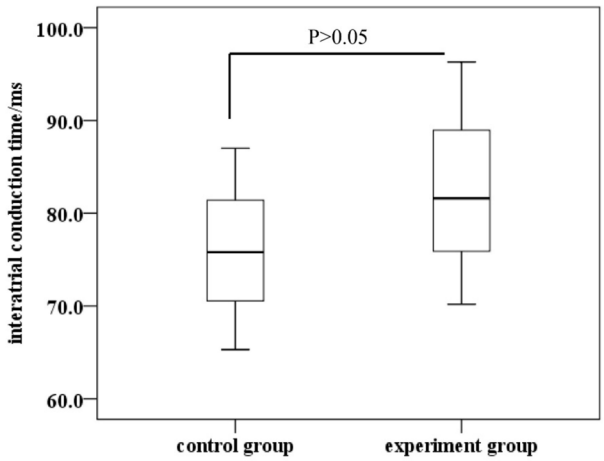

Figure 4. Interatrial conduction time in the control group and experiment group are measured by polyconductive physiological recorder and the value depicted in Figure 3. P > 0.05 vs. control group.

efficacy for AF patients [Johnson 2021; Antoun 2021]. To further clarify the effect of radiofrequency ablation surgery in AF patients and the detailed effect of pulmonary vein antrum potential in AF patients, it is urgent to take measures to prevent the development of OSAHS. Electrophysiological features and radiofrequency ablation of patients with atrial fibrillation in our study were investigated.

To assess the treatment outcome of radiofrequency ablation surgery in AF patients, general clinical materials for all patients were collected and used to analyze the difference between AF patients and patients with arrhythmias. General clinical materials, such as gender, age, atrial fibrillation history, left atrial anteroposterior diameter, and left ventricular dilatation were recorded in our study; these items are consistent with corresponding clinical studies [Yonekawa 2021]. In addition, intra-right atrial conduction time, intra-left atrial conduction time, interatrial conduction time between the pre-treatment group and post-treatment group also were used to evaluate the efficacy radiofrequency ablation surgery in AF patients. These outcomes showed that radiofrequency ablation surgery can effectively prevent the development of AF by decreasing the intra-right atrial conduction time, intra-left atrial conduction time, interatrial conduction time, and decrease the risk of atrial dysfunction. These results are similar to studies by Ghandi et al. and Hayashi et al. [Ghandi 2019; Hayashi 2021]. These clinical outcomes suggest that radiofrequency ablation surgery has a protective effect in the patients with AF.

To further confirm electrophysiological features of pulmonary veins in AF patients, time interval of conduction time between the atrium and pulmonary veins were used to monitor the effect of radiofrequency ablation surgery in patients with AF. Thus, we can more clearly distinguish the electrophysiological features of AF patients. The results in our study showed that time interval of conduction time between the atrium and pulmonary veins in post-treatment in the experiment group was significantly decreased than that in pre-treatment in the experiment group. However, there was no significant difference in time interval of conduction time between the atrium and pulmonary veins between post-treatment and pre-treatment in the experiment group. These outcomes illustrate that radiofrequency ablation surgery can effectively treat the patients with AF by regulating the pulmonary veins. Retrospective clinical studies by Shroff et al. and Kumagai suggest that the A/N value of adenoid hypertrophy in patients with OSAHS are significantly decreasing [Kumagai 2022; Shroff 2021]. The results are consistent with those reported in previous studies.

CONCLUSION

In conclusion, the results in our clinical study suggest that radiofrequency ablation surgery has shown potential protective effect in patients with AF by regulating the electrophysiological features in the pulmonary veins, which provides a foundation of radiofrequency ablation surgery treatment for AF patients by minimizing the conduction time between the atrium and pulmonary veins.

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