Efficacy of catheter ablation and surgical CryoMaze procedure in patients with long-lasting persistent atrial fibrillation and rheumatic heart disease: a randomized trial

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Aims
Catheter ablation and surgical Maze procedure are effective in treating atrial fibrillation (AF) patients. However, there is no study that compares the effect of circumferential pulmonary vein isolation (CPVI) combined with substrate ablation after valvular surgery and the concomitant Maze procedure for the treatment of AF in patients with rheumatic heart disease (RHD). The aim of this study was to compare the effectiveness of CPVI combined with substrate modification and surgical Maze procedure using Saline-Irrigated Cooled-tip Radiofrequency Ablation (SICTRA) system for the treatment of long-lasting persistent AF in patients with RHD.

Methods and results
Between January 2006 and June 2008, 99 patients with long-lasting persistent AF and RHD were randomly assigned to undergo valvular operation and CPVI combined with substrate modification 6 months after the surgery (Group A, 49 patients) or valvular operation and concomitant Maze procedure (Group B, 50 patients). The mean follow-up periods were 15 ± 5 and 20 ± 8 months in Groups A and B, respectively. After one procedure, Group B had a significantly higher freedom from atrial arrhythmias compared with Group A (82% in Group B vs. 55.2% in Group A, P < 0.001). Fifteen patients in Group A underwent a redo procedure. Six patients in Group B underwent catheter ablation and four were treated successfully. The cumulative rates of sinus rhythm were 71% in Group A and 88% in Group B (P < 0.001).

Conclusion
The concomitant Cox Maze procedure using SICTRA is more effective than subsequent CPVI combined with substrate modification in treating patients with long-lasting persistent AF and RHD.

Keywords
Atrial fibrillation • Catheter ablation • Maze procedure • Rheumatic heart disease

Introduction
Atrial fibrillation (AF) is the most common arrhythmia, being present in 0.4% of the general population and up to 60% of patients with rheumatic heart disease (RHD). Catheter ablation for AF which contains circumferential pulmonary vein isolation (CPVI), mapping and ablating complex fractionated atrial electrograms (CFAEs), and left atrial linear ablation, has been shown to be effective in treating patients with paroxysmal and persistent AF. In a recent study, we have demonstrated that CPVI in combination with substrate modification was safe and effective in treating patients with persistent AF and RHD, with a success rate of 66.7% after 12 months follow-up. The Cox Maze procedure was developed as a surgical treatment for AF, and the restoration of sinus rhythm has been reported to be effective in 90% of patients. Despite its high efficacy, however, the Cox Maze procedure has not gained wide acceptance because of the complexity of the procedure. To reduce the complexity of the
procedure, other sources of energy such as radiofrequency (RF) have been used to create transmural intra-atrial lesions instead of the original ‘cut and sew’ technique. In patients with RHD, the effectiveness of the Maze procedure is questionable and showed diminished efficacy.

Therefore, we hypothesized that CPVI combined with substrate modification of AF is as effective as Cox Maze operation in case of RHD. The purpose of this study was to compare the efficacy of CPVI combined with substrate modification and Cox Maze in treating patients with RHD and our primary endpoint was single procedure success rate.

Methods

Study design and study populations
This study was a prospective, randomized, controlled trial. The study protocol was approved by the Ethics Committee of our institution. Eligible patients were assigned to one of the two study arms according to the randomization sequence generated by random number table. All patients were informed of the investigation nature of the procedure and informed consents were obtained from all subjects. We consecutively selected 106 patients with RHD and persistent AF pre-existing for more than 1 year who underwent valvular heart operation at Shanghai Chest Hospital Affiliated to Shanghai Jiaotong University from January 2006 to June 2008. The pre-operative records of the patients were carefully scrutinized to ensure that the AF was continuous and not intermittent. The patients were randomly divided into two groups: catheter ablation group (Group A) and Cox Maze group (Group B), with 53 patients in each group. The inclusion criteria were as follows: inpatients of either sex, aged 18 or greater, with RHD and long-lasting persistent AF, AF must be symptomatic and refractory to at least one anti-arrhythmic medication, and the patients willing to provide written informed consent. Patients with paroxysmal AF, non-RHD, left atrial thrombus on transoesophageal echo prior to the procedure, previously undergone AF ablation and valve commissurotomy were excluded. Figure 1 summarized the flowchart and the ablation strategy of the study.

Surgical procedure
All operations were performed by means of a median sternotomy using standard cardiopulmonary bypass. The heart was arrested by infusing a cold blood cardioplegic solution through the aortic root. The diseased valve was either repaired or replaced and the left atrial appendage was sewn at its base in both groups of patients. An additional modified Maze III procedure using Saline-Irrigated Cooled-tip Radiofrequency Ablation (SICTRA) system (Cardioblate, Medtronic Inc.) was performed in patients of Group B as described previously. The SICTRA set-up consisted of radiofrequency generator (CardioRhythm-ATAKR, Medtronic) and a unipolar catheter (Cardioblate, Medtronic). The catheter was irrigated with saline solution at a flow rate of 300 mL/h. The energy delivered by the SICTRA to create the lesions was 30 W. The temperature-guided energy applications were performed with a pre-selected catheter-tip temperature of 60°C. For catheter ablation of AF was mainly performed in left atrial, we did not perform right atrial SICTRA, and left-side SICTRA was performed as described by Abreu Filho et al. The ablation pattern in the left atrium (LA) included RF isolation of the left and right pulmonary veins (PVs), an interconnecting line between them, a left PV to atrial appendage line, and a mitral annulus to PV line. Patients in Group A only underwent valvular operation.

Post-operative care and follow-up in Group B
Early post-operative care was similar to that for the routine open-heart surgery. The cardiac rhythm was continuously monitored until a stable rhythm returned. Anti-arrhythmic drugs was administrated on a routine basis, and amiodarone was the first choice anti-arrhythmic drug given intravenously, starting at a dose between 900 mg and 1200 mg/day after weaning from cardiopulmonary bypass. After the patients were discharged from the intensive care unit, the drug was given orally, starting at 600 mg/day for 1 week and then tapered to 200–400 mg/day for 3 month. Amiodarone was discontinued if the patient remained in sinus rhythm 3 month after the surgical procedure.

The anticoagulation management protocol was the same as that applied for routine open-heart surgery. Heparin was administrated after resolution of post-operative bleeding. After removal of chest tubes, oral anticoagulant therapy with warfarin was started as a long-lasting treatment, targeting international normalized ratio range 2.5–3.0.

All data were obtained for each patient during the post-operative period, before hospital discharge, and after the third, sixth, and twelfth post-operative month. Surface electrocardiogram (ECG) was performed and repeated 1 day, 1 week, 1, 3, 6, and 12 months post-procedure. Monthly telephone inquiry was applied to evaluate the severity of symptoms, and cases were always asked to record their ECG when having symptoms indicating AF onset. Twenty-four hour Holter recording was performed at 3-month intervals post-procedure to document any form of atrial arrhythmias. Spiral computed tomography was performed at 3 months after the procedure in all cases to assess PV stenosis.

We set the blanking period of the first 1 month after operation. After the blanking period, any episode of symptomatic or asymptomatic atrial tachyarrhythmias lasting over 30 s with ECG/Holter documentation was considered a recurrence. All patients diagnosed with post-operative atrial arrhythmias were advised to undergo electrophysiological study with radiofrequency ablation option. Cather ablation was performed at least 6 month after the operation. First, we checked if there PV-left atria reconnection and ablated, then CFAEs and linear ablation was performed using the method described in the following section.

Post-operative care and catheter ablation for atrial fibrillation in Group A

Post-operative care
Patients in Group A received only rate control therapy after open-heart surgery. Beta-blockers and digoxin was used and cardiac rhythm was continuously monitored until a stable rhythm returned. Other anti-arrhythmic drugs were not used to avoid the effect of sinus rhythm restoration of those drugs. Surface ECG were performed and repeated 1 day, 1 week, 1, 3, and 6 month post-operation. Twenty-four hour Holter morning was performed at 3 and 6 month after the operation. Patients with post-operative AF were subjected to catheter ablation. Warfarin was used as a long-lasting anticoagulation treatment, targeting INR range 2.5–3.

Electrophysiological study
Patients with post-operative atrial arrhythmias received an electrophysiological study and subsequent catheter ablation of AF 6 months after the heart surgery. Before ablation, all patients underwent transoesophageal echocardiography to exclude intracardiac thrombi. Warfarin was discontinued and low-molecular heparin was used 3 days pre-ablation. All anti-arrhythmic drugs were discontinued five half-lives before electrophysiological study and ablation. Electrophysiological study was performed under post-absorptive state with conscious
Patients received heparin before the transseptal puncture and throughout the electrophysiological study and ablation procedure to maintain an active clotting time (ACT) of 300–350 s and usually ACT was measured at 30 min interval during the procedure. One decapolar catheter (Biosense Webster) was advanced into coronary sinus via left subclavian vein access. One decapolar circular mapping catheter (Lasso, Biosense Webster) was positioned in every PV ostium via transseptal approach to map PV potentials (PVP). Surface ECG and bipolar endocardial electrograms were stored continuously for further analysis. Bipolar recording were filtered from 30 to 500 Hz. The sheaths were irrigated with saline at the dose of 1 mL/min throughout the procedure.

Figure 1 Flowchart of the study protocol.
Catheter ablation for atrial fibrillation

After repeat transseptal puncture, an 8F Swartz sheath was introduced into LA. Selective retrograde PV venography was performed via the sheath to identify the ostia of PVs. A saline-irrigated 3.5 mm catheter (Thermocool Navistar, Biosense Webster) was utilized. Under the guidance of electroanatomical mapping system (CARTO, Biosense Webster), we reconstructed LA anatomy, taking care to avoid metal valve impairment or catheter entrapment when manipulating the catheter at the mitral annulus. Each PV ostium was identified and tagged on the electroanatomical map. Under the guidance of electroanatomical mapping system (CARTO, Biosense Webster), we reconstructed LA anatomy, taking care to avoid metal valve impairment or catheter entrapment when manipulating the catheter at the mitral annulus. Each PV ostium was identified and tagged on the electroanatomical map. Under the guidance of electroanatomical mapping system (CARTO, Biosense Webster), we reconstructed LA anatomy, taking care to avoid metal valve impairment or catheter entrapment when manipulating the catheter at the mitral annulus. Each PV ostium was identified and tagged on the electroanatomical map.

Electrophysiological mapping and ablation of atrial tachycardia

Atrial tachycardia after circumferential PV isolation, CFAEs, and linear ablation were mapped and ablated. According to the results of entrainment manoeuvres and activation mapping, AT could be classified as focal origin, small-loop/macro-reentry and unidentified. Focal AT was ablated by targeting the earliest focus by activation mapping. Pulmonary vein-originated AT was ablated by CPVI. Small-loop/macroreentry was ablated by linear lesions blocking the key isthmus. In cases with mitral isthmus-dependent macro-reentry concomitant with metal valve prostheses, the catheter was positioned in proximity to the mitral valve at right anterior oblique 30° projection to avoid catheter entrapment, and was dragged clockwise to the ostia of left inferior PV. When the endocardial approach failed to block the mitral isthmus, ablation within coronary sinus was applied, with the maximum power of 25 W, 43°C and saline irrigation speed of 30 mL/min. After CPVI, CFAEs ablation, linear ablation, and AT ablation, if AF or AT was not terminated, 300–360 Joules direct current cardioversion was applied to restore sinus rhythm.

Post-ablation management and follow-up

All cases received low-molecular-weight heparin injection for 3–5 days and warfarin anticoagulation, keeping INR between 2.5 and 3. Amiodarone was given intravenously at a dose of 600 mg/day for 3 days. Then the drug was given orally, starting at 600 mg/day for 1 week and then tapered to 200–400 mg/day for 3 months after the ablation, and was withdrawn 3 months later in cases without AF recurrence, but was continued in cases with AF recurrence. Patients were routinely followed-up using the aforementioned method as used in Group B.

We set the blanking period of the first 1 month after ablation. Atrial tachyarrhythmias recurred within the blanking period were defined as early recurrence, otherwise, they were defined as late recurrence.

Figure 2 Circumferential pulmonary vein isolation and complex fractionated atrial electrograms ablation guided by electroanatomic and shortest confidential interval mapping. Anteroposterior (A) and posteroanterior (B) projections of a three-dimensional electroanatomic depiction of the left atrium. Red tags indicate ablation sites. Note that CFAEs in septum, anterior wall and mitral isthmus were ablated.
After the blanking period, any episode of symptomatic or asymptomatic atrial tachyarrhythmias lasting over 30 s with ECG/Holter documentation was considered a recurrence. Re-ablation was performed at least 1 month after the initial procedure. Spiral computed tomography was performed at 3 months after the procedure in all cases to assess PV stenosis.

**Study endpoints**

The primary endpoint of the study was freedom of any recurrence of atrial arrhythmias lasting >30 s 12 months post-ablation after one procedure. The second endpoints included incidence of peri-procedural complications.

**Statistical analysis**

Statistical analysis was performed using the Statistical Program for Social Sciences (version 13.0 SPSS Inc., Chicago, IL, USA). All data are expressed as mean ± standard deviation unless stated otherwise. The Shapiro–Wilk test was used to analyse the distribution of all quantitative variables. Student’s two-tail t-test was used to compare the difference between two groups. Kaplan–Meier survival analysis with the log-rank test was also performed to compare late AT-free survival between two groups. Two-tailed test of significance are reported and a P < 0.05 was considered statistically significant.

To detect a 25% difference in clinical outcome at a power of 0.80 and one-tailed α of 0.05, 46 patients in each group would be necessary. Considering a potential drop out of 5%, a total study cohort of 97 patients was calculated. Therefore, 53 patients were randomly assigned to Group A and B.

**Results**

**Patient characteristics**

The mean follow-up was 15 ± 5 months (range 12–20 months) in Group A and 20 ± 8 months (range 12–27 months) in Group B. Three patients in Group A showed no atrial arrhythmias after valvular operation and did not perform electrophysiological examination. One patient in Group A and three in Group B were lost to follow-up over the study period. There were 49 patients in Group A and 50 patients in Group B that completed the entire study. Thus, results of rhythm are available for those remaining 99 patients.

Baseline characteristics are presented in Table 1. The two groups were similar with respect to gender distribution, duration of AF. Left atrium size (60.4 ± 10.7 mm in Group A and 61.3 ± 9.8 mm in Group B; P = NS) and left ventricular ejection fraction (LVEF) were similar among the two groups measured on standard trans-thoracic echocardiogram. The various surgical procedures that the patients underwent were also similar between two groups. Mitral valve replacement was performed in 49 patients (98%) for right PVs and in 46 cases (94%) for left PVs. AF converted to AT in 54 cases (10%) after CPVI, we performed CFAEs mapping and ablation in 44 patients. A total of 186 CFAE sites were detected and mapped in 44 patients, distributed among the five pre-defined LA regions: around PV area (37, 20%), anterior wall (40, 21%), and septum (52, 28%), LA roof (25, 13%), and posterior-inferior wall (32, 17%).

By ablating CFAEs, AF converted to sinus rhythm in six cases and to AT in 10 cases. The linear ablation was carried out in the remaining patients with AF persisted (28 patients). After linear ablation, AF terminated in four patients and converted to AT in four cases.

**Electrophysiological study and catheter ablation of atrial fibrillation in Group A**

All patients in Group A underwent the procedure successfully. For all cases the total procedural time was 168 ± 34 (range 110–240) min and the total fluoroscopic time was 30 ± 14 (range 19–46) min. There was tough transseptal procedure in six cases, probably due to scar formation resulting from interatrial septum discussion.

By initial CPVI, complete PV isolation was achieved in 45 (92%) cases for right PVs and in 42 (86%) cases for left PVs. For the remaining cases without PV isolation after CPVI, additional ‘gap’ ablation was performed along the initial lines to eliminate residual PV conduction. As a result, right PVs were isolated in three of four cases and left PVs were isolated in four of seven cases. Totally PV isolation was achieved in 48 cases (98%) for right PVs and in 46 cases (94%) for left PVs. AF converted to AT in five (10%) cases after CPVI. Owing to the inability to map CFAEs when AF converted to AT (five cases) after CPVI, we performed CFAEs mapping and ablation in 44 patients. A total of 186 CFAE sites were detected and mapped in 44 patients, distributed among the five pre-defined LA regions: around PV area (37, 20%), anterior wall (40, 21%), and septum (52, 28%), LA roof (25, 13%), and posterior-inferior wall (32, 17%).

By ablating CFAEs, AF converted to sinus rhythm in six cases and to AT in 10 cases. The linear ablation was carried out in the remaining patients with AF persisted (28 patients). After linear ablation, AF terminated in four patients and converted to AT in four cases.

**AT** in 19 cases were mapped and ablated. Mitral isthmus-dependent flutter was identified in three cases and was terminated by mitral isthmus ablation (epicardial ablation within coronary sinus was performed in one case). Small-loop reentrant tachycardia at anterior wall of LA was found in three cases and was terminated in two cases. Focal AT in LA was mapped and terminated in five cases. Tricuspid-isthmus-dependent flutter was identified and
terminated in four cases. The origin of AT could not be depicted in four cases. Direct current cardioversion was performed when ablation failed to terminated AT (Figure 3).

Follow-up data
In Group B, two patients were in junctional rhythm when coming off cardiopulmonary bypass, and they recovered sinus rhythm in the intensive care unit. At 6, 12, and 18 month after the procedure, 37 patients (74%), 41 patients (82%), and 40 patients (80%) were in sinus rhythm, respectively. The atrial arrhythmias observed in Group B was AF in three patients, AT in three patients, and atrial flutter in four patients. Among those patients, six were received an electrophysiological examination and catheter ablation for the post-operative arrhythmias (two patients with AF, three with atrial flutter, and one with AF and AT). Pulmonary veins atrial reconnection was found in two patients, and the AF was terminated in one case by ablation right superior PV and in one case by ablation superior vena cava. Mitral isthmus-dependent flutter was identified in one case and was terminated by mitral isthmus ablation. Tricuspid-isthmus-dependent flutter was identified and terminated in two cases. Focal AT in anterior-lateral wall of right atrium was mapped and terminated in one case. The other four patients were taking amiodarone 200 mg per day orally because of frequent atrial premature beats or short run of AT on Holter monitoring (Figure 4).

In Group A, during the blanking period of 1 month after the procedure, atrial tachyarrhythmias recurred in 13 patients. The recurrent arrhythmias were AF alone in six cases, AF concomitant with AT in three cases, and AT alone in four cases, and were converted to sinus rhythm by anti-arrhythmic drugs in five cases or direct

![Figure 3](image1.png) Diagram of electrophysiological findings and ablation results in patients of Group A.

![Figure 4](image2.png) Diagram to demonstrating the follow-up results in Group A and B.

A total of 35 patients (71%) were in sinus rhythm at the end of the study.

A total of 44 patients (88%) in sinus rhythm at the end of the study.
current cardioversion in eight cases. During the later follow-up period, atrial tachyarrhythmias still relapsed in 9 cases with early recurrence, and recurred in 13 cases without early recurrence. Totally 22 (44.8%) cases had atrial tachyarrhythmias recurrence at a median of 6 ± 2 months (range 3–10 months) after the initial ablation. The recurrent arrhythmias were AF alone in 11 cases, AF concomitant with AT in seven cases, and AT alone in four cases. Re-ablation was performed in 15 of 22 (68%) cases (five cases with AF, six cases with AF and AT, four cases with AT). Re-mapping of AT revealed PV-originated tachycardia in two cases, and re-isolation of PVP terminated the tachycardia. Macro-reentry around mitral annulus without PV reconnection was found in one case and was terminated by endocardial mitral isthmus ablation. Macro-reentry around tricuspid annulus without PV reconnection was found in one case and was terminated by endocardial tricuspid isthmus ablation. Electrophysiological mapping for AF and AF plus AT (n = 11) demonstrated the recurrence of PV conduction in eight cases (left-sided PVP recurrence in six cases and right-sided PVP recurrence in five cases), and by second CPVI all PVPs were re-isolated successfully. Complex fractionated atrial electrograms were mapped and ablated in 10 patients with AF persistence after PV isolation, and DC cardioversion was performed to restore sinus rhythm. During subsequent follow-up, eight patients were in sinus rhythm, three were in sinus rhythm with oral administration of amiodarone, and four patients still presented AF (Figure 4).

Clinical outcomes

At the end of 12-month follow-up, after one catheter ablation or Maze procedure, the freedom from atrial arrhythmias was higher in Group B than in Group A (82% in Group B vs. 55.2% in Group A, \( P < 0.001 \), Figure 5).

At the end of the study, in Group B, 44 patients were AF-free when taking the re-ablation case into consideration (40 patients maintains sinus rhythm after the Maze procedure and 4 after Maze procedure and catheter ablation). Although in Group A, at the end of follow-up, totally 35 patients were free of recurrent atrial arrhythmias (27 patients maintains sinus rhythm after one catheter ablation procedure and 8 after two procedure). The AF-free survival was significantly higher in Group B than in Group A (44 in Group B and 35 in Group A; 88 vs. 71%, \( P < 0.001 \)).

Complications

Catheter-tip entrapment developed in one case in Group A when manoeuvring the catheter in the vicinity to mitral valve prosthesis. By pulling it back the catheter detached from the metal valve without any damage to the prosthesis. One case in Group A developed major stroke with right-sided hemiplegia during the procedure (ACT was measured 290 s when this event occurred). There was no femoral vein access site complication and cardiac tamponade for both groups, and there was no PV stenosis during follow-up. One patient in Group B had pericardial effusion 5 days after the operation and it disappeared 15 days after the procedure. Sternal wound infection was found in three patients of Group A and four patients of Group B and was treated with intravenous antibiotics. Pneumonia was developed in four cases of Group A and three cases of Group B and was recovered in all cases. There was no significant difference in term of complications between two groups (\( P > 0.05 \)).

Discussion

The main findings of the present study are as follows: First, in AF patients with RHD who underwent valvular surgery, the concomitant Cox Maze procedure using SICTRA is more effective than subsequent CPVI combined with substrate modification. Second, catheter-based mapping and ablation of atrial arrhythmias after surgical maze procedure is effective.

Atrial fibrillation is commonly associated with RHD. The structural changes and the degeneration of the atrial myocardium might generate ectopic atrial beats and unidirectional conduction block, as well as elevated atrial pressure and macro-reentrant circus, all of which are involved in the maintenance of AF.14,15 The Cox Maze procedure, developed by James Cox for the treatment of AF,16 and after subsequent modifications, came to be known as the Maze III procedure. Although the Maze procedure cures AF in more than 90% of patients, several studies have shown insufficient sinus rhythm restoration rate in AF associated for RHD.11,14,17 The complexity of the procedure and the length of time required to perform it are the deficiency inherent to Cox Maze procedure. In addition, there is a mortality and morbidity associated with the procedure, and the mean mortality was reported to be 2.1%.15,16 Therefore, new techniques are needed to make the procedure safer and easier to perform. Other sources of energy such as radio-frequency have been used to create transmural intra-atrial lesions, similar to those used in the original ‘cut and sew’ technique. Abreu Filho et al.10 demonstrated that SICTRA is effective for treating permanent AF associated with RHD.

Circumferential pulmonary vein isolation as one of several catheter ablation strategies has been proved effective to eliminate AF in recent years.3,17 This ablating approach is based on the theory that PV firing is responsible for AF initiation and perpetuation.
However, due to the complexity of AF mechanisms, different approaches have been introduced into clinical use and proved their feasibility and efficacy. Nademanee et al. demonstrated by ablating areas of CFAEs AF could be cured in over 90% cases. Complex fractionated atrial electrograms located mostly in areas of slow conduction or functional block and were believed to represent the pivot points or regions of very slow conduction responsible for multiple wavelet reentries, serving as promising targets for AF substrate modification. Several studies have evaluated the role of CFAEs ablation in persistent or permanent AF ablation. Estner et al. reported by utilizing a combined approach of CPVI and CFAEs ablation AF could be terminated in 74% of cases. Verma et al. observed that CPVI plus additional CFAEs ablation resulted in AF cycle length prolongation, regularization, and non-inducibility in most patients and that AF terminated in 54% of cases, and they concluded that CPVI with adjuvant CFAEs ablation had a high efficacy and might be superior to CPVI alone. Knecht et al. demonstrated that left atrial linear ablation including roof line and mitral isthmus line was required for patient with persistent AF. However, in those studies, only AF patients without RHD were included. We have demonstrated that CPVI plus CFAEs ablation is an effective strategy for patients with persistent AF and RHD. We also demonstrated that CFAEs initiation sites showed increased fibrosis and decreased expression of Connexin 43 in animal study. CFAEs sites may represent conduction slowing at pivotal points of reentrant circuit, and patients with RHD showed special pathophysiological characteristics such as elevated atrial pressure, structural remodeling of myocardium, and persistent inflammatory activity in the atrial myocardium, it is rational to consider that LA substrate modification is one of effective strategy to treating AF patients with RHD. As already mentioned, Maze procedure is less effective in case of RHD. And thus it is tempting to compare the effect of concomitant Maze procedure and subsequent catheter ablation with combination of CPVI and CFAEs ablation in those patients.

In the present study, we prospectively enrolled patients with persistent AF and RHD, and randomly divided into two groups. Patients in Group A underwent valvular surgery first, and after 6 months they underwent CPVI, CFAEs ablation and left atrial linear ablation if they present persistent AF, and patients in Group B underwent Maze operation concomitant with valvular surgery. After a mean of more than 15 months follow-up, 88% patients in Group B were free of recurrent atrial tachyarrhythmias, whereas in Group A, only 71% patients were in sinus rhythm including patients underwent a redo procedure. It seems that in AF patients with RHD who underwent valvular surgery, the concomitant Maze procedure using SICTRA is more effective than subsequent catheter ablation with combination of CPVI and CFAEs ablation in those patients.

Several studies have described the characteristics of post-surgery arrhythmias in AF patients underwent Maze procedure. Wazni et al. reported that after surgical ‘cut and sew’ Maze, approximately one-third of patients experiencing atrial arrhythmias due to PVs–LA conduction recovery, and incision related atrial flutter is also the common findings. Golovchiner et al. demonstrated that in patients underwent mitral valve surgery and radiofrequency ablation, post-operative atrial flutter was the main arrhythmia, and the atrial flutter originated from left-side in most cases. In our study, six of nine patients with post-operative arrhythmias were examined by electrophysiological study, and PVs atrial reconnection was found in two patients, mitral isthmus-dependent flutter was identified in one case and tricuspid-isthmus-dependent flutter in two cases, and focal AT in lateral wall of right atrium in one case. At the end of this study, four patients maintain sinus rhythm. In accordance with these studies, our results indicate that catheter ablation of post-surgery arrhythmias is a feasible and effective method.

In this study, we investigate the effect of the combined strategy for treating patients with AF and RHD, and found the success rate was 71% at the end of the follow-up period. In accordance with our previous study, the results of the present study have implications for potential clinical intervention in patients with RHD, especially in those who underwent valvular surgery but not Maze procedure or those presented no evidence of AF when receive surgical procedure, the subsequent catheter ablation is a feasible and relatively effective strategy.

**Conclusions**

This is the first report to compare the effect of subsequent catheter ablation using combined strategy and concomitant AF ablation using SICTRA in RHD patients undergoing cardiac surgery. The main findings are, that concomitant AF ablation is more effective than subsequent catheter ablation in patients with RHD underwent cardiac surgery. Certainly, ongoing research has to prove these results in large cohorts and during long-term follow-up.

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