A Novel Alternately Energy Source Strategy for Re-Ablation of Patients with Recurrent Atrial Fibrillation –Cryoballoon or Radiofrequency Current Energy Ablation. A Case-Control Study

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Research Article

Keywords: AF Recurrence, Repeat Ablation, Cryoballoon, Radiofrequency Ablation, Alternate energy sequence ablation strategy

Posted Date: December 22nd, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1165778/v1>

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Abstract

Background: Atrial fibrillation recurrence after circumferential pulmonary vein (PV) isolation was common. Which ablation technique is better for repeat ablation in patients with recurrent atrial fibrillation (AF) remains unclear. We aimed to investigate long-term efficacy of repeat ablation using a novel alternately energy source sequence for re-ablation of patients with recurrent atrial fibrillation: cryoballoon (CB) re-ablation for patients with a failed radiofrequency (RFC) ablation (RFC-CB redo group); radiofrequency energy re-ablation for patients with a failed cryoballoon ablation (CB-RFC redo group).

Method: Recurrent AF patients received a repeat ablation procedure in our hospital were enrolled into the study. Demographic and re-ablation procedural characteristics and outcomes were compared among groups.

Results: A total of 156 patients were enrolled into the study, 60 patients (38.5%) were in the CB-RFC-redo group and 96 patients (61.5%) were in the RFC-CB-redo group. Longer duration of AF (69.31 ± 64.69 vs 50.78 ± 51.48 months; $P=0.039$) and longer time from first ablation to re-ablation (54.02 ± 38.10 vs 14.2 ± 10.5 months; $P=0.001$) were observed in the RFC-CB-redo group as compared with the CB-RFC redo group. Early recurrence rates of atrial fibrillation following initial ablation were equal among groups (RFC-CB-redo group: 42.7% vs CB-RFC-redo group: 48.3%, $p=0.515$). The number of reconnected PVs was significantly higher in the RFC-CB redo group than the CB-RFC redo group (3.36 ± 0.96 vs 1.50 ± 0.81 , $p=0.01$). During the average follow-up of 10.7 ± 2.41 months, significantly less AF recurrence was observed in the CB-RFC redo group (16.7% vs 31.3%, $p=0.045$). In the multivariate analysis, different energy ablation sequence, AF type and early recurrence after the initial ablation were independent predictors of AF recurrence after re-ablation.

Conclusions: Alternate energy source sequence strategy for re-ablation of patients with recurrent atrial fibrillation was safe and moderately effective. However, Large multi-center studies must be warranted to provide conclusive evidence.

Background

Atrial fibrillation (AF) is the most common clinical arrhythmia in the world, which often impaired life quality and led to serious complications [1]. Radiofrequency catheter (RFC) ablation or cryoballoon (CB) ablation therapy based on pulmonary vein (PV) isolation is an well-established treatment strategy for drug-refractory AF [2–3]. Long lasting PVs isolation is fundamental to avoid the AF recurrence and is the primary goal of AF ablation regardless of RFC or CB ablation [3–4]. Despite the high success rate of RFC or CB ablation, 20-30% of AF patients may suffer from PVs-left atrium(LA) reconnection and AF recurrence [5]. Due to the high AF recurrence rate after RFC ablation or CB ablation, repeated ablation is very common in the clinical practice related to recurrent AF patients [6–7]. Pulmonary vein (PV)–LA reconnection is the main cause of recurrent arrhythmia after RFC ablation or CB ablation [8–9]. However, appropriate AF ablation strategy (RFC or CB ablation) used in the repeat ablation is still controversial.

Recent, repeat AF ablation using the alternately energy source sequence (CB re-ablation after a failed RFC ablation, RFC repeat ablation following a failed CB ablation) was suggested [9]. However, there was still few data comparing the long-term efficacy or safety of this alternately energy source ablation strategy for recurrent AF patients because only one study reported the strategy [9]. Therefore, the present study was aimed to compare the electrophysiological outcome of those patients who underwent repeat ablation and investigate long-term efficacy and safety of alternate energy source ablation strategy (Cryoballoon or Radiofrequency Ablation) for repeat ablation procedure in patients with recurrent atrial fibrillation.

Methods

Patients

We retrospectively recruited 250 patients from September 2016 to February 2018, all patients who underwent a repeat catheter ablation procedure after a failed RFC ablation or CB PV isolation were eligible in this study. The study protocol was approved by the Human Research Ethics Committee of the Fuwai hospital according to the Helsinki Declaration. Repeat ablation strategy was used by the alternately energy source ablation sequence. For instance, patients firstly ablated with RFC ablation underwent re-ablation with CB (RFC-CB-redo group) and patients initially treated with CB ablation underwent redo PV isolation with RFC ablation (CB- RFC-redo group). All patients provided written informed consent.

Radiofrequency ablation procedure

The ablation procedure was performed on uninterrupted oral anticoagulant drug on the ablation procedural day. All the anti-arrhythmic drug except amiodarone were stopped five half-live time before the procedure. Vascular puncture was performed under local anesthesia. A 6F decapolar electrode catheter via the right internal jugular vein was inserted into the coronary sinus. Transseptal puncture was performed under X-fluoroscopy and the Lasso [Biosense Webster, Diamond Bar, CA, USA]) and 3.5-mm tip irrigated ablation catheter (SmartTouch catheter (Biosense Webster)) were advanced to the LA . LA map construction was performed using the CARTO 3 system (Biosense Webster). Each PV ostium was identified by selective venography and was then tagged on the LA electroanatomic map. The Lasso catheter [Biosense Webster, Diamond Bar, CA, USA]) was placed approximately 0.5 cm within the PV ostium for real-time monitoring of LA- PVs conduction. The infusion rate of perfusion during radiofrequency ablation is 17 ml / min, the maximum temperature is 43 °C, and the contact force is 10 – 20 g and each ablation point is at least 30 s to achieve more than 70% local voltage reduction. Circumferential PV ostium ablation to isolate the PV veins would be performed if LA-PVs conduction was demonstrated. If AF continued to persist after PVs isolation, the cardioversion was performed.

Second-generation cryoballoon ablation procedure

Cryoballoon ablation procedure was performed under mild conscious sedation. Simply, a 28 mm second-generation cryoballoon catheter (Art Front Advance, Medtronic, Minneapolis, Mn, USA) and a 20-mm-diameter inner lumen Achieve catheter (Achieve™, Medtronic, MN, USA) were inserted through a 12F steerable sheath (FlexCath, Medtronic, Minneapolis, Mn, USA) and then directed to each targeted PV ostium to record PV signals before, during and after ablation. The PV ostium occlusion was evaluated using the selective angiography via the inner lumen of the CB catheter. According to CB ablation routine, single ablation procedure time for second-generation balloon was ≤ 180 s. If the PVs isolated were completed within 60 s, only one CB ablation cycle was used. If PVs isolation was achieved and PVs-LA conduction did not recur, no bonus ablation was needed. If a time-to-isolation (TTI) ≥ 60 s, a second CB cycle application within 180 s was performed. Phrenic nerve stimulation was applied through a steerable multipolar catheter in the superior vena cava (cycle length 1000 ms, 15 mA/3.0 ms pulse width) during isolation of the right-sided PVs to reduce the risk of phrenic nerve palsy. If a decrease of phrenic nerve capture was observed, the CB ablation procedure was immediately stopped.

Repeat Ablation Procedure

During the repeat ablation procedure (regardless of RFC or CB ablation used), the first objective was to check the LA-PVs conduction using a multipolar circular catheter (Lasso® catheter, Biosense Webster or Achieve mapping catheter, Medtronic, Minneapolis, MN). LA-PVs reconnection was defined as an absence of entry block at the PV ostium during pacing [11]. Any repetitive premature atrial complex, atrial tachycardia, and beats triggering atrial flutter or AF were identified as the non-PVs triggers and were targeted for re-ablation. If the patients in the initial ablation procedure originally treated with RFC ablation, those patients would be re-ablated with CB ablation. By contrary, the patients originally treated with CB ablation, RFC ablation would be applied at the redo-procedure.

Follow-up

Post re-ablation follow-up protocol was for all patients, the data was collected during outpatient visits, or from all other forms of contact with the patients or their referring doctors, including clinical letters and telephone calls. Clinical follow-up and 12 lead ECG were arranged at 3, 6 and 12 months after ablation, and then once a year. For each patient with recurrent arrhythmias and patients with serious symptoms, more frequent follow-up should be arranged as patients needed. Any episodes of atrial tachyarrhythmia of longer than 30 s as detected by the ECG or Holter beyond the black 3-month period were considered as AF recurrence.

Statistical analysis

Continuous variables are expressed as Mean $\pm$ SD, while classified variables are expressed as percentage. The survival curve was analyzed by the Kaplan Meier method. The Cox regression analysis was used to analyze the risk predictors of AF recurrence. Nonparametric t tests were used to examine continuous outcomes and Pearson's chi-squared test was used to compare categorical outcomes among groups. A P-value of < 0.05 was considered statistically significant. All statistics were performed using the SPSS version 25.0 (SPSS Inc, Chicago, IL, USA).

Results

Baseline characteristics

Among the 250 consecutive patients with AF recurrence who underwent repeat ablation, 85 patients who met the major exclusion criteria and 9 patients lost to follow-up were excluded (as was shown in **Fig.1**). The Research flow chart and redo-ablation procedure were summarized in **Fig.1**. A total of 156 patients with a repeat PVs isolation procedure in our hospital were enrolled into the study, 60 patients (38.5%) were in the CB-RFC-redo group and 96 patients (61.5%) were in the RFC-CB-redo group. Patient characteristics were shown in **Table 1**. A total of 34 patients (21.8%) had persistent AF, while 122 patients (78.2%) had paroxysmal AF (44 patients were in CB-RFC-redo group and 78 patients were in RFC-CB-redo group). Mean age of enrolled patients was 58.19 ± 9.26 years, 114 patients (73.1%) were male, and the mean Body Mass Index (BMI) was 25.9 ± 2.9 kg/m². The average CHA₂DS₂-VASc score was not statistically significant difference (1.02 ± 1.01 in the CB-RFC-redo group vs 1.29 ± 1.09 in the RFC-CB-redo group, $p=0.249$). Similarly, the average HAS-BLED score of two group was not statistically significant difference (0.31 ± 0.47 in the CB-RFC-redo group vs 0.72 ± 0.71 in the RFC-CB-redo group, $p=0.090$). The mean LA diameter at the time of enrollment in this study was 38.85 ± 4.60 mm. The two groups were comparable in terms of age, BMI, AF history, drug usage and cardiac geometry. Patients in the RFC-CB-redo group had longer duration of AF history (69.31 ± 64.69 vs 50.78 ± 51.48 months, $P=0.039$). Early recurrence (ER) rate after the first ablation procedure in the CB-RFC-redo group and RFC-CB-redo group was not significant (48.3% vs 42.7%, $p=0.515$). Similarly, no significant difference was found for the other clinical baseline features of the two groups (**Table 1**). Most re-ablation patients recurred with paroxysmal AF (67/96, 69.8% patients in the RFC-CB redo group vs 44/60, 73.3% patients in the CB-RFC redo group, $p=0.15$), 34 patients recurred with persistent atrial fibrillation (18/96, 18.8% patients in the RFC-CB redo group vs 16/60, 26.7% patients in the CB-RFC redo group, $p=0.35$), 24 patients recurred with atrial tachycardia or atrial flutter (11/96, 11.5% patients in the RFC-CB redo group vs 13/60, 21.7% patients in the CB-RFC redo group, $p=0.035$) (**Fig. 2**). As was indicated in **Fig 2**, more patients recurred with atrial tachycardia or atrial flutter were observed in those patients after initial CB ablation.

Electrophysiological Findings

The mean time from initial ablation to repeat ablation was longer in the RFC-CB redo group than those in the CB-RFC redo group (54.02 ± 38.10 vs 14.2 ± 10.5 months, respectively; $P=0.001$). During the redo

ablation procedure, 148 (94.9%) patients were found to have reconnected left atrial-PVs conduction, while 7 patients in CB-RFC-redo group and one patients in RFC-CB-redo group had none reconnected PVs at the time of repeat ablation ($p=0.045$) (**Table 2**). Overall, the mean number of reconnected LA-PVs per patient was significantly higher in the RFC-CB redo group (3.36 ± 0.96) than in the CB-RFC-redo group (1.50 ± 0.81 , $p=0.010$) (**Table 2**). The number of reconnected LA-PVs per patient in both group is depicted in **Fig. 3**. As was shown in **Fig. 3**, 64 patients (66.7%) in the RFC-CB redo group showed reconnected PVs requiring repeat ablation of all four PVs, as compared with none patients in the CB-RFC-redo group ($p<0.001$). In the CB-RFC-redo group, there were significantly more reconnected left superior PVs (32/91, 35.2%) and fewer reconnected right superior PVs (14/91, 15.4%), in compared to other PVs. In the RFC-CB-redo group, there were significantly more reconnected left superior PVs (89/317, 28.1%), in compared to other PVs. More PVs treated per patient were observed in the RFC-CB-redo group, in comparison with CB-RFC-redo group (3.36 ± 0.96 vs 1.5 ± 0.81 , $p=0.01$) (**Table 3**). More non-PVs related atrial arrhythmia was observed in the initial CB ablation (CB-RFC-redo vs RFC-CB-redo: 11.7% vs 1.04%, $p=0.030$) at the re-ablation procedure (**Table 2**).

Repeat ablation procedural Data

Procedural data for repeat ablation was summarized in **Table 4**. The mean repeat ablation procedure time was 70.6 ± 20.7 min in the CB-RFC-redo group, and it was significantly shorter in the RFC-CB-Redo group (49.5 ± 12.7 min, $p=0.025$). However, patients in the RFC-CB redo group required longer fluoroscopy time (15.9 ± 0.8 min vs 4.2 ± 0.9 min, $p=0.001$) and more fluoroscopy dose (232.5 ± 138.1 mGy vs 156.3 ± 15.3 mGy, $p=0.02$) in compared to CB-RFC redo group. More patients in the CB-RFC redo group need cavotricuspid isthmus ablation (27 patients vs 19

patients, $p=0.03$). One patients in the CB-RFC-redo group had pericardial tamponade, two patients in the RFC-CB-redo group had hemoptysis and two patients in the RFC-CB-redo group demonstrated a short-time vagal reflex. No other severe adverse events, including acute cerebrovascular event, major bleeding event, embolic complication, vascular complication, PV stenosis, or death were reported.

Recurrence of AF and Predictors

The average follow-up time after repeat ablation was 10.7 ± 2.41 months (range 3-12 months) in the total population: 10.4 ± 2.59 months in the RFC-CB redo group and 11.2 ± 2.04 months in the CB-RFC redo group ($p=0.06$). Forty patients experienced AF recurrence during follow-up, including thirty patients (31.3%) in the RFC-CB redo group and ten patients (16.7%) in the CB-RFC redo group. As was shown in **Fig. 4**, the freedom from AF recurrence after repeat ablation was 83.35% in the CB-RFC-redo group and 68.7% in the RFC-CB redo group, respectively (HR=4.035, Log-rank $P=0.045$). Univariate Cox analysis showed that early recurrence (ER) after first ablation (HR = 2.527, 95% CI: 1.296-4.927, $P=0.006$) and the different energy ablation sequence (RFC- CB redo group) (HR = 2.528, 95% CI: 1.175-5.439, $P=0.018$) were risk factors for AF recurrence following the repeat ablation. On the multivariate Cox regression

analysis, different energy source ablation sequence (RFC- CB redo group) was still independently risk factors for AF recurrence following the repeat ablation (HR = 2.314, 95% CI: 1.128-4.747, P =0.022). Moreover, the multivariate Cox regression analysis also shown that AF type (persistent AF) and early recurrence (ER) after the initial ablation were also significantly associated with the poor outcome after re-ablation (HR = 2.107, 95% CI: 1.085-4.091, P=0.028; HR = 2.431, 95% CI: 1.279-4.618, P=0.007, respectively)(**Table 5**). As was shown in **Fig. 5A**, those patients without early recurrence after the initial ablation had better re-ablation outcome compared with those with early recurrence regardless of ablation energy source used (82.6 % vs 64.3%, HR=6.57, Log-rank P =0.010). The AF-free rate of persistent AF was 61.8% after one-year follow-up (vs paroxysmal AF 77.9% , HR=10.15, 95% CI: 10.35–11.1, P = 0.05) (**Fig. 5B**) regardless of the energy source of re- ablation. No severe complications or embolic events occurred during the follow-up period.

Discussion

Major findings

In this analysis, we aimed to describe long-term follow-up outcome of AF patients undergoing two alternate energy source sequence ablation (RFC-CB redo ablation vs CB-RFC redo ablation) for either recurrent AF. The main findings of our research were as follows, including: 1) 40 patients (25.6% of the total population) recurred after repeat ablation procedure at the mean follow-up of 10.7 ± 2.41 months; 2) we found that significantly fewer reconnected PVs were observed in patients originally treated with the CB ablation than in patients originally treated with RFC ablation (1.50 ± 0.81 vs 3.36 ± 0.96 , $p=0.01$ per patients) and more non-PVs related atrial arrhythmia (CB-RFC-redo vs RFC-CB-redo: 11.7% vs 1.04%, $p=0.030$) following the initial CB ablation was observed at the re-ablation procedure ; 3) for recurrent AF with post-ablation, repeat ablation with the alternate energy source sequence was effective and safe, with up to 74.4% arrhythmia-free patients in the total population during the follow up; 4) the early recurrence after the initial ablation strongly predicted the poor outcome of the re-ablation. 5) different alternately energy source sequence (AF patients originally treated with RFC ablation, then repeated with CB ablation at the redo procedure, RFC-CB redo group) was the predictive risk factor for AF recurrence after redo ablation;

PVs Reconnection at the re-ablation procedure

It was proved that durable PVs isolation is fundamental to freedom from AF recurrence and is also primary goal of catheter ablation therapy [11]. In this study, we found that recurrent AF patients initially treated with CB ablation had significantly fewer all four PVs reconnection and few reconnected PVs per patient with the mean of 1.50 ± 0.81 PVs, in comparison with AF patients firstly treated with RFC ablation. In the FIRE AND ICE trial, patients initially treated with the CB ablation had significantly fewer reconnected PVs and thus required fewer lesions at the re-ablation procedure [6]. Generally, CB ablation shown catheter stability in anatomically challenging locations, compared to RFC ablation [12]. For instance,

significantly fewer reconnected left superior PVs were observed in the CB initial ablation group. However, AF patients initially treated with RFC ablation had more left superior PVs reconnection and bilateral reconnected pulmonary veins in our study. These data may reflect differences in catheter stability in those anatomical challenging locations. RFC ablation usually created contiguous and transmural ablation line [13], but may not be readily achieved along the myocardial ridge separating the left-sided PVs from the LA appendage [14-15]. By contrast, the myocardial ridge may not influence the ability of the cryoballoon to create durable lesions in this area [16].

Biophysics of Radiofrequency ablation vs Cryoablation

Radiofrequency ablation is to transform electromagnetic energy into thermal energy and created myocardial injury around the pulmonary vein antrum [17-18]. However, myocardial injury caused by radiofrequency ablation is usually related to coagulative necrosis deformation[19], hemorrhagic injury[20] and inflammatory cell infiltration [21]around injury tissue. When the edema tissues subsided, these gaps around the PV antrum would resume LA- PVs conduction [22]. It has been well proved that the variable anatomical characteristics of PVs may have an impact on the efficacy of radiofrequency ablation [23]. Anatomical studies found that the muscle sleeves of the lower wall of the superior pulmonary vein and the upper wall of the inferior pulmonary vein were the thickest and catheter in these lesions is unstable [24], so those sites were also common location for atrial -pulmonary vein potential recovery after RFC ablation [25]. Furthermore, center experience would influence the efficiency of radiofrequency ablation [26]. It was reported that center experience was independent risk factor of late AF recurrence related to RFC ablation [26,27]. In the present study, 66.7% patients in the RFC-CB redo group showed all four PVs reconnection requiring repeat ablation, while significant fewer patients in the CB-RFC redo group required four PVs ablation. Cryoablation emerged as a novel ablation technique improving the outcome of PVs isolation and then minimized thrombus formation [16], preserved the basic underlying tissue architecture and alleviated inflammation reaction [11]. Because the relapse of LA-PVs reconnection is still the main cause of late recurrent arrhythmia after the initial AF ablation with either CB or RFC ablation [8]. Cryoablation was usually with a durable PVs isolation [11]. However, more non-PVs triggers and LA flutters were found at repeat ablation following the CB ablation [11]. In this study, we found that 7 patients (11.7%) firstly treated with CB ablation require non-PVs lesions ablation, while only one patient (1.04%) following RFC ablation needed non-PVs lesions ablation.

Alternately Ablation energy sequence and Recurrence of AF

So far, there were few reports dedicated to evaluate the efficacy and safety of the usage of the alternately energy source sequence for repeat ablation of recurrent AF patients. At the average of 10.7 ± 2.41 months follow-up after repeat ablation, we found that a total of 40 patients (25.6%) recurred after the re- ablation, with better re-ablation outcome in the CB-RFC redo group (16.7% vs 31.3% , Log-rank $P = 0.045$). In Verlati et al's study, significantly fewer AF recurrences (10.9%) occurred in patients after RFC repeat ablation

after initial CB PV isolation [9]. The outcome of arrhythmia-free rate in this study was similar to previous published reports for repeat AF ablation (70%-79.4%) [9,27]. Consequently, the present study further supported the safety and modest efficacy of the alternately energy sequence for repeat ablation after RFC or CB ablation. Several factors had been established as potential risk predictors for the AF recurrence after re-ablation, such as the greater LA diameter, AF type, sex, obesity and CHA₂DS₂-VASc score. The Cox regression analysis indicated that the different energy source ablation sequence (RFC-CB redo group) was independently risk of AF recurrence (HR = 2.528, 95% CI: 1.175-5.439, P = 0.018). Conversely, RFC ablation after initial CB PV isolation (CB-RFC redo group) may be highly effective to prevent further AF recurrence following redo ablation procedure. Also, we found that the early AF recurrence in the initial ablation was association with the poor re-ablation outcome regardless of ablation energy used. The Kaplan-Meier analysis shown that those patients with early recurrence after the initial ablation had more AF recurrence compared with those without early recurrence (35.7 % vs 17.4 %, Log-rank P =0.010) after re-ablation. A previous study by Miao et al [27] also reported that patients with early recurrences after initial radiofrequency ablation respond worse to repeat ablation, but initial ablation and re-ablation in their study were all performed by radiofrequency current energy. For other clinical risk factors, we found that LA diameter, sex and CHA₂DS₂-VASc score were not correlated with AF recurrence after re-ablation.

Study limitations

Several limitations existed in this study as follows: (1) this is a single-center retrospective study; Moreover, the sample of this study was small; Larger multi-center studies must be warranted to provide conclusive evidence; (2) In this study, 24-h Holter monitoring was used for follow-up investigate but it may be underpowered when implantable loop recorder was widely used now; (3) the AF history of some patients could not be precisely identified in the present study.

Conclusions

Alternately energy source sequence ablation strategy for re-ablation of patients with recurrent atrial fibrillation was effective and safe. However, Large multi-center randomized controlled trials must be warranted to provide conclusive evidence.

Abbreviations

AF: atrial fibrillation; BMI: body mass index; CAD: coronary heart disease; LVEF: left ventricular ejection fraction; LAD: Left atrial diameter; TIA: transient ischemic attack; RFC: radiofrequency current; CB: cryoballoon.

Declarations

Acknowledgements

The authors would like to thank the research staff for their help.

Authors' contributions

QHT and XGG: Conceptualization, Investigation, Data curation,

Methodology, Formal analysis, Validation, Writing original draft; JM: Conceptualization, Methodology, Validation, Formal analysis. All the authors were involved in the draft, revision and approval of the final version.

Funding

This study was supported by the National Natural Science Foundation of China (No.81670309).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval

The retrospective study was approved by the Ethics Committee of the Fuwai Hospital, National Center for Cardiovascular Diseases, Chinese Academy of Medical Sciences and Peking Union Medical College ((No.2016-829) according to the Helsinki Declaration.

Consent to participate

Written informed consent was provided by all participants or their legal guardians. All methods were performed in accordance with the relevant guidelines and regulations of the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing Interests

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Tables

Due to technical limitations, tables are only available as a download in the Supplemental Files section.

Figures

Figure 1

Research flow chart

Figure 2

Recurrent arrhythmias before re-ablation. Paroxysmal atrial fibrillation (PAF) was the most prevalent recurrent arrhythmia in both patient groups (RFC-CB redo group vs CB-RFC redo group). Numbers in stacked columns denote numbers of patients. AFL indicates atrial flutter; AT indicates atrial tachycardia; PAF, paroxysmal atrial fibrillation; PersAF, persistent atrial fibrillation.

Figure 3

Pulmonary vein (PV) reconnections identified during repeat ablation. A, Mean number of reconnected PVs according to patient group. B, Percentage of patients with 0 to 4 reconnected PVs per patient according to patient group.

Figure 4

Freedom from recurrent atrial fibrillation (AF) following the repeat catheter ablation. RFC-CB-redo group: patients firstly ablated with RFC ablation underwent re-ablation with CB; CB- RFC-redo group: patients initially treated with CB underwent redo PV isolation with RFC ablation.

Figure 5

Subgroup analysis of freedom from recurrent atrial fibrillation (AF) following the repeat catheter ablation. **A**, early recurrence (ER) after the initial ablation vs no early recurrence (ER) after the initial ablation; **B**, PAF, paroxysmal atrial fibrillation vs PersAF, persistent atrial fibrillation.

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