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Original paper

Procedural arrhythmia termination during beating-heart, stand-alone surgical ablation and long-term outcome in patients with persistent atrial fibrillation

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Summary

Objectives: Termination of atrial fibrillation (AF) during transcatheter ablation has been associated with improved outcomes in some studies. Our aim was to determine if termination of AF during beating-heart surgical ablation affects long-term results.

Design and methods: This observational, retrospective study included 69 patients who underwent minimally invasive stand-alone surgical epicardial ablation for non-valvular, persistent AF using a bipolar ablation device. Patients with confirmed pulmonary vein isolation were included in the evaluation. Absence of arrhythmia was confirmed at 3, 6, and 12 months and annually thereafter with 24-h Holter monitoring.

Results: Altogether, 39 (57%) patients were in AF at the beginning of surgical procedure. Among them, 21 (54%) recovered their sinus rhythm (SR) during the ablation: 7 (18%) had AF termination during left atrial ablation, 14 (36%) had AF termination during right atrial (RA) ablation. The remaining 18 (46%) patients required cardioversion to achieve SR. The mean follow-up was 55 ± 24 months. There were no significant differences in the patients' preoperative and intraoperative data. The percentages of patients without AF termination during ablation who experienced freedom from AF and antiarrhythmic medications at 1, 2, 3, 4, and 5 years postoperatively were 78%, 63%, 50%, 33%, and 43%, respectively. The corresponding percentages in patients with AF termination were 83%, 74%, 67%, 71%, and 75%, respectively.

Conclusions: There is a trend towards better long-term results if arrhythmia was terminated during surgical epicardial ablation on beating heart. Termination of AF during RA ablation (observed in 36% of patients), suggests that AF is a biatrial disease in patients with persistent AF.

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Keywords: minimally invasive, surgical ablation, termination of atrial fibrillation, long term results

Introduction

Termination of atrial fibrillation (AF) during AF ablation procedures is considered to be one of the ablation endpoints [1]. During the transcatheter ablation procedure, AF termination is the preferred outcome and AF termination during ablation is related with improved long-term clinical outcomes [2–5].

AF termination could be observed during surgical epicardial ablation if the procedure is performed on the beating heart. The impact of AF termination during beating-heart surgical ablation regarding long-term results of the procedure is poorly analyzed in the literature. The aim of this study was to determine if AF termination during beating-heart surgical ablation has an impact on long-term sinus rhythm (SR) maintenance.

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Design and methods

This was an observational, retrospective study. Indications for procedures were highly symptomatic AF (European Heart Rhythm Association classes III–IV), ineffective pharmacological treatment, and patient's preference to undergo surgical intervention [6]. The same surgeon performed all procedures. Surgical ablation lesions were identical for every patient. We evaluated 69 patients with persistent AF who had undergone video-assisted, stand-alone, bipolar radiofrequency (RF) ablation for nonvalvular AF at our institution from 2008 to 2014. Only patients with confirmed pulmonary vein isolation (PVI) were included in this evaluation.

Surgical technique

Intraoperative transesophageal echocardiography (TEE) was used to rule out thrombus of the atrial appendage and to evaluate the quality of its closure. Bilateral mini-thoracotomy was used to access the atria. The box isolation of four pulmonary veins was created using a bipolar RF clamp (Cardioblate® Gemini® Surgical Ablation System; Medtronic, Inc., Minneapolis, MN, USA). The pulmonary veins were encircled passing jaws of the device through transverse and oblique sinuses of the heart. The exit block of the pulmonary vein isolation (PVI) box created by the ablation lines was checked in all cases. Each pulmonary vein distal to the ablation line was paced at a rate higher than the patient's heart rate. A 20-mA stimulus was used to confirm the exit block. If PVI was not achieved, individual ablation of each of the four pulmonary veins was performed.

Right atrial ablation was performed after PVI was achieved. Using the bipolar ablation device, additional lines were created on the right atrium: a longitudinal line from the RA appendage targeting the intraatrial septum between the right pulmonary veins; a line from the lateral part of the RA toward the tricuspid valve annulus; and a circular line at the ostium of the inferior vena cava. These ablation lines were targeting cavotricuspid isthmus. Although there are numerous evidences showing triggers coming from superior vena cava, superior vena cava was not isolated to avoid damage to sinus node. The ablation lines are showed in Fig. 1. Linear block after ablation has not been checked. Ligation of the left atrial appendage and division of the ligament of Marshall were also performed in all patients.

Postoperative care and follow-up

Clinical, demographic and postoperative outcome variables were recorded. Anticoagulation with warfarin was initiated in all patients during the early postoperative period. Class IC (propafenone), class II (β-blockers), or class III (amiodarone, sotalol, dronedarone) antiarrhythmic drugs (AADs) were initiated if AF was noted during the postoperative course. Patients with postoperative atrial tachyarrhythmia were electrically cardioverted if medical conversion was not effective. If patients were in SR and free of atrial tachyarrhythmias 6 months after the procedure,

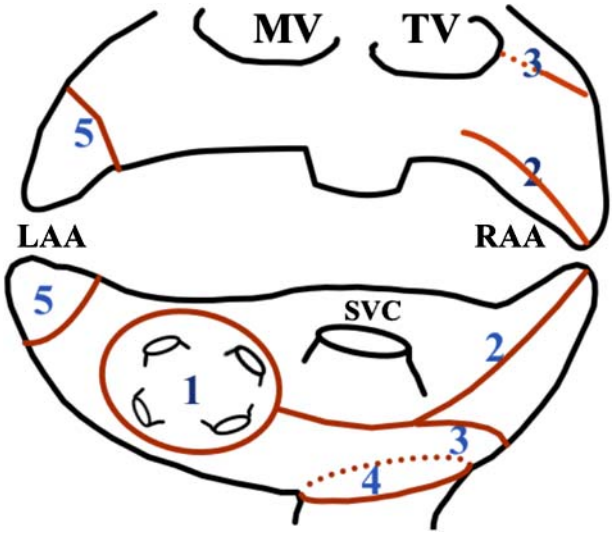

Figure 1. Ablation lines. Pulmonary vein isolation (1); right atrial ablation: line from the RAA targeting the intraatrial septum between the right pulmonary veins (2); line from the lateral part of the right atrium toward the TV annulus (3); circular line at the ostium of the inferior vena cava (4); ligation of the left atrial appendage (5). LAA – left atrial appendage; MV – mitral valve; RAA – right atrial appendage; SVC – superior vena cava; TV – tricuspid valve.

AADs were discontinued. If CHA_2DS_2-VASc score was less than 2, warfarin was discontinued. TEE was performed before discontinuation of warfarin to rule out an atrial thrombus. Follow-up was conducted according to guidelines for reporting data and outcomes for the surgical treatment of AF at 3, 6, and 12 months and annually thereafter [7]. At each visit, the patient's history, physical examination, electrocardiogram, and 24-h Holter monitoring, if patient had pacemaker, pacemaker interrogation were undertaken. Recurrence was defined as any episode of AF, atrial flutter, or atrial tachycardia that lasted >30 s [6,8]. Episodes of AF or atrial flutter were treated with AADs, electrical cardioversion, or catheter ablation using a three-dimensional navigation irrigated ablation procedure (CARTO® Thermocool Catheter, Biosense Webster, Diamond Bar, CA, USA). Treatment was considered successful if the patient was free of AF and off class I or class III AADs.

Statistical analysis

Surgical ablation effectiveness was compared in two patient groups (patients in whom AF termination was observed during the procedure, and patients in whom SR was restored with cardioversion). Categorical variables are presented as proportions and were compared with Pearson's χ^2 test and Fisher's exact test. Continuous variables are expressed as means ± SD and were compared with Student's unpaired *t*-test or the Mann–Whitney *U*-test. All reported *P* values were two-sided. A value of $P < 0.05$ was considered to indicate statistical significance. IBM SPSS for Macintosh software, Version 20.0 (IBM Corp., Armonk, NY, USA) was used for statistical analyses.

Results

Among the total 69 patients, 39 (57%) were in AF at the beginning of surgical procedure, other 30 patients did not have arrhythmia during procedure. Twenty-one (54%) patients recovered their SR during ablation: 7 (18%) had AF termination during left atrial ablation and 14 (36%) experienced AF termination during right atrial ablation. The remaining 18 (46%) patients required cardiovertion to achieve their SR. Preoperative patient characteristics, including sex, age, and medications, atrial dimensions, ablation history, co-morbidities, and operative data are presented in Table 1. There were no significant differences between patients with and without AF termination during ablation.

In the group where SR was not restored with ablation, three (17%) patients required postoperative permanent pacemaker (PM) implantation to treat sinus node chronotropic incompetence. One patient (5%) from the group where SR was restored with surgical ablation required postoperative PM to treat sinus node chronotropic incompetence. The need for PM was not significantly different between the two groups ($P = 0.318$). Catheter ablation was not needed for any patients who were in AF at the beginning of surgical procedure and was needed for 3 (10%) patients who were in SR during procedure ($P = 0.043$).

The average follow-up time was 55 ± 24 months (range 15–88 months). Patients who achieved freedom from AF and antiarrhythmic medications are shown in Fig. 2. There were no statistically significant differences in those two groups. There were no complications related to bilateral mini-thoracotomy in any group.

Discussion

There are numerous evidences showing the relationship between AF termination during transcatheter ablation and improved outcomes. O'Neill et al. have showed a lower incidence of reoccurrence AF in those patients in whom AF was terminated during the procedure compared with those who had not (5 vs. 39% $P < 0.0001$, mean follow-up 32 ± 11 months) [9]. After repeat ablation, sinus rhythm was maintained in 95% in whom AF was terminated compared with 52% in those in whom AF could not be terminated [9]. In the study by Zhou et all catheter ablation in 200 consecutive patients with non-paroxysmal AF who underwent first-time radiofrequency catheter ablation there was a significant difference in long-term success between patients with SR restoration by ablation and by cardioversion (63.8% vs. 36.8%; $P < 0.001$), SR restoration by ablation was the only predictor of single-procedure success [2]. Some authors have not found relation of AF termination during ablation to the long-term SR maintenance [10].

In this study, we wanted to determine if the termination of AF during surgical epicardial ablation on beating heart has any impact on long-term effectiveness of the treatment. Our results show trend towards better long term results if arrhythmia was terminated during ablation. The long term AF procedural termination outcome seems better than non-termination (Fig. 2), but not significant statistically, which might be secondary to small patient number. Patient number is too limited in this study, and it failed to show significant

Table 1.
Patients' characteristics

Characteristic	Arrhythmia terminated during ablation	Arrhythmia did not terminate during ablation	*P*
N	21	18	
Follow up (months)	55 ± 24	56 ± 23	0.875
Preoperatively			
Age (years)	53 ± 6	55 ± 9	0.462
Male sex	14 (67%)	15 (83%)	0.207
Hypertension	18 (86%)	13 (72%)	0.432
Thyroid dysfunction	4 (19%)	3 (17%)	0.847
AF duration (months)	70 ± 52	89 ± 87	0.439
Failed catheter ablation	4 (19%)	3 (16%)	0.549
LV EF (%)	55 ± 5	53 ± 7	0.359
LVEDD (cm)	5.3 ± 0.4	5.4 ± 0.5	0.383
LVESD (cm)	3.4 ± 0.5	3.6 ± 0.4	0.289
LA diameter length (cm)	5.8 ± 0.75	5.9 ± 0.8	0.723
LA diameter width (cm)	4.7 ± 0.6	4.8 ± 0.5	0.315
RA diameter length (cm)	5.3 ± 0.6	5.3 ± 0.5	0.938
RA diameter width (cm)	4.0 ± 0.56	4.2 ± 0.5	0.378
Operatively			
Mean operation duration (min)	158 ± 25	167 ± 33	0.343
Ablation time (s)	763 ± 204	924 ± 291	0.189
PVI ablation time (s)	450 ± 95	659 ± 178	0.036
RA ablation time (s)	416 ± 333	326 ± 163	0.544
Added individual PV ablation	5 (24%)	7 (39%)	0.488
Division of Marshall's ligament	16 (76%)	16 (89%)	0.418

AF – atrial fibrillation; LA – left atrium; LVEDD – left ventricular end-diastolic diameter; LVESD – left ventricular end-systolic diameter; PVI – pulmonary vein isolation; RA – right atrium.

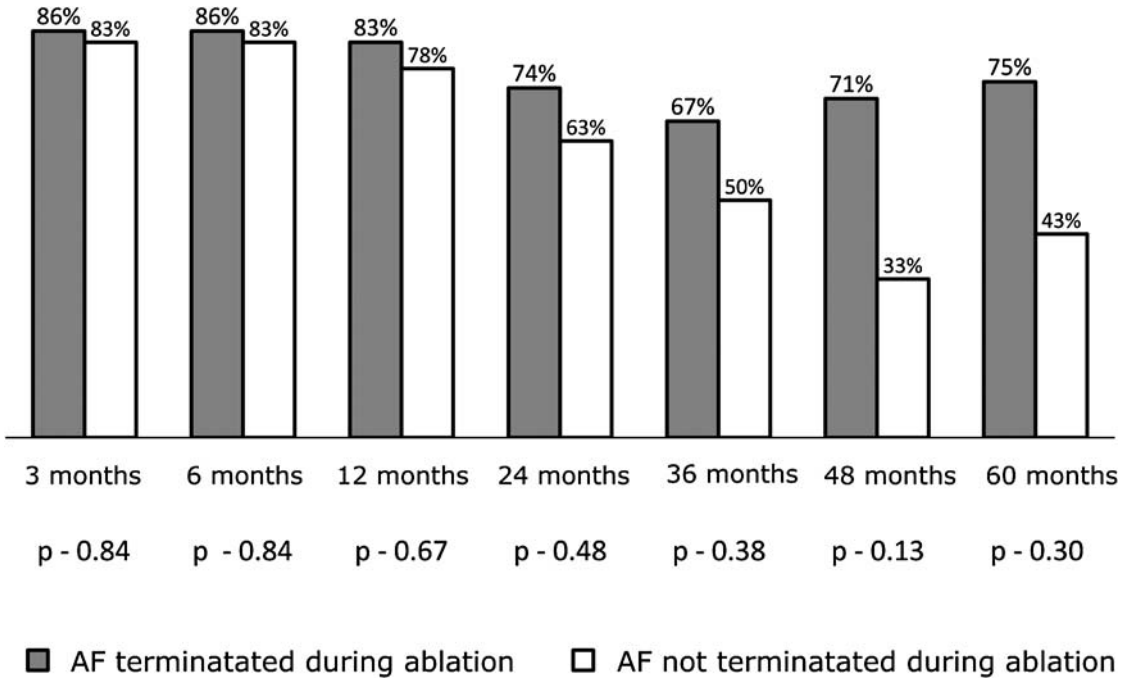

Figure 2. Freedom from arrhythmia off antiarrhythmic drugs at follow-up in patients with and without termination of atrial fibrillation during ablation.

benefit of AF procedural termination. Statistical significance could be reached in larger patient groups.

In the analyzed patient group, more than one third of the patients (36%) had recovered their SR during right atrial surgical ablation on the beating heart. Termination of AF during RA ablation suggests that AF is a biatrial disease.

Many studies have discussed the need for biatrial ablation. The left atrial Maze procedure was considered to be as effective as the biatrial Maze operation when done concomitantly with open-heart surgical procedures [11,12]. Other publications have shown that biatrial ablation during mitral valve surgery has been more effective than left atrial ablation for restoring and maintaining the sinus rhythm [13–16]. Soni et al. argued that right atrial ablation increases the risk of complications and did not agree that biatrial ablation is needed [17].

The data for left atrial versus biatrial ablation are discrepant. There are few meta-analyses with attempts to summarize all available published data. Barnett and Ad, in 2006, concluded from their meta-analysis that biatrial ablation surgery was more effective in controlling AF than surgical procedures confined to the left atrium [18]. In 2015, Phan et al. showed, via a meta-analysis, that biatrial ablation is more effective than left atrial ablation in achieving sinus rhythm at 1 year in patients undergoing a concomitant cardiac operation, but this difference was not maintained beyond 1 year [19].

The original Cox–Maze III procedure was designed to create lesions that interrupt macroreentrant circuits. It was based on concepts introduced by Moe and Abildskov [20] and confirmed by Allessie et al. [21] Cox believed that the high efficacy of the Cox–Maze procedure was the result of successfully placed lesions [22]. The lesions on the right atrium were part of the procedure. Their necessity was proven by their previous experimental work, which showed nonuniform conduction around regions of bidirectional block in both atria, resulting in multiple discrete wave fronts [23]. Liu et al. showed that not all classic Cox–Maze right atrial lines are needed, and even simplified right atrial ablation is as effective as biatrial ablation [24]. Narayan et al. demonstrated that 33% of AF rotors are located in the right atrium. They also showed that AF sources in 45% of conventional transcatheter ablation cases were ablated coincidentally [25]. Right atrial ablation may decrease the amount of tissue hosting a variety of triggers for AF and eliminate the substrate of atrial tachyarrhythmia's, which may improve the clinical outcome in patients with non-paroxysmal AF [2,13].

Without intraoperative electrophysiological investigation, intraoperative AF termination during right atrial ablation is just accidental. Termination of AF during ablation may be the result of coincidental elimination of a focal driver or modification of the atrial substrate required to sustain atrial arrhythmia. Termination of AF during surgical ablation of the right atrium could be used as an ablation end point in hybrid procedures where intraoperative electrophysiological mapping is used. In our study, AF termination during ablation was not statistically significantly related to improved long-term SR maintenance. Accumulating observations of AF termination during surgical ablation, however, should offer new insight on the AF termination influence to long-term effectiveness of surgical ablation.

Conclusions

There is a trend towards better long-term results if arrhythmia was terminated during surgical epicardial ablation on beating heart. The long term AF procedural termination outcome seems better than non-termination, but not significant statistically, which might be secondary to small patient number. Statistical significance could be reached in larger patient groups. Termination of AF during RA ablation (observed in 36% of patients), suggests that AF is a biatrial disease in patients with persistent AF.

Competing interests

The authors declare that they have no competing interests.

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