Original Article

Radiofrequency Atrial Fibrillation Ablation Technique in Patients with Mitral Valve Surgery and Left Atrial Reduction Procedures

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Abstract

Background: *About half of all patients who undergo mitral valve surgery suffer from atrial fibrillation (AF). Cox described the surgical cut-and-sew Maze procedure, which is an effective surgical method but has some complications. This study was designed to evaluate the efficacy of a substitution method of radiofrequency ablation (RFA) for patients undergoing mitral valve surgery with AF.*

Methods: *We evaluated 50 patients, comprising 40 men and 10 women at a mean age of 61.8 ± 7.5 years, who underwent mitral valve surgery with RFA between March 2010 and August 2013. All the patients had permanent AF with an enlarged left atrium (LA). The first indication for surgery was underlying organic lesions. Mitral valve replacement or repair was performed in the patients as a single procedure or in combination with aortic valve replacement or coronary artery bypass grafting. Radiofrequency energy was used to create continuous endocardial lesions mimicking most incisions and sutures. We evaluated the pre- and postoperative LA size, duration of aortic cross-clamping, cardiopulmonary bypass time, intensive care unit stay, and total hospital stay.*

Results: *The mean preoperative and postoperative LA sizes were 7.5 ± 1.4 cm and 4.3 ± 0.7 cm (p value = 0.0001), respectively. The mean cardiopulmonary bypass time and the aortic cross-clamping time were 134.3 ± 33.7 minand 109.0 ± 28.4 min, respectively. The average stay at the intensive care unit was 2.1 ± 1.2 days, and the total hospital stay was 8.3 ± 2.4 days. Rebleeding was the only complication, found in one patient. There was no early or late mortality. Eighty-two percent of the patients were discharged in normal sinus rhythm. Five other patients had normal sinus rhythm at 6months' follow-up, and the remaining 4 patients did not have a normal sinus rhythm after 6 months.*

Conclusion: *Radiofrequency ablation, combined with LA reduction, is an effective option for the treatment of permanent AF concomitant with mitral valve surgery.*

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Introduction

Atrial fibrillation (AF) raises cardiovascular mortality in addition to cerebral and systemic embolic accidents up to 18 fold.[1, 2] AF also deteriorates the cardiac function and cardiomyopathy.[3] About half of all patients undergoing mitral valve surgery (MVS) suffer from AF.[4] Although MVS recovers transmitral hemodynamics, long-term follow-up reveals normal sinus rhythm (NSR) in less than a quarter of the patients after one year.[4, 5] Even in successful MVS, most patients are symptomatic and need anticoagulation therapy.[5]

Cox et al.[6] described the surgical cut-and-sew Maze procedure as an effective surgical procedure. The majority of patients resume NSR, and health-related quality of life improves significantly in those refractory to antiarrhythmic therapy.[6, 7] Combining the Maze or modified Maze procedures with other open-heart surgical modalities induces a maintained NSR in patients.[8, 9]

The cut-and-sew Maze operation has some complications such as the difficulty of the technique, notable time consumption, and potentially increased morbidity for the total procedure.[3] Its destructive nature and the risk of preoperative complications and uncertainties regarding the atrial mechanical function are other problems of this procedure.[3]

Radiofrequency ablation (RFA) is a novel technique that allows surgeons to perform the Maze procedure by applying radiofrequency energy instead of using a scalpel/surgical incision. This substitution reduces time and complications.[3] In this study we evaluated 50 patients undergoing MVS via RFA.

Methods

Between March 2010 and August 2013, 50 consecutive drug-resistant patients with permanent AF and left atrial (LA) enlargement (anteroposterior diameter $\geq$ 60 mm) who required MVS were evaluated. Permanent AF was defined as arrhythmia continually resistant to electrical or pharmacological cardioversion. Also included were patients for whom further efforts to restore NSR had been decided against[10] The first indication for surgery was underlying organic lesions in patients; none had undergone surgery due to arrhythmia. Mitral valve replacement or repair was performed in the patients as a single procedure or in combination with aortic valve replacement or coronary artery bypass grafting. None of the patients had previously undergone a cardiac operation. Informed consent was obtained from all the patients before their procedures. Preoperative functional class was ranked according to the New York Heart Association (NYHA) classification system.[11]

All the patients were evaluated with preoperative clinical examinations, including electrocardiography (ECG), cardiac catheterization, and transthoracic echocardiography, followed by intraoperative transesophageal echocardiography. Two independent observers confirmed the preoperative ECG findings of AF. Echocardiographic studies were performed by experienced independent echocardiographers. LA enlargement was initially assessed via transthoracic parasternal long-axis M-mode echocardiography[12] and then confirmed through intraoperative transesophageal echocardiography.

Radiofrequency energy was used to create continuous endocardial lesions mimicking most of the incisions and sutures as is described in the Cox-Maze.[13, 14] RFA was carried out on the lesions using the Cobra® surgical monopolar device (Boston Scientific Corporation). The system consists of a flexible surgical probe with seven electrode terminals for separation or combined use (which creates continuous linear lesion), the generator of RFA energy, an ablation controller, and connecting cables. Ablation was performed using an RF maximum power of 150 W for one minute. The local temperature was set at 70 °C.

The same surgical team operated on all the patients. In all the cases, cardiopulmonary bypass was established via the ascending aorta and bicaval cannulation.

The aorta was clamped, and a blood cardiologic solution was infused through the root of the ascending aorta. The patient was cooled to 35 °C. The LA was opened with an incision through the interatrial groove (Waterston). The mitral leaflets were excised (the posterior leaflet was preserved if possible), and single sutures were laid on the mitral annulus. At this point, valve implantation was interrupted and LA RFA was performed. Subsequently, valve implantation was done with interrupted sutures.

The LA incision was complemented by a semilunar RFA line to isolate the right pulmonary veins. The left pulmonary veins were then encircled, and two lines were drawn connecting the two encircling lines. The mitral valve annulus and the LA appendage orifice were encircled and connected to the left pulmonary vein encircling line. LA reduction was initiated by closing the LA appendage orifice anteriorly with continuous 3-0 monofilament sutures. In the next stage, with the same suture, along the interatrial groove, paraannular plication parallel to the posterior mitral annulus of approximately 10-20 mm was performed at 15-20 mm from the ostia and 10 mm from the annulus (Figure 1). The LA appendage orifice ablation lines were used as markers to linearly exclude the appendage without excision using a running 3-0 monofilament suture to enhance the reduction of the anteromedial LA. The existing atriotomy was thereafter simply extended to the midpoint between the right and left inferior pulmonary veins, approaching the base of the radiofrequency mitral annular-connecting lesion. Excess LA tissue was then removed as a crescent-shaped wedge, uniting at the apex of the atriotomy. The closure of the extended single atriotomy incision was performed with a double-

layer 3-0 monofilament suture to bring the pulmonary veins closer to the mitral annulus, thus significantly reducing the posterolateral LA wall. Electrophysiology examination to confirm conduction block was not performed during surgery. Mitralvalve prosthesis implantation was continued typically. The aortic clamp was open, and the myocardium was reperfused. Once the rewarming bypass was terminated, the cannulae were withdrawn, temporary pacing wires were placed over the right ventricle, and the sternotomy was closed.

The presence of atrial contraction as documented by transthoracic and transesophageal Doppler echocardiography was investigated at 3 to 6months after surgery and related to the ECGs.

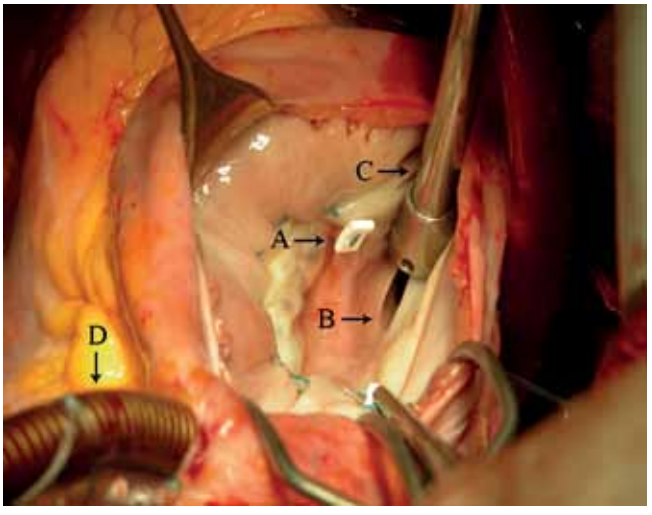

Figure 1. Reduction plasty of the left atrium

A) Left atrium plication suture; B) Mitral valve; C) Suction device; D) Inferior vena cava cannula

All the patients received an intraoperative intravenous (IV) loading dose of Amiodarone (3-5 mg/kg in 30 minutes), followed by one 2-hour and an additional 10-hour postoperative IV infusion (one mg/kg/hr and 0.5mg/kg/hr, respectively). Oral Amiodarone (5-10 mg/kg/day once a day) was administered upon extubation as tolerated and continued until hospital discharge. Cardioversion was generally performed before hospital discharge in any patient who was not in NSR. Amiodarone was continued until NSRwas maintained for 4 weeks, or up to 3 months postoperatively (5-10 mg/kg/day once a day). Amiodarone was generally discontinued one month after surgery. If a patient did not tolerate Amiodarone postoperatively, it was changed to Sotalol with the same regimen. No patients received prophylactic calcium-channel blockers. Life-long anticoagulation was initiated in all the patients because of mechanical heart valves.

Results

Fifty patients, comprising 40 (80%) men and 10 (20%) women at a mean age of 61.8 ± 7.5 years (47-78 years), were included in this study. The whole study population suffered from AF within the range of 3 to 300 months. The mean preoperative LA size was 7.5 ± 1.4 cm (confidence interval [CI]: 4.8 - 10.2), which was reduced to 4.3 ± 0.7cm (CI: 2.92 - 5.67) postoperatively (p value = 0.0001). The patients' characteristics are summarized in Table 1.

Table 1. Patients' characteristics

Characteristic	Number	Percent
Preoperative risk factors		
Prior myocardial infarction	8	16.0
Transient ischemic attack	1	2.0
Cerebrovascular accident	3	6.0
Pervious cardiovascular intervention		
Prior cardioversion	9	18.0
Ablation	2	4.0
Pacemaker	N/A	
Percutaneous coronary Intervention	11	22.0
Coronary artery bypass grafting	N/A	
Valve procedure	N/A	
Preoperative functional class		
Class I	0	0
Class II	6	12.0
Class III	35	70.0
Class IV	9	18.0
Ejection fraction		
> 50%	17	34.0
30-50%	28	56.0
< 30%	5	10.0
Valve dysfunction		
Aortic stenosis	1	2.0
Aortic insufficiency	1	2.0
Aortic stenosis and insufficiency	1	2.0
Mitral stenosis	15	30.0
Mitral insufficiency	50	100
Mitral stenosis and insufficiency	15	30.0
Tricuspid insufficiency	18	36.0

The mean cardiopulmonary bypass time was 134.3 ± 33.7 minutes (range = 73 to 208 min, median = 102 minutes), and the mean duration of aortic cross-clamping was 109.0 ± 28.4 min (range = 64 to 145 min, median = 87 min). The Maze procedure was not performed on right-sided lesions in 10 patients, who required a tricuspid valve repair. The average stay at the intensive care unit and the total hospital stay were 2.1 ± 1.2 days (range = one to 5 days, median = 1.4 days) and

8.3 ± 2.4 days (range = 4 to 14 days), respectively.

Only one patient needed reoperation, because of rebleeding. There were no transient ischemic attacks, cerebral vascular accidents, permanent pacemaker implantation, or myocardial ischemic events. There were also no ablation device-related complications such as esophagealinjuries or iatrogenic coronary artery lesion in the series. Eight (16%) patients underwent cardioversion during the first postoperative month. There was no mortality at 6 months' follow-up.

Forty-one (82%) patients were discharged in NSR. Five other patients had NSR 6 months later. Four patients did not have NSR at 6 months' follow-up. A comparison of the patients who received antiarrhythmic agents at hospital discharge (96%) demonstrated that only 11% used these agents during the next 6 months (p value = 0.0001). A significant number of the patients (96%) were able to return to their daily activities after their operation.

Discussion

The success of the Maze procedure after MVS in patients with large LAs and permanent AF currently remains suboptimal. Despite the 90-97% success rate with the traditional cut-and-sew Cox-Maze III operation, its complexity has limited its universal acceptance.[15-17] The multitude of surgical-technique modifications and energy-source variations now available tend to obscure the surgical decision-making algorithm when this challenging cohort of patients is managed. Some reports discuss the use of one or occasionally two energy sources, and many combine data from patients with paroxysmal, persistent, and permanent AF with results of 60% to 80% freedom from AF.[18-21]

Our primary focus in this study was to control the lesion set, operative technique, and AF type. Each patient underwent an identical LA-only Cox-Maze III lesion set using one radiofrequency energy source, combined with LA reduction and LAappendage linear-suture closure. We further chose to examine this treatment paradigm in a homogenous cohort of patients presenting with only permanent AF and undergoing MVS. Unlike paroxysmal or recent-onset AF, permanent AF does not revert spontaneously after MVS, and its persistence post operation has been implicated as a predictor of late stroke and mortality.[22] A large LA is commonly associated with permanent AF and mitral valve disease. Additional AF foci in the wall of the enlarged remodelled LA may contribute to the failure of simple pulmonary vein isolation and other modified Maze procedures in patients with permanent AF and large LAs. Reduction in the LA size has been suggested to play a central role in improving the Maze procedure outcomes.[23-25] Scherer et al.[26] reported that when LA application alone was performed with MVS, 63% of their patients with permanent AF were in NSR at one year.

In our experience, minimal morbidity was observed with no esophageal injuries and no early or late cerebrovascular accidents. There were no late deaths. This is similar to other studies on patients with different types of procedures using for example MVS alone, MVS + RFA, or MVS + RFA + modified Maze (Table 2).[27-32] Accordingly, adding RFA to MSV does not increase the mortality rate. The other cardiac, ablation, and cerebrovascular complications of surgery in our patients were the same as those shown in other studies (Table 3).[32-35]

Yuda et al.[36] suggested that improvements in exercise capacity and peak oxygen uptake may have more to do with a reduction in the LA size than in restoring NSR and atrial contraction after MVS with a concomitant Maze procedure. This may explain why 98% of our patients reported that they were "somewhat better" or "much better" than before their operation.

The mean cardiopulmonary bypass time for the patients in this study was not longer than usual, 134.3 ± 33.7 minutes, which is almost the same as that in other researchers' results, 176 ± 42 minutes.[3] However, surgical times for our patients were less than those for the minimally invasive surgery of the mitral valve that was performed at Leipzig Heart Centre (Germany) with a mean length of surgery of 179.6 ± 56.2 minutes and mean cross-clamp time of 74.2 ± 36 minutes.[37] This means thatadding this procedure to the Maze procedure does not appear to induce the prolongation of cardiac surgery time.

It has been suggested that in the LA only the Maze procedure results in an increase of right-sided atrial flutter, and bilateral reduction is necessary to avoid this complication while optimizing outcomes.[38] Nonetheless, electrophysiology studies have recently revealed that in patients experiencing atrial flutter after LA radiofrequency lesions created during MVS, the flutter is predominantly of a left-sided origin.[39] This argues against the routine ablation of the cavotricuspid isthmus during AF surgery. Furthermore, the routine excision of the left and right atrial appendage during the Maze operation has been associated with an elevation in circulating arginine vasopressin and aldosterone levels, presumably due to alterations in atrial baroreceptor response, thus resulting in excessive postoperative fluid retention.[3] With the LA-isolation approach examined in this study, no patient underwent right-sided ablation excision of either atrial appendage. This may explain the negligible postoperative fluid retention and the relatively low incidence of cardioversion responsive atrial flutter (6%) found in this series.

Among the patients, the total freedom rate from AF was 93.3% beyond 6 months and 94.4% beyond one year. The results of our study are similar to those in the existing literature. Oueida[40] reported 84.6% and 88.5% SNR in patients who underwent intraoperative radiofrequency AF ablation at discharge and ablation 12 months later during MVS. Bogachev-Prokophiev et al.[33] revealed 85.1% (at

Table 2. Mortality and morbidity after different type of mitral valve surgery with atrial fibrillation modality procedures

Authors	Year	Method	Mortality	Heart complication	Ablation complication	Cerebrovascular accidents or other ischemic accident
Zhou et al.	2009	RFA + MVS	2.5% (CHF)	10% (CHF, temporary A-V block)	0	
vonOppell et al.	2009	RFA + MVS + MMZ MVS	0 0			0
Chevalier et al.	2009	RFA + MVS MVS	4.8% 0			
Goel et al.	2002	RFA + MVS	4.3%		0	0
Wellens et al.	2002	RFA + MVS	0	6.6% (PPI)		3.3%
Jeanmart et al.	2006	RFA + MVS + MMZ	1%	1% (myocardial infarction) 5.9% (PPI)		1.9% (TIA)
Bogachev-Prokophiev et al.	2012	RFA + MVS + MMZ	2.1%			
Oueida et al.	2014	RFA + MVS	0	1.9% (Reexploration)	0	0
Nezafati et al. (current study)	2014	RFA + MVS + MMZ	0	2% (Rebleeding)	Cardioversion	0

RFA, Radio frequency Ablation; MVS, Mitral valve surgery; CHF, Congestive heart failure; A-V block, Atrioventricular block; MMZ, Modified Maze procedure; PPI, Permanent pacemaker implantation

Table 3. Outcome of different studies on patients with mitral valve surgery procedures

Authors	Year	Method	Percentage of patients with SNR at discharge	Percentage of patients with SNR at 12 months
Oueida et al.	2014	RFA + MVS	84.6	88.5
Bogachev-Prokophiev et al.	2012	RFA + MVS + MMS	85.1	65.2
Bartus et al.	2011	MVS + EM3	75.1	85.0
Mesana et al.	2006	RFA + MVS	67.2	85.2

SNR, Normal sinus rhythm; RFA, Radiofrequency ablation; MVS, Mitral valve surgery; MMZ, Modified Maze procedure

discharge) and 65.2% (12 months later) SNR in patients that underwent the LA Maze procedure with bipolar radiofrequency and valve surgery. Other researchers have also reported similar results with different procedures.[34, 35]

Conclusion

LA reduction can be safely and effectively combined with isolation LA-only RFA to treat permanent AF during concomitant MVS. Continued clinical evaluation and further follow-ups remain essential to confirm long-term outcomes.

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