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 min and 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 6 months’ 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 transmural hemodynamics, long-term follow-up reveals normal sinus rhythm (NSR) in less than a quarter of the patients after one year.5,6 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.5,9

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 ≥ 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 against10 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 echocardiography12 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.11,14 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. Mitral valve 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 6 months after surgery and related to the ECGs.

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 0.5 mg/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 NSR was 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.

Figure 1. Reduction plasty of the left atrium
A) Left atrium plication suture; B) Mitral valve; C) Suction device; D) Inferior vena cava cannula

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 ± 0.7 cm (CI: 2.92 - 5.67) postoperatively (p value = 0.0001). The patients’ characteristics are summarized in Table 1.

| Preoperative risk factors                  | Number | Percent |
|-------------------------------------------|--------|---------|
| 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             | Number | Percent |
|-------------------------------------------|--------|---------|
| 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                         | Number | Percent |
|-------------------------------------------|--------|---------|
| 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
from patients with paroxysmal, persistent, and permanent occasionally two energy sources, and many combine data
patients is managed. Some reports discuss the use of one or decision-making algorithm when this challenging cohort of
source variations now available tend to obscure the surgical
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).33-35

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 that adding 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. Oueida40 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
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.\textsuperscript{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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