Surgical Radiofrequency MAZE III Ablation for Treatment of Atrial Fibrillation during Open Heart Surgery

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Abstract

Background- Atrial fibrillation is a common arrhythmia in patients with rheumatic mitral and other valve diseases who are candidates for valve repair surgery. Conversion to sinus rhythm has positive effects on quality of life and lowering medication use. The aim of this clinical study was to evaluate the effectiveness of the radiofrequency ablation Maze III procedure in the treatment of atrial fibrillation associated with rheumatic heart valve disease.

Methods- We applied the modified Cox III Maze procedure with the use of radiofrequency ablation in the treatment of atrial fibrillation associated with rheumatic heart valve disease and evaluated the outcome in 20 patients with atrial fibrillation. Demographic, echocardiographic, electrocardiographic and Doppler study data were calculated before and six months and one year after surgery.

Results- No perioperative deaths occurred in the study group. Duration of additional time needed for doing radiofrequency ablation was about 22 minutes. Freedom from atrial fibrillation was 85% and 75% at six months and one-year follow up, respectively.

Conclusions- The addition of the radiofrequency ablation Maze procedure to heart valve surgery is safe and effective in the treatment of atrial fibrillation associated with rheumatic heart valve disease ***(Iranian Heart Journal 2006; 7 (4):6-12)***.

Key words: radiofrequency ablation < Maze < atrial fibrillation ■ rheumatic heart valve disease

Among the varieties of supraventricular arrhythmias that confront electrophysiologists, atrial fibrillation remains the most vexing, affecting 0.4% of the general population and up to 10% of persons older than 65 years of age. Not only is atrial fibrillation extremely common, it is a progressive disorder that is often poorly controlled with anti-arrhythmic medications.[1,2]

More importantly, atrial fibrillation (AF) is often associated with other cardiac diseases, compromising the patient's clinical outcome. 60% of patients admitted for mitral valve surgery and up to 5% of patients undergoing coronary revascularization are known to have chronic AF.

Restoration of sinus rhythm (SR) with atrioventricular resynchronization may be difficult in patients with chronic or permanent AF or other risk factors for AF.[2,3] Over the past 5 years, increasing attention has been focused on the development of catheter ablation techniques and ablation systems to cure atrial fibrillation.

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The importance of this endeavor has been fueled by a number of factors including the clinical importance of atrial fibrillation because of its high prevalence in the general population, associated symptoms, stroke risk, and increased mortality; as well as the limited efficacy, side effects, and risks associated with pharmacologic therapy and demonstration of the feasibility of curing atrial fibrillation with open heart surgical procedures and with catheter ablation techniques.[4]

Cox and colleagues developed and applied the Maze procedure successfully in patients with lone atrial fibrillation (AF). Although isolated AF itself has been reported to carry a low risk of thromboembolism, AF increases the risk significantly when associated with organic disease. Once AF becomes sustained in these patients, it usually persists even after otherwise successful operations for the underlying lesions. Because developing AF signifies pathologic degradation and symptomatic deterioration in these patients, simultaneous treatment of the rhythm and organic lesions has long been desired and expected to improve prognosis. Nonetheless, adding the Maze procedure may increase the risk because of extensive atrial incisions and suturing requiring longer cardiac arrest and cardiopulmonary bypass time. For this reason, we used radiofrequency ablation and modified the Maze atriotomy so as to shorten the operating time and preserve the sinus node artery. Moreover, myocardial changes and fibrosis derived from underlying diseases may render the Maze procedure less effective than in lone AF.[5,6]

Methods

Patients

From October 2003 to January 2005, twenty consecutive patients with a history of at least one year duration of chronic atrial fibrillation (AF) caused by mitral valve (MV) and other valvular disorders underwent a radiofrequency modified maze III procedure combined with mitral and other valvular surgery and left atrial reduction surgery when needed. All patients had documented AF for at least one year duration before operation. Demographic, echocardiographic, angiographic and catheterization data were collected before surgery. The average size of the left atrium was measured on M-mode tracing taken from a two-dimensional parasternal long-axis view (E 850, Vingmed). In all patients ventricular rate control medication, i.e. calcium blockers and/or digoxin, was allowed until the day before surgery. Oral anticoagulant therapy (warfarin) for the prevention of thromboembolism secondary to chronic AF, was discontinued 2 days before surgery. Beta-adrenergic blockers were continued.

Surgical Procedure Unipolar radiofrequency energy was used to create long continuous endocardial lesions under direct vision with a hand-held cooled tip probe in all patients. The ablation procedure was done in a bloodless operating field and temperature-guided energy applications were performed with a pre-selected catheter tip temperature. The heart was exposed through a median sternotomy and suspended in a pericardial cradle. Cardiopulmonary bypass was instituted using standard aortic and bi-caval cannulation and moderate hypothermia. The operative procedure was based on the Maze III procedure as described by Cox et al.[6]

In our RF modification, all atrial incisions currently used in the maze III were replaced by endocardial linear ablation lines as illustrated in Fig. 1 except for the incisions to enter the left and right atrial cavity. According to the original Maze III, both appendages were excised as well. The right-sided maze was performed on the beating heart without cross-clamp.

The left-sided Maze procedure was started after the heart was arrested with cold cardioplegic solution and the aorta cross-clamped. Both left and right pulmonary veins were isolated separately. Concomitant procedures, e.g. tricuspid valve repair, were performed immediately after aortic cross-clamping and prior to completing the left-sided Maze and the mitral valve procedure.

During rewarming the left atrium was closed and the cross-clamp released. The heart was then de-aired extensively prior to defibrillation and to closing of the right atrium. Occasionally, atrial pacing or ventricular pacing was needed to wean off bypass.

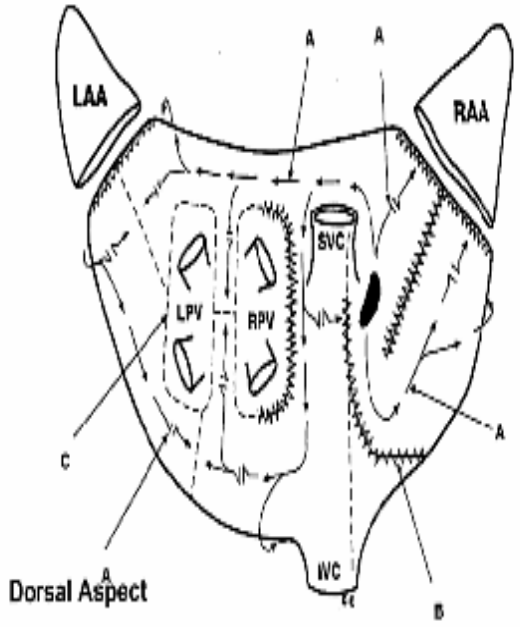

Fig. 1. RF-modified MAZE, schematic view of the dorsal aspect of the heart. Line A, electrical activation; zig-zag line B, incisions in the ablation lines. LAA, left atrial appendage; RAA, right atrial appendage; IVC, inferior vena cava; SVC, superior vena cava; LPV, left pulmonary veins; RPV, right pulmonary veins.

Follow-up

Early postoperative care was similar to that for routine open-heart surgery. Cardiac rhythm was continuously monitored after surgery until stable rhythm returned. Temporary epicardial wire attached to the right ventricle was used to pace the patient in case of severe bradycardia. We started infusion of amiodarone after surgery (150 mg loading dose and 0.5 mg/min) during the 1st day of ICU care and gave 200mg orally per day for 6 months.[2] Postoperative atrial tachy-arrhythmias were treated with additional doses of amiodarone and beta blockers, sometimes combined with DC cardioversion if necessary.

Patients were seen in the outpatient clinic monthly and at 6 months and one year after operation, or earlier when necessary. Antiarrhythmic drugs were tapered gradually after cardiac rhythm was considered stable, and amiodarone was stopped after 6 months. Transthoracic Doppler echocardiography studies were performed at 6 months and 1 year after surgery to assess atrial mechanical function. AF after surgery is defined as AF which persists for more than 48 hours.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation. Means were compared using student's t-test. In the case of non-normal distribution, the non-parametric Wilcoxon test was used. A P value less than 0.05 was considered statistically significant.

Results

Demographic data

We studied twenty patients (nine men and 11 women), mean age was 46.35 ± 10.6 years. Table I shows demographic data of patients.

Table I. Demographic data of patients

Patients	No: Total, (Male)	Age	
		Male (Mean±SD)	Female (mean±SD)
	20 (9)	44.9 ±6	47.5 ± 13.6

Operative data

The mean time for doing radiofrequency ablation was about 22±3 min. Concomitant cardiac procedures (Table II) included mitral valve (MV) repair (2), MV replacement (18), tricuspid valve repair (3), aortic valve (AV) repair (1), AV replacement (9), and left atrial reduction (n=6). In three patients the procedure was a redo surgical procedure.

Table II. Operative data of patients

Patients	MV Disease		AV Disease		TV Disease/therapy	Therapy MV		Therapy AV	
	MS	MR	AS	AR		OMVC	MVR	AV Rep	AVR
Men	9	4	0	5	2	0	9	0	5
Women	10	5	1	4	1	2	9	1	4
Total	19	9	1	9	3	2	18	1	9

MV: Mitral valve, **AV:** Aortic valve, **TV:** Tricuspid valve, **MS:** Mitral stenosis, **MR:** Mitral regurgitation, **AS:** Aortic stenosis, **AR:** Aortic regurgitation, **OMVC:** Open MV commissurotomy, **MVR:** MV replacement, **AV Rep:** AV repair, **AVR:** AV replacement

Cardiac rhythm and atrial transport

The heart rhythm of all patients except one was sinus upon arriving to the ICU, and except for two patients, the rhythm was sinus at discharge. Two patients had low-rate junctional rhythm during their stay in the ICU, so amiodarone was discontinued and temporary ventricular pacing was continued until the rhythm converted to sinus. During ICU stay, the rhythm of four patients reverted to AF; for two of them cardioversion converted their rhythm to sinus, in one patient the rhythm converted to sinus automatically and in one patient cardioversion was unsuccessful to convert the rhythm to sinus. During follow up, five patients underwent DC-shock therapy for treatment of AF, which was successful in three patients and converted their rhythm to sinus. The rhythm of two patients converted to sinus automatically. One of our patients developed atrial flutter during follow-up, which was treated successfully with DC-shock therapy. All patients completed six month follow up and 85% of patients were free of AF. At six month follow-up in patients who were in sinus rhythm, left atrial transport and contractility were assessed by transthoracic Doppler study and 82% had left atrial contraction.

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In patients who were free of AF, amiodarone (200 mg/day) was discontinued after six months. In patients with AF whose rhythm did not convert to sinus by DC-shock or patients who did not give consent to this therapy, amiodarone was discontinued and rate control strategy started. At one year follow-up, the rhythm of 75% of patients was sinus by 24-hour ambulatory electrocardiographic study, and in patients with sinus rhythm, transthoracic Doppler study showed 80% atrial transport (Fig. 2).

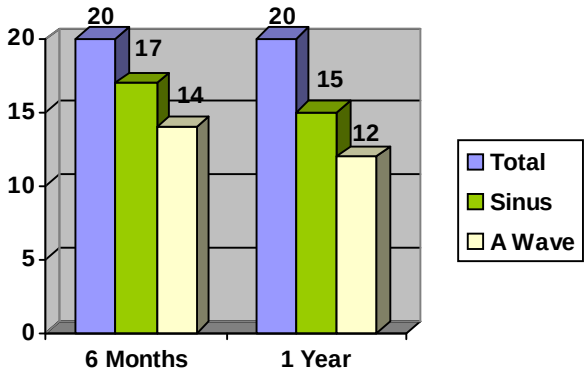

Fig. 2. Rhythm and atrial contraction of patients during follow-up.

The mean ejection fraction of patients was 51.25% ± 8.7 and 53.25% ± 6.3 before and one year after surgery; this difference was statistically significant (P= 0.035).
The LA size was 5.03 ± 0.74 before surgery, which decreased to 4.4 ± 0.58 one year after surgery; this difference was statistically significant (P= 0.002) also.

Complications
Hospital and ICU stay did not chang significantly in our patients. There was no major bleeding or need for permanent pacing.

Discussion

In the majority of patients who undergo MV surgery in chronic AF at the time of operation, the arrhythmia will remain after surgical correction of the underlying cardiac disease.[6,7,8] However, in patients with intermittent AF or AF duration of less than 1 year, MV surgery alone is sufficient to restore sinus rhythm in the majority of patients.[6,7,9] In this study we included only patients with a history of AF of at least 1-year duration and in whom it is unlikely that sinus rhythm will be regained after valve surgery. The Cox Maze procedure[6,10,11] has apparently remained a universally applicable and potentially effective treatment to restore sinus rhythm in patients with chronic AF and concomitant structural heart disease.[6,12,13] However, this surgical procedure involves extensive incisions and suturing of the atria. In an attempt to simplify the original Maze, our group and others[4,14,15] used radiofrequency (RF) energy intraoperatively to create linear ablation lines endocardially, under direct visual guidance, to eliminate AF. The RF pattern we used is based on the Maze III concept,[11] and most of the atrial incisions of the original Maze procedure are replaced by RF lesions. As a consequence, the extra cardiac arrest time to complete the left-sided part of the Maze procedure was only 22 min.
The aim of AF surgery is restoration of sinus rhythm and reestablishment of atrial mechanical function. This was achieved in the majority of the patients in our study, which is comparable with the surgical maze III in patients with long-standing AF and structural heart disease.[16,17] Swartz reported that sinus rhythm could be maintained in long-term follow-up in over 70% of patients with this approach.[1] Our study showed restoration of sinus rhythm in 75% of patients at one year follow up, which is comparable with most other studies.
Conduction gaps within the ablation lines may predispose patients to iatrogenic left atrial macro-reentrant arrhythmias that may necessitate a second ablation procedure in as many as 55% of patients.[1] In our study one patient had atrial flutter during follow up, which was treated successfully with DC shock cardioversion permanently. Cox and associates[18] demonstrated that 85.1% of patients had preservation of atrial transport function in the left atrium after the Maze III when evaluated by transthoracic Doppler echocardiography, although when additional techniques were used such as transesophageal Doppler echocardiography or magnetic resonance imaging, preservation of transport function was as high as 94% in the left atrium. The high percentage of atrial contractility in this patient group contrasts to other studies,[11,19,20] but perhaps can be explained by the use of transesophageal Doppler echocardiography to assess atrial transport function while others have relied on transthoracic Doppler echocardiography as a means to show atrial contractility. Furthermore, we have observed recovery of left atrial function in the majority of patients undergoing intraoperative RF ablation which was about 80% with Doppler echocardiography study.[21]
There is no significant difference in the postoperative sinus rhythm conversion rates between the classical ‘cut and sew’ technique and the alternative sources of energy which were used to treat atrial fibrillation,[22] so we conclude that our results are not significantly different from the conventional Maze procedure.
Finally, some studies reported better results of conversion to sinus rhythm by radiofrequency ablation applied at limited epicardial and or endocardial sites in patients with AF during MV

surgery,[14,23,24,25] but in contrast to our patient population, these studies also included patients with paroxysmal AF and AF duration less than 1 year and according to recent studies,[9,26] these patients have a higher likelihood of remaining in sinus rhythm after surgery.

We are continuing with RF ablation in our AF patients who are otherwise candidates for cardiac surgery, so these results are preliminary during the last couple of years. We anticipate that hopefully with an increasing number of patients in this study, we could obtain better and more reliable results.

Conclusion

The Cox Maze III radiofrequency ablation remains the gold standard for the treatment of atrial fibrillation and has excellent long-term efficacy.

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References

1. Neal Kay G. Catheter Ablation of Atrial Fibrillation: Challenges and Promise. Am J Cardiol 2000; 86(suppl): 25K–27K.

2. Guden M, Akpınar B, Sanisoglu I, Sagbas E, Bayındır O. Intraoperative saline-irrigated radiofrequency modified maze procedure for atrial fibrillation. Ann Thorac Surg 2002; 74: S1301– 6.

3. Deneke T, Khargi K, Hubert Grewe P, Dryander SV, Kuschkowitz F, Lawo T, et al. Left atrial versus bi-atrial maze operation using intraoperatively cooled-tip radiofrequency ablation in patients undergoing open-heart surgery safety and efficacy. American College of Cardiology 2002; 39(10): 1644-1650.

4. Calkins H, Hall J, Ellenbogen K, Walcott G, Sherman M, Bowe W, et al. A new system for catheter ablation of atrial fibrillation. Am J Cardiol 1999; 83:227D–236D.

5. Kawguchi A, Kosakai Y, Sasako Y, Eishi K, Nakano K, Kawashima Y. risks and benefits of combined maze procedure for atrial fibrillation associated with organic heart disease. J Am Coll Cardiol 1996; 28: 985-90.

6. Siea TH, Beukemaa WP, Ramdat Misiera AR, Elvana A, Ennemaa JJ, Wellensb HJJ. The radiofrequency modied maze procedure. A less invasive surgical approach to atrial fibrillation during open-heart surgery. European Journal of Cardiothoracic Surgery 2001; 19: 443-447.

7. Williams JM, Ungerleider RM, Loand GK, Cox JL. Left atrial isolation: new technique for the treatment of supraventricular arrhythmias. J Thorac Cardiovasc Surg 1980; 80: 373-380.

8. Scheinmann MM, Morady F, Hess DS, Gonzalez R. Catheter-induced ablation of the atrioventricular junction to control refractory supraventricular arrhythmias. J Am Med Assoc 1982; 248: 851-855.

9. Obaida JF, El Farra M, Bastien OH, Lievre M, Martelloni Y, Chassignolle JF. Outcome of atrial fibrillation after mitral valve repair. J Thorac Cardiovasc Surg 1997; 114: 179-185.

10. Defauw JJAMT, Guiraudon GM, Van Hemel NM, Vermeulen FEE, Kingma JH, De Bakker JMT. Surgical therapy of paroxysmal atrial fibrillation with the corridor operation. Ann Thorac Surg 1992; 53: 564-571.

11. Feinberg MS, Waggoner AD, Kater KM, Cox JL, Lindsay BD, Perez JE. Restoration of atrial function after the maze procedure for patients with atrial fibrillation. Assessment by Doppler echocardiography. Circulation 1994; 90(Part 2): II285 -II292.

12. Hioki M, Ikeshita M, Iedokoro Y, Nitta T, Harada A, Asano T, Tanaka S, Shoji T. Successful combined operation for mitral stenosis and atrial fibrillation. Ann Thorac Surg 1993; 55: 776-778.

13. Izumoto H, Kawazoe K, Kitahara H, Kamata J. Operative results after Cox/maze procedure combined with mitral valve operation. Ann Thorac Surg 1998; 66(3): 800-804.

14. Melo J, Adraga P, Neves J, Ferreira M, Timoteo A, Santiago T, Ribeiras R, Canada M. Endocardial and epicardial radiofrequency ablation in the treatment of atrial fibrillation with a new intra-operative device. Eur J Cardiothorac Surg 2000; 18: 182-186.

15. Chen MC, Guo GBF, Chang JP, Yeh KH, Fu M. Radiofrequency and cryoablation of atrial fibrillation in patients undergoing valvular operations. Ann Thorac Surg 1998; 65: 1666-1672.

16. Kosakai Y, Kawaguchi AT, Isobe F, Sasako Y, Nakano K, Eishi K, Kito Y, Tanaka N, Kawashima Y. Cox maze procedure for chronic atrial fibrillation associated with mitral valve disease. J Thorac Cardiovasc Surg 1994; 108: 1049-1055.

17. Kamata J, Kawazoe K, Izumoto H, Kitahara H, Shiina Y, Sato Y, Nakai K, Kubo T, Tsuji I, Hiramori K. Predictors of sinus rhythm restoration after Cox Maze procedure concomitant with other cardiac operations. Ann Thorac Surg 1997; 64: 394-398.

18. Cox JL, Boineau JP, Schuessler RB, Jaquiss RDB, Lappas DG. Modification of the maze procedure for atrial flutter and atrial fibrillation. I. Rationale and surgical results. J Thorac Cardiovasc Surg 1995; 110: 473-484.

19. Kosakai Y, Kawaguchi AT, Isobe F, Sasako Y, Nakano K, Eishi K, Kito Y, Kawashima Y. Modified maze procedure for patients with atrial fibrillation undergoing simultaneous open heart surgery. Circulation 1995; 92 (Suppl II): 359-364.

20. Kim KB, Cho KR, Sohn DW, Ahn H, Rho JR. The Cox-maze III procedure for atrial fibrillation associated with rheumatic mitral valve disease. Ann Thorac Surg 1999; 68:799-804.

21. Beukema WP, Ramdat Misier AR, Sie HT, Ennema JJ, Wellens HJJ. Immediate and long-term recovery of atrial function in patients with chronic atrial fibrillation undergoing intraoperative radiofrequency ablation. Pace 2000; 23 (Part 2): 600.

22. Khargia K, Huttenb BA, Lemkec B, Deneked T. Surgical treatment of atrial fibrillation; a systematic review. Eur J Cardiothorac Surg 2005; 27; 258–265.

23. Benussi S, Pappone C, Nascimbene S, Oreto G, Caldarola A, Stefano PL, Casati V, Alfieri O. A simple way to treat chronic atrial fibrillation during mitral valve surgery: the epicardial radiofrequency approach. Eur J Cardiothorac Surg 2000; 17: 524-529.

24. Sie HT, Beukema WP, Ramdat Misier AR, Elvan AE, Ennema JJ, Haalebos MMP, Wellens HJJ. Radiofrequency modified maze in patients with atrial fibrillation undergoing concomitant cardiac surgery. J Thorac Cardiovasc Surg 2001; 122 (2): 249-256.

25. Guang Y, Zhen-jie C, Yong LW, Tong L, Ying L. Evaluation of clinical treatment of atrial fibrillation associated with rheumatic mitral valve disease by radiofrequency ablation. Eur J Cardiothorac Surg 2002; 21: 249–254.