Mitral valve surgery with transseptal or septal-superior approaches combined with the intra-operative radiofrequency modified Maze procedure for the treatment of atrial fibrillation

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Summary

Objective: the aim of our study was to evaluate the safety and efficacy of radiofrequency (RF) ablation as a surgical adjunct in the treatment of atrial fibrillation (AF) and to adapt the Maze principles to mitral valve (MV) surgery using the transseptal approach (TA) and the septal-superior approach (SSA).

Design and Methods: from January 2001 to January 2004, 37 patients with permanent or persistent AF underwent an irrigated RF modified Maze procedure in combination with MV surgery. Patients were prospectively assigned to a TA group (26 patients) or a SSA group (11 patients).

Results: All the patients underwent a bi-atrial RF modified Maze procedure. The total mean time of the RF Maze procedure was 21 ± 3 min (range 15–30 min). In-hospital mortality was 2.7% (1 patient). 35 patients were free of AF at discharge. All the patients reached the 12-month follow-up, no AF or flutter was observed in 29 patients (81%) and 18 of them received no antiarrhythmics. Permanent pacing was necessary in 19% of the SSA group patients and in 18% of the TA group patients. Doppler echocardiographic examination detected the transmitral A wave in 85% of patients at 6 months postoperatively.

Conclusions: irrigated radiofrequency modified Maze procedure using both transeptal and septal-superior approaches is an effective and safe procedure abolishing atrial fibrillation in 81% of patients at 12 months of follow-up.

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Keywords: atrial fibrillation, heart surgery, Maze procedure

Atrial fibrillation (AF) is often associated with other cardiac diseases, thus compromising a patient’s outcome. AF is present in 30–50% of patients who have undergone MV operations [1]. The Maze III procedure, described by Cox and co-workers, is an effective established surgical method to eliminate AF [2]. Sie and co-workers [3], Khargi and co-workers [4] were among the first to use an irrigated radiofrequency (RF) device to create lesions similar to those in the Maze III procedure, and they named it the “irrigated radiofrequency modified Maze procedure”.

The conventional longitudinal left atrial incision posterior to the interatrial groove is routinely used with the RF modified Maze procedure. The optimal exposure of the MV and the subvalvular apparatus plays a key role in the successful outcome of MV surgery. The exposure of the MV can be particularly difficult especially in case of redo MV operations. Several approaches to MV operations have been described in the earlier studies [5–9].

The septal-superior approach (SSA) combines the advantages of the superior approach [7,10] with those of the transseptal approach (TA) [9,11,12] joining these two incisions by the division of the superior interatrial septum.

In our institution the SSA has been used since 1992 if the left atrium (LA) is small, the heart
is rotated to the right, especially in combination with aortic valve disease and left ventricular hypertrophy and during re-operations [13]. We have started the standard Cox III Maze procedure since 2000 and the RF modified Maze procedure with MV surgery through the TA and SSA – since 2001.

The aim of our study was to evaluate the safety and efficacy of RF ablation as a surgical adjunct in the treatment of AF and to adapt the Maze principles to mitral valve (MV) surgery using the TA and the SSA.

**Design and Methods**

This study was conducted in a prospective, non-randomised fashion. From January 2001 to January 2004, 37 patients aged between 27–71 years with permanent or persistent AF underwent the RF modified Maze procedure in combination with surgery for hemodynamically significant MV disease. All the patients were in NYHA class III–IV preoperatively (Table 1).

Significant tricuspid valve incompetence secondary to MV disease was present in 33 patients (89%). Concomitant aortic valve disease was found in 4 patients (11%), 1 patient (3%) also had an atrial septal defect and 1 (3%) – coronary artery disease.

Six patients (16%) underwent previous open-heart surgery: 5 patients had open mitral commissurotomy and 1 patient had 2 previous operations: correction of an atrial septal defect, MV and tricuspid valve plasty.

According to the approach to the MV, the patients were prospectively assigned to one of two groups: the TA group – 26 patients and the SSA group – 11 patients.

All the patients signed a written informed consent before they were enrolled into the study.

**The radiofrequency ablation system**

The system consisted of a RF energy generator (HAT 2008 (Sulzer-Osypka GmbH)), an infusion pump and an ablation electrode. Linear lesions were performed by cooled-tip electro-

**Surgical procedure**

Through a median sternotomy, the heart was exposed and suspended in a pericardial cradle. Cardiopulmonary bypass was instituted using standard aortic and bicaval cannulation and moderate hypothermia (28–32°C).

Antegrade tepid (28–32°C) blood cardioplegia was used in all the patients; in 4 patients retrograde cardioplegia was additionally used for myocardial protection. After both caval cannulas were snared, the right atrial appendage (RAA) was excised (a) and an incision (b) was made anteriorly from the amputated RAA towards the inferior vena cava (Figure 1). The second postero-lateral longitudinal incision (c) was curved and extended along the border of the interatrial septum, ending at the atroventricular groove opposite to the inferior caval cannulation site. In the TA group (25 patients) access to the inside of the LA was gained via the incision d1 in the interatrial septum (Figure 2). In the SSA group (11 patients) the incision d2 in the interatrial septum was extended superiorly to the right atrium and connected with the remain of the RAA (Figure 3).

If ultrasound control was used, the transesophageal probe was removed from the esophagus during RF ablation. The RF Maze procedure was performed prior to the MV surgery.

After the excision of the LA appendage, the left-sided RF Maze was performed by linear ablation as illustrated in Figures 2 and 3. Both left and right pulmonary veins were encircled separately by RF ablation lines (dotted lines k and l), and a connecting line (line m) was drawn between both islands of pulmonary veins, as close to the LA roof as possible to avoid injury to esophagus. Another two ablation lines were added to the ablation line isolating the left pulmonary vein towards the base of the LA appendage amputation site (line j) and towards the posterior MV annulus (line o). In 6 patients with previous open mitral commissurotomy and in 3 patients with a fragile tissue, the LA appendage was not amputated. Instead of that, a circumferential RF lesion was

<table>
<thead>
<tr>
<th>Table 1. Baseline patient characteristics</th>
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<tr>
<td>Male/Female</td>
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<tr>
<td>Age, years</td>
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<tr>
<td>NYHA III</td>
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<td>NYHA IV</td>
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<td>Persistent AF</td>
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<td>Permanent AF</td>
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<td>Preoperative AF, months</td>
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AF – atrial fibrillation.
performed around the base of the LA appendage, followed by the oversewing of the LA appendage orifice from the inside.

In the right atrium, irrigated RF ablation lines were made from the excised RAA to the anterior tricuspid leaflet (line f) and from the caudal end of the posterior longitudinal incision at the atrioventricular groove to the posterior portion of the annulus of the tricuspid valve (line g) (Figure 4). Irrigated RF energy was applied to the endocardial surface from the posterior longitudinal curved incision (c) to the inferior caval cannulation site (line e) in patients of the SSA group (Figure 3). In the TA group, the RF ablation line d was performed between the transseptal incision and the vena cava inferior and did not perform a line e (Figure 4).

Subsequently MV surgery or other combined procedures were carried out.

All the patients were operated on by the same surgical team.

Follow-up

The patients were followed up from 1 month to 2.5 years after surgery (mean, 10.8 ± 7.4 months). The patients were prospectively followed up at 1, 3, 6 and 12 months, and then every 6 months after the operation.

If the patients remained in sinus rhythm after the operation, no antiarrhythmic medications were prescribed. Patients with AF or atrial flutter
(AFI) relapse during hospitalisation were treated with either amiodarone or metoprolol, sotalol, propafenone, or amiodarone/propafenone combination. If the patients did not convert into sinus rhythm under medical therapy, a direct current shock cardioversion was performed. After discharge from the hospital, the same regimen of antiarrhythmics was recommended for the patients with episodes of postoperative AF to use for the other 3 or 6 months. If the patients had atrial arrhythmia at that time, these medications were continued. Warfarin was administered in every case of valve replacement or in patients with AF relapses. In patients with MV repair and without AF/AFL relapses warfarin was used within 3–6 months after the operation.

At each follow-up visit echocardiographic indices (left and right atrial diameters, left ventricular ejection fraction, atrial kick on transmitral and transcusp flow) and electrocardiogram were obtained. The patients were questioned about their
medications and any postoperative occurrence of arrhythmia at the latest follow-up.

**Statistical analysis**
Continuous variables are expressed as the mean value ± standard deviation. The Student unpaired t-test was used for the comparison of variables between the two groups. Differences were considered statistically significant at $P < 0.05$.

**Results**

**Operative data**
14 of 37 patients (38%) had MV repair and 23 patients (62%) – MV replacement. 33 patients underwent 39 concomitant cardiac procedures (Table 2).

All the patients underwent the bi-atrial Maze procedure. The mean operative time was 280 ± 63 min (range: 160–425 min). The mean aortic cross clamp time was 99 ± 23 min (range: 44–149 min). The mean total extracorporeal circulation time was 162 ± 38 min (range: 71–225 min). The mean right atrial RF Maze procedure time was 10 ± 3 min (range: 6–17 min). The mean RF Maze procedure time in the LA was 12 ± 2 min (range: 7–17 min). The total bi-atrial RF Maze procedure mean time was 21 ± 3 min (range: 15–30 min).

One patient died of acute hepato-renal failure and low cardiac output syndrome (2.7% mortality) 10 days after the operation. None of the patients died or experienced cerebral thromboembolic complications in the follow-up period.

**Dynamics of cardiac rhythm and atrial function**
In all 37 patients, AF was absent after the operation. Between 2 and 15 days after the operation, AF recurred in 15 patients (42%), and sinus rhythm was restored in 14 patients with pharmacological or electrical cardioversion. One patient developed permanent AF on the 9th day after the operation due to a postoperative fistula between the left ventricle and the right atrium. She was re-operated after 2 months and the fistula was closed, but she was left in normosystolic AF at her request. AF developed on the third day after the operation and the patient died.

Among 36 survivors, 35 were free of AF at discharge. The dynamics of cardiac rhythm is shown in Figure 5. During 1 month of follow-up, 11/36 (31%) patients had AF/AFl recurrences and sinus rhythm was restored in 9 patients. Two patients had developed permanent AF. One of these two patients developed permanent AF on the first month after the operation due to failed MV repair. The second operation was performed after 3 months and MV was replaced. He was left in normosystolic AF at his request.

During the next 2 months of follow-up AF/AFl relapsed in 4/36 patients (11%) and they were treated with antiarrhythmic agents.

All the patients reached the 12-month follow-up, no AF/AFl was observed in 29 patients (81%) and 18 of them received no antiarrhythmics. The percentage of patients free of AF did not differ in the TA and SSA groups.

12 patients (32%) were temporarily paced after the operation because of sinus bradycardia and 1 patient was paced because of complete AV block. In the SSA group the need of postoperative pacing was not significantly higher compared with the TA patients – 5/11 (45%) vs 8/26 (31%), respectively, $P$ – nonsignificant. A permanent pacemaker was implanted in 7 patients (19%). The need for permanent pacing did not significantly differ in the SSA (19%) and the TA (18%) groups.

At 6 months after the operation 29 patients (without AF/AFl) underwent Doppler echocardiographic examination and the transmitral A wave was detected in 85% of them. Preoperative and postoperative atrial sizes (both vertical and transversal diameters measured from apical 4-chamber view) decreased in patients who remained free of AF, the reduction being statistically significant after 6 months (Table 3).

**Discussion**
In this study we have evaluated the safety and efficacy of the RF modified Maze procedure for AF treatment in patients undergoing MV surgery using transseptal and septal-superior approaches. The lesion set that we designed was intended to isolate the pulmonary veins and to eliminate the possibility of re-entry circuits within the left and right atria.
A 100% success rate (freedom of AF/AFl) was documented in both the SSA and TA groups of patients immediately after the operation. Most of the recurrences of AF were observed within 3 months after the surgery. We found that the proportion of patients free of AF increased in the course of time, and more than 75% of the patients showed sinus rhythm after 3 months postoperatively. Heart rhythm stabilized at 6 months postoperatively in both groups. These findings are in agreement with the data reported by other authors [3,4,14].

The traditional longitudinal LA incision posterior to the interatrial groove may not provide optimal visualization in some cases: in patients with a deep chest, a small LA in combination with aortic valve disease and left ventricular hypertrophy or redo operations. This can often be resolved by a transseptal incision or extending this incision through the roof of the LA.

Sinus node dysfunction is frequent in patients who have undergone cardiosurgical procedures, especially in case of the septal-superior approach to the MV where the superior posterior border of the interatrial septum is divided [15,16].

Even the conventional transseptal approach, which avoids the superior septum, has been said to carry an increased risk of atrial arrhythmias [8,11]. In our opinion, seeking to avoid intraatrial “incisional” tachycardias facilitated by the transseptal incision in patients with the TA it is necessary to perform the additional RF ablation line (d) between the transseptal incision and the vena cava inferior (Figure 4) and do not perform the line e, which would isolate the anteroinferior part of the right atrium.

To avoid sinus node dysfunction arising due to the injury to the sinus node blood supply or innervation, we have abandoned the line connecting the right atrial incision (c) to the superior vena cava. If atrial tachycardias would occur due to re-entry around the superior vena cava, it is possible to locate and abolish them by catheter ablation using a three-dimensional mapping system.

A relatively high incidence of sinus bradycardia or junctional rhythm during early postoperative period (the TA group – 31%, the SSA group – 45%) was revealed in our study. Although the efficacy of the SSA is widely accepted, preservation...
of sinus node function is questioned by some authors as the sinus node artery could be injured [7,17–22]. Some authors mention that the use of the SSA can probably lead to postoperative arrhythmias and should be used with caution [21,22]. Originally the SSA was used by Cox as a part of the Maze I and the Maze II procedures. Later it was modified by moving the entire LA dome incision more posteriorly in the Maze III procedure to preserve Bachmann’s bundle and to remove long term sinus node function and atrial transport [23].

On the other hand, others reported more favourable results [15,24]. Some recent data describe how the SSA can be associated with an increased incidence of early, but not late, cardiac arrhythmias [20,25].

We also tried to preserve internodal pathways and the sinus node artery when possible. Most of our patients have been operated on using the TA and only in 30% of cases using the SSA because of a small atrium or redo operations.

The exact role of the sinus node ischemia and its impact on the cardiac rhythm is not clearly understood yet. It is known that once the sinus node artery is totally sectioned, a period of rhythm instability is generally observed during 1–2 weeks [27].

Worthy of note is that the permanent pacemaker implantation rates show no significant differences in both groups of patients (19% vs 18%). Our data are comparable with the results of other authors, when the bi-atrial Maze procedure and conventional longitudinal LA incision were used. The reported need for atrial or dual-chamber permanent pacing varies from 3.2% to 25% in patients operated on with the Maze procedure [28,29].

Our study had some limitations: a small number of patients did not allow definite conclusions regarding effects of the SSA and TA with the RF modified Maze procedure on the sinus node function and postoperative arrhythmias.

In conclusion, the present study has shown that the irrigated radiofrequency modified Maze procedure using both transeptal and superior septal approaches is the effective and safe procedure abolishing atrial fibrillation in 81% of patients at 12 months of follow-up.

The septal-superior approach is most likely to be useful in complex operations, in procedures necessitating right atriotomy for other reasons, and in patients with a small left atrium and redo operations.

### References


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Table 4.
The postoperative rhythm after the Maze procedure in the transseptal approach and septal-superior approach groups

<table>
<thead>
<tr>
<th>Postoperative rhythm</th>
<th>TA group (n = 26)</th>
<th>SSA group (n = 11)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free of AF/AFl immediately after operation</td>
<td>26 (100%)</td>
<td>11 (100%)</td>
<td>NS</td>
</tr>
<tr>
<td>Temporary postoperative pacing</td>
<td>8 (31%)</td>
<td>5 (45%)</td>
<td>NS</td>
</tr>
<tr>
<td>Permanent pacemaker</td>
<td>5 (19%)</td>
<td>2 (18%)</td>
<td>NS</td>
</tr>
<tr>
<td>Early AF/AFl relapse (during 2–15 days)</td>
<td>11 (42%)</td>
<td>5 (45%)</td>
<td>NS</td>
</tr>
<tr>
<td>Permanent AF/AFl or relapse 15 days–1 month postoperatively</td>
<td>6 (23%)</td>
<td>5 (45%)</td>
<td>NS</td>
</tr>
<tr>
<td>Permanent AF/AFl or relapse 1–3 months postoperatively</td>
<td>3 (11%)</td>
<td>3 (27%)</td>
<td>NS</td>
</tr>
<tr>
<td>Permanent AF/AFl or relapse 3–6 months postoperatively</td>
<td>6 (23%)</td>
<td>2 (18%)</td>
<td>NS</td>
</tr>
</tbody>
</table>

AF/AFl – atrial fibrillation/atrial flutter; NS – nonsignificant; SSA – septal-superior approach; TA – transseptal approach.


