

# Treatment of Atrial Fibrillation in Elderly Patients with the Cox Maze Procedure Concurrently with Other Cardiac Operations

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**Background:** In elderly patients who have atrial fibrillation (AF), surgical ablation of the arrhythmia during cardiac surgery may be challenging. Despite the reported advantages of ablating AF with the Cox maze procedure (CMP), the addition of the CMP may complicate other cardiac operations. We evaluated the effect of the CMP in elderly patients concurrent with other cardiac operations. **Methods:** From October 2007 to December 2015, we enrolled 27 patients aged >70 years who had AF and who underwent the CMP concurrently with other cardiac operations. The mean preoperative additive European System for Cardiac Operative Risk Evaluation score was 8±11 (high risk). **Results:** Only 1 hospital death occurred (4%). The Kaplan-Meier method showed a high 5-year cumulative survival rate (92%). At mean follow-up of 51 months, 23 patients (89%) had sinus rhythm conversion. The postoperative left atrial dimensions did not significantly differ between the 8 patients who had reduction plasty for giant left atrium (53.4±7.5 cm) and the 19 patients who did not have reduction plasty (48.7±5.7 cm). **Conclusion:** In patients aged >70 years, concurrent CMP may be associated with a high rate of sinus rhythm conversion without increased surgical risk, despite the added complexity of the main cardiac procedure.

*Key words:* 1. Arrhythmia  
2. Surgery  
3. Geriatrics  
4. Heart atria  
5. Heart valve disease

## Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia, with a prevalence of 2.1% in people aged >65 years, with the highest prevalence in people aged >80 years [1]. The occurrence of AF is as-

sociated with age, sex, and, most importantly, cardiac disease. Fifty percent of patients undergoing mitral valve surgery present with AF, as do 1% to 6% of patients undergoing coronary artery bypass grafting or aortic valve surgery [1-3]. In addition, AF is associated with an increased risk of developing throm-

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**Table 1.** Preoperative characteristics of patients who underwent the Cox maze procedure concurrent with other cardiac procedures (N=27)

Characteristic	Value
Age (yr)	72 (70-84)
Male sex	7 (26)
Additive European System for Cardiac Operative Risk Evaluation	8±11
Hypertension	17 (63)
Diabetes mellitus	2 (7)
Congestive heart failure	6 (22)
AF duration (mo) <sup>a)</sup>	70±103 (6-500)
Left atrial dimension (mm)	57±11 (43-83)
Giant left atrium <sup>b)</sup>	8 (30)
AF: permanent, persistent, paroxysmal	23 (85), 3 (11), 1 (4)
Left ventricular ejection fraction (%)	54±10
Previous stroke	4 (15)
Revision valve surgery	1 (4)
Mitral valve lesion	24 (89)
Mitral stenosis dominant	6 (25)
Mitral regurgitation dominant	18 (75)
Double- and triple-valve disease	23 (85)
Non-valve lesion	0

Values are presented as median (range), number (%), or mean± standard deviation (range).

AF, atrial fibrillation.

<sup>a)</sup>Median AF duration=36 months. <sup>b)</sup>Left atrial dimension >60 mm.

boembolism, suffering from a stroke, and death [4,5], and people who have AF have a 5-fold increased risk of suffering an embolic stroke [6].

The restoration of sinus rhythm decreases the need for anticoagulant therapy and improves long-term survival [7]. The Cox maze procedure may be performed in addition to other cardiac surgery procedures. However, some surgeons may not perform a concurrent Cox maze procedure because of concerns that the Cox maze procedure may increase overall surgical risk.

We hypothesized that a concurrent Cox maze procedure does not increase overall risk in cardiac surgery. The purpose of this study was to evaluate the outcomes of concurrent Cox maze procedures in elderly patients (aged ≥70 years).

## Methods

### 1) Patients and indications for surgery

From October 2007 to December 2015, we enrolled 27 patients aged ≥70 years who had AF for a

**Table 2.** Surgical procedures performed concurrently with the Cox maze procedure (N=27)

Procedure	No. of patients (%)
<b>Surgical procedures</b>	
Mitral valve replacement (tissue valve)	7 (26)
Mitral valve repair	17 (63)
Tricuspid valve repair	20 (74)
Isolated tricuspid valve repair	1 (4)
Coronary artery bypass graft	3 (11)
Ascending aortic aneurysm repair	4 (15)
Aortic root reimplantation	1 (4)
Myxoma excision	1 (4)
<b>No. of procedures per patient</b>	
2	2 (7)
3	17 (63)
4	5 (19)
5	2 (7)
6	1 (4)
Left atrial reduction plasty	8 (30)

mean of 5.8 years, and who were underwent the Cox maze procedure concurrent with other cardiac surgery procedures (Table 1). The patients were considered high risk based on the mean additive score of the European System for Cardiac Operative Risk Evaluation. All data were obtained from patient medical records and retrospectively analyzed. The study was approved by our the institutional review board of Chonbuk National University Hospital (2016-07-020), and all patients gave informed consent.

The primary surgical indication in all patients was structural cardiac valve disease (mostly mitral and tricuspid valve disease) (Table 1), and most patients underwent mitral valve repair or replacement and tricuspid valve repair (Table 2); 23 patients (85%) underwent multi-valve surgery. Non-valve cardiac disease was present in 8 patients (30%) (ascending aorta aneurysm, 4 patients; coronary artery disease, 3 patients; myxoma, 1 patient) (Table 2).

A giant left atrium (>60 mm) was present in 8 patients (30%), and these patients were treated with left atrial reduction plasty (plication sutures, 5 patients; isthmus resection, 3 patients) (Table 2). One patient underwent tricuspid valve repair and right atrial reduction plasty due to marked dilation of the right atrium [8].

## 2) Surgical procedures

**(1) The Cox maze procedure:** The Cox maze procedure was performed with combined radiofrequency and cryoablation, as reported previously [9]. The bipolar radiofrequency electrodes (Medtronic Inc., Minneapolis, MN, USA) were applied twice to make 1 ablation line in both atrial walls. A cryoprobe (Cooper Surgical Inc., Trumbull, CT, USA) was applied for 90 seconds to ablate the perivascular portion, annular portion, and coronary sinus [8]. In patients who underwent non-mitral valve surgery, including aortic and tricuspid valve surgery, the left atrial maze procedure was performed utilizing the same technique as with mitral valve surgery, through left atriotomy with resection of the left atrial appendage. The box ablations circumscribing 4 pulmonary veins using radiofrequency electrodes were made within 3.0 cm of the mitral annulus in all directions [9]. After the maze procedure was performed, the left atrial appendage opening was closed externally with continuous 4-0 or 5-0 polypropylene suture and reinforced with 4-5 interrupted 4-0 polypropylene mattress sutures with pledgets. The right atrial maze procedures were also performed using the same equipment as described previously [8,9]. The maze procedures for both atria required >40 minutes for each patient.

**(2) Atrial reduction plasty:** Atrial reduction plasty was performed by 2 methods: elliptical excision of the atrial isthmus and plication of redundant left atrial walls using 2 rows of continuous 4-0 or 5-0 polypropylene suture after the maze procedure [10].

## 3) Postoperative medications and follow-up

All patients were treated with an anticoagulant (warfarin sodium) for 3 months after surgery, and amiodarone was prescribed for patients who had AF relapse during the hospital stay; in patients who had persistent AF after surgery, amiodarone was continued for 3 months only, regardless of restoration of the sinus rhythm. Warfarin was prescribed for the first 3 months postoperatively in patients with sinus conversion. Echocardiography (ECG) was performed before surgery, during the hospitalization after surgery, upon discharge from the hospital, at the 6-month follow-up and annually after surgery. Cardiac rhythm was evaluated by spot ECG and additive Holter monitoring (n=10, 37%). For patients who had parox-

ysmal palpitation, 24-hour Holter monitoring was performed to evaluate paroxysmal arrhythmias.

## 4) Statistical analysis

All data analysis was conducted with statistical software PASW SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean± standard deviation and compared using nonparametric tests. Categorical variables were compared using the chi-square or Fisher exact test. A confidence level of 95% was considered statistically significant.

## Results

The Kaplan-Meier analysis showed that the 5-year cumulative survival rate after the Cox maze procedure was 92%±5%. In the operating room after surgery, 10 patients (37%) required temporary ventricular pacing due to bradycardia. A total of 11 patients (41%) maintained sinus rhythm conversion after surgery, and 9 patients (33%) achieved sinus rhythm conversion before hospital discharge. A total of 6 patients (22%) had persistent AF at hospital discharge.

One patient (4%) died in the hospital because of respiratory insufficiency and right heart failure at 81 days after surgery; this patient had undergone mitral valve repair 19 years earlier and underwent the second (current) cardiac operation for revision mitral valve replacement and tricuspid valve repair.

The other 26 patients had a mean follow-up period of 51±31 months (range, 6 to 96 months). At hospital discharge, 20 patients (77%) had sinus rhythm, and 13 patients (50%) were discharged on amiodarone. Two (7%) of 6 patients who had persistent AF at hospital discharge had sinus rhythm conversion within 3 months after discharge and 1 other patient (4%) had sinus rhythm conversion >2 years after surgery (Table 3).

One patient underwent the insertion of a permanent pacemaker because of dizziness secondary to sinus bradycardia (<40 beats/min). In 5 patients who had sinus rhythm conversion but experienced palpitation, there was no evidence of tachyarrhythmia on 24-hour Holter monitoring. In the 23 patients who had sinus rhythm conversion at final follow-up, 15 patients (65%) had left atrial 'a' waves in follow-up ECG.

Table 3. Perioperative data and postoperative outcomes with the Cox maze procedure for atrial fibrillation concurrent with other cardiac operations (N=27)

Parameter	Value
Bypass time (min)	211±38
Cross-clamp time (min)	170±33
Postoperative temporary pacing	10 (37)
In-hospital postoperative atrial fibrillation	11 (41)
Respiratory insufficiency	1 (4)
Permanent pacemaker for sinus node dysfunction	1 (4)
Recovery to sinus rhythm <sup>a)</sup>	
Hospital discharge	20 of 26 (77)
6-Month follow-up	22 of 26 (85)
Final follow-up	23 of 26 (89)
Clinical follow-up (mo)	51±31
Echocardiographic follow-up period (mo)	21±14

Values are presented as mean±standard deviation or number (%).

<sup>a)</sup>Not including the 1 patient who died in the hospital because of respiratory insufficiency and right heart failure 81 days after surgery.

After surgery, the mean left atrial dimension was significantly decreased (before surgery, 57±11 cm; after surgery, 50±7 cm;  $p < 0.001$ ). The mean preoperative left atrial dimension was greater in the 8 patients (27%) who were treated with left atrial reduction plasty (69±11 cm) than in the 19 patients (70%) who did not undergo left atrial reduction plasty (52±6 cm,  $p = 0.001$ ), but the postoperative mean left atrial dimension was similar between these 2 groups (left atrial reduction plasty, 53±8 cm; no reduction plasty, 49±6 cm; not significant). Significant postoperative reduction in the mean atrial dimension was observed in both groups: the 8 patients who underwent left atrial reduction plasty (before surgery, 60±12 cm; after surgery, 50±7 cm;  $p < 0.0001$ ) and the 19 patients who did not undergo left atrial reduction plasty (before surgery, 52±6 cm; after surgery, 49±6 cm;  $p < 0.001$ ).

One patient underwent isolated tricuspid valve repair and right atrial reduction plasty; this patient had sinus rhythm conversion immediately after surgery. Only 1 of 7 patients who underwent atrial reduction plasty had persistent AF after surgery.

No patient suffered an embolic stroke in the follow-up period, but 3 patients suffered from cerebral hemorrhage in the early postoperative period with warfarinization. They recovered without any sequelae.

## Discussion

The present study showed satisfactory results for the Cox maze procedure performed in addition to other cardiac surgery. This is consistent with our previous report that showed a high frequency of postoperative sinus rhythm conversion (94.2%) [9]. The sinus conversion frequency in patients aged  $\geq 70$  years was comparable to those of most reports (conversion rates of 80%–90%) [11–13]. In 20 of 22 patients (90%) who had sinus rhythm at 6 months after surgery, sinus rhythm conversion had been established before hospital discharge, and the remaining 2 patients had conversion within 3 months after surgery. The patients who had sinus rhythm conversion maintained sinus rhythm without AF relapse during follow-up. In our previous report, amiodarone was not prescribed for patients who had AF after surgery, but sinus rhythm recovered in most patients [9]. In our study of elderly patients, preventive amiodarone was not prescribed for patients who did not have AF relapse; in patients who had AF relapse, amiodarone was given only for 3 months, regardless of sinus rhythm conversion.

Dilated or diseased atria may cause AF by triggering activity around pulmonary veins or causing re-entrant circuits in the atrial wall [14]. The purpose of the maze procedure is to direct the sinus node impulse to the atrioventricular node along a specific route as soon as most re-entrant circuits are interrupted [15]. The re-entrant circuits in dilated atria have variable dimensions according to their different refractory periods [16]. Mazes that are made in the same pattern in giant left atria cannot effectively interrupt the re-entrant circuits of various sizes in the same atrium due to the large width of the mazes. Therefore, reduction of giant atria should be performed to increase effectiveness with narrower mazes [9].

In the present study, 65% patients who had sinus rhythm conversion had left atrial 'a' waves on ECG, suggestive of a mechanically active left atrium, and a lower frequency of atrial activity was observed compared with previous reports (69%–90%) [17,18]. Loss of atrial contraction in patients who have sinus rhythm conversion is probably caused by a chronically diseased atrial wall and marked atrial-wall injury secondary to the maze procedure and left atrial

reduction plasty. Absence of left atrial contraction after the maze procedure has been associated with a 5-fold increase in the risk of suffering a stroke, and large left atrial volume (volume index  $>33 \text{ mL/m}^2$ ) has been associated with a 3-fold increased risk of suffering a stroke [17]. However, the present study did not distinguish between possible causes, most likely because the enlarged left atria were sufficiently reduced by surgery and the left atrial appendage was effectively excised.

The preoperative and postoperative left atrial sizes are predictors of recurrent AF after the maze procedure [19-21]. The frequency of recurrence of AF may decrease when the left atrial size is reduced effectively. Moderately dilated left atria (50-55 mm) could be reduced by removal of the left atrial appendage and mitral valve surgery. However, larger left atria (55-60 mm) were sufficiently reduced by excising the redundant inferior left atrial wall and the left atrial appendage. To reduce giant left atria ( $>60 \text{ mm}$ ), plication of the redundant posterior wall between the right and left pulmonary veins, the redundant left lateral wall, and the inferior wall (the left atrial isthmus) should be performed to achieve sufficient volume reduction [10,21,22].

No case of embolic stroke occurred in the present study; there were 3 cases of cerebral hemorrhage without any sequelae. Ad et al. [23] reported that application of the Cox maze procedure to patients over 75 years old does not increase operative risks such as stroke or major bleeding, and thus age should not be the only discriminating factor in deciding whether to perform a concurrent Cox maze procedure.

The limitations of the present study included the small number of patients who had AF relapse, which limited the potential for determining predictors of AF relapse after the maze procedure. In addition, this study was not a randomized controlled trial or comparative study. This may be resolved with further studies of more cases. Furthermore, although we did not observe any atrial arrhythmias with 24-hour Holter monitoring in symptomatic patients who had sinus rhythm and palpitations, we cannot exclude paroxysmal AF because of the limitations of 24-hour monitoring.

In conclusion, although the concurrent Cox maze procedure in patients aged  $\geq 70$  years made the main cardiac procedure more complex, it provided

excellent sinus rhythm conversion without major morbidity or mortality. The outcomes of this study suggest that the concurrent Cox maze procedure in patients aged  $\geq 70$  years is an excellent procedure for sinus rhythm conversion without increased surgical risk. Age may not itself be a contraindication for performing the Cox maze procedure in elderly patients.

### Conflict of interest

No potential conflicts of interest relevant to this article are reported.

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