

Original
Article

Cryosurgical Left-sided Maze Procedure in Patients with Valvular Heart Disease: Medium-term Results

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Purpose: We evaluated medium-term results of the left-sided maze procedure using cryoablation in patients with valvular heart disease.

Methods: We retrospectively evaluated 111 patients with valvular heart disease who underwent the cryosurgical left-sided maze procedure. The mean follow-up period was 36.8 ± 24.9 months, and the mean duration of atrial fibrillation was 5.6 ± 6.0 years. The primary surgical procedure was mitral valve replacement in 42 patients, mitral valve plasty in 28, aortic valve replacement in 25, and combined aortic and mitral replacement or plasty in 16.

Results: The 7-year actuarial survival rate was $82.9 \pm 11.4\%$ for patients in sinus rhythm and $87.0 \pm 7.0\%$ for patients with atrial fibrillation, showing no difference between the two groups ($p = 0.236$). At final follow-up, 86 out of 111 patients (77.5%) remained free from atrial fibrillation. Sinus rhythm was maintained in 26 of 42 patients (61.9%) in the mitral valve replacement group, 26 of 28 patients (92.9%) in the mitral valve plasty group, 15 of 17 patients (88.2%) in the aortic valve replacement group, and 18 of 24 patients (75.0%) in the combined aortic and mitral replacement or plasty group. The overall actuarial rate of freedom from atrial fibrillation at 5 years after surgery was $70.4 \pm 6.0\%$.

Conclusion: The cryosurgical left-sided maze procedure is a safe, simple, and excellent operation for medically refractory atrial fibrillation.

Key words: adult, arrhythmia surgery, atrial fibrillation, heart valve

Introduction

Surgical treatment of atrial fibrillation (AF) was first performed by Cox,^{1,2)} and his method, though recognized

as the most effective surgical procedure for AF, is not widely accepted by cardiac surgeons because of the risk of perioperative bleeding and other problems. Following the recent introduction of various heating and cooling energy sources for linear ablation; however, the Cox maze procedure has been simplified by replacing the traditional cut-and-sew approach with ablation using these new devices.³⁻⁷⁾ Since 2000, we have routinely performed a simplified left-sided cryosurgical maze procedure in patients with AF undergoing heart valve surgery for mitral valve disease, aortic valve disease, or both. The objective of this study was to assess the medium-term outcome and predictors of the restoration of sinus rhythm (SR) after the simplified cryosurgical maze procedure in patients with valvular heart disease.

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Table 1 Patient profile

Age (yrs)	65.1 ± 9.6
Male/female	63/48
Follow-up duration (mo)	36.8 ± 24.9
AF duration (yrs)	5.6 ± 6.0
LAD (cm)	5.6 ± 0.9
Chronic AF (%)	97.3
Paroxysmal AF (%)	2.7

All data are presented as mean ± standard deviation.
AF, atrial fibrillation; LAD, left atrial diameter

Table 2 Concomitant valve procedures

MVR (TAP 22, CABG 4, TVR 1)	42 (37.8%)
MVP (TAP 4, CABG 1)	28 (25.2%)
AVR (OMC 3, TAP 1, CABG 1, Replacement of ascending aorta 2)	17 (15.3%)
AVR + MVR (or MVP) (MVP8, TAP 7, CABG 1, Closure of ASD 1)	24 (21.6%)

MVR, mitral valve replacement; MVP, mitral valve plasty; TAP, tricuspid annuloplasty; CABG, coronary artery bypass graft; TVR, tricuspid valve replacement; OMC, open mitral commissurotomy; AVR, aortic valve replacement; MVP, mitral valve plasty; ASD, atrial septal defect

Patients and Methods

After obtaining institutional review board approval and waiver of informed consent, we retrospectively reviewed the medical records of all patients.

Study population

From December 2000 through December 2007, 111 patients who had AF associated with valvular heart disease underwent a simplified left-sided cryosurgical maze procedure. The subjects included 63 men (57.8%) and 48 women (43.2%) with a mean age of 65.1 ± 9.6 years. Preoperatively, 97.3% of the patients had chronic AF and 2.7% had paroxysmal AF and the mean duration of AF was 5.6 ± 6.0 years. The mean follow-up period was 36.8 ± 24.9 months for the entire group. Five patients had permanent pacemakers because of AF-induced bradycardia. The clinical characteristics of the subjects are summarized in **Table 1**. All patients underwent transthoracic echocardiography before operation to measure left atrial dimension and left ventricular function.

Surgical procedure

Primary surgical procedures were mitral valve replacement (MVR) in 42 patients, mitral valve plasty (MVP) in 28, aortic valve replacement (AVR) in 25, and combined aortic and mitral valve replacement or plasty (DVR/P) in 16 (**Table 2**).

Patients were placed on standard cardiopulmonary bypass with bicaval venous cannulation. After the start of the bypass, antegrade and retrograde cold blood cardioplegic arrest was established. We then dissected the interatrial groove to enter the roof of the left atrium and create a right-sided left atriotomy. Cryoablation (−60°C or 1 minute) was delivered to the posterior wall of the left

atrium with T-shaped and straight cryoprobes and directed toward the left atrial incision for isolation of the pulmonary venous orifices on both sides for the isolation of the left atrial appendage orifice. Two lines of cryoablation were then added from the pulmonary venous box lines to the mitral annulus and the left atrial appendage. The left atrial appendage was not excised and instead was closed with a running 3-0 monofilament suture (**Fig. 1**). After the completion of cryosurgery, major procedures for the diseased heart valves were performed.

Postoperative management and follow-up

Cardiac rhythm was monitored with an electrocardiogram until hospital discharge. An atrial temporary pacing lead, placed intraoperatively, was maintained for several days. During the hospital stay, recurrence of AF or atrial flutter was treated with Ia or Ic antiarrhythmic drugs. If those were ineffective, cardioversion was attempted 4–5 days later. After hospital discharge, a standard 12-channel surface electrocardiography was routinely checked in outpatient clinic every 6–12 months regardless of symptoms. If a patient had any symptoms, including palpitation or faintness, Holter ECG was carried out to detect the arrhythmic event. Patients who underwent valve plasty or replacement with bioprosthesis were routinely administered anticoagulation therapy with warfarin with target international normalized ratio of 1.5 to 2.5. The warfarin was discontinued within 3–6 months in patients who had no recurrence of AF. For patients with mechanical valve implantation, an international normalized ratio of 2.5 to 3.0 was the aim, regardless of cardiac rhythm status.

Statistical analysis

Continuous variables were expressed as the mean ±

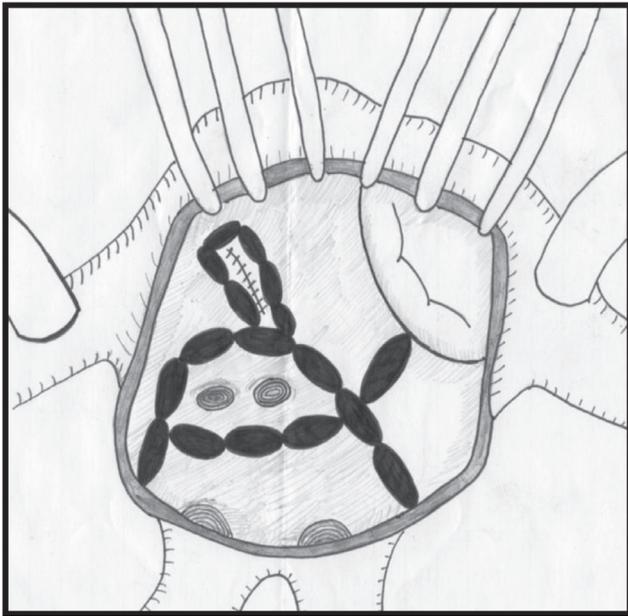


Fig. 1 Cryoablation was directed toward the left atrial incision line for isolation of the pulmonary venous orifices and the left atrial appendage orifice. Another two lines of cryoablation were added from the pulmonary venous box to the mitral annulus and the left atrial appendage. The left atrial appendage was not excised and was closed using a running 3-0 monofilament suture.

standard deviation. Univariate analysis was performed for all relevant categorical variables by the paired t test and χ^2 test, with a p value of less than 0.05 being considered significant. Kaplan-Meier estimates were used to assess actuarial survival, as well as the rates of freedom from AF and thromboembolism.

Results

Mortality and morbidity

Of 111 patients, 1 died during the operation from low output syndrome, and 5 (4.5%) died during the follow-up period. The causes of death during follow-up were chronic heart failure in 1 patient, prosthetic valve endocarditis in 1, cancer in 1, and sudden death in 2. Among 85 patients converted to SR from AF, one patient had cerebral thromboembolism and another had cerebral hemorrhage postoperatively. One of 26 patients with persistent AF had paralysis of the lower limbs.

Survival and thromboembolic events

The 7-year actuarial survival rate was $82.9 \pm 11.4\%$ for

patients in SR and $87.0 \pm 7.0\%$ for patients with AF, showing no difference between the two groups ($p = 0.236$). The 7-year rate for freedom from thromboembolism was $98.8 \pm 1.2\%$ and $96.0 \pm 3.8\%$ in the SR and AF groups, respectively, showing no statistical difference between these two groups. Thirty-nine (66.1%) out of 59 patients without a mechanical valve were not receiving warfarin at the latest follow-up, but all patients with AF and 44% of patients in SR were still on warfarin therapy.

AF-free rate

At final follow-up, 86 of 111 patients (77.5%) remained free of AF. Sinus rhythm was maintained in 26 (61.9%) of the 42 patients from the MVR group, 26 (92.9%) of the 28 patients from the MVP group, 15 (88.2%) of the 17 patients from the AVR group, and 18 (75.0%) of the 24 patients from the DVR/P group (**Fig. 2**). Five of these 86 patients (5.8%) required catheter ablation for atrial flutter during the follow-up period. The overall actuarial AF-free rate at 5 years after surgery was $70.4 \pm 6.0\%$ (**Fig. 3**). A permanent pacemaker was inserted in five patients during the follow-up period after hospital discharge because of sick sinus syndrome.

Predictors of the restoration of SR

The variables assessed as predictors for the restoration of SR after cryoablation are listed in **Table 3**. There were significant differences in terms of the preoperative duration of AF, f-wave voltage, left atrial diameter (LAD), and cardiothoracic ratio (CTR) between the SR group and the AF group. With respect to the influence of the underlying valvular disease, the LAD of the MVR and DVR/P group was significantly larger than that of the other groups (**Table 4**).

Discussion

In 1996, the simplified left-sided maze procedure was reported by Sueda and colleagues.⁸⁾ Their procedure included isolation of the four pulmonary vein orifices, excision of the left atrial appendage, and connection of the atrial lesions to the mitral valve annulus. They reported disappearance of AF associated with mitral valve disease at six months after the operation in 78% of patients and the actuarial AF-free rate was 74% at 3 years after surgery.^{9, 10)} Since 2000, on the basis of excellent previous results,^{8, 11)} we have routinely performed the cryosurgical left-sided maze procedure in all AF patients who underwent heart valve surgery. The overall SR restoration

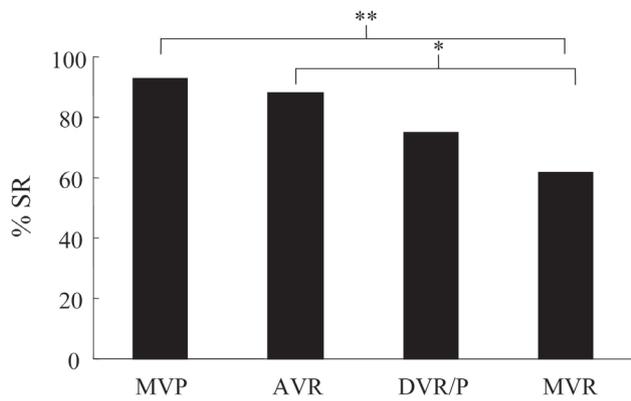


Fig. 2 Results of follow-up. This bar graph shows the percentage of patients in SR.

SR, sinus rhythm; MVP, mitral valve plasty; AVR, aortic valve replacement; DVR, double valve replacement or plasty; MVR, mitral valve replacement

* $p < 0.03$, ** $p < 0.003$.

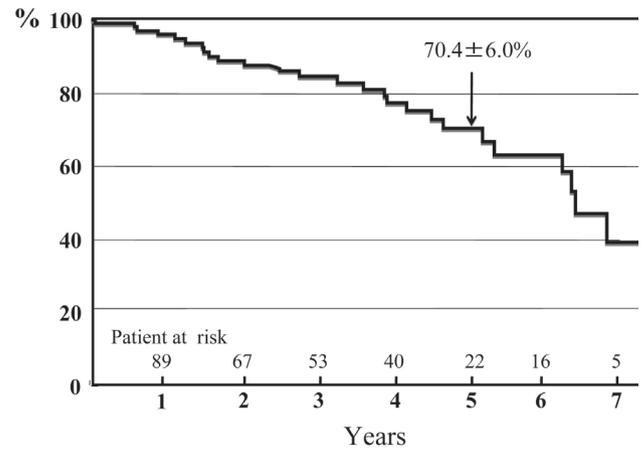


Fig. 3 The AF-free rate shown by Kaplan-Meier analysis. The overall rate of freedom from AF at 5 years was $70.4 \pm 6.0\%$.

Table 3 Preoperative parameters

	SR (n = 86)	AF (n = 25)	p value
Age (yrs)	63.9 ± 10.0	68.2 ± 7.6	0.050
AF duration (yrs)	4.5 ± 5.6	8.8 ± 6.2	0.003
CTR (%)	59 ± 7	63 ± 7	0.003
LAD (mm)	56 ± 9	60 ± 10	0.034
V1f amplitude (mV)	1.4 ± 0.7	0.9 ± 0.6	0.0003

SR, sinus rhythm; AF, atrial fibrillation; CTR, cardiothoracic ratio; LAD, left atrial diameter

Table 4 Comparison of preoperative variables

	MVR (42)	MVP (28)	AVR (17)	DVR/P (24)
LAD (mm)	$59.6 \pm 8.7^*$	54.7 ± 8.7	52.1 ± 7.9	$57.8 \pm 10.0^*$
Duration (years)	6.5 ± 6.1	4.7 ± 6.2	4.3 ± 5.3	5.9 ± 6.2
V1f (mm)	1.2 ± 0.7	1.3 ± 0.7	1.4 ± 0.6	1.3 ± 0.8
CTR (%)	60 ± 7	59 ± 7	58 ± 6	61 ± 8
Age (years)	$67 \pm 8^*$	60 ± 12	$69 \pm 8^*$	58 ± 10

MVR, mitral valve replacement; MVP, mitral valve plasty; AVR, aortic valve replacement; DVR/P, double valve replacement or plasty; LAD, left atrial diameter; CTR, cardiothoracic ratio

* $p < 0.05$

rate thus achieved is 70.4% at 5 years of follow-up. We found that there were statistically significant differences in restoration of SR depending on the underlying valve disease, and the success rate was lower in patients with MVR or DVR than in patients with AVR or MVP. All patients who underwent MVR had mitral valve stenosis caused by rheumatic heart disease. We did not study pathological changes of the atrial tissue in our patients.

In our analysis, atrial enlargement rather than the duration of AF was correlated with an increased failure rate. The size of the atrium reflects the degree of structural remodeling with cardiac myocyte hypertrophy and fibrosis.¹²⁾ Fukada also suggested that fibrosis of the atrial myocardium caused by a long duration of AF and rheumatic inflammation might contribute to a poor outcome of the maze procedure.¹³⁾ In our series, 5 patients needed

a pacemaker implantation (4.5%) because of sick sinus syndrome. All patients who underwent MVR had mitral stenosis caused by rheumatic heart disease. Predisposing factors for persistence of AF after surgery are a long duration of AF, low f-wave voltage, and enlarged left atrium,^{14–17} which were also confirmed in this study.

Although AF can be treated by the left-sided maze procedure, there is an increased risk of initiating atrial flutter, which is usually of right atrial origin. Recent studies have shown that common atrial flutter after the simplified left-sided maze procedure can be prevented by performing cryoablation of the right atrial isthmus between the inferior vena cava and the tricuspid annulus.^{18, 19} The frequency of postoperative atrial flutter is said to be 5% to 10%. In this series, five of the 86 patients (5.8%) without recurrence of AF developed atrial flutter or atrial tachycardia. These patients underwent additional catheter ablation and returned to SR after the intervention.

Conclusion

The cryosurgical left-sided maze procedure is a safe, simple, and excellent operation for medically refractory AF. In order to improve the overall success rate for restoration of SR, active and early surgical intervention before dilatation of the left atrium should be performed, particularly in patients with rheumatic mitral valve changes. Finally, larger studies with longer follow-up are necessary to confirm that the patients in sinus rhythm had better survival.

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