Medium-term results after the modified Cox/Maze procedure combined with other cardiac surgery

Hiroshi Izumoto*, Kohei Kawazoe, Kiyoyuki Eishi, Junya Kamata

Department of Cardiovascular Surgery, Iwate Medical University Memorial Heart Center, Iwate Medical University, 1-2-1 Chuodori, Morioka, Iwate 020, Japan

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Abstract

Objective: Long-term results after the modified Cox/Maze III procedure combined with other cardiac procedure for the treatment of organic heart disease and chronic atrial fibrillation (AF) has not been clarified. This report describes our medium-term results after such operation.

Methods: Between March 1993 and August 1995, 104 consecutive patients with chronic AF underwent the modified Cox/Maze III procedure combined with other cardiac procedure. There were 100 long-term survivors. There were 45 men and 55 women, with ages ranging from 21 to 77 years (mean 59.7). Patients were followed up and changes in rhythm, need for pacemaker implantation, and the incidence of CNS (central nervous system) complications were retrospectively studied.

Results: The follow-up was complete in 103 patients and 99 long-term survivors (99%). The mean follow-up period was 44.6 ± 1.1 months. In the immediate postoperative period, 73 patients regained sinus rhythm (SR group), 21 patients were in AF (AF group), and six patients underwent pacemaker implantation because of sick sinus syndrome (SSS). During the follow-up period, eight patients died. One- and 5-year survival rates (Kaplan–Meier) after surgery was 95.1 ± 2.3 and 87.8 ± 3.4% for the entire group. Preoperative NYHA class was 2.5 ± 0.7 and medium-term NYHA class was 1.5 ± 0.5. (P < 0.001) Changes in rhythm for the SR group were followed. Fifty-two patients of the SR group stayed in SR (72%), 16 patients converted back to AF (22%), and four patients had newly-developed SSS (6%) at follow-up period. Probability in SR maintenance for SR group at 1 year was 88.8 ± 3.7% and at 5 years was 64.8 ± 7.5%. Five patients experienced the CNS complication during the follow-up period. Two of the AF group and two of the SR group patients developed cerebral/cerebral infarction. One of the SR group patients experienced small cerebral bleeding.

Conclusions: The medium-term results after the modified Cox/Maze III procedure concomitant with other cardiac procedure are good with improved functional status and good survival rate. However, there seems to be gradual but constant attrition in the rate of SR maintenance in SR group.

Keywords: Atrial fibrillation; Modified Cox/Maze III procedure; Sinus rate maintenance; Central nervous system complication

1. Introduction

The Cox/Maze procedure is one of surgical treatments for symptomatic patients with drug-resistant chronic and paroxysmal atrial fibrillation, originally developed by Cox in 1991 [1]. The aim of this procedure is to block the macro-reentrant circuit by multiple atrial incisions of maze-like configuration and to cure atrial fibrillation (AF). Cox and his associates performed this procedure in patients with non-valvular atrial fibrillation in their initial series. As a significant number of patients undergoing mitral valve surgery are associated with chronic drug-resistant atrial fibrillation in Japan and Asian countries, the Cox/Maze procedure has been concomitantly performed with valve surgery in an attempt to improve the quality of life after surgery, by eliminating the morbidity associated with chronic atrial fibrillation. In 1994, Kosakai and his associates reported a modification of Cox/Maze III procedure [2]. One of the modifications is the modest use of cryoprobes to replace atriotomies of original Cox/Maze III procedure, on the grounds that technical modification shortens the cross-clamp time and save blood loss during surgery. There have been some reports describing early results after the modified procedure combined with other cardiac surgery. [3–5]. Little is known, however, about the medium-term results after the modified Cox/Maze procedure combined with other cardiac surgery. This study was undertaken to update the medium-term results (including changes of rhythm status, incidence of cerebrovascular accident) in patients having undergone the modified Cox/Maze proce-
2. Patients and methods

2.1. Patients

In 1997, our group reported the electrocardiographic nature of restored sinus rhythm after the Cox/Maze procedure elsewhere [6]. This is the follow-up of the patients reported. Between March 1993 and August 1995, 104 consecutive patients with chronic atrial fibrillation (of more than 3 months duration) and organic heart disease underwent the Cox/Maze procedure and other cardiac surgery at Iwate Medical University. Four patients died within 3 months after surgery. There were 100 long-term survivors (more than 3 months). Among the long-term survivors, there were 45 men and 55 women, with ages ranging from 21 to 77 years (mean 59.7). All patients had organic heart disease. Seventy-eight patients had mitral valve disease, nine patients had aortic valve disease, eight patients had congenital heart disease, and five others had other cardiac diseases. Eight of the long-term survivors had had previous cardiac surgery (8%). As concomitant cardiac operations, 30 patients received mitral valve replacement, 48 patients received mitral valve repair, eight patients received aortic valve replacement, one patient had aortic valve repair, two had coronary artery bypass grafting, and 11 others received other cardiac operations.

This study was approved by Iwate Medical University Hospital Ethics Committee and informed consent was obtained from all patients.

2.2. Follow-up

All long-term survivors \((n = 100)\) were sent back to the referring hospitals or clinics after hospital discharge. They were closely followed by the cardiologists on a monthly or bi-monthly basis. The use and choice of anti-arrhythmics are by the preference of the referring cardiologists, if any. All notes of clinic appointments and results of any examinations performed, including electrocardiography (ECG), were recorded. Changes in cardiac rhythm were followed at the referring clinic on a bi-monthly or monthly basis. The anti-coagulation therapy was started when the recurrence of atrial fibrillation was documented. The incidences of any cerebrovascular accidents were recorded and the New York Heart Association class was also recorded.

All clinical data were collected during the period of June and July 1998. The closing date was the end of July 1998.

2.3. Surgical procedure

All procedures were performed using cardiopulmonary bypass under moderate hypothermia. Atriotomies made in the maze procedure were basically similar to the Cox second modification (Maze III) [7]. However, we utilized cryoablation in several parts of Cox’s second modification instead of surgical atriotomy. Lines of extended left atriotomy and a line of vertical incision toward the mitral annulus, line of incision for posterior longitudinal right atriotomy, and a line of incision in anterior limbus are replaced with the cryoablation. Details of operative procedure have been presented in Fig. 1. The modified Cox/Maze procedure we perform at the Iwate University is not equivalent with the modification by Dr Kosakai.

After surgery, patients were transferred to the unit. Inotropes were administered to every patient postoperatively, and cardiac rhythm was monitored continuously. When hemodynamically significant supraventricular tachyarrhythmia occurred, overdrive suppression and/or pharmacological suppression were attempted. If these measures were ineffective, patients were treated with electrical cardioversion.

2.4. Statistical analysis

The operation reports, discharge summaries, and full hospital records were reviewed and collected data were entered into a database. Continuous variables were expressed as mean ± standard deviation. The survival rate and the SR maintenance rate were calculated according to the Kaplan–Meier method.

3. Results

3.1. Survival and functional status after surgery and redo surgery

The follow-up was complete in 99 of 100 long-term survivors (99%). The mean follow-up period was 44.6 ± 1.1 months. For operative survivors (103 patients who survived more than 1 month), 1- and 5-year survival rates

Fig. 1. Illustration of the modified Cox/Maze procedure. The use of cryoablation is shown.
were 95.1 ± 2.3 and 87.8 ± 3.4% respectively according to the Kaplan–Meier method (Fig. 2).

During the follow-up period after hospital discharge, eight patients died (8/99). Three patients died of cardiac failure, one patient died of gastric cancer, one patient died of colon cancer, one patient died of ovarian cancer, one patient died of chronic pleuritis of exacerbating tuberculous, and one patient died of unknown cause.

Preoperative NYHA class was 2.5 ± 0.7 and NYHA class at follow-up was 1.5 ± 0.5 (P < 0.001).

There were two cases of re-do surgery during the follow-up period. Redo mitral valve replacement was performed in a female patient who had had the modified Cox/Maze procedure and concomitant mitral valve repair 3 years after initial surgery. The patient had deterioration of mitral regurgitation over the follow-up period. Another male patient who had received the modified Cox/Maze procedure, concomitant mitral valve repair, and tricuspid annuloplasty developed new stenotic lesion in the circumflex coronary artery and had the recurrence of mitral regurgitation. This patient was treated with single coronary bypass graft and re-repair of the mitral valve 1 month after initial surgery. The development of circumflex coronary artery stenotic lesion was considered to be related with the cryoablation.

3.2. Changes of cardiac rhythm after surgery

For long-term survivors, 73 patients regained sinus rhythm (SR group), 21 patients were in atrial fibrillation (AF group), and six patients underwent pacemaker implantation because of sick sinus syndrome, at immediate postoperative period. For AF group patients, most patients had been in AF during the follow-up period except in two patients. Two of the AF group patients spontaneously regained SR during the follow-up period. Changes of cardiac rhythm for the SR group were followed during the follow-up period. Fig. 3 summarizes the changes of postoperative rhythm status. Some of them lost SR and converted to AF. None of the SR to AF converted patients regained SR during the follow-up period. Therefore, we define the SR maintenance rate as the rate continuously keeping the SR as baseline rhythm and the absence of AF of more than 1 month duration. The SR maintenance rates and curve was obtained according to the Kaplan–Meier method for the SR group. Fifty-two patients of the SR
group stayed in SR (72%), 16 patients became AF (22%), and four patients had newly-developed SSS (6%) at the follow-up period. Probability in SR maintenance for SR group at 1-year was 88.8 ± 3.7% and at 5 years was 64.8 ± 7.5% (Fig. 4). The calculated linealized attrition rate is 0.6%/patient month.

3.3. CVA after surgery

Our anticoagulation protocol of postoperative patients is as follows. Patients with AF and/or with mechanical cardiac valve(s) are anticoagulated permanently. Patients with repaired valve or implanted biological valve are anticoagulated temporarily for 3 months. Five patients experienced the CVA during the follow-up period. Two of AF group patients developed cerebral infarction. One of them was the patient who received redo-mitral valve replacement during the follow-up period for the recurrence of mitral regurgitation. This patient developed left atrial (LA) thrombus and cerebral infarction after redo-mitral valve replacement due to poor warfarin control. Two of SR group patients developed cerebral or cerebellar infarction. One of them was found to have AF at the time of hospital admission for cerebellar infarction after a stable period of SR for 2 years. One of SR group patients developed cerebral bleeding.

4. Discussion

Since the pioneering work of Cox and his associates in 1991, the Cox/Maze procedure has been modified by his group [8] and by others [2,5,9]. Cox and his associates reported two problems of the original Maze procedure; (1) the frequent inability to generate an appropriate sinus tachycardia in response to maximal exercise, and (2) occasional left atrial dysfunction. Then they modified the procedure to Cox/Maze III. Kosakai and associates reported a modification of the Cox/Maze procedure to reduce the postoperative incidence of SSS and shorten the operative time by using the cryoprobe ablation instead of surgical ablation [2].

In 1996, Cox and others demonstrated that the AF recurrence rate during the follow-up period is only 2% after the Cox/Maze III procedure, although 24% of the patients required pacemakers (Cox). In 33% of his patients group, concomitant cardiac surgery has been performed [10].

It has been reported that operative results or the short-term results after the modified Cox/Maze procedure are satisfactory in several reports [11,12]. However, there is paucity of information regarding the longer-term results after the modified Cox/Maze procedure combined with other concomitant cardiac surgery. This paper updates our series of the modified Cox/Maze III procedure combined with other cardiac surgery. The result of the study demonstrates that the survival rate after the combined procedure is good and 5-year survival rate reaches to 87%. However, when the rhythm status is followed, the results suggest that there seems to be constant attrition in the rate of SR maintenance in the SR group. The probability of SR maintenance for SR group at 1 year was 88% and the probability at 5 years gradually decreased to 65%.

A couple of factors might be involved in the decline of SR maintenance during the follow-up period. One of them is the fact that all of the patients had concomitant organic cardiac disease at the time of operation. Seventy-eight percent of them had mitral valve disease in our series. It is probable that the underlying heart disease could have negative impact on postoperative SR maintenance rate. Another factor is probable negative effect with the modest use of the cryoablation. Cox and associates reported a 2% of AF recurrence rate in their series of 118 patients between 3 months and 8.5 years after surgery. The only technical difference between Cox’s series and ours is the modest use of cryoprobe. The modest use of cryoablation technique could have resulted in less satisfactory transmural lesion, which then predisposed to later recurrence of AF.

When the incidence of central nervous system (CNS) complications are examined, two of SR patients developed cerebral or cerebellar infarction during the follow-up period. As stated in the results, one of them is a recent converter to AF and it is reasonable to assume that this patient developed left atrial thrombus during the undetected AF period and had cerebral infarction, although the echocardiography at the time of admission did not demonstrate LA thrombus.

4.1. Limitations of the study

A major limitation in this study is the assumption that the SR patients who convert to AF never regain SR during the follow-up period, when the probability of SR maintenance curve is calculated with the use of the Kaplain–Meier method. This assumption is arbitrary and, therefore, the use of the Kaplain–Meier method may not be good to represent the postoperative rhythm changes in SR group patients.
However, if we define the term the SR maintenance rate as stated, the Kaplan–Meier method may be utilized.

5. Conclusions

Although there is limitation in this study, we conclude that the medium-term results, after the modified Cox/Maze procedure combined with other cardiac surgery, are good with good survival rate and improved functional status. However, when the probability of SR maintenance is examined, there is gradual but continuous decline in the rate of SR maintenance for postoperative SR group. Causes and factors affecting this decline should be further clarified.

Since there is decline in the rate of SR maintenance, close follow-up of the patients is needed even in patients who regained SR after the combined procedure to minimize CNS complication at follow-up period.

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References
