

Clinical Benefits of Concomitant Maze During Cardiac Surgery

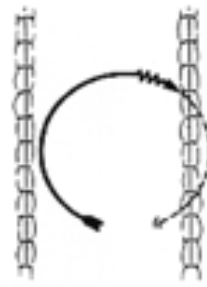
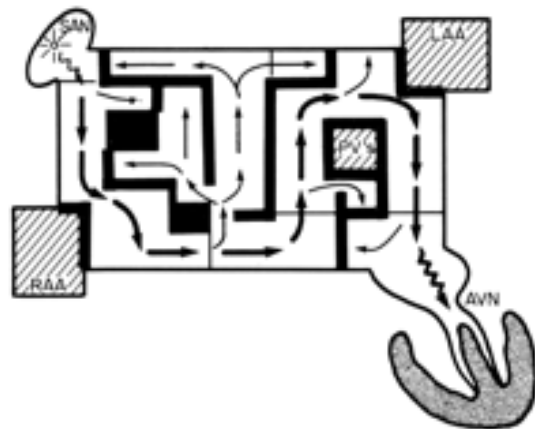
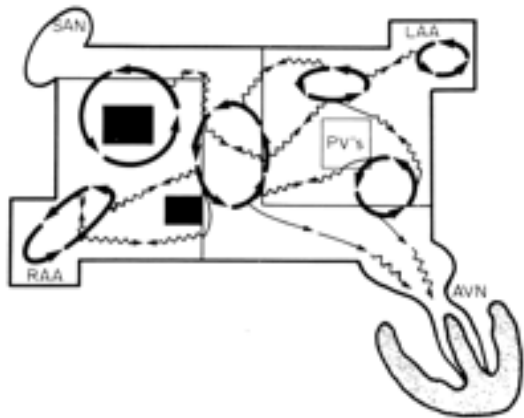
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Substrate of AF

- **Paroxysmal AF**
 - **Pulmonary vein**: trigger of AF
 - Majority (90%) of patients cured with **PV isolation**
- **Chronic AF**
 - **LA (dilated)** : substrate for AF
 - **Macro-reentrant circuits** in dilated LA
 - Failed with PV isolation
 - Cured with **Cox-maze procedure**.

Chronic AF



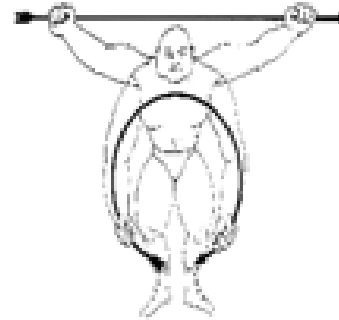
A



B

Long Refractory Period

Short Refractory Period

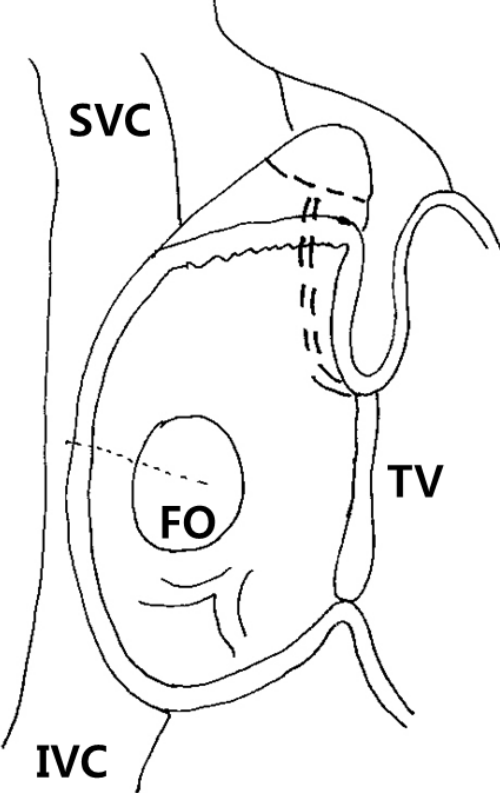
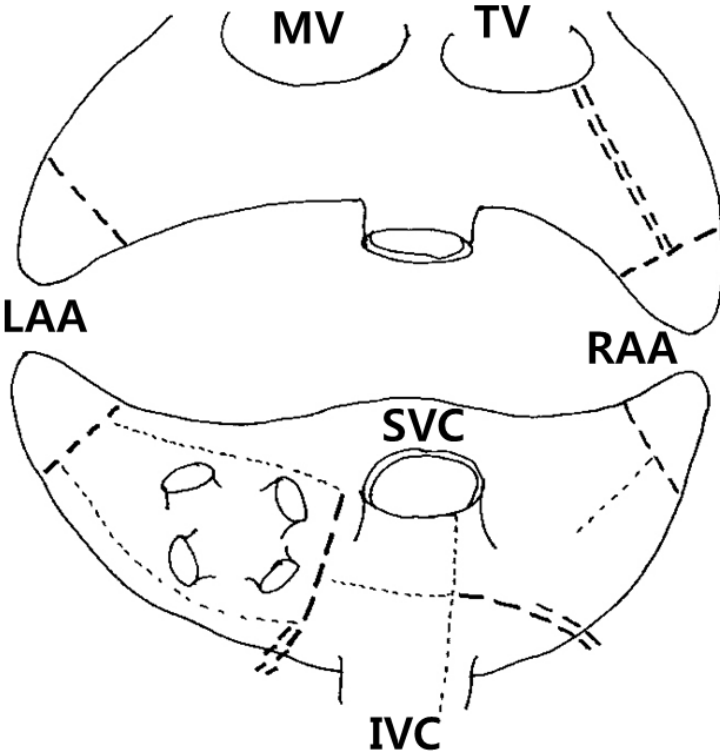


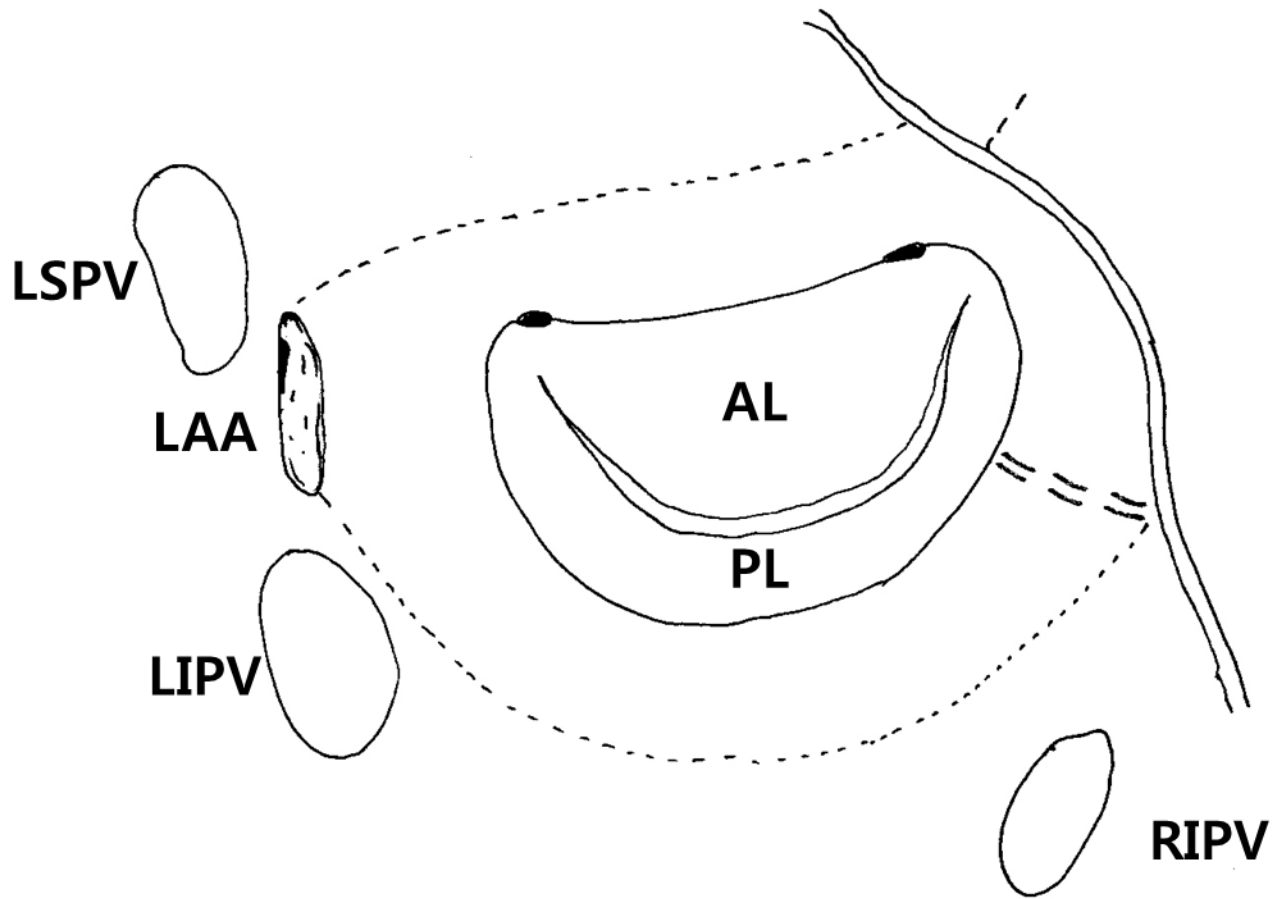
Large Macro-reentrant Circuit



Smaller Macro-reentrant Circuit

Maze procedure





Main Sequelae of AF

1. Patients **anxiety** : rapid heart rate
 2. Cardiac **hemodynamic** deterioration : loss of synchronous AV contraction
 3. **Stroke** : thromboembolic risk
- **Management:** Rate control vs. rhythm control
Prevention of thromboembolism

AFFIRM (Atrial Fibrillation Follow-Up Investigation of Rhythm Management) trial

- **Poor long-term success**
 - **63% resumed sinus rhythm**
 - **Unwanted side effects of chronic medical therapy**

Early surgery for asymptomatic mitral regurgitation: importance of atrial fibrillation.

Abstract

BACKGROUND AND AIM OF THE STUDY: It remains controversial whether early mitral valve (MV) repair should be performed for severe degenerative mitral regurgitation (MR) without symptoms, left ventricular (LV) dilatation or dysfunction, atrial fibrillation (AF) or pulmonary artery hypertension (PH), even at experienced surgical centers. The study aim was to reconsider the optimal timing of intervention for asymptomatic patients with severe degenerative MR at experienced surgical centers.

METHODS: Clinical outcomes were reviewed retrospectively for 298 consecutive asymptomatic patients (mean age 57 +/- 12 years) who underwent MV surgery for degenerative MR. The patients were allocated to two groups based on the following comorbid conditions: LVEF < or = 60%, LV end-systolic dimension 40 mm, AF, and PH. Group A comprised 122 patients with none of these conditions, while group B comprised 176 patients with any one of the conditions. The clinical outcomes were compared between the two groups at a mean of 7.0 +/- 4.5 years after surgery.

RESULTS: MV repair had been attempted in all patients, with a success rate of 100%. At 10 years, survival among group B patients was poorer than in group A (93% and 81%, respectively; $p = 0.02$), and there was a lower freedom from valve-related events (89% and 71%, respectively; $p < 0.01$). The independent predictors of valve-related events were preoperative AF (hazard ratio 3.34; $p < 0.001$) and age > 60 years (hazard ratio 2.50; $p < 0.01$).

CONCLUSION: Early MV repair is a reasonable option in asymptomatic patients, while preoperative AF may be a more appropriate predictor of an adverse outcome than LV function, as is currently recommended.

Long-term clinical outcome of mitral valve repair in asymptomatic severe mitral regurgitation.

OBJECTIVE: To assess the long-term survival, the incidence of cardiac complications and the factors that predict outcome in asymptomatic patients with severe degenerative mitral regurgitation (MR) undergoing mitral valve repair.

METHODS: Up to 143 asymptomatic patients (mean age 63 \pm 12 years) with severe degenerative MR who underwent mitral valve repair between 1990 and 2001 were subsequently followed up for a median of 8 years. The study population was subdivided into three subgroups: patients with left ventricular (LV) dysfunction and/or dilatation (n=18), patients with atrial fibrillation and/or pulmonary hypertension (n=44) and patients without MR-related complications (n=81).

RESULTS: For the patients, 10-year overall and cardiovascular survival was 82 \pm 4% and 90 \pm 3%. At 10 years, patients without preoperative MR-related complications had significantly better overall survival than patients with preoperative LV dysfunction and/or dilatation (89 \pm 4% vs 57 \pm 13%, log rank p=0.001). Patients without preoperative MR-related complications also tended to have a better 10-year overall and cardiovascular survival than patients with atrial fibrillation and/or pulmonary hypertension (overall survival of 79 \pm 8%), although this did not reach statistical significance (log rank p=0.17). Cox regression analysis identified the baseline left ventricular ejection fraction and age as the sole independent predictors of outcome.

CONCLUSION: Our data indicate that in asymptomatic patients with severe degenerative MR, mitral valve repair is associated with an excellent long-term prognosis. Nonetheless, the presence of preoperative MR-related complications, in particular LV dysfunction and/or dilatation, greatly attenuates the benefits of surgery. This suggests that mitral valve repair should be performed early, before any MR-related complications ensue.

Novel strategies for treatment of AF

1. Ablation and pace strategy

- AV node ablation and permanent PM implantation
- Disadvantages
 - Rate controlled, but PM dependent and **thromboembolic risk** (stroke)
- Advantages
 - **Exercise performance and ventricular function** comparable to medically managed patients

2. Cox work

– Indications

- AF associated with **structural heart disease**
- **Isolated (lone) AF** that is symptomatic despite medical treatment and catheter ablation

– Selection of surgical ablation

- Surgical **indication**
- Anticipated **morbidity**

ex) Double valve replacement + cut-and-sew technique + **aged + well-controlled AF with medication**

Cox-Maze procedure

- **Standard 'cut-and-sew' method**
 - **Most effective and reliable method**
 - Complete transmural atrial lesion
- **Partial modification**
 - **Cryolesion instead of 'cut' lesion**
 - On medial aspect of RA
 - For pulmonary vein isolation
- **Modified Cox-maze procedure (Cox-maze IV)**

'Cut-and-sew' technique for complete transmural atrial lesion

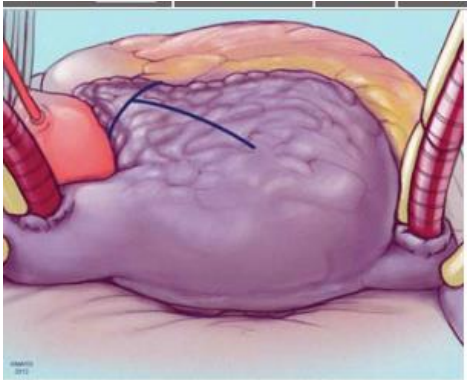
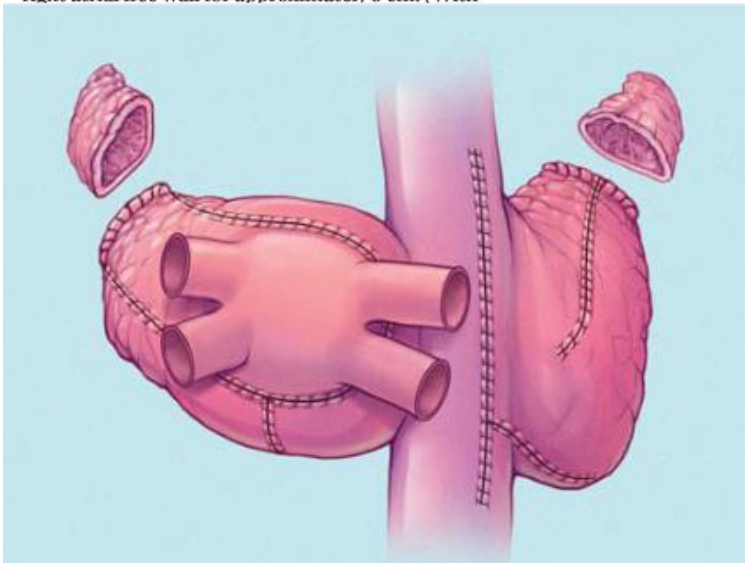
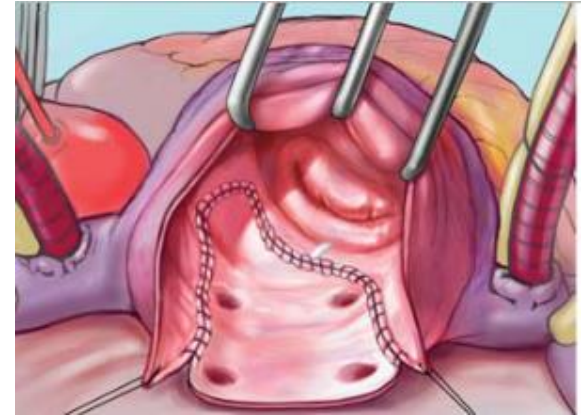
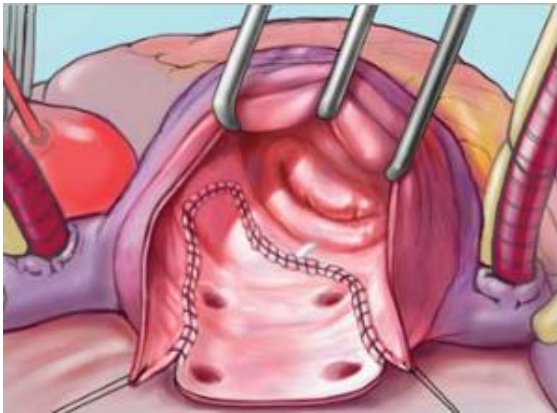
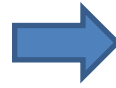


Fig. 65.1. Modified "cut-and-sew" Cox-maze III procedure. The first incision includes amputation of the right atrial appendage and extension on the right atrial free wall for approximately 5 cm. (With



Most effective and reliable method

Partial (two) modification from 'Cut-and-sew' technique



1. Cryoablation for RA medial aspect
2. Cryoablation for pulmonary vein isolation

Cox-maze IV procedure

- Most incisions → Cryolesion and/or bipolar RF energy
 - Less invasive
 - Shorter ablation time
 - Minimal collateral injuries
 - ✓ **Questioned durability**

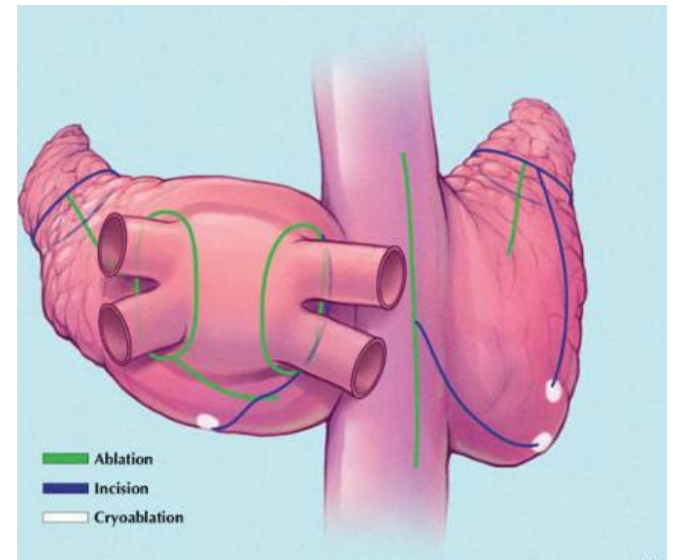
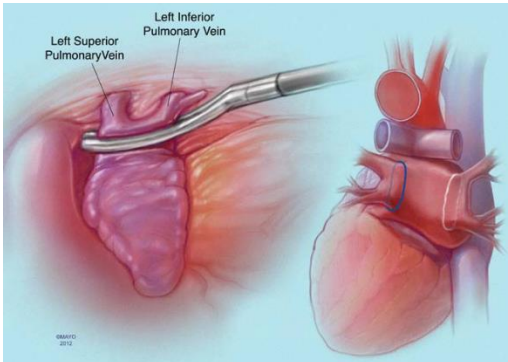
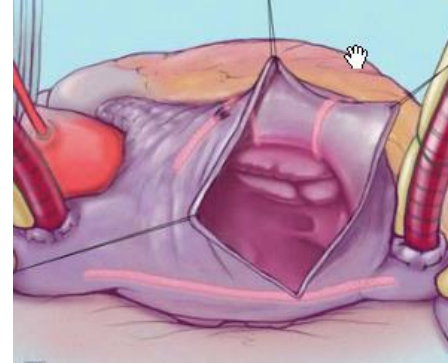


TABLE 2. Operative characteristics

Operative variable	CSM (n = 514)	PVI (n = 269)	LA (n = 110)	BA-A (n = 296)	P value
MV surgery	308 (60)	105 (39)	96 (87)	204 (69)	<.001
Crossclamp time (min)	59 ± 5	65 ± 6	81 ± 6	85 ± 6	<.001
Bypass time (min)	103 ± 7	90 ± 8	109 ± 7	119 ± 7	<.001
LAA ligation	514 (100)	188 (70)	88 (80)	218 (74)	<.001

Data presented as n (%) or mean ± standard deviation. CSM, Cut and sew Cox maze III procedure; PVI, pulmonary vein isolation; LA, left atrial; BA-A, biatrial with alternative sources of energy; MV, mitral valve; LAA, left atrial ablation.]

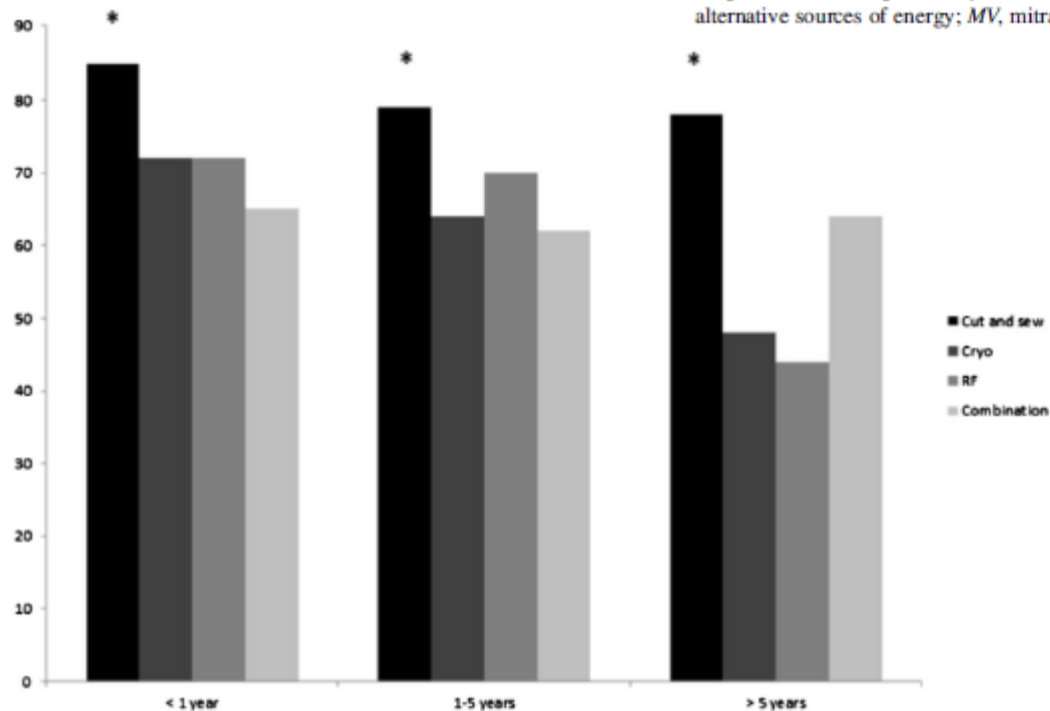


FIGURE 4. Overall freedom from atrial fibrillation without antiarrhythmic medication (%) at each follow-up point according to type of ablative energy source. Cut and sew was superior at each follow-up interval ($P = .01$, $P = .03$, and $P < .001$, respectively). *Cryo*, Cryotherapy; *RF*, radiofrequency.

*Statistically significant difference.

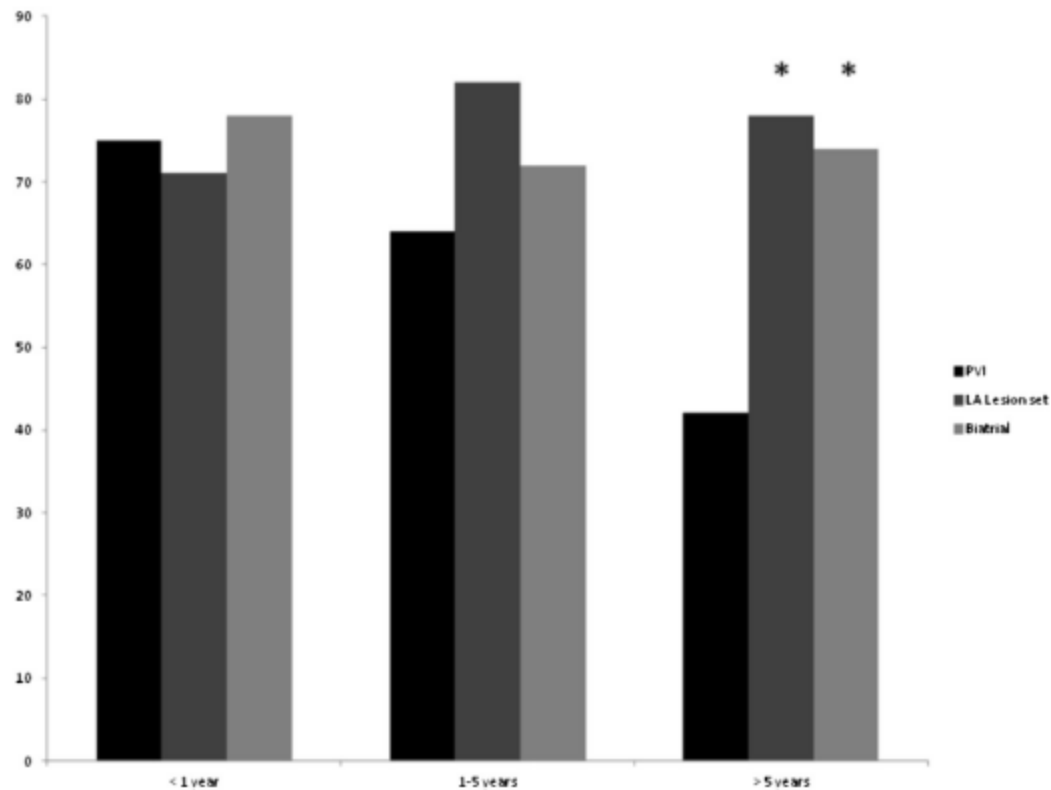


FIGURE 5. Overall freedom from atrial fibrillation without antiarrhythmic medication (%) at each follow-up interval according to the type of lesion set. Biatrial and complete left atrial (LA) lesion sets were superior at >5 years postoperatively ($P = .004$). *Statistically significant difference. PVI, Pulmonary vein isolation.

Mitral Valve Surgery

- AF in **40%** of patients undergoing MV surgery
 - Chronic LA enlargement : substrate for AF
 - Majority of patients **chronic AF**
 - Failed with medical therapy and PV isolation
 - Cured with **Cox-maze procedure.**
- **Paroxysmal AF**
 - Pulmonary vein: trigger of AF
 - Majority of patients cured with **PV isolation**

Paroxysmal AF

- **90%** of patients
 - **Pulmonary vein** : substrate for AF
 - Cured with **PV isolation**
- **10%**
 - **Pulmonary vein** : not a substrate for AF
 - PV isolation : not ablation procedure.
 - '**Macro reentry pathways**' in MV regurgitation

Cox-maze op in MV surgery

Objective: The objective was to determine whether the Cox maze procedure provides adjunctive benefit in patients with atrial fibrillation undergoing mitral valve repair. **Methods:** We compared the outcome of 39 patients who had the Cox maze procedure plus mitral valve repair between January 1993 and December 1996 (maze group) with that of 58 patients with preoperative atrial fibrillation who had mitral valve repair during the same interval by the same surgeons (control group). Patients in the 2 cohorts were similar for age, gender, preoperative New York Heart Association class III or IV, and duration of preoperative atrial fibrillation. The control group had a higher incidence of previous heart surgery and coronary artery disease. **Results:** No operative deaths occurred, and 1 patient in each group required pacemaker implantation after the operation. Duration of cardiopulmonary bypass (122 ± 40 minutes vs 58 ± 27 minutes, $P < .0001$) and hospitalization (12.6 ± 6.4 vs 9.3 ± 3.4 days, $P < .0025$) were prolonged in patients having the Cox maze procedure. Overall, 2-year survival was similar ($92\% \pm 5\%$ for maze patients and $96\% \pm 3\%$ for controls). Freedom from atrial fibrillation in the maze group was $74\% \pm 8\%$ 2 years after the operation compared with $27\% \pm 7\%$ for the control group ($P < .0001$). Freedom from stroke or anticoagulant-associated bleeding in the maze group was 100% 2 years after the operation compared with $90\% \pm 8\%$ in the control group ($P = .04$). At most recent follow-up, 82% of maze patients were in normal sinus rhythm (53% in control group). **Conclusion:** The addition of the Cox maze procedure to mitral valve repair is safe and effective for selected patients, and elimination of atrial fibrillation decreased late complications. (J Thorac Cardiovasc Surg 1999;118:628-35)

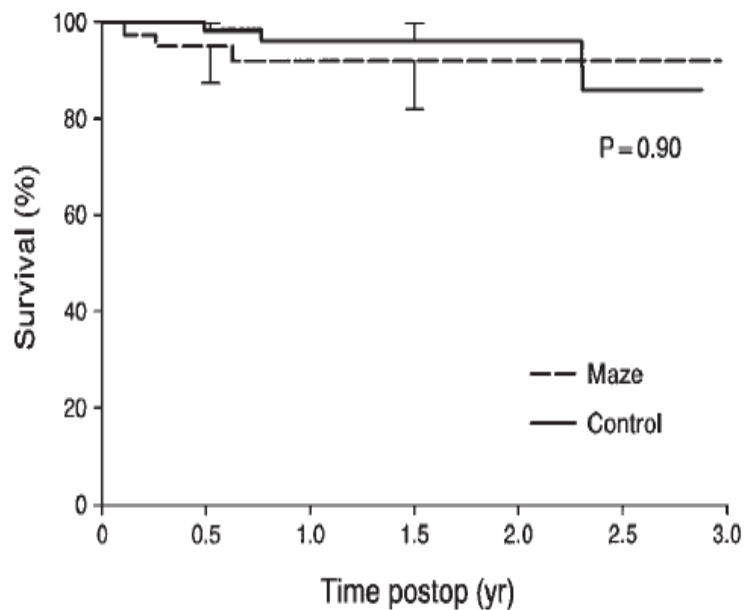


Fig 1. Actuarial survival analyses. *postop*, Postoperatively. Free of event: death $P = .90$.

	<i>Maze group</i>	<i>Control group</i>
	<i>Survival (No. at risk)</i>	<i>Survival (No. at risk)</i>
One year	91.8% ± 4.6% (26)	96.0% ± 2.8% (36)
Two years	91.8% ± 4.6% (15)	96.0% ± 2.8% (22)
Three years	91.8% ± 4.6% (3)	85.9% ± 7.2% (11)

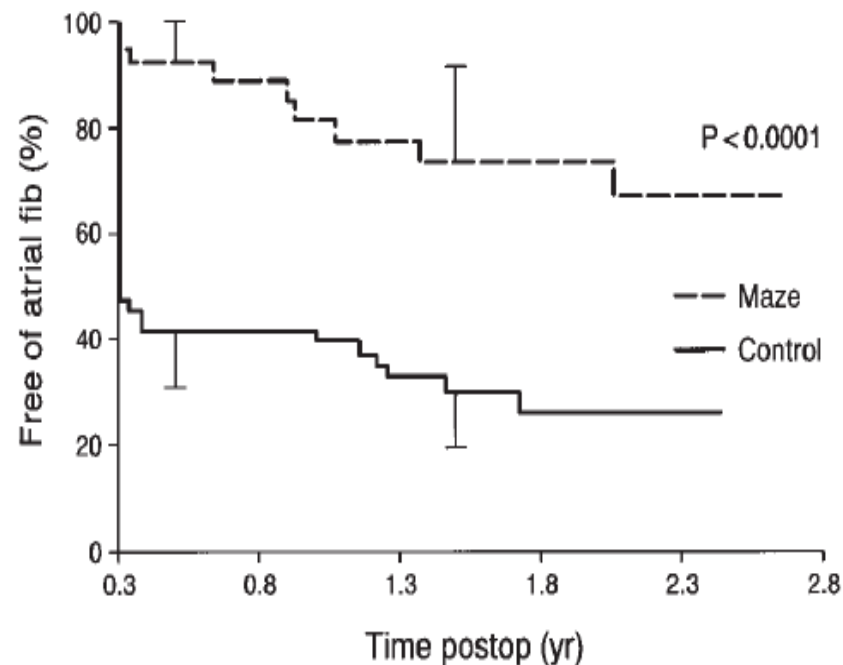


Fig 2. Survival analyses of freedom from recurrent atrial fibrillation starting at 3 months after operation. *fib*, Fibrillation; *postop*, postoperatively. Free of event: atrial fibrillation $P < .001$.

	<i>Maze group</i>	<i>Control group</i>
	<i>Survival (No. at risk)</i>	<i>Survival (No. at risk)</i>
Three months	94.7% ± 3.6% (35)	46.6% ± 6.5% (27)
One year	81.5% ± 6.9% (21)	41.2% ± 6.5% (18)
Two years	73.5% ± 8.2% (12)	26.3% ± 6.5% (8)

Persistent Atrial Fibrillation is Associated with Inability to Recover Atrial Contractility after MAZE IV Surgery in Rheumatic Disease

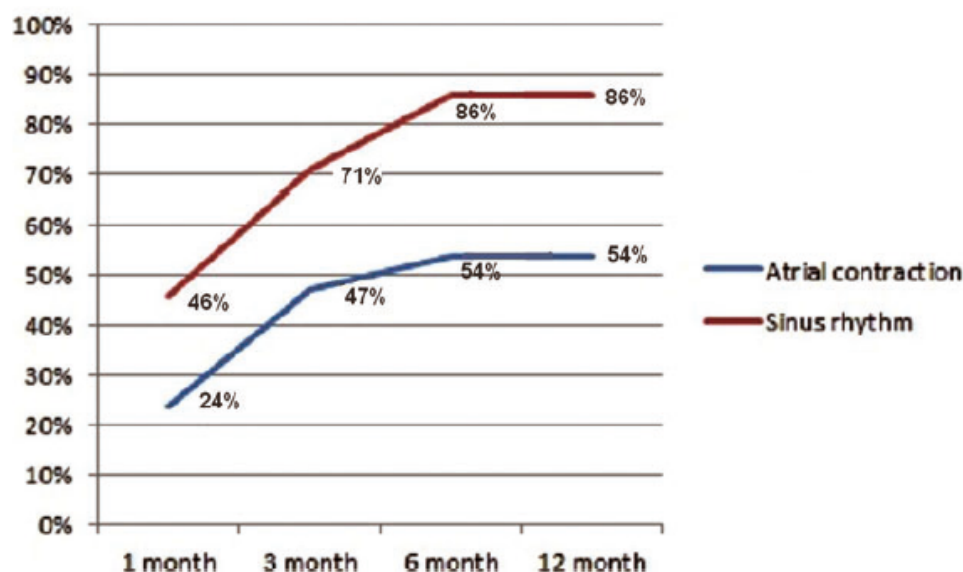


Figure 2. Recovery of sinus rhythm and atrial contraction during the follow-up.

Table II.

Patients with and Without Atrial Contraction (AC)

Variable	AC (Group A) (n = 22)	No AC (Group B) (n = 37)	P Value
Male gender	14 (58%)	10 (42%)	0.007
Age	61 ± 9	59 ± 11	0.36
Patients with AF duration >5 years	<u>3 (14%)</u>	<u>27 (73%)</u>	<u>0.00001</u>
Hypertension	17 (77%)	30 (81%)	0.72
Diabetes	6	9	0.80
Prior stroke	2	2	0.58
Mitral stenosis	18 (81%)	34 (92%)	0.24
Mitral regurgitation	4 (9%)	3 (8%)	0.24
Congestive heart failure	5 (22%)	9 (24%)	0.88
Left atrial area (cm ²)	36 ± 8	37 ± 7	0.4
Left ventricular ejection fraction (%)	52 ± 5	50 ± 1	0.73
DDVI (mm)	49 ± 2	51 ± 35	0.20
Mechanical prosthetic valve implantation	9 (41%)	14 (38%)	0.81

Coronary Bypass Surgery and Aortic valve Surgery

Do we increase the operative risk by adding the Cox Maze III procedure to aortic valve replacement and coronary artery bypass surgery?

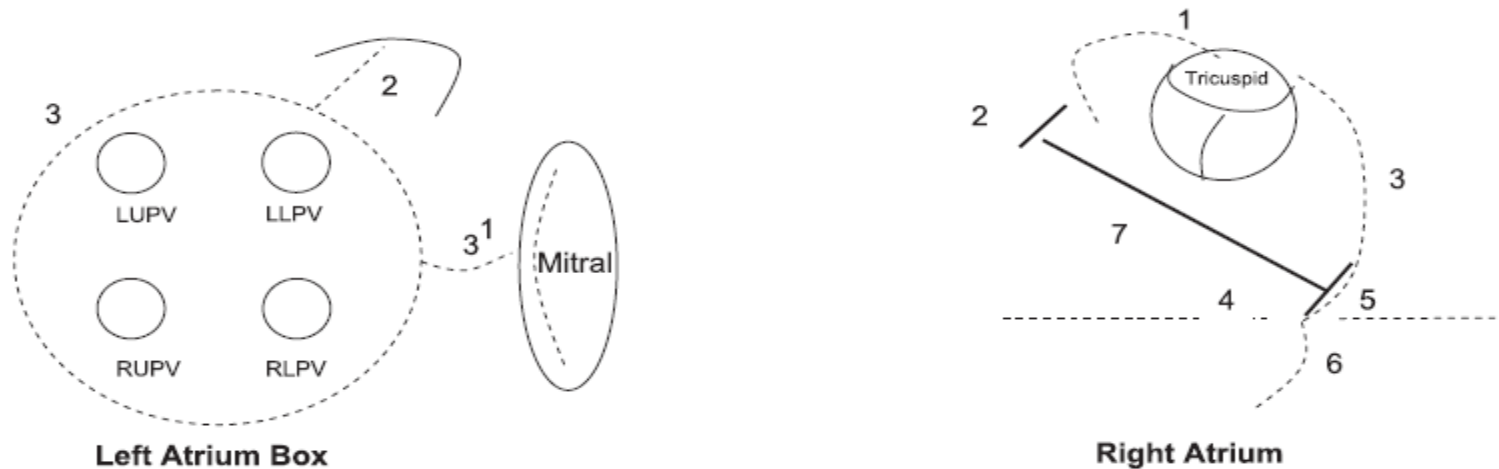
Objective: Recent reports from Europe and the United States have suggested that patients presenting for open surgery with a significant history of atrial fibrillation (AF) have inferior early and late outcomes if AF is left untreated. On the other hand, there is reluctance among surgeons to treat AF surgically, especially when atriotomies may be required otherwise, which is the case with aortic valve replacement (AVR) or coronary artery bypass grafting (CABG). The objective of this study was to explore the potential impact of the addition of the Cox Maze III procedure on short- and long-term outcomes of patients when combined with AVR or CABG.

Methods: Since 2005, 485 patients have undergone the Cox Maze III procedure at Inova Heart and Vascular Institute, 95 of whom had a full Cox Maze III with an AVR or CABG (Cox Maze III/AVR = 30; Cox Maze III/CABG = 47; Cox Maze III/AVR/CABG = 18). In addition, 4255 patients with no history of AF underwent AVR or CABG without surgical ablation (AVR = 422; CABG = 3518; AVR/CABG = 315). Data from our CABG, valve, and AF registries were used for analyses. Patients with and without the Cox Maze III were propensity score matched using a 0.10 caliper to improve balance on clinical and demographic variables. Differences in perioperative and postoperative outcomes by group were evaluated using the Fisher exact test, and a Kaplan–Meier survival analysis was completed. Health-related quality of life (Short Form 12) was obtained at baseline and 6 months post-surgery (n = 72).

Results: All 95 patients who underwent the Cox Maze III were propensity score matched with patients who did not undergo the Cox Maze III. Mean age ($t = 0.3, P = .79$) and European System for Cardiac Operative Risk Evaluation score ($t = -1.8, P = .07$) were similar between the groups. There were no significant differences in major postoperative morbidities between the groups despite the Cox Maze III group being on bypass longer (164.4 vs 108.8 minutes; $t = -9.8, P < .001$). Pacemaker implantation was significantly higher in the Cox Maze III group ($P = .03$). Survival during follow-up (mean = 35 months) was not different between patients who did and did not undergo the Cox Maze III procedure (log rank = 0.49, $P = .48$). Improvement in physical health-related quality of life was similar for both groups ($F = 0.01, P = .94$). At 1 year, 94% of the patients (60/64) who underwent the Cox Maze III procedure were in sinus rhythm (81% off class I and III antiarrhythmic drugs).

Conclusions: The addition of the Cox Maze III procedure to AVR or CABG did not convey an increase in major morbidity and perioperative risk. Patients who underwent the Cox Maze III procedure demonstrated similar survival over time with improvement in health-related quality of life. The Cox Maze III should not be denied to patients in whom the cardiac surgical procedure does not include atriotomies because of the perceived increased operative risk. The Cox Maze III may significantly improve their outcome. (J Thorac Cardiovasc Surg 2012;143:936-44)

Maze Ablation Lesion Set



1. Mitral Valve Annulus
 - a) Endo
 - b) Epicar
2. Left SPV to LAA
3. Connecting Lesion: Left to Right Inferior Pulmonary Vein (IPV)

Right Atrial (RA) Lesions

1. Tricuspid Valve Annulus 10 o'clock
2. Right Atrial Free Wall
3. Tricuspid Valve Annulus to Atrial Free Wall; (T Lesion) Tricuspid Valve Annulus 2 o'clock
- 4-5. Superior Vena Cava to Inferior Vena Cava
6. Inter-atrial septal
7. Right atrial corridor

FIGURE 1. Cox Maze III lesion set. *SPV*, Superior pulmonary vein; *LAA*, left atrial appendage; *LUPV*, left upper pulmonary vein; *LLPV*, left lower pulmonary vein; *RUPV*, right upper pulmonary vein; *RLPV*, right lower pulmonary vein.

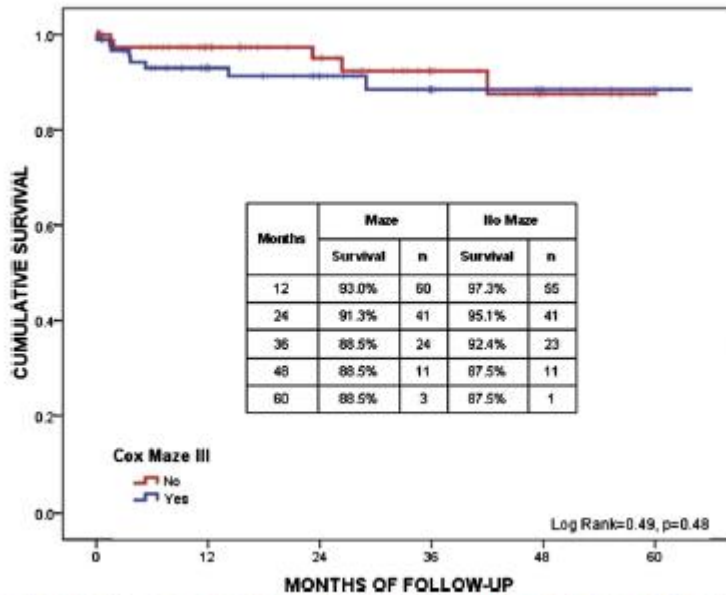


FIGURE 3. Kaplan–Meier survival curves comparing cumulative survival between patients with and without the Cox Maze

- **PV isolation + LA appendage exclusion** for CABG or AV surgery (+/-)
- **Cox-maze procedure** for enlarged LA and long-standing AF (++)

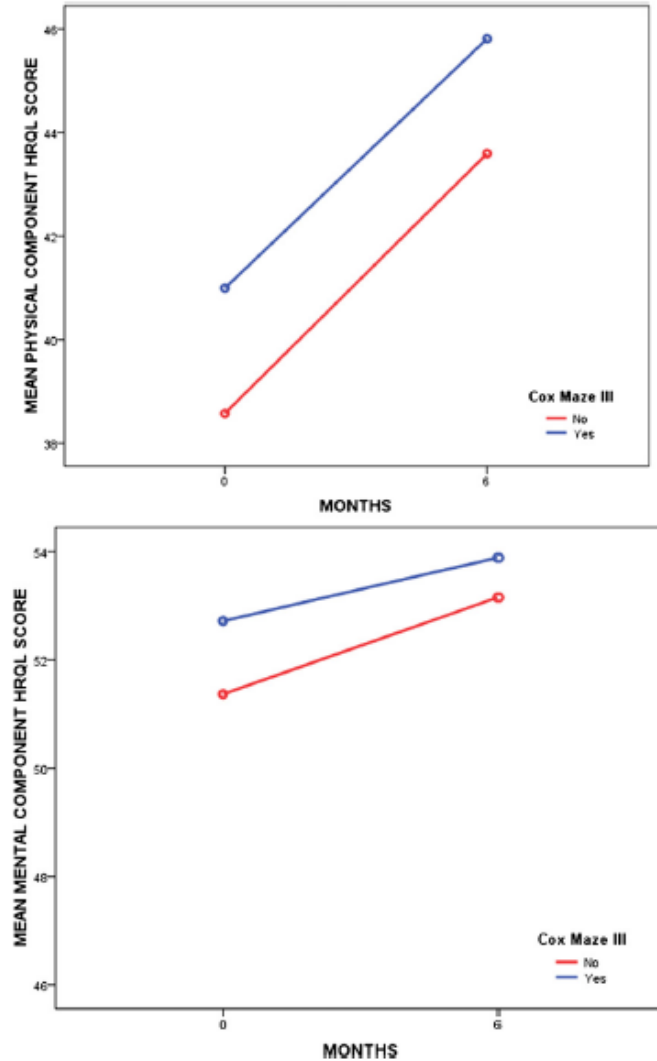


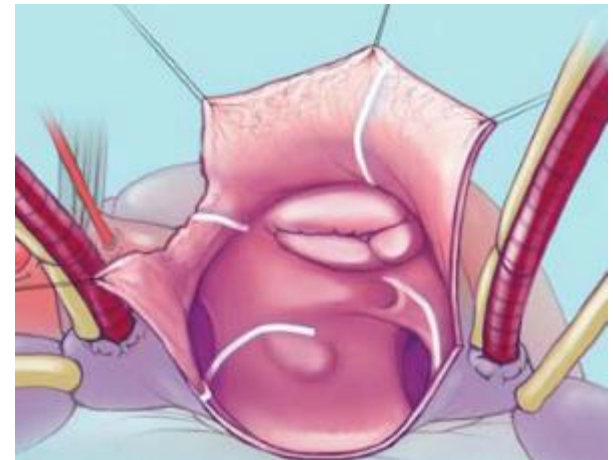
FIGURE 4. HRQL improvement from pre-surgery to 6 months post-surgery. HRQL, Health-related quality of li

Septal Myectomy for hypertrophic Cardiomyopathy

- **Loss of LA component of LV filling**
 - Profound clinical deterioration
 - After myectomy: dramatic relief of symptom and improved exercise capacity
- **AF in many patients**
 - Due to diastolic dysfunction, LAP increased, and LA enlargement
 - Septal myectomy **without AF ablation: 2/3** free from AF
- **Maze operation**
 - Indication: **symptomatic** with medical therapy, intolerable to medication, failed catheter ablation
 - AF ablation: **safe**, mortality and morbidity not increased,
 - Recurrence rate: LV muscle regression and decreased; but **higher** than MV surgery

Congenital Heart Diseases

- Most common atrial tachyarrhythmia among **adults** with CHD
 - Atrial flutter and fibrillation
 - Effective with **right-sided** Cox-maze procedure.
 - Procedure time **shortened** with newer devices (RF or Cryoablation)
- Chronic AF, **LA dilatation**, concomitant mitral regurgitation
 - **Bia**trial maze procedure
- Atrial flutter
 - **Maze** procedure + **right atrial isthmus lesion**



Right-Sided Maze Procedure for Right Atrial Arrhythmias in Congenital Heart Disease

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Background. Atrial fibrillation and flutter, commonly associated with congenital heart anomalies that cause right atrial dilatation, may cause significant morbidity and reduction of quality of life, even after surgical repair of the anomalies.

Methods. In an effort to reduce the incidence of atrial tachyarrhythmias after repair of right-sided congenital heart disease, we performed a concomitant right-sided maze procedure.

Results. Eighteen patients with paroxysmal atrial fibrillation or flutter (n = 12) or chronic atrial fibrillation or flutter (n = 6) aged 10.9 to 68.4 years (mean 34.9 years) underwent a right-sided maze in association with repair of Ebstein's anomaly (n = 15), congenital tricuspid insufficiency (n = 2), and isolated atrial septal defect (n = 1).

There were no early deaths, reoperations, or complete heart block. Discharge rhythm was sinus (n = 16) or junctional (n = 2). Follow-up was complete in all 18 patients and ranged from 3.1 to 17.2 months (mean 8.1 months); all are in New York Heart Association class I. Early postoperative arrhythmias developed in 3 patients (all were converted to sinus rhythm by antiarrhythmic drugs). There were no late deaths or reoperations.

Conclusions. The inclusion of a right-sided maze procedure with cardiac repair in patients having congenital heart anomalies that cause right atrial dilatation and associated atrial tachyarrhythmias is effective in eliminating or reducing the incidence of those arrhythmias.

(Ann Thorac Surg 1998;65:149-54)

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Right-Sided Maze Procedure for Atrial Tachyarrhythmias in Congenital Heart Disease

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Background. Congenital heart disease (CHD) that causes right atrial dilatation is commonly associated with atrial flutter and/or fibrillation (AFI/F). To reduce late recurrence of AFI/F in patients undergoing repair of CHD, we utilized a concomitant right-sided maze procedure.

Methods. From 1993 to 2003, 99 patients with CHD and associated AFI/F underwent a concomitant right-sided maze procedure at the time of CHD repair. Ages ranged from 9 to 72 years (median, 43 years). Atrial flutter and/or fibrillation was paroxysmal in 81 and chronic in 18; duration ranged from less than 1 month to 39.5 years (median, 2.9 years). Primary cardiac diagnoses were Ebstein anomaly (n = 47), other congenital tricuspid regurgitation (n = 19), univentricular heart (n = 11), isolated atrial septal defect (ASD, n = 8), tetralogy of Fallot (n = 8), and other (n = 6).

Results. Other concomitant procedures included tricuspid valve repair or replacement (n = 70), ASD closure (n = 39), and pulmonary valve procedures (n = 18). There were 6 early deaths. At hospital dismissal, 83 patients were free of AFI/F and 63 were in sinus rhythm. Follow-up in 87 of the 93 early survivors extended up to 8 years (mean, 2.7 years). There were 4 late deaths, all from noncardiac causes. Of the 83 known late survivors, 77 (93%) were free of AFI/F. Eighty-two of the 83 survivors were in New York Heart Association class I or II.

Conclusions. In patients with AFI/F associated with CHD, a concomitant right-sided maze procedure at the time of intracardiac repair is effective in reducing late recurrent AFI/F. Most patients enjoy an excellent quality of life.

(Ann Thorac Surg 2006;81:1780-5)

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Atrial tachyarrhythmias and the Cox-maze procedure in congenital heart disease.

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⊕ Author information

Abstract

INTRODUCTION: Atrial tachyarrhythmias, particularly atrial flutter and fibrillation, are commonly associated with congenital heart disease and are a major cause of morbidity and mortality. The Cox-maze procedure, introduced by Dr. James Cox in 1987, is effective at controlling atrial fibrillation in structurally normal hearts. Though the Cox-maze procedure has been used for atrial tachyarrhythmias in patients with congenital heart disease, few studies have looked at its effectiveness.

METHODS: A retrospective chart review was performed on 24 patients with congenital heart disease who underwent the Cox-maze procedure at the Medical College of Wisconsin from 2004 through 2010.

RESULTS: Mean age at time of Cox-maze procedure for the cohort was 40.9 years (range, 14 to 66 years). The most common congenital heart diseases among the patients included tetralogy of Fallot (n = 8) and atrioventricular septal defect (n = 4). All patients had concomitant cardiac procedures with the most common being right ventricular outflow tract reconstruction (n = 10), tricuspid valve repair (n = 8), and atrial septal defect repair (n = 7). Prior to the Cox-maze procedure, arrhythmias consisted of atrial flutter or intratrial reentrant tachycardia (n = 19) and atrial fibrillation (n = 5). There were three early postoperative deaths and one late postoperative death. Follow-up was available for 19 of 21 (90%) survivors with a mean length to follow-up from Cox-maze procedure of 2.8 years (range, 0.14-5.7 years). At last follow-up, 14 (74%) of the survivors remained arrhythmia-free.

CONCLUSIONS: In patients with congenital heart disease and atrial tachyarrhythmias, the majority were rendered arrhythmia-free by the Cox-maze procedure.

Atrial Fibrillation and Tricuspid Valve Disease

- Tricuspid valve disease
 - 10-50% of patients with significant MV disease
 - Concomitant TR and pulmonary hypertension
 - Functional in etiology
- AF
 - Predictor of late development of TR after MV surgery

Impact of the maze procedure and postoperative atrial fibrillation on progression of functional tricuspid regurgitation in patients undergoing degenerative mitral repair

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Abstract

OBJECTIVES: The aim of this study is to investigate the factors contributing to the progression of functional tricuspid regurgitation (TR) after mitral repair for degenerative mitral regurgitation (MR) in relation to pre and postoperative atrial fibrillation (AF) and performance of the maze procedure.

METHODS: We assessed 398 patients with less than moderate TR who did not undergo tricuspid valve repair at the time of isolated mitral valve repair for degenerative MR between January 1999 and January 2010.

RESULTS: Clinical follow-up was complete in 385 patients (96.7%) with a median follow-up of 48.3 months (range 0.13-148.5). During this time, there were 21 late deaths (5.5%) and 17 major complications (4.4%), including 11 reoperations for MR recurrence (2.9%). On late follow-up echocardiography performed on 395 patients (median 44.6 months, range 6.0-147.3), 34 (9.6%) experienced moderate or greater MR and 16 (4.5%) experienced moderate or greater TR. The 5-year freedom from moderate or greater MR and moderate or greater TR rates were 88.3 ± 2.1 and $95.3 \pm 1.5\%$, respectively. Time-updated Cox regression analysis showed that male gender [hazard ratio (HR) 3.83, 95% confidence interval (CI) 1.28-11.40, $P=0.016$], New York Heart Association functional class III or IV (HR 2.64, 95% CI 0.88-8.00, $P=0.085$), preoperative AF without maze (HR 10.48, 95% CI 2.49-44.21, $P=0.001$), and postoperative AF (HR 14.56, 95% CI 4.46-47.58, $P<0.001$) were significant risk factors for postoperative moderate or greater TR. Of the 79 patients with preoperative AF, 68 (86.1%) underwent concomitant maze procedures. Of them, eight (11.8%) experienced late AF (>3 months) recurrence. Freedom from AF at 5 years after the concomitant maze procedure was $87.8 \pm 4.6\%$.

CONCLUSIONS: Preoperative AF without the maze procedure and postoperative AF can contribute to the development of moderate or greater functional TR after mitral repair for degenerative MR.

Predictors for the Development of Severe Tricuspid Regurgitation with Anatomically Normal Valve in Patients with Atrial Fibrillation

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Background and Aims: Atrial fibrillation (AF) may be a risk factor for severe functional tricuspid valve regurgitation (FTR). We aimed to determine the predictors of severe FTR in patients with AF. Methods and Results: From our echocardiographic laboratory database, we searched for and reviewed the medical records of consecutive patients with severe FTR and AF seen at Mayo Clinic in Arizona from 2002 through 2009. Our search identified 42 patients who met all inclusion criteria. These patients (cases) with severe FTR and AF were compared with 38 patients (controls) with AF who had no greater than mild tricuspid regurgitation. Case patients with severe FTR were older than controls (mean, 81 years vs. 76 years; $P < 0.001$) and more frequently had chronic AF (69% vs 26%; $P < 0.001$). Mean right atrial volume (86 mL/m^2 vs 46 mL/m^2 ; $P < 0.001$), right ventricular volume ($42 \text{ mL} \pm 33 \text{ mL}$ vs $22 \text{ mL} \pm 8 \text{ mL}$; $P < 0.001$) and tricuspid annular diameter (3.6 cm vs 3.0 cm; $P < 0.001$) were larger in cases than in controls. Patients with severe FTR also had a higher prevalence of right-sided heart failure (69% vs 16%; $P < 0.001$). After adjusting for age and gender, right atrial and right ventricular volumes were independent predictors for the development of severe FTR in patients with AF (odds ratio, 1.7 [95% CI, 1.3–2.8] for every 10 mL/m^2 increase in right atrial volume; $P = 0.0002$ and odds ratio, 3.1 [95% CI, 1.5–8.9] for every 10 mL increase in right ventricular volume; $P = 0.0002$). Conclusions: Severe FTR occurs in older patients with chronic AF as a result of marked right atrial and right ventricular dilatation; and enlargement of the tricuspid annulus in the absence of pulmonary hypertension. More importantly, severe FTR leads to increased prevalence of right-sided heart failure underscoring the nonbenign nature of chronic AF. (Echocardiography 2012;29:140-146)

Low Ejection Fraction

- **AF** → **LV dysfunction**
- **Conversion to sinus rhythm** → **LV dysfunction cured**
- **Mechanism of impaired hemodynamics**
 - Loss of AV synchrony and atrial contraction (C/O reduced)
 - Ex) Hypertrophied ventricles, restrictive CM, MS
 - Tachycardia-induced CM
 - Rapid ventricular response to **minimal activity**
 - Ex) **Resting HR not important** (Paroxymal AF 62/min; postop HR 84/min; tachycardia-induced CM 84/min)
- **Diagnosis of tachycardia-induced CM**
 - No structural heart disease
 - Documentation of AF before LV dysfunction

Prophylactic Cox-maze

- **New AF** after MV repair
 - No history of preop AF
 - Old age
 - RV strain and function changed; AF developing not decreased with TV repair
- **Predictors of late AF** (Stulak JM, etc. Ann Thorac Surg 2010;89;1395-401)
 - Advanced age
 - LA size > 50 mm
 - Moderate preop TR
 - Diabetes
- **Indication** of prophylactic Maze
 - Severe MR
 - Enlarged LA
 - Moderate TR

Postoperative Management

- **Coumadin** for 3 months
- **High normal range of potassium and magnesium**
- **Liberal use of diuretics**
 - **Atrial appendages: important source of natriuretic peptide**
- **Postop recurrent AF: amiodarone** for 3 months

Outcomes

- **Cox-maze procedure**
 - **Most effective** surgical procedure to manage AF and its adverse consequences
- **New techniques and instruments**
 - Indication of its application **evolved**
 - Surgical application **simplified**
 - Surgical ablation **expanded**
- **Report of surgical results**
 - EKG / **Holter** monitoring
- **Report of results**
 - **Last follow-up findings: high success rate**
 - **Freedom from AF: low success rate**
 - **Confusing factors**
 - **Terminology** (intermittent vs. paroxysmal)
 - **Patients population** (Lone paroxysmal AF vs. AF with MV disease)

Future Directions

- **New instruments and lesion sets** vs. standard cut-and-sew maze procedure
- **PV isolation** vs. full Cox-maze procedure
 - For both paroxysmal AF and AF with MV disease
- **LA reduction plasty (?)** for dilated LA
- **Prophylactic maze procedure (?)** for MV disease, dilated LA and sinus rhythm

The Influence of Simplified Surgical Procedures on the Surgical Treatment for Atrial Fibrillation with using the Cut-and-Sew Technique

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Background: The Cox maze-III procedure is considered as the most effective surgical treatment for atrial fibrillation. Because this procedure takes a long time and it complicates the concomitant cardiac surgery, some surgeons perform a left atrial maze procedure or pulmonary vein isolation only to reduce the operation time. This study was performed to evaluate how the modified procedures, with using cut-and-sew techniques, can influence the treatment of atrial fibrillation. **Material and Method:** Between Feb 1999 and June 2005, 40 patients (17 males and 23 females) with organic heart disease and atrial fibrillation underwent the Cox maze-III procedure (23), the left atrial maze procedure (10) or pulmonary vein isolation (7). The cut-an-sew technique was used to ablate the atrial wall, but cryoablation was used instead of the cut-and-sew technique for the coronary sinus and the inferior wall between the pulmonary vein and the mitral annulus. **Result:** After a mean follow-up period of 50.0±21.6 months, all (100%) of the 23 patients who underwent the Cox maze-III procedure had regular sinus or atrial rhythm conversion, and 7 (70%) of 10 with a left atrial maze procedure and 4 (57.1%) of 7 with pulmonary vein isolation had regular sinus or atrial rhythm conversion (p=0.002). **Conclusion:** To obtain a high conversion rate from atrial fibrillation to a regular sinus rhythm or a regular atrial rhythm, the standard Cox maze-III procedure should be performed in both atria. The limited modified procedures like the left atrial maze procedure or pulmonary vein isolation may reduce the cure rate of atrial fibrillation.

(Korean J Thorac Cardiovasc Surg 2008;41:313-319)

Table 1. Clinical characteristics of patients undergoing surgical procedures for atrial fibrillation

Patient no	40 (M/F, 17/23)
Age (yr)	55.8±9.8 (25~71)
Af (Continuous/Paroxysmal)	36/4 (90/10%)
Cardiac disease	
MS dominant group	23
MR dominant group	14
Other cardiac disease	3
Associated main operation	
<u>MVR</u>	<u>29</u>
MVR alone	13
+AVP	7
+AVR	6
+TAP	9
+CABG	3
<u>MVP</u>	<u>8</u>
MVP alone	1
+AVP	1
+TAP	7
+VSD	1
ASD closure + TAP	3
Af duration (mon)	56.8±51.9 (5~240)
LA dimension (mm)	58.2±10.9 (32~89)
Follow-up (mon)	50.0±21.6 (23~96)

Mean±SD; Af=Atrial fibrillation; MS=Mitral stenosis; MR=Mitral regurgitation dominant; MVR=Mitral valve replacement; AVP=Aortic valvuloplasty; AVR=Aortic valve replacement; TAP=Tricuspid annuloplasty; CABG=Coronary artery bypass surgery; MVP=Mitral valvuloplasty; VSD=Ventricular septal defect; ASD=Atrial septal defect; LA=Left atrium.

Table 2. Early and late conversion rate to sinus rhythm after Cox maze-III procedure, left atrial maze procedure, or pulmonary vein isolation in patients with atrial fibrillation

	Maze (n=23)	LA maze (n=10)	PV isolation (n=7)
Early conversion to sinus rhythm	21 (91.3%)	8 (80%)	5 (71.4%)
			p=0.405
Late conversion to sinus rhythm	23 (100%)	7 (70%)	4 (57.1%)
			p=0.002

LA=Left atrium; PV=Pulmonary vein.

Table 4. Recurrence of atrial fibrillation or flutter after early conversion to sinus rhythm

	Maze (n=23)	LA maze (n=8)	PV isolation (n=5)
Atrial fibrillation	0	0	1 (20.0%)
Atrial flutter	0	1 (12.5%)	0

n=Number of early conversion to sinus rhythm; LA=Left atrial; PV=Pulmonary vein.

Predictive Factors of Sustained Sinus Rhythm and Recurrent Atrial Fibrillation after the Maze Procedure

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Background: We examined perioperative predictors of sustained sinus rhythm (SR) in patients undergoing the Cox maze operation and concomitant cardiac surgery for structural heart disease. **Materials and Methods:** From October 1999 to December 2008, 90 patients with atrial fibrillation (AF) underwent the Cox maze operation and other concomitant cardiac surgery. Eighty-nine patients, all except for one postoperative death, were followed-up with serial electrocardiographic studies, 24-hour Holter monitoring tests, and regular echocardiographic studies. **Results:** Eighty-nine patients undergoing the maze operation were divided into two groups according to the presence of SR. At the time of last follow-up (mean follow-up period, 51.0±30.8 months), 79 patients (88.8%) showed SR (SR group) and 10 patients (11.2%) had recurrent AF (AF group). Factors predictive of sustained SR were the immediate postoperative conversion to SR (odds ratio, 97.2; p=0.001) and the presence of SR at the 6th month postoperatively (odds ratio, 155.7; p=0.002). Duration of AF, mitral valve surgery, number of valves undergoing surgery, left atrial dimension, and perioperative left ventricular dimensions and ejection fractions were not predictors of postoperative maintenance of SR. **Conclusion:** Immediate postoperative SR conversion and the presence of SR at the 6th postoperative month were independent predictors of sustained SR after the maze operation.

Table 1. Patient characteristics (n=89)

Characteristic	Value
Age (yr)	57.1±9.8 (25–75)
Male gender	38/89 (42.7)
Duration AF (mo)	41.8±37.7
Duration AF (median, range, mo)	36 (6–240)
Left atrial dimension (mm)	55.4±9.4 (32–86)
Giant left atrium ^{a)}	4/89 (4.5)
Persistent/permanent AF (%)	11/78 (12.4/87.6)
Mitral valve lesion	82/89 (92.1)
MS dominant	51/89 (57.3)
MR dominant	31/89 (34.8)
Single mitral valve disease	54/89 (60.7)
Single aortic valve disease	2/89 (2.2)
Double and triple valve disease	28/89 (31.5)
Non-valve lesion	5/89 (5.5)

Values are presented as mean±standard deviation or number (%).
 AF, atrial fibrillation; MS, mitral stenosis; MR, mitral regurgitation.

^{a)}Left atrial dimension >65 mm.

ative characteristics of patients undergoing the maze procedure

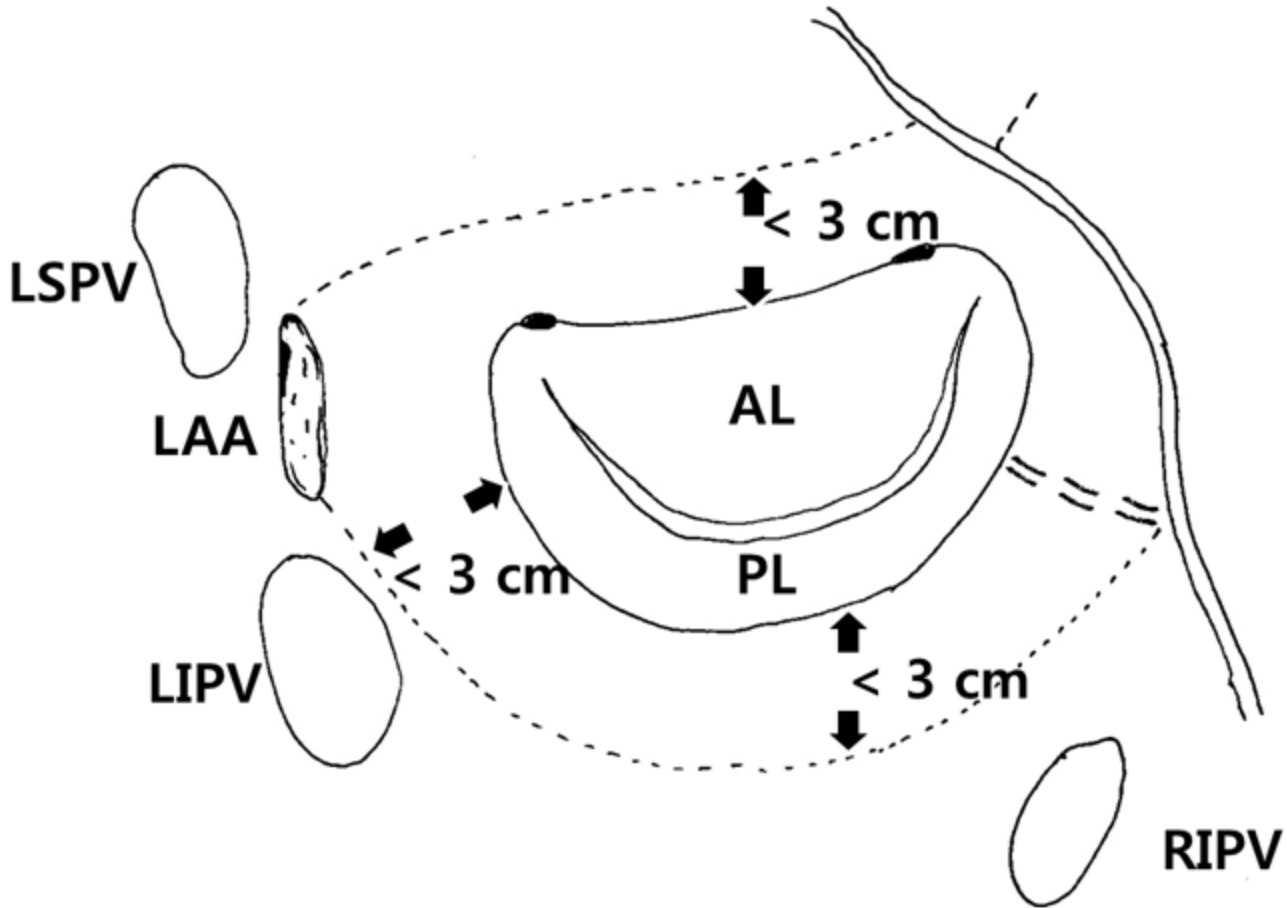
Characteristic	SR group ^{a)} (n=79)	AF group ^{b)} (n=10)	p-value
Age (yr)	56.5±9.7	61.6±10.0	0.12
Male	34 (43.0)	4 (40)	
Duration of AF (mo)	38.2±32.2	76.3±65.6	0.004
<u>Persistent/permanent AF</u>	10/69 (12.7/87.3)	1/9 (10.0/90.0)	1.0
Mitral valve lesion			0.30
MS dominant	43 (54.4)	8 (80)	
MR dominant	29 (36.7)	2 (20)	
Other cardiac disease without mitral valve disease	7 (8.9)	0	1.0
Non-valve cardiac disease	5 (6.3)	0	1.0
Follow-up (mo)	49.7±29.5	61.0±40.4	0.28
<u>Preoperative LA dimension (mm)</u>	54.6±8.7	61.7±13.0	0.13
Preoperative giant LA	10 (12.7)	3 (30)	0.16
Preoperative LVEF (%)	57.5±9.8	54.0±7.1	0.81

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

SR, sinus rhythm; AF, atrial fibrillation; MS, mitral stenosis; MR, mitral regurgitation; LA, left atrium; LVEF, left ventricular ejection fraction.

^{a)}SR at the last follow-up time.

^{b)}Recurrent AF at the last follow-up time.

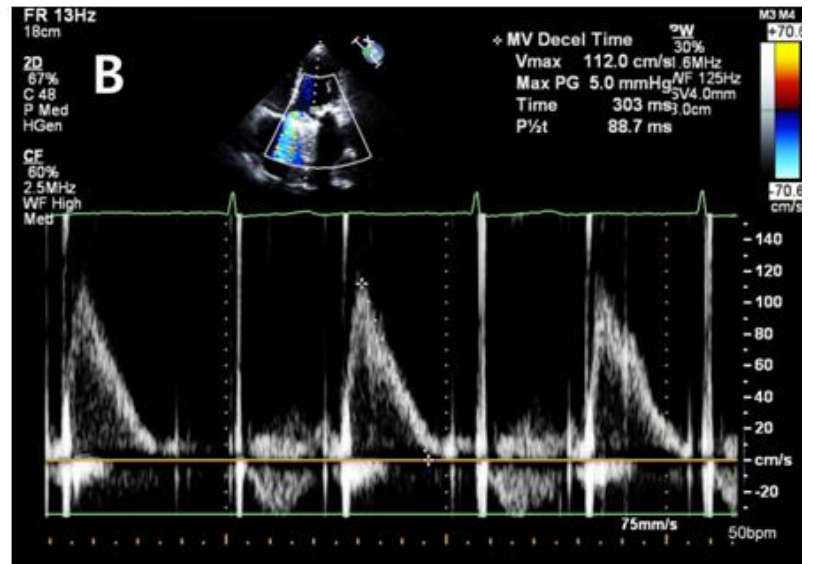
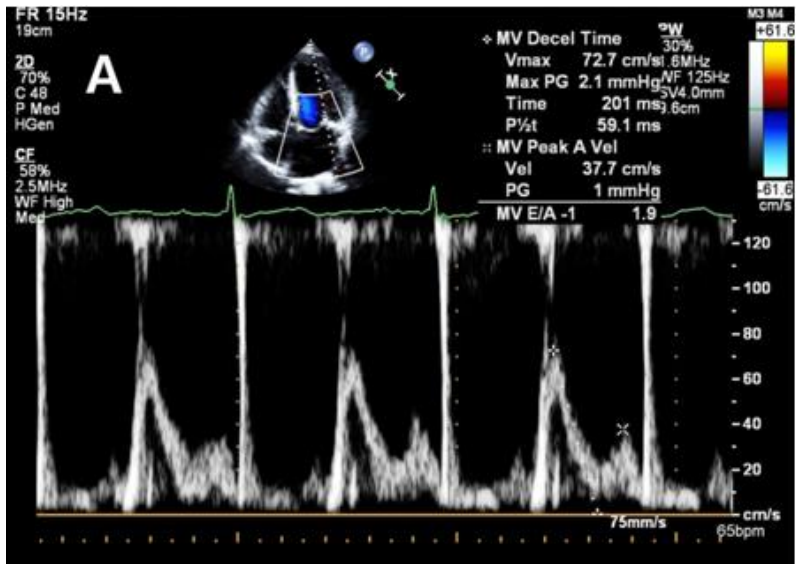


Concomitant procedures	No. (%)
Mitral valve replacement	43 (50.0%)
Mitral valve repair	43 (50.0%)
Tricuspid valve repair	68 (79.1%)
Coronary artery bypass graft	2 (2.3%)
Ascending aortic aneurysm	3 (3.5%)
Aortic root reimplantation	1 (1.2%)
Atrial septal defect	1 (1.2%)
Ventricular septal defect	1 (1.2%)
No. of procedures	
2	7 (8.1%)
3	49 (57.0%)
4	26 (30.2%)
5	4 (4.7%)
Left atrial reduction plasty	34 (39.5%)
Isthmus resection	33 (38.4%)
Left atrial lateral wall plication	11 (12.8%)

Results

Variables	No (%), Mean ± SD
Bypass time, min	232 ± 43
Cross clamp time, min	191 ± 40
Postoperative temporary pacing	21 (24.4%)
Pneumonia	1 (1.2%)
Permanent pacemaker for sinus node dysfunction	1 (1.2%)
Recovery to sinus rhythm	
Immediately after surgery	86/86 (100%)
In-hospital postoperative atrial fibrillation	21/86 (24.4%)
At postoperative 6th month	79/85 (91.9%)
At the last follow-up time	81/85 (95.3%)
Left atrial A waves on echocardiography	52/81 (64.2%)
Mean clinical follow-up period, months	38.7 ± 20.7
Mean echocardiographic follow-up period, months	17.6 ± 17.4

- Preop giant LA, **27 (31.4%)** vs. Postop giant LA, **4 (4.6%)**



MV repair vs. MV replacement on left atrial A wave presence

Variables	Rheumatic	Non-rheumatic	P value
n	47	34	
Presence of 'A' wave	24 (46.2%)	28 (82.4%)	<0.005

Mantel-Haenszel χ^2 test adjusted by non-rheumatic cause (rheumatic vs. non-rheumatic) on the presence of the left atrial A waves

Variables		MV Repair	MV Replacement	Total
Rheumatic	'A' waves +	9 (75.0%)	15 (42.9%)	24
	'A' waves -	3 (25.0%)	20 (57.1%)	23
	Total	12	35	47
Non-rheumatic	'A' waves +	25 (89.3%)	3 (50%)	28
	'A' waves -	3 (10.7%)	3 (50%)	6
	Total	28	6	

$P = 0.009$

Conclusion

- **Cox-maze** procedure
 - New instruments : simplified and effective surgery
 - **Biatrial maze** procedure for **chronic AF** (LA enlargement)
- Structural cardiac diseases with AF
 - Maze procedure
 - Mortality/morbidity
 - Biatrial cox-maze procedure
- **Prophylactic** maze procedure
 - Severe MR + dilated LA +Moderate TR
 - Considering morbidity and mortality