The Cox maze III procedure for atrial fibrillation: Long-term efficacy in patients undergoing lone versus concomitant procedures

Sunil M. Prasad, MD
Hersh S. Maniar, MD
Cindy J. Camillo, RN
Richard B. Schuessler, PhD
John P. Boineau, MD
Thoralf M. Sundt III, MD
James L. Cox, MD
Ralph J. Damiano, Jr, MD

CSP

Background: For the last decade, the Cox maze III procedure has been available for the treatment of atrial fibrillation. It is unknown whether the operation has similar efficacy in patients with lone atrial fibrillation compared with that in patients with atrial fibrillation associated with coronary, valve, or congenital heart disease. This study examined the long-term outcome of patients who underwent this procedure either as a lone operation or as a concomitant procedure.

Methods: From 1988 to 2001, 198 patients underwent a Cox maze III procedure; 112 were lone operations, and 86 were concomitant procedures. Major complications included renal failure, reoperation for bleeding, mediastinitis, stroke, and balloon pump insertion. Follow-up was performed by means of mail and telephone questionnaires with both the patients and their cardiologists. All patients who had any history of arrhythmia or who were taking medication had their rhythm documented by means of electrocardiography.

Results: The lone operation group was significantly younger (51.3 ± 10.5 vs 58.8 ± 9.9 years) and had a higher male/female ratio (4:1 vs 2:1). There was no difference in operative mortality between groups (1.8% vs 1.2%). At a follow-up of 5.4 ± 2.9 years, 96.6% (172/178) of all patients were free of atrial fibrillation. There was no difference between the lone operation and concomitant procedure groups (95.9% vs 97.5%).

Conclusion: The Cox maze III procedure has equivalent operative risk and long-term efficacy in patients undergoing both lone operations and concomitant procedures. The Cox maze III procedure remains the standard against which alternative procedures for atrial fibrillation must be judged.

From the Division of Cardiothoracic Surgery, Barnes-Jewish Hospital, Washington University School of Medicine, St Louis, Mo.

Supported by National Institutes of Health grants 5 R01 HL32257, T32 HL07275, and T32 HL07776.

Read at the Eighty-second Annual Meeting of The American Association for Thoracic Surgery, Washington, DC, May 5-8, 2002.

Received for publication Oct 11, 2002; revisions requested Nov 25, 2002; revisions received Jan 17, 2003; accepted for publication April 14, 2003.

Address for reprints: Ralph J. Damiano, Jr, MD, Chief of Cardiac Surgery, Washington University School of Medicine, Barnes-Jewish Hospital, One Barnes-Jewish Plaza, Queeny Tower Suite 3108, St Louis, MO 63110 (E-mail: damiano@msnotes.wustl.edu).

J Thorac Cardiovasc Surg 2003;126:1822-8

Copyright © 2003 by The American Association for Thoracic Surgery

0022-5223/2003 \$30.00 + 0

doi:10.1016/S0022-5223(03)01287-X

In the United States more than 2.2 million persons are known to have atrial fibrillation (AF).¹ This arrhythmia is particularly common in the elderly, with an incidence of 6% in patients older than 80 years.² AF causes significant morbidity as a result of hemodynamic compromise, tachycardia-induced cardiomyopathy, and thromboembolic events. Stroke remains the most feared complication, with an overall incidence of 5% per year.³ This is 2 to 7 times the risk of the general population without AF.⁴ In addition, a staggering 24% of strokes in patients older than 80 years are due to AF.¹ The seriousness of this arrhythmia is evidenced by the fact that the mortality of patients with AF is twice that of patients with normal sinus rhythm.⁵ Because of the

significantly increased morbidity and mortality associated with this disease, there have been aggressive attempts to find a cure over the last several decades. Medical therapy, transvenous ablation, and surgical intervention all play a role in the modern treatment of AF.

The first Cox maze III procedure was performed in 1988. The operation is based on the theory that AF results from multiple macroreentry circuits in the atria. The operation creates a maze-like series of incisions in both atria to prevent the formation of these macroreentrant circuits. During the operation, the pulmonary veins are completely isolated, and both appendages are removed.^{6,7} This was fortuitous because the importance of the pulmonary veins in the initiation of AF has become more appreciated in recent years.⁸ The procedure has been proved to be effective, with a high success rate and elimination of late strokes.⁹

The present indications for a Cox maze III operation include drug intolerance, arrhythmia intolerance, and recurrent embolic events. There are 2 major groups of patients who are referred for this procedure: those with symptomatic lone AF and those with AF associated with other organic cardiac disease. It is likely that the underlying pathophysiology responsible for the genesis of AF in these 2 groups of patients is different. Thus one can expect differences in the results of the Cox maze III procedure in these 2 populations. This study examined the long-term efficacy of the Cox maze procedure in patients undergoing the procedure either for lone AF or as an adjunct to another major cardiac operation.

Methods

The full Cox maze III procedure was performed in all cases. In each instance the patient underwent cardiopulmonary bypass and cardioplegic arrest. Three surgeons at our institution performed all operations (JC, TS, and RD). The majority of these procedures (158) were performed by Dr James Cox. From January 1988 to January 2002, 198 patients underwent a Cox maze III procedure for AF. One hundred twelve patients had a lone procedure, and 86 patients had the operation performed as a concomitant procedure.

Follow-up and Data Analysis

The patients' clinical profiles and perioperative outcomes were recorded prospectively in a computerized database. Perioperative complications were considered to be reoperation for bleeding, renal failure requiring dialysis, mediastinitis, placement of an intra-aortic balloon pump, perioperative transient ischemic accident or stroke, and perioperative myocardial infarction. Follow-up was conducted by means of a mailed questionnaire or telephone interview with the patient. A review of both the referring cardiologist's office charts and recent electrocardiograms (ECGs) was performed for any patient who stated that they were in AF or were taking medication. Information on each patient who died during the follow-up period was obtained from relatives, family physicians, or county death certificates. Atrial tachyarrhythmias occurring in the first 3 months were not counted.

TABLE 1. Concomitant procedures (n = 86)

Mitral valve repair/replacement	26
Mitral valve procedure + CABG	9
Mitral valve procedure + TVR	2
Mitral valve procedure + AVR	1
Mitral valve repair + ASD	1
CABG + AVR	1
CABG	31
CABG + AVR	1
AVR	3
TVR	1
ASD	10

CABG, Coronary artery bypass grafting; TVR, tricuspid valve repair; AVR, aortic valve replacement; ASD, closure of atrial septal defect.

All of the patients in this series had chronic AF, which was defined as a documented duration of longer than 6 months. Paroxysmal AF was defined as patients who were intermittently in AF. Persistent AF was defined as patients who were continuously in AF. This study was approved by the Washington University School of Medicine/Barnes-Jewish Hospital Institutional Review Board. Informed consent and release of information was obtained from each participant. The closing date for enrolling patient data for this study was January 1, 2002. Thus all patients had a minimum of 3 months' follow-up. Late survival and outcomes were recorded and analyzed according to Society of Thoracic Surgeons database guidelines. Data were collected and managed in Microsoft Access 2000 and analyzed with SysStat version 10.0 software (SPSS Corp, Chicago, Ill). The clinical profiles of the 2 groups of patients were compared by using the χ^2 test or the Fisher exact test. Continuous variables, such as age, were compared with the unpaired *t* test with a Dunn correction. Late survival and time-dependant morbidity were evaluated univariately by means of Kaplan-Meier analysis with the Mantel log-rank test and, a multivariate analysis was performed by using Cox regression.

Results

Patient Demographics

Lone maze procedure. The mean age of these patients was 51.3 ± 10.5 years (range, 20-77 years). There was a 4:1 ratio of men to women (90:22). There were 72 (64.3%) patients with paroxysmal AF lasting for a mean of 8.5 ± 7.5 years before the operation. Forty (35.7%) patients were operated on for persistent AF, with a mean preoperative duration of 11.6 ± 10.0 years.

In this group the indication for arrhythmia surgery was 19 (17%) of 112 patients with documented cerebral vascular accidents, 5 (4%) patients with medication intolerance, and the majority of patients (88 [79%]) with arrhythmia intolerance.

Concomitant maze procedure. The Cox maze procedure was performed as a concomitant procedure at our institution starting in April 1992. The most common concomitant procedures were mitral repair, mitral valve replacement, and coronary artery bypass grafting (Table 1). The mean age of patients in this group was 58.8 ± 9.9 years (range, 25-75

TABLE 2. Patient demographics

	Lone Maze procedure	Concomitant maze procedure	P value
Age (y)	51.3 ± 10.5	58.8 ± 9.9	<.001
Sex (M:F)	90:22	53:33	.003
PAF:PTAF	72:40	45:41	.08
Pump time (min)	162 ± 35	201 ± 42	<.001
Crossclamp time (min)	93 ± 34	122 ± 37	<.001
Mortality	2/112, 1.8%	1/86, 1.2%	.99
Median ICU stay (d)	2	3	.007
Median LOS (d)	9	12	.01

PAF, Paroxysmal atrial fibrillation; PTAF, persistent atrial fibrillation; LOS, length of stay.

years), which was significantly higher than that in the lone operation group ($P < .01$, Table 2). In this group the indications for the procedure included documented cerebral vascular event (19/86 [22%]), failed medications (2/86 [2%]), and arrhythmia intolerance (65/86 [76%]). There was an approximately 2:1 ratio in favor of men (53:33), which was a significantly smaller ratio than in the lone operation group ($P < .01$). There were 45 (52.3%) patients with persistent AF and 41 (47.7%) with paroxysmal AF. The mean length of AF in the persistent AF group was 5.4 ± 4.9 years, and in the paroxysmal AF group it was 6.3 ± 5.1 years.

Perioperative Results

Lone maze procedure. The average aortic crossclamp time was 93 ± 34 minutes, with a mean cardiopulmonary bypass time of 163 ± 35 minutes. The median intensive care unit (ICU) stay was 2 days (range, 1-50 days), and the median total length of stay was 9 days (range, 4-50 days). There were 2 (1.8%) perioperative deaths among 112 patients. One patient dies on postoperative day 28 from multiorgan system failure caused by delayed tamponade. The second patient died from acute respiratory failure caused by aminodarone toxicity on postoperative day 8.

There were 12 (10.7%) major complications: 3 (2.7%) reoperations for bleeding, 2 (1.8%) patients with renal failure, 4 (3.6%) patients with intra-aortic balloon pump placement, and 1 (0.9%) patient with mediastinitis. There were 2 (1.8%) perioperative strokes/transient ischemic accidents. There were no documented postoperative myocardial infarctions. A total of 9 (8.0%) patients required placement of a pacemaker postoperatively. Six (67%) patients who received postoperative pacemakers had been given a diagnosis of sick sinus syndrome preoperatively. The incidence of postoperative pacemaker placement with normal preoperative sinus node function was 3% (3/106).

TABLE 3. Perioperative complications

	Lone maze procedure	Concomitant maze procedure	P value
Reoperations for bleeding	3/112, 2.7%	6/86, 7.0%	.18
Renal failure	2/112, 1.8%	1/86, 1.2%	.99
Intra-aortic balloon pump	4/112, 3.8%	3/86, 3.5%	.99
Mediastinitis	1/112, 0.9%	1/86, 1.2%	.99
Stroke	2/112, 1.8%	1/86, 1.2%	.99
Postoperative pacemaker	9/112, 8.0%	20/86, 23.3%	.004

Concomitant maze procedure. The mean cardiopulmonary bypass time in this group was 201 ± 42 minutes, with an average crossclamp time of 123 ± 35 minutes. The median ICU stay was 3 days (range, 1-78 days). The median total length of stay was 12 days (range, 5-78 days). There was 1 (1.2%) perioperative death among 86 patients. This patient died from respiratory failure caused by adult respiratory distress syndrome on postoperative day 22. There were 12 (13.9%) perioperative complications: 6 (7.0%) patients returned to the operating room for bleeding, 1 (1.2%) patient had renal failure, 3 (3.5%) patients required the placement of an intra-aortic balloon pump, and 1 (1.2%) patient had mediastinitis. There was 1 (1.2%) patient with a stroke. None of the patients had a postoperative myocardial infarction. Twenty (23.3%) of these patients required postoperative pacemakers (Table 3).

The most significant differences between the 2 groups were age, sex, pump time, and crossclamp time (Table 3). The lone operation group was younger by almost 7 years, and there was a greater proportion of male patients in this group. Obviously the pump and crossclamp times in the concomitant procedure group were longer because of the concomitant procedures. The ICU time and length of stay were both longer in the concomitant procedure group, most likely because of the significantly longer crossclamp and pump times. There was no difference in operative mortality between the groups despite the differences in their demographics. Interestingly, the patients with lone AF had a significantly smaller chance of receiving a pacemaker postoperatively. This is intriguing because the duration of preoperative AF was longer in this group. The majority of the pacemakers placed after a concomitant procedure were the result of bradycardia, and 9 (45%) of the 20 patients had the preoperative diagnosis of sick sinus syndrome. The incidence of postoperative pacemaker placement in patients with normal sinus node function preoperatively in both

Figure 1. Kaplan-Meier survival analysis of freedom from recurrent AF. The numbers on each line indicate the number of patients at risk. There was no difference in the long-term estimate of freedom from AF between the lone maze group (L) and the concomitant group (C; $P = .64$).

groups (lone operation plus concomitant procedure) was 7.7% (14/183).

Late Follow-up

There was no significant difference between the groups in mean duration of follow-up or percentage of patients lost to follow-up. The mean duration of follow up was 5.4 ± 3.0 and 5.4 ± 2.7 years in the lone operation and concomitant procedure groups, respectively. Late follow-up was achieved in 98 (87.5%) of 112 patients in the lone operation group and in 79 (91.9%) of 86 patients in the concomitant group.

Patient survival. In the lone Maze procedure there were 3 (3.1%) late deaths in the lone operation group among 98 patients. All patients were free of AF. In the concomitant procedure group there were 7 (8.9%) late deaths, and all patients were free of AF before death. Six patients died as a result of a noncardiac cause, such as cancer, ischemic colitis, and late renal failure. One patient died of chronic heart failure. Information on the other 3 patients is currently unavailable.

Thromboembolic events. There was only one late stroke in the entire series, and this was in the lone operation group. This patient had a cerebrovascular accident to the right temporal lobe with residual symptoms of hoarseness, loss of fine motor abilities, and difficulty concentrating.

Warfarin sodium. All patients discharged after a Cox maze III procedure were prescribed warfarin sodium (Coumadin) for 3 months. In the lone operation group the majority of our patients were referrals from other states (95/112 [84.8%]). After their postoperative clinic visit, their medications were managed by their cardiologists or family physicians. In our study 12 (12.2%) of the 98 responders were taking warfarin at late follow-up.

Similar to the lone operation group, the majority of patients were out of state in the concomitant procedure group (66/86 [76.7%]). In this study 18 (20.9%) of the 86 responders were taking warfarin. Eleven (61.1%) of these 18 required anticoagulation for their prosthetic valve. The overall use of warfarin, excluding these patients, was 9.3% (7/75).

Recurrence of AF. In the lone maze procedure group all patients who identified themselves as being in AF were considered failures unless their cardiologist and an ECG or Holter recording documented otherwise. Only 4 (4.1%) of 98 patients in the lone operation group were in AF at follow-up. Seventy-eight (79.6%) patients were not in AF and free of antiarrhythmic medications. Sixteen (16.3%) patients were in normal sinus rhythm but were taking antiarrhythmic drugs.

In the concomitant maze procedure group, of the 79 responders, 2 (2.5%) patients were in AF. Fifty-eight (73.4%) patients were in sinus rhythm and off all antiarrhythmic medication. An additional 19 (24%) patients were free of AF but were taking medications. There was no difference in freedom from AF between the 2 groups (Figure 1).

Overall, the Kaplan-Meier estimate for freedom from AF for patients in the lone operation group at 14 years is 92%. The concomitant procedure had a freedom from AF of 97% at 10 years. Statistically time matched at 10 years, there was no difference in freedom from AF between the 2 groups ($P = .64$). There also was no statistical difference in late freedom from AF when comparing patients with persistent versus paroxysmal AF.

Discussion

This is the first study to compare the long-term efficacy of the Cox maze III procedure either as a lone operation or as

an adjunct to another major cardiac procedure. Supporting our initial hypothesis, there were significant differences between the 2 patient populations. The lone operation group had a higher population of patients with paroxysmal AF than the concomitant procedure group ($P = .08$). The lone operation group was significantly younger, was more likely to be male, and had shorter cardiopulmonary bypass times. Postoperatively, the lone operation group, as would be expected, had shorter ICU and postoperative stays. The incidence of postoperative pacemaker placement was less in the lone operation group.

In this study this procedure had excellent results in curing AF in both groups. Despite the longer crossclamp and cardiopulmonary bypass times, there was no difference in the morbidity and mortality between these 2 populations. The incidence of postoperative complications was identical between groups, except for a trend toward more reoperations for bleeding in the concomitant procedure group. Late complications were rare in both groups. It was noteworthy that there was only one late stroke reported in both groups. The Cox maze III procedure reduced the risk of stroke in this high-risk population. The incidence of stroke in patients with AF has been reported by the American Heart Association and the American College of Cardiology to be 5% per year, and even with anticoagulation, the risk is 2% to 3% per year.¹⁰ One of the greatest benefits of this procedure was the reduction of stroke as a late complication at a follow-up period of 5.4 ± 2.9 years. Moreover, the majority of patients (148/178 [83.1%]) were able to discontinue warfarin, which carries its own long-term risk of morbidity. In patients without prosthetic valves, only 9% still required anticoagulation.

The overall freedom from AF at follow-up was 97%. The great majority of these patients also had stopped taking both antiarrhythmic drugs and warfarin. With a high long-term cure rate and the benefits of being able to stop all medications, why is the Cox maze procedure so seldom performed in patients with refractory AF?

First, the procedure has been viewed as invasive and entailing significant morbidity because of the prolonged period of cardiopulmonary bypass required to perform the operation. However, a close examination of the alternatives for many patients clearly favors a more aggressive surgical approach. In patients with lone AF, the arrhythmia itself, antiarrhythmic drugs, and anticoagulation all have well-documented and significant complications.¹¹ This study demonstrated that the Cox maze III procedure has a low mortality in this population (2/112 [1.8%]) while offering the patient a greater than 95% chance of a cure, reducing the risk of stroke.

In patients who have preoperative AF and are undergoing primary cardiac surgery for other reasons, these data suggest that selected patients would benefit from a Cox

maze III procedure. The mortality of the concomitant procedure was low (1/86 [1.2%]), which compares favorably with the national average for coronary and mitral valve surgery.¹² At our institution, our comparative mortality over a similar time period for elective coronary artery bypass grafting was 2.6% and for mitral valve repair was 2.4%. Although the addition of the Cox maze III procedure did not increase perioperative mortality, it did lengthen hospital stay (median, 12 days). However, the long-term benefits of this procedure in preventing stroke and eliminating the need for anticoagulation, particularly in patients undergoing mitral valve repair, would appear to outweigh this short-term inconvenience.

The long-term success rates in these patients would argue strongly for a more widespread adoption of the Cox maze procedure. The success of this procedure in the concomitant procedure group might be due to the correction of physiologic abnormalities, such as ischemia or left atrial distension, which could predispose a patient to AF. Our results are supported by other studies that have reported the efficacy of the Cox maze III procedure in patients undergoing mitral valve surgery.¹³⁻¹⁵

In this series 15% (29/198) of patients required a postoperative pacemaker. This has been used by some physicians as a reason to discourage the wider use of this operation. However, it is instructive to closely look at this group of patients. First of all, there was a significant difference in postoperative pacemaker placement between the 2 groups, 8% in the lone operation group versus 23% in the concomitant procedure group. Second, many of these patients were given a preoperative diagnosis of sick sinus syndrome. In patients with normal preoperative sinus node function, our rate of pacemaker placement was only 8% (14/183 [7.7%]).

Left atrial dysfunction has been reported as a common late sequelae of the Cox maze III procedure, occurring as a result of the extensive surgical manipulation of the left atrium.¹⁶ In this study left atrial function was not quantified. Regardless of the precise incidence of left atrial dysfunction, our data would suggest that if it occurs, it is not of physiologic significance. The great majority of our patients (148/178 [83.1%]) were not receiving anticoagulation. If there had been a physiologically significant reduction in left atrial function, especially in a study that spanned 14 years, one would have expected a higher rate of stroke, mortality, or both caused by heart failure. Neither of these problems was observed in this patient population.

Another reason the procedure has not had widespread adoption is the impression that the long-term efficacy is not sufficient to warrant the risk. This study clearly supports the success of this procedure in both groups of patients for the treatment of paroxysmal and persistent AF. This misconception might be the result of many published reports that inappropriately use the term "Cox maze" or "maze" proce-

cedure. Many of these studies use a different lesion set and are based on the empiric elimination of one or more incisions to simplify the procedure.¹⁷ These “maze” procedures have had mixed results with short-term or immediate follow-up.^{18,19} Moreover, the inappropriate use of the term “catheter maze” by electrophysiologists has further confused the issue. The catheter-based procedures have not been able to fully replicate the entire set of surgical lesions described in the classic Cox maze III procedure. Any procedure less than a complete Cox maze III procedure must be considered a new operation for AF and be carefully evaluated as such both experimentally and clinically.

In summary, the Cox maze III procedure is effective in curing AF in the majority of patients for whom nonsurgical therapy has failed. The Cox maze III procedure is efficacious in patients with lone AF and should be offered to a larger population of symptomatic patients. In patients undergoing coronary or valve surgery, the Cox maze III procedure is successful in curing AF in virtually all patients and did not add significantly to the expected mortality or morbidity of this group of patients. These data support a policy of offering a curative Cox maze III procedure to patients with refractory AF undergoing open cardiac surgery.

The major strength of our study was the large number of patients and the high percentage and duration of the follow-up. The major limitation of this study was that it might have underestimated the failure rate. Electrocardiographic follow-up was not obtained on patients who stated that they were in normal sinus rhythm and had stopped all medications. However, our follow-up of all patients who identified themselves as having any atrial dysarrhythmia should have captured the majority of treatment failures. Another limitation of any long-term AF study is the possibility that the patient might have had asymptomatic episodes of AF. Our follow-up in many patients was only annual physician visit ECGs, and this might have missed asymptomatic intermittent rare episodes of AF. Unfortunately, the logistics of continuously monitoring patients for years is not possible. If patients were indeed in intermittent AF, one would have expected a higher incidence of late strokes.

References

1. Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke: the Framingham Study. *Stroke*. 1991;22:983-8.
2. Furberg CD, Psaty BM, Manilo TA, Gardin JM, Smith VE, Rautaharju PM. Prevalence of atrial fibrillation in elderly subjects (the Cardiovascular Health Study). *Am J Cardiol*. 1994;74:236-41.
3. Risk factors for stroke and efficacy of antithrombotic therapy in atrial fibrillation: analysis of pooled data from five randomized controlled trials [published erratum appears in *Arch Intern Med*. 1994;154:2254]. *Arch Intern Med*. 1994;154:1449-57.
4. Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation: a major contributor to stroke in the elderly: the Framingham Study. *Arch Intern Med*. 1987;147:1561-4.
5. Krahn AD, Manfreda J, Tate RB, Mathewson FA, Cuddy TE. The natural history of atrial fibrillation: incidence, risk factors, and prognosis in the Manitoba Follow-Up Study. *Am J Med*. 1995;98:476-84.
6. Cox JL, Schuessler RB, D'Agostino HJ Jr, et al. The surgical treatment of atrial fibrillation, III: development of a definitive surgical procedure. *J Thorac Cardiovasc Surg*. 1991;101:569-83.
7. Cox JL, Boineau JP, Schuessler RB, Jaquiss RD, Lappas DG. Modification of the maze procedure for atrial flutter and atrial fibrillation. I. Rationale and surgical results. *J Thorac Cardiovasc Surg*. 1995;110(2):473-84.
8. Haissaguerre M, Shah DC, Jais P, et al. Spontaneous initiation of atrial fibrillation by ectopic beats originating in the pulmonary veins. *N Engl J Med*. 1998;339:659-66.
9. Cox JL, Schuessler RB, Lappas DG, Boineau JP. An 8½-year clinical experience with surgery for atrial fibrillation. *Ann Surg*. 1996;224(3):267-75.
10. Fuster V, Ryden LE, Asinger RW, et al. ACC/AHA/ESC guidelines for the management of patients with atrial fibrillation: executive summary. A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the European Society of Cardiology Committee for Practice Guidelines and Policy Conferences (Committee to Develop Guidelines for the Management of Patients With Atrial Fibrillation): developed in Collaboration With the North American Society of Pacing and Electrophysiology. *J Am Coll Cardiol*. 2001;38(4):1231-66.
11. Ruigomez A, Johansson S, Wallander M, Rodriguez G. Incidence of chronic atrial fibrillation in general practice and its treatment pattern. *J Clin Epidemiol*. 2002;55:358-63.
12. Society of Thoracic Surgeons National Database, Spring 2003. www.sts.org.
13. Raanani E, Albarg A, David TE, Yau TM, Armstrong S. The efficacy of the Cox/maze procedure combined with mitral valve surgery: a matched control study. *Eur J Cardiothorac Surg*. 2001;19(4):438-42.
14. Doty DB, Dilip KA, Millar RC. Mitral valve replacement with homograft and Maze III procedure. *Ann Thorac Surg*. 2000;69(3):739-42.
15. Schaff HV, Dearani JA, Daly RC, Orszulak TA, Danielson GK. Cox-Maze procedure for atrial fibrillation: Mayo Clinic experience. *Semin Thorac Cardiovasc Surg*. 2000;12(1):30-7.
16. Feinberg MS, Waggoner AD, Kater KM, Cox JL, Lindsay BD, Perez JE. Restoration of atrial function after the maze procedure for patients with atrial fibrillation. Assessment by Doppler echocardiography. *Circulation*. 1994;90:II285-92.
17. Isobe F, Kumano H, Ishikawa T, et al. A new procedure for chronic atrial fibrillation: bilateral appendage-preserving maze procedure. *Ann Thorac Surg*. 200;72(5):1473-8.
18. Pasic M, Bergs P, Muller P, et al. Intraoperative radiofrequency maze ablation for atrial fibrillation: the Berlin modification. *Ann Thorac Surg*. 2001;72(5):1484-91.
19. Khargi K, Deneke T, Haardt H, et al. Saline-irrigated, cooled-tip radiofrequency ablation is an effective technique to perform the maze procedure. *Ann Thorac Surg*. 2001;72(3):S1090-5.

Discussion

Dr Hartzell V. Schaff (Rochester, Minn). I agree with your conclusion that the Cox maze operation is the gold standard against which alternative procedures for AF must be judged. In your clinical review you found a similarly low operative risk for patients who had only the maze procedure compared with patients who had concomitant cardiac surgery, and furthermore, you conclude that the late freedom from AF was similar in these groups. Because this report will be widely quoted in the future and the results compared with outcomes of new procedures and devices, I think it is important to clarify a few issues and expand on 2 points.

First is the issue of patient selection and the generalizability of your results to other practices. In this series of operations for AF, concomitant operations were performed in 43% of patients. In our experience with more than 400 maze operations, more than 80% of patients have had valve repair or replacement, and therefore the issue of incremental risk and long-term efficacy is important. And although you found little difference in operative mortality between