Association of operative risk with the outcome of concomitant Cox Maze procedure: A comparison of results across risk groups

Niv Ad, MD, Sari D. Holmes, PhD, Graciela Pritchard, BS, and Deborah J. Shuman, BS

Objectives: Cardiac surgery patients with atrial fibrillation face increased risks for perioperative morbidity and decreased survival, yet only 39% of patients presenting with atrial fibrillation undergo concomitant surgical ablation. This low percentage may relate to the perception of lower yield for surgical ablation, especially in patients with complex clinical presentations. In this study, we compared outcomes after a concomitant Cox maze III/IV procedure in patients with high, intermediate, and low predicted operative risk.

Methods: Outcome data were prospectively captured after surgery. The additive European System for Cardiac Operative Risk Evaluation (EuroSCORE) was greater than 6 for high-risk patients ($n = 145$), 3 or less for low-risk patients ($n = 76$), and greater than 3 and 6 or less for intermediate-risk patients ($n = 149$).

Results: No differences were found for perioperative morbidities, including operative mortality (high vs low risk, 2% vs 1%, $P = 1.00$; high vs intermediate risk, 2% vs 0.7%, $P = .37$). Median length of stay was longer in high-risk patients versus low-risk patients (8 vs 5 days, $P < .001$) and intermediate-risk patients (8 vs 6 days, $P < .001$). Return to sinus rhythm was comparable for high-risk versus low- and intermediate-risk patients at 6, 12, and 24 months. Physical health-related quality of life scores improved similarly for all groups at 12 months. No difference in long-term survival was found (log rank = 0.40; $P = .82$).

Conclusions: The Cox maze III/IV procedure can be performed safely and effectively in patients with higher operative risk, who fare well when compared with lower-risk patients. The Cox maze III/IV procedure should be considered carefully in patients with a significant history of atrial fibrillation. (J Thorac Cardiovasc Surg 2014;148:3027-33)

See related commentary on pages 3034-5.

Atrial fibrillation (AF) is associated with increased morbidity and decreased survival after cardiac surgery,^{1,2} yet a significant number of patients do not have their AF addressed at the time of cardiac surgery. Several studies using the Society of Thoracic Surgeons (STS) database have found that only approximately 28% to 39% of patients with AF have surgical ablation at the time of surgery.³ Both our and others' experience suggests that surgical complexity and predicted operative risk are major variables in the decision of whether to perform surgical ablation for AF at the time of other cardiac procedures, because there is a general perception that ablation significantly increases the risk for perioperative complications.^{1,2,4,5}

Several studies reporting long-term experience with Cox maze procedures have revealed excellent results.⁶ The

safety and efficacy of surgical ablation for AF, both preoperatively and long term, are well documented.⁷⁻⁹ These and other studies have led to our recommendation to include surgical ablation for AF at the time of other cardiac procedures.^{4,5} In this study, we examined the outcomes of patients with a significant history of AF who were at high, intermediate, and low operative risk and who underwent a concomitant Cox maze III/IV procedure.

METHODS

This was a single-center cohort study in which all data related to a patient's surgical and postoperative course were prospectively collected in our detailed AF registry, which is designed to follow patients longitudinally, and merged with our local STS data.^{10,11} The study was approved by our institutional review board (No. 06.095 and 07.025). All consecutive patients without congenital heart disease who underwent the full Cox maze III/IV procedure with another cardiac procedure for the first time between January 2005 and January 2012 were included in the analyses (Figure 1). The Cox maze III/IV procedure was performed as described previously and included all lesions produced with ablation technology; in addition, all patients underwent excision or exclusion of the left atrial appendage.^{12,13} The decision of whether to add the Cox maze III/IV procedure to a specific surgical procedure was left to the discretion of the surgeon.

The additive form of the European System for Cardiac Operative Risk Evaluation (EuroSCORE) I was used to stratify risk. This form of the EuroSCORE I was not designed to define the percent risk for mortality, but rather to stratify mortality risk as low, intermediate, or high.¹⁴ In this study, high-risk patients were defined as those with an additive EuroSCORE I of greater than 6, low-risk patients were defined as those with an additive EuroSCORE I of 3 or less, and intermediate-risk patients included all others with an additive EuroSCORE I of greater than 3 and 6 or less.

From the Inova Heart and Vascular Institute, Falls Church, Va.

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Address for reprints: Niv Ad, MD, Inova Heart and Vascular Institute, 3300 Gallows Rd, Falls Church, VA 22042 (E-mail: Niv.Ad@inova.org).

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Abbreviations and Acronyms

AF	= atrial fibrillation
ANOVA	= analysis of variance
CHADS ₂	= Congestive heart failure, Hypertension, Age >75, Diabetes mellitus, and prior Stroke or transient ischemic attack
EuroSCORE	= European System for Cardiac Operative Risk Evaluation
HRQL	= health-related quality of life
MCS	= mental composite summary
PCS	= physical composite summary
SF-12	= 12-Item Short-Form Health Survey
STS	= Society of Thoracic Surgeons

Clinical Outcomes

STS definitions were used for perioperative outcomes.¹¹ Rhythm status in patients who underwent the Cox maze III/IV procedure was verified by electrocardiogram and 24-hour Holter monitoring at all time points in all monitored patients (6, 12, and 24 months). The Heart Rhythm Society definition of failure (all documented atrial arrhythmias of ≥ 30 seconds occurring ≥ 3 months after ablation) was used to determine the rate at which patients returned to sinus rhythm at 6, 12, and 24 months.⁹ We also captured patients' status regarding class I or III antiarrhythmic therapy at each of these time points. All other clinical information during follow-up was collected prospectively at the same intervals via patient report and record review. A number of patients were lost to clinical follow-up at 6, 12, and 24 months ($n = 34$, $n = 31$, $n = 55$, respectively) for patient and treating physician nonresponse. The majority of these patients (68%, 52%, 80%) were not lost permanently. Long-term survival was continually updated through information obtained from the National Death Index and the Social Security Death Index.

Health-Related Quality of Life and Atrial Fibrillation Symptom Burden

To better understand the impact of surgery on areas other than those measured in the clinical follow-up, we asked all patients to complete a baseline (preoperative) health-related quality of life (HRQL) survey and mailed follow-up surveys after surgery. Our analyses focused on HRQL at 12 months. We used the 12-Item Short-Form Health Survey (SF-12), one of a family of Short-Form instruments that have been validated in patients undergoing cardiac surgery.¹⁵ The SF-12 measures 8 domains of HRQL and 2 summary scores, a physical composite summary (PCS) and a mental composite summary (MCS). Higher numeric scores on the SF-12 indicate better HRQL and can be compared with age group- and disease-based norms.

This study was unique in its use of the AF Symptom Checklist: Frequency and Severity (version 3) to capture patients' perceptions of AF symptoms and their severity.¹⁶ The checklist comprises 16 items measuring frequency and severity of AF-specific symptoms, including heart fluttering, heart racing, tiredness, shortness of breath, and difficulty sleeping. Higher scores indicate greater frequency and severity of AF symptoms. Use of this checklist began partway through this study, so only 83 patients completed baseline and 6-month checklist forms at the time of these analyses.

Statistical Analysis

Continuous data are presented as mean $\pm$ standard deviation, and categorical data are presented as frequency (percent) unless otherwise noted. All analyses were conducted using SPSS version 17.0 (SPSS Inc, Chicago, Ill).

For risk group comparisons on preoperative characteristics, chi-square or Fisher exact tests were used for categorical variables, and analysis of variance (ANOVA) with Dunnett's post hoc tests was used for continuous measures. Univariate differences in perioperative and postoperative outcomes by risk group were evaluated with chi-square or Fisher exact test for categorical variables and ANOVA or the Kruskal-Wallis test for continuous measures. Kaplan-Meier analysis was conducted to compare cumulative survival among the risk groups. Changes in HRQL from baseline to 12 months were evaluated via repeated-measures ANOVAs, whereas differences between groups at a single time point were evaluated using ANOVA with Dunnett's post hoc tests.

Multivariate analyses were conducted to adjust for the following clinical factors: age, gender, diabetes, ejection fraction, hypertension, chronic lung disease, urgent status, cardiopulmonary bypass time, concomitant coronary artery bypass grafting, concomitant valve surgery, duration of AF, and left atrial size. For categorical outcome variables, logistic regression was conducted, and for continuous outcome variables, linear regression was conducted. Cox proportional hazards regression was conducted to examine differences in cumulative survival between risk groups after adjustment for the covariate set.

RESULTS**Full Sample**

Of the 499 full Cox maze III/IV procedures performed at our center, 370 patients with concomitant surgical procedures were included in the analyses. Seventy-six patients were classified as low risk, 149 patients were classified as intermediate risk, and 145 patients were classified as high risk (Figure 1). As expected, the high-risk group was significantly different from the low- and intermediate-risk groups on several preoperative characteristics (Table 1). The high-risk group was older, had lower ejection fraction, and had more patients with congestive heart failure and cerebrovascular disease than the low- and intermediate-risk groups. In addition, the high-risk group was more likely than the low-risk group to have concomitant coronary artery bypass grafting. There were no significant differences among groups in the proportion of patients who presented with long-standing persistent AF (Table 1).

Perioperative Outcomes

Overall, patients in this sample had a low incidence of perioperative complications. Univariate analyses were used to compare the 3 risk groups on perioperative outcomes (Table 2). Patients in the high-risk group were more likely to have postoperative atrial arrhythmia during their hospital stay than the intermediate-risk group ($P = .049$) or the low-risk group ($P = .006$). High-risk patients were more likely to have a longer median length of stay (8 days) than intermediate-risk patients (6 days; $P < .001$) or low-risk patients (5 days; $P < .001$). Patients in the high-risk group were more likely to receive blood products intraoperatively than patients in the intermediate-risk group ($P = .01$) or the low-risk group ($P = .002$) and were more likely to receive blood products postoperatively than patients in the low-risk group ($P = .008$). After multivariate adjustment for the aforementioned variables (Table 2), high-risk patients had greater

FIGURE 1. Flow chart showing the study sample with inclusion and exclusion criteria. CM, Cox maze.

odds of receiving intraoperative blood than low-risk patients ($P = .013$) or intermediate-risk patients ($P = .013$). There were no other significant differences between the risk groups on any perioperative outcomes in multivariate analyses.

Long-Term Follow-Up Results

Freedom from AF and any atrial arrhythmia at 6, 12, and 24 months was similar in all groups. In univariate analyses of freedom from AF and any atrial arrhythmia, the high-risk

group was not significantly different from the low-risk group at 6 months ($P = .79$), 12 months ($P = .77$), or 24 months ($P = .53$; [Figure 2, A](#)). The high-risk group also did not differ significantly from the intermediate-risk group at 6 months ($P = .67$), 12 months ($P = 1.00$), or 24 months ($P = .63$). A similar result was found between the high- and the low-risk groups for freedom from AF in patients not taking class I or III antiarrhythmic medications at 6 months ($P = .85$), 12 months ($P = .38$), and 24 months ($P = .09$) and between the high- and intermediate-risk groups at 6 months ($P = .58$), 12 months ($P = .89$), and 24 months ($P = .24$; [Figure 2, B](#)). Even after adjustment for the covariate set, the 3 risk groups did not differ in freedom from AF and any atrial arrhythmia at 6 months ($P = .45$), 12 months ($P = .59$), or 24 months ($P = .99$). The same pattern of results was found for freedom from AF and any atrial arrhythmia in patients not taking antiarrhythmic drugs at 6 months ($P = .43$), 12 months ($P = .84$), and 24 months ($P = .91$).

The mean follow-up time for this sample was 37.9 ± 25.4 months. The number of patients requiring percutaneous

TABLE 1. Baseline patient characteristics†

Characteristic	Risk		
	High (n = 145)	Intermediate (n = 149)	Low (n = 76)
Age, y	71.6 ± 10.2	65.9 ± 8.6*	54.1 ± 6.2*
Female sex	72 (50)	58 (39)	16 (21)*
Preoperative hematocrit (%)	39.2 ± 5.3	40.7 ± 4.2	40.9 ± 5.5
Body mass index (kg/m²)	27.0 ± 5.7	28.8 ± 5.9*	27.9 ± 5.7
Hypertension	112 (77)	101 (68)	43 (57)*
Ejection fraction (%)	52.3 ± 14.1	57.3 ± 9.5*	57.7 ± 9.6*
Congestive heart failure	86 (59)	60 (40)*	23 (30)*
Cerebrovascular disease	41 (28)	5 (3)*	0*
Previous cerebrovascular accident	29 (20)	1 (0.7)*	0*
Diabetes	27 (19)	25 (17)	5 (7)*
Previous myocardial infarction	29 (20)	8 (5)*	0*
Chronic lung disease	32 (22)	25 (17)	0*
Smoker	23 (16)	23 (15)	9 (12)
Urgent status	33 (23)	25 (17)	6 (8)*
EuroSCORE I (additive)	8.5 ± 1.6	5.2 ± 0.8*	2.6 ± 0.5*
EuroSCORE I (logistic)	12.9 ± 7.2	4.2 ± 1.1*	1.8 ± 0.3*
Concomitant CABG	56 (39)	58 (39)	15 (20)*
Concomitant valve	124 (86)	119 (80)	68 (90)
Cross-clamp time (min)	116.4 ± 38.2	124.8 ± 38.3	125.6 ± 38.1
Cardiopulmonary bypass time (min)	174.8 ± 46.3	177.6 ± 44.4	188.3 ± 52.6
Duration of AF (mo)	36.9 ± 62.2	40.6 ± 58.3	29.3 ± 33.6
Left atrial size (cm)	4.9 ± 0.9	5.2 ± 1.0	5.3 ± 1.1*
Range	3.1-7.6	3.3-7.7	2.7-8.2
Type of AF			
Long-standing persistent	74 (51)	72 (48)	32 (42)
Persistent	55 (38)	61 (41)	34 (45)
Paroxysmal/other	16 (11)	16 (11)	10 (13)

AF, Atrial fibrillation; CABG, coronary artery bypass grafting; EuroSCORE, European System for Cardiac Operative Risk Evaluation. *Significant difference with high-risk group ($P < .05$). †Except where otherwise indicated, values are given as frequency (%) or mean ± standard deviation.

TABLE 2. Perioperative morbidity among low-, intermediate-, and high-risk patients before and after adjustment for clinical covariates

Outcome	Univariate			Multivariate, OR (95% CI)	
	High	Intermediate	Low	Low-high	Intermediate-high
Stroke†	3 (2)	2 (1)	0		
Prolonged ventilation (>24 h)	18 (12)	9 (6)	4 (5)	0.54 (0.10-2.92)	0.79 (0.26-2.34)
Pneumonia	10 (7)	4 (3)	1 (1)	1.19 (0.06-23.49)	0.80 (0.18-3.58)
Deep sternal wound infection†	1 (0.7)	0	0		
Renal failure requiring dialysis	6 (4)	2 (1)	2 (3)	0.45 (0.03-5.91)	0.49 (0.06-4.28)
Reoperation for bleeding	5 (3)	7 (5)	1 (1)	1.96 (0.08-46.87)	3.79 (0.62-23.00)
AF during stay	72 (50)	57 (38)*	24 (32)*	0.65 (0.27-1.61)	0.77 (0.43-1.38)
Intraoperative blood	49 (34)	29 (20)*	11 (15)*	0.26 (0.09-0.75)*	0.43 (0.22-0.84)*
Postoperative blood	63 (44)	50 (34)	19 (26)*	0.57 (0.22-1.45)	0.70 (0.39-1.27)
Length of stay (d)‡	8 [6-12]	6 [5-10]*	5 [4-8]*	B = -0.82	B = -0.91
Readmissions within 30 d	15 (10)	23 (15)	13 (17)	1.42 (0.35-5.76)	1.47 (0.60-3.61)
Operative death (<30 d)†	3 (2)	1 (0.7)	1 (1)		

AF, Atrial fibrillation; CI, confidence interval; OR, odds ratio. *Significant difference with high-risk group ($P < .05$). †Incidence of perioperative complication was too small to model with multivariate analyses. ‡Median [interquartile range], evaluated with the Mann-Whitney test for univariate and linear regression for multivariate.

catheter ablation during follow-up was not different between the high-risk group (1%) and the intermediate-risk group (5%; $P = .10$) or the low-risk group (3%; $P = .61$). There was also no difference in the number of patients with at least 1 cardioversion during follow-up between the high-risk group (15%) and the intermediate-risk group (16%; $P = .83$) or the low-risk group (18%; $P = .57$). Unadjusted ablation-free survival (log rank = 3.79; $P = .15$) and cardioversion-free survival (log rank = 0.25; $P = .88$) also did not differ among the 3 risk groups. After multivariate adjustment, there was still no difference among the risk groups in the incidence of follow-up ablations ($P = .10$) or cardioversions ($P = .48$).

Of 370 patients, 331 (89%) were discharged from the hospital on warfarin. By 12 months after surgery, only 40% of patients in the full sample (101/251) remained on warfarin. After exclusion of patients who were taking warfarin for other clinical indications (eg, pulmonary emboli, deep vein thrombosis, mechanical valves, atrial arrhythmia), only 23% of patients (46/196) remained on warfarin for the sole indication of history of AF. All but 1 of these patients (23%) were in sinus rhythm at 12 months. At 12 months after surgery, the high-risk group (46%) did not differ from the intermediate-risk group (40%; $P = .42$) or the low-risk group (31%; $P = .11$) in the percentage taking warfarin. After removing from the analysis those patients who were on warfarin for other clinical indications, no differences were noted between the high-risk group (29%) and the intermediate-risk group (23%; $P = .36$) or the low-risk group (15%; $P = .11$). The median Congestive heart failure, Hypertension, Age >75, Diabetes mellitus, and prior Stroke or transient ischemic attack (CHADS₂) score was found to be significantly higher in the high-risk group (2 [2-3]) than in the intermediate-risk

group (1 [1-2]; $P < .001$) or the low-risk group (1 [0-1]; $P < .001$).

There were no embolic strokes within the first 12 months after surgery in the high- and low-risk groups and only 3 embolic strokes in the high- and low-risk groups over the course of the remaining follow-up period. There were 3 embolic strokes in the intermediate-risk group, all of which occurred during the blanking period (≤ 3 months). During the entirety of the follow-up period, there was no difference among the risk groups in the incidence of embolic strokes ($P = .49$). One patient in the high-risk group (0.6%) had an embolic stroke (CHADS₂ score = 3); this patient was taking warfarin and was not in score sinus rhythm. In the low-risk group, 2 patients (2.6%) had embolic strokes (CHADS₂ score = 1, 0); 1 of these patients was taking warfarin and the score other was taking aspirin, and both were in sinus rhythm at the time of the embolic event. The patient who was in sinus rhythm and taking warfarin had an international normalized ratio of 1.9 at the time of the event. The embolic event occurred 18 months after this patient underwent a Cox maze procedure and approximately 2 weeks after an outpatient procedure for pacemaker placement. Three patients in the intermediate-risk group (CHADS₂ score = 3, 1, and 1) had embolic strokes that occurred during score the blanking period; all were taking warfarin and 2 were in sinus rhythm.

Kaplan-Meier analysis found no difference in 2-year cumulative survival (log rank = 0.40; $P = .82$) among the low-risk (93.9%), intermediate-risk (91.8%), and high-risk (91.5%) groups (Figure 3). After multivariate adjustment via Cox proportional hazards regression, 2-year survival in the high-risk group remained similar to that in the intermediate-risk group (hazard ratio, 1.52; 95% confidence interval, 0.51-4.53; $P = .45$) and the low-risk group

FIGURE 2. A, Comparison of high-, intermediate-, and low-risk groups on percentage of patients in normal sinus rhythm at 6, 12, and 24 months. B, Comparison of high-, intermediate-, and low-risk groups on percentage of patients in normal sinus rhythm off class I and III antiarrhythmic drugs at 6, 12, and 24 months. AAD, Antiarrhythmic drugs; NSR, normal sinus rhythm.

(hazard ratio, 1.45; 95% confidence interval, 0.26-8.17; $P = .68$).

Health-Related Quality of Life and Atrial Fibrillation Symptom Burden

Data on HRQL were captured at baseline (preoperatively) and 12 months after surgery for a subset of 156 patients. Physical HRQL (PCS) scores at baseline ($F = 3.94$, $P = .02$) were significantly lower in the high-risk group (37.3) than in the low-risk group (43.6; $P = .03$) and the intermediate risk group (41.7; $P = .048$), but baseline mental HRQL (MCS) scores were similar for all 3 groups ($F = 0.54$, $P = .58$). Overall, PCS increased significantly from baseline to 12 months after surgery ($F = 44.9$, $P < .001$) and improved similarly for all 3

risk group ($F = 1.26$, $P = .29$; Figure 4). However, across both time points, the high-risk group had significantly lower PCS scores than the other risk groups ($F = 10.81$, $P < .001$). By 12 months after surgery, the national heart disease norms for PCS had been exceeded in the low-risk ($t = 7.51$, $P < .001$), intermediate-risk ($t = 7.54$, $P < .001$), and high-risk ($t = 2.56$, $P = .01$) groups. Improvement in MCS scores was significant overall ($F = 9.57$, $P = .002$) and was also similar for the 3 groups ($F = 0.60$, $P = .55$). By 12 months after surgery, the national heart disease norms for MCS also had been exceeded in the low-risk ($t = 2.60$, $P = .01$), intermediate-risk ($t = 5.63$, $P < .001$), and high-risk ($t = 4.70$, $P < .001$) groups.

Overall, frequency of symptoms specific to AF decreased by 48% from baseline to 6 months ($n = 83$; $F = 66.31$, $P < .001$) and improved similarly ($F = 0.14$, $P = .87$) in all 3 risk groups. The severity of these AF-specific symptoms also improved over time, decreasing by 48% ($F = 59.51$, $P < .001$), and there was no difference in improvement among the 3 risk groups ($F = 0.34$, $P = .71$). These findings from the AF Symptom Checklist, combined with the findings from the SF-12, indicate that not only general HRQL but also quality of life in relation to specific AF-related symptoms improved in these patients.

DISCUSSION

We compared the clinical and rhythm outcomes of patients with high, intermediate, and low operative risk who underwent a concomitant Cox maze III/IV procedure for AF. The main purpose of the study was to address the perception among surgeons that adding the procedure in patients with relevant operative risk is associated with increased perioperative morbidity. Our findings suggest that high-risk patients did as well, both perioperatively and in the long term, as patients in the intermediate- and low-risk groups. This finding was maintained for patient survival. In addition, all patient groups reported significant improvement in the physical component of HRQL and arrhythmia-related symptoms.

In this study, we compared outcomes in patients classified as high, intermediate, and low risk on the basis of additive EuroSCORE I.¹⁴ Although we are aware of the criticism that the original EuroSCORE I overestimated risk, the current analysis is not devised around observed-to-expected ratio, and therefore the additive EuroSCORE is used here to understand the relative risk of the patients stratified by predefined risk groups. To date, there are no published data on which to objectively base the categorization of EuroSCORE II scores into low, intermediate, and high risk. The additive EuroSCORE I can be classified into 3 groupings: low risk (0-3), intermediate risk (4-5), and high risk (≥ 6).¹⁷ In addition, the EuroSCORE I is a more encompassing measure than other risk stratification systems, such as the STS score, which limits the surgical

FIGURE 3. Kaplan-Meier analysis comparing cumulative survival for the low-, intermediate-, and high-risk groups.

procedures for which a score can be calculated. In this study, patients did well after surgical ablation regardless of EuroSCORE I. These findings are important because the perceived complexity and predicted risk of patients may be closely associated with the surgeon's decision of whether to perform surgical ablation to treat AF.

The rate of sinus rhythm restoration in the presence and absence of antiarrhythmic drugs was also satisfactory over time for all of our patient groups. After the Cox maze

procedure, the rate of interventions to restore sinus rhythm, whether by catheter ablation or cardioversion, was extremely low and not different among groups, another indication that high-risk patients do well over time. The relatively high rate of sinus rhythm restoration supports our position that, when appropriate, surgeons should consider a more proactive approach to treating AF, even in patients who are at high risk. Support for this position is strengthened by the rate of embolic stroke and use of warfarin over time seen in our study. Outside of the blanking period, no embolic strokes occurred in the first 12 months in any of our groups, and in a mean follow-up of 38.9 ± 26.1 months, a total of 6 embolic strokes occurred (only 1 in the high-risk group). At the time of this study, all patients who experienced an embolic stroke were alive.

A secondary benefit of surgical ablation is the potential to discontinue anticoagulation therapy because of the closure of the left atrial appendage and the restoration of sinus rhythm. Among patients eligible to discontinue warfarin, 71% in the high-risk group, 77% in the intermediate-risk group, and 85% in the low-risk group had discontinued warfarin by 12 months. Of patients remaining on warfarin at 12 months, most continued the medication for clinically indicated reasons. In light of the low stroke rate and decreased use of anticoagulation, these findings are promising for their potential to eliminate the risks associated with anticoagulation without increasing the risk of stroke. These results extend earlier findings demonstrating that a

FIGURE 4. Comparison of low-, intermediate-, and high-risk groups on change in physical composite score of the SF-12 from before surgery to 12 months after surgery. Dashed line represents the norm for patients with heart disease.

surgical ablation procedure added to cardiac surgery in patients with low ejection fraction, heart failure, and other high-risk factors is safe and effective.⁵

One of the potential benefits of successful AF ablation is improved quality of life and reduced arrhythmia-related symptoms. We demonstrated a significant improvement in physical HRQL for all 3 groups that surpassed national norms. Although this improvement may be partly attributable to the concomitant procedure, the high rate of sinus rhythm restoration by 12 months in all groups suggests that this had some impact on HRQL. In fact, several recent publications report that sinus rhythm restoration in patients with AF conveys a significant improvement in quality of life, similar to what was observed in this study.¹⁸⁻²⁰ The results of the AF Symptom Checklist also corroborated our findings, showing a significant reduction in the frequency and severity of reported AF symptoms after surgical ablation.

We recognize that surgeons approach risk differently and give more weight to certain clinical variables over others when defining risk. The relatively low penetration of surgical treatment for AF, especially in high-risk patients, may be attributed to the perception that patients with AF have more advanced disease and significantly more atrial remodeling, leading to an expected success rate that is significantly lower while increasing operative risk.³ Although approximately half of the patients in each risk group presented with long-standing persistent AF, the rate of sinus rhythm restoration at 24 months was high in all groups, as was the percentage of patients in sinus rhythm without antiarrhythmic drugs. These findings support the contention that surgical ablation of AF should not be withheld on the basis of perceived risk or duration of AF. It should be noted that further research regarding rhythm outcomes across risk groups is necessary given the smaller sample sizes available during follow-up, particularly by 2 years. It is encouraging that there was no increase in operative risk by adding the Cox maze III/IV procedure in higher-risk patients and restoration of sinus rhythm remained high over the course of 2 years after surgery.

CONCLUSIONS

Our results indicate that the Cox maze III/IV procedure can be performed safely and effectively in patients with higher complexity and risk. Surgical ablation for AF, including the Cox maze III/IV procedure, should be given careful consideration for all patients undergoing cardiac surgery who present with a significant history of AF, because correction of AF may improve long-term outcomes

without increasing perioperative risk. Patients undergoing cardiac surgery should not be denied the Cox maze III/IV procedure only on the basis of characteristics that may place them at higher risk for complications after surgery.

References

- Gillinov AM, Saltman AE. Ablation of atrial fibrillation with concomitant cardiac surgery. *Semin Thorac Cardiovasc Surg*. 2007;19:25-32.
- Ad N, Barnett SD, Haan CK, O'Brien SM, Milford-Beland S, Speir AM. Does preoperative atrial fibrillation increase the risk for mortality and morbidity after coronary artery bypass grafting? *J Thorac Cardiovasc Surg*. 2009;137:901-6.
- Ad N, Suri RM, Gammie JS, Sheng S, O'Brien SM, Henry L. Surgical ablation of atrial fibrillation trends and outcomes in North America. *J Thorac Cardiovasc Surg*. 2012;144:1051-60.
- Ad N, Henry L, Hunt S, Holmes SD. Do we increase the operative risk by adding the Cox Maze III procedure to aortic valve replacement and coronary artery bypass surgery? *J Thorac Cardiovasc Surg*. 2012;143:936-44.
- Ad N, Henry LL, Holmes SD, Hunt SL. The impact of surgical ablation for atrial fibrillation in high-risk patients. *Ann Thorac Surg*. 2012;93:1897-904.
- Weimar T, Schena S, Bailey MS, Maniar HS, Schuessler RB, Cox JL, et al. The Cox-Maze procedure for lone atrial fibrillation: a single-center experience over 2 decades. *Circ Arrhythm Electrophysiol*. 2012;5:8-14.
- Lee R, Jivan A, Kruse J, McGee EC Jr, Malaisrie SC, Bernstein R, et al. Late neurologic events after surgery for atrial fibrillation: rare but relevant. *Ann Thorac Surg*. 2013;95:126-32.
- Ad N, Cox JL. The significance of atrial fibrillation ablation in patients undergoing mitral valve surgery. *Semin Thorac Cardiovasc Surg*. 2002;14:193-7.
- Calkins H, Kuck KH, Cappato R, Brugada J, Camm AJ, Chen SA, et al. 2012 HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of atrial fibrillation: recommendations for patient selection, procedural techniques, patient management and follow-up, definitions, endpoints, and research trial design: a report of the Heart Rhythm Society (HRS) Task Force on Catheter and Surgical Ablation of Atrial Fibrillation. *Heart Rhythm*. 2012;9:632-96.e21.
- Hunt S, Henry L, Ad N. Using multiple databases to produce comprehensive follow-up in an effort to enhance evaluation of outcome measurements: surgical ablation (Maze) exemplar. *J Healthc Qual*. 2011;33:50-63.
- The Society of Thoracic Surgeons National Adult Cardiac Surgery Database. Available at <http://www.sts.org/national-database>. Accessed February 12, 2013.
- Cox JL, Schuessler RB, D'Agostino HJ Jr, Stone CM, Chang BC, Cain ME, et al. The surgical treatment of atrial fibrillation. III. Development of a definitive surgical procedure. *J Thorac Cardiovasc Surg*. 1991;101:569-83.
- Cox JL, Ad N. New surgical and catheter-based modifications of the Maze procedure. *Semin Thorac Cardiovasc Surg*. 2000;12:68-73.
- Roques F, Nashef SA, Michel P, Gauducheau E, de Vincentiis C, Baudet E, et al. Risk factors and outcome in European cardiac surgery: analysis of the EuroSCORE multinational database of 19030 patients. *Eur J Cardiothorac Surg*. 1999;15:816-23.
- Ware J, Kosinski M, Turner-Bowker D, Gandek B. How to Score Version 2 of the SF-12 Health Survey. Lincoln, RI: Quality Metric, Inc; 2002.
- Jenkins L. *Test Specifications for the Buben and Kay (Revised Jenkins) Symptom Checklist: Frequency and Severity*. Baltimore, MD: University of Maryland; 1993.
- Ad N, Barnett SD, Speir AM. The performance of the EuroSCORE and the Society of Thoracic Surgeons mortality risk score: the gender factor. *Interact Cardiovasc Thorac Surg*. 2007;6:192-5.
- Ad N, Henry L, Hunt S. The concomitant cryosurgical Cox-Maze procedure using Argon based cryoprobes: 12 month results. *J Cardiovasc Surg (Torino)*. 2011;52:593-9.
- Camm J. Antiarrhythmic drugs for the maintenance of sinus rhythm: risks and benefits. *Int J Cardiol*. 2012;155:362-71.
- Saliba W, Wazni OM. Sinus rhythm restoration and treatment success: insight from recent clinical trials. *Clin Cardiol*. 2011;34:12-22.