Atrial Fibrillation Ablation in Patients Undergoing Aortic Valve Replacement

S. Chris Malaisrie[1], Richard Lee[1], Jane Kruse[1], Brittany Lapin[1], Edward C. Wang[1], Robert O. Bonow[2], Patrick M. McCarthy[1]

Divisions of [1]Cardiac Surgery and [2]Cardiology, Northwestern University, Feinberg School of Medicine, Bluhm Cardiovascular Institute at Northwestern Memorial Hospital, Chicago, Illinois, USA

Background and aim of the study: **Current guidelines suggest that the use of a mechanical prosthesis is favored when patients are already receiving long-term anticoagulation for conditions such as atrial fibrillation (AF). Surgical AF ablation can restore normal sinus rhythm (NSR) and obviate the need for anticoagulation. The study aim was to determine the impact of concomitant AF ablation in patients with AF undergoing aortic valve replacement (AVR) on the restoration of NSR and subsequent requirement for anticoagulation.**

Methods: **Between April 2004 and December 2009, a total of 124 patients (mean age 74 ± 12 years) with pre-existing AF underwent AVR with or without coronary artery bypass grafting. The documented preoperative rhythm was long-standing persistent AF in 39 patients (32%), persistent AF in five (4%), and paroxysmal AF in 80 (65%). Eighty patients (65%) had concomitant surgical AF ablation. In the ablation group, bilateral pulmonary vein isolation was performed in 55 cases (69%), left atrial-maze in 15 (19%), and Cox-maze in 10 (13%). A left atrial appendage closure was performed in 70 patients (88%). Sinus rhythm, in addition to anti-arrhythmic and warfarin use, were assessed between three and 15 months after surgery. Postoperatively, 13 patients died and 18 were lost to follow up during the three- to 15-month window; consequently, 71 patients were available for analysis in the ablation group, and 22 in the non-ablation group.**

Results: **In-hospital mortality was 4% (the Ambler score predicted a median (IQR) of 6 (4-9)%). Freedom from AF when not receiving anti-arrhythmic drugs (AADs) occurred in 58 patients (82%) in the ablation group, compared to eight (36%) in the non-ablation group (p <0.001). Fifty patients (70%) were free from warfarin in the ablation group, compared to six (27%) in the non-ablation group (p <0.001). No differences were identified in freedom from AF between the surgical AF lesion sets. AF ablation, younger age, and paroxysmal AF were independently associated with freedom from AF when not receiving AADs.**

Conclusion: **Surgical AF ablation is associated with an improved restoration of NSR in patients with AF requiring AVR. The need for anticoagulation is reduced in the majority of patients. A bioprosthetic valve may be an acceptable option for a patient with AF who requires AVR.**

The Journal of Heart Valve Disease 2012;21:350-357

Atrial fibrillation (AF) predisposes to thromboembolism (1), and is therefore usually treated with chronic oral anticoagulation (2). The fact that both surgical and catheter-based ablation of AF have proved successful in restoring normal sinus rhythm (NSR) (3) led to a recommendation by the Heart Rhythm Society and the Society of Thoracic Surgeons (STS) that patients undergoing cardiac surgery should receive concomitant surgical AF ablation for pre-existing AF, when it does not add to the complexity of the procedure (3). With the successful elimination of AF, the future risk of thromboembolism can be reduced and anticoagulation discontinued.

The study aim was to determine the impact of concomitant surgical AF ablation in patients undergoing aortic valve replacement (AVR) with pre-existing AF on the restoration of NSR and subsequent freedom from anticoagulation. It has been hypothesized that patients who require AVR with pre-existing AF may not require oral anticoagulation if concomitant AF ablation is performed at the time of AVR. Hence, successful surgical AF ablation may affect the decision of valve choice in patients undergoing AVR.

Address for correspondence:
S. Chris Malaisrie MD, 201 E Huron St., Galter Pavilion 11-140, Chicago, IL 60611, USA
e-mail: malaisrie@northwestern.edu

Clinical material and methods

Study design

The Bluhm Cardiovascular Institute's Clinical Trials Units Cardiac Surgery Outcomes Registry at Northwestern Memorial Hospital was examined to identify all patients who had undergone AVR since the inception of the database in April 2004, through to December 2009. This registry is approved by the Institutional Review Board (IRB) at Northwestern University (IRB project # STU000012288). The data were collected from patients enrolled in the Registry, and also from medical record reviews. Only those patients who agreed to participate in the research investigation were included in this study.

Data collection from the database and medical records included patient demographics, comorbidities, and operative characteristics. Comorbidities were defined and classified according to the STS National Database (www.sts.org), and included NYHA functional class, ejection fraction, peripheral vascular disease, cerebrovascular disease, coronary artery disease, hypertension, renal failure requiring dialysis, current smoker, chronic obstructive pulmonary disease (COPD), and reoperative status. Some of these comorbidities, along with preoperative characteristics of age, gender, and body mass index, were entered into the Ambler risk model to generate an estimated in-hospital mortality for each patient (4). The logistic EuroSCORE was calculated to determine the predicted 30-day mortality (5). Currently, the STS-predicted risk of operative mortality does not apply to patients who undergo AF ablation, and therefore was not used. Postoperative stroke, sinus rhythm, and medication use was accessed from the patient chart review during the perioperative period.

Table I: Preoperative characteristics of patients undergoing AVR with coexisting AF.

Characteristic	Ablation group (n = 80)	Non-ablation group (n = 44)	Total (n = 124)	p-value
Age (years)*	73 ± 11	75 ± 14	74 ± 12	0.302
Gender (male)	61 (76)	29 (66)	90 (73)	0.217
Body mass index (kg/m^2)*	28 ± 6	29 ± 7	28 ± 7	0.528
Current smoker	2 (3)	1 (2)	3 (2)	0.999
NYHA class III/IV	30 (38)	35 (80)	65 (52)	<0.001
Ejection fraction (%)*	57 ± 10	52 ± 15	55 ± 13	0.032
Hypertension	58 (73)	28 (64)	86 (69)	0.306
COPD	9 (11)	16 (36)	25 (20)	<0.001
Stroke	8 (10)	7 (16)	15 (12)	0.334
Cerebrovascular disease	12 (15)	11 (25)	23 (19)	0.171
Peripheral vascular disease	11 (14)	4 (9)	15 (12)	0.447
Coronary artery disease	50 (63)	26 (59)	76 (61)	0.709
Hyperlipidemia	57 (71)	23 (52)	80 (65)	0.035
Renal dialysis	1 (1)	1 (2)	2 (2)	0.999
Warfarin use	46 (58)	21 (48)	67 (54)	0.244
Prior PCI	13 (16)	7 (16)	20 (16)	0.961
Repeat sternotomy	4 (5)	23 (52)	27 (22)	<0.001
Prior CABG	2 (3)	19 (43)	21 (17)	<0.001
Prior valve	1 (1)	8 (18)	9 (7)	0.001
Operative indication				0.525
Aortic valve tumor	0 (0)	1 (2)	1 (1)	
Aortic stenosis	69 (86)	38 (86)	107 (86)	
Aortic insufficiency	11 (14)	5 (11)	16 (13)	
Left atrial size (cm^2)*	4 ± 1	4 ± 1	4 ± 1	0.177
Atrial fibrillation type				0.891
Paroxysmal	51 (64)	29 (66)	80 (65)	
Persistent	4 (5)	1 (2)	5 (4)	
Long-standing persistent	25 (31)	14 (32)	39 (32)	

*Values are mean ± SD.
Values in parentheses are percentages.
CABG: Coronary artery bypass graft; COPD : Chronic obstructive pulmonary disease; PCI: Percutaneous coronary intervention.

Table II: Lesion set performed and management of the left atrial appendage in patients undergoing AF ablation surgery.

Procedure	Paroxysmal AF (n = 51)	Persistent AF (n = 4)	Long-standing persistent AF (n = 80)	Total (n = 25)	p-value
Lesion set performed					
PVI	38 (75)	3 (75)	14 (56)	55 (69)	0.259
LA-maze	9 (18)	0 (0)	6 (24)	15 (19)	
Cox-maze	4 (8)	1 (25)	5 (20)	10 (13)	
Appendix management					
Closure of LA appendage	46 (90)	4 (100)	20 (80)	70 (88)	0.399

Values in parentheses are percentages.
LA: left atrial; PVI: Pulmonary vein isolation.

Patient population

A total of 617 patients (average age 74 ± 12 years; range: 26 to 95 years) was identified who underwent AVR (with or without coronary artery bypass grafting; CABG) during the study period. Patients who underwent any other type of aortic valve surgery, mitral/tricuspid valve surgery, or ventricular assist device implant were excluded. Of these 617 patients, 124 (20%) had pre-existing AF and agreed to participate in the research. Among these 124 patients, 80 (65%) underwent an AVR with surgical AF ablation, while 44 patients had preoperative AF but were not treated with AF ablation. Compared to patients in the non-ablation group, those in the ablation group had more previous sternotomies (52% versus 5%, p <0.001), NYHA functional class III/IV (80% versus 38%, p <0.001), COPD (36% versus 11%, p <0.001), a minimally invasive approach via partial upper sternotomy (25% versus 0%, p <0.001), and less hyperlipidemia (52% versus 71%, p = 0.035). Aortic stenosis was the indication for operation in 86% of patients. The documented preoperative rhythm did not differ between groups, and was long-standing persistent AF in 39 patients (32%), persistent AF in five (4%), and paroxysmal AF in 80 (65%) (Tables I and II). A bias towards bioprosthetic valves was apparent, due to an improved durability with recent-generation valves, and the potential for later transcatheter valve-in-valve procedure for failed bioprostheses (6). In total, 98% of the patients received a bioprosthetic valve.

Surgical decision-making

Atrial fibrillation ablation is the preferred treatment, but was not employed in patients undergoing most reoperations because adhesions limited the access to the pulmonary veins and the left atrial appendage. In reoperations, the performance of AF ablation may significantly increase the cardiopulmonary bypass (CPB) time and add to the complexity of the case, with a resultant increase in morbidity. In addition, the preference for a minimally invasive approach to AVR, particularly in patients with chronic lung disease, precluded a facile access for AF ablation through a partial upper sternotomy. In the non-ablation group, 32 patients (73%) had either a repeat median sternotomy or a mini-sternotomy; among the remaining 12 patients (27%), 10 had paroxysmal AF. Pulmonary vein isolation (PVI) was chosen because the left atrium is not opened routinely during AVR. However, more left atrial-maze procedures and Cox-maze procedures (bi-atrial maze and cut-and-sew maze) were performed for AF in symptomatic, younger patients (7). Bilateral PVI was performed in 55 patients (69%), a left atrial-maze procedure in 15 (19%), and a Cox-maze procedure in 10 (13%) (Table II). All of these ablations were analyzed together as AF ablation, as the individual groups were small. In elderly patients the left atrial appendage was closed unless thin, friable tissue was encountered; hence, left atrial appendage closure was performed in 70 patients (88%).

Postoperative AF ablation protocol

Patients in the AF treatment group were followed prospectively by a dedicated AF clinical/research nurse from January 2006 onwards. A postoperative protocol to manage monitoring, anticoagulation, and AADs was developed in collaboration with Northwestern electrophysiologists; these guidelines were shared with the patients and the referring cardiologists. Patients were discharged on anticoagulation and AADs, unless these were contraindicated. The protocol also recommended cardioversion for patients with persistent AF or atrial flutter after six weeks. Continuous electrocardiographic (ECG) monitoring was recommended at three and six months, to guide any changes in medication.

The preferred method of monitoring was via the Mobile Cardiac Outpatient Telemetry (MCOT: CardioNet; CardioNet, Conshohocken, PA, USA; or ACT Ambulatory Cardiac Telemetry; LifeWatch Corp., Rosemont, IL, USA) at three and six months. If these monitors were not available, attempts were made to provide the patient with an AF Express (LifeWatch Corp., Rosemont, IL, USA) monitor for 30 days or, at

the cardiologist's discretion, a Holter monitor. Patients with dual-chamber implanted defibrillators or permanent pacemakers had their parameters set to track atrial arrhythmias. Monitor results were also obtained from cardiac rehabilitation sessions, providing up to 36 h of monitoring data over a 12-week period. If the continuous ECG monitoring showed that sinus rhythm was maintained without AADs, then warfarin was discontinued at the discretion of the cardiologist. Patients in the AF ablation group were also contacted by telephone within the first month, and again at three, six and 12 months, to track their progress and to provide support for treatment options and referrals as needed. Additionally, those patients participating in the Cardiac Surgery Outcomes database from either treatment group were sent surveys at three, six, and 12 months, and annually thereafter. Any self-reported events from these surveys were verified by the patients' medical records.

Follow up

After a blanking period of 90 days, the sinus rhythm, AAD use and oral anticoagulation (warfarin) use were each assessed through a 15-month period. Failure to maintain sinus rhythm was determined by any episode of AF lasting more than 30 s and occurring after a 90-day blanking period and prior to the 15-month cut-off. Freedom from AAD and warfarin use was also accessed within this time window. The primary end-point of sinus restoration was defined as freedom from AF when off AAD at the initial follow up. The secondary end-point was freedom from warfarin use by 15 months following surgery, and freedom from AF at the last follow up examination.

The rhythm follow up was 86% complete (106/124). The average time to initial rhythm determination was 9 ± 3 months in the ablation group, and 9 ± 4 months in the non-ablation group. In the ablation group, five patients did not have follow up and four died prior to 15 months; hence, 71 patients remained available for analysis. Two of the patients without follow up had surgery prior to the inclusion of a dedicated AF clinical/research nurse. In the non-ablation group, 13 patients did not have follow up during the time period, and nine died within the window; hence, 22 patients remained available for analysis. Six of the 13 patients lost to follow up had surgery prior to the inclusion of a dedicated AF clinical/research nurse. Despite more patients being lost to follow up in the non-ablation group, there were no differences in patient characteristics in those without follow up between the two groups. Of the 93 patients with valid follow up outcomes, 68 (73%) were evaluated by continuous ECG monitoring; these included 60 patients (85%) in the ablation group and eight (36%) in the non-ablation group. Patients with persistent AF, as determined by multiple ECGs, were excluded from more extensive monitoring. Four of these patients were included in the ablated group, and nine in the non-ablated group. Excluding these patients from the denominator yielded 84% evaluated by continuous ECG monitoring - that is, 90% in the ablated group and 57% in the non-ablated group. In total, there were 97 patients with final follow up rhythm information. The average time to the last follow up examination was 17

Table III: Operative outcomes of patients undergoing AVR (±CABG) with coexisting atrial fibrillation (AF).

Operative outcome	Ablation group (n = 80)	Non-ablation group (n = 44)	Total (n = 124)	p-value
Concomitant CABG	39 (49)	12 (27)	51 (41)	0.020
Minimally invasive AVR	0 (0)	11 (25)	11 (9)	<0.001
Bioprosthetic valve	80 (100)	41 (93)	121 (98)	0.043
CPB time (min)*	110 (84-133)	98 (77-119)	106 (81-132)	0.572
Cross-clamp time (min)*	82 (64-114)	76 (60-95)	80 (62-106)	0.388
ICU stay (h)*	30 (24-55)	49 (26-125)	44 (24-72)	0.012
Stroke/TIA pre-discharge	0 (0)	1 (2)	1 (1)	0.355
Pacemaker implant pre-discharge	1 (1)	0 (0)	1 (1)	0.999
In-hospital mortality	2 (3)	3 (7)	5 (4)	0.346
Freedom from AF at discharge#	57 (73)	15 (38)	72 (61)	<0.001
Discharged on warfarin#	60 (77)	33 (81)	93 (78)	0.816
Hospital stay (days)*	6 (5-9)	9 (6-13)	7 (5-10)	0.005
Discharged home#	49 (63)	22 (54)	71 (60)	0.333
Ambler score (%)*	6 (3-7)	9 (6-16)	6 (4-9)	<0.001

*Values are median (IQR).
Values expressed as a percentage of patients alive at discharge (n = 119).
AVR: Aortic valve replacement; CPB: Cardiopulmonary bypass; ICU: Intensive care unit; TIA: transient ischemic attack.

Table IV: Freedom from atrial fibrillation (AF), freedom from atrial fibrillation off anti-arrhythmic drugs (AADs) and freedom from warfarin, by group.

Postoperative outcome	Ablation group (n = 71)	Non-ablation group (n = 22)	Total (n = 93)	p-value
Freedom from AF	60 (85)	11 (50)	71 (76)	<0.001
Freedom from AF off AAD	58 (82)	8 (36)	66 (71)	<0.001
Freedom from warfarin	50 (70)	6 (27)	56 (60)	<0.001

± 12 months in the ablated group, and 18 ± 13 months in the non-ablated group.

Statistical analysis

Demographic variables, symptoms, comorbidities, operative characteristics, and morbidity and mortality in patients undergoing AVR were compared between patients who had concomitant surgical AF ablation versus non-ablation patients. Chi-square tests and Fisher exact tests were used for categorical variables, and *t*-tests for continuous variables. Variables with distributions that deviated from normality were reported by median and interquartile range (IQR), rather than by conventional mean ± SD. Logistic regression was used to identify univariate predictors of freedom from AF. Success included the restoration of NSR, as well as AAD discontinuation. Multivariable analysis was performed to identify independent risk factors for freedom from AF following AVR, using multiple logistic regression. Propensity scores were calculated based on the probability of undergoing a surgical AF ablation procedure, and were adjusted in the final statistical analysis. The covariates balance after propensity adjustment was tested statistically by linear regression for the continuous variables, and by logistic regression for the dichotomous variables. Throughout the report, statistical significance was established at an alpha level of 0.05 All statistical analyses were performed using SAS 9.2 statistical software (SAS Inc., Cary, NC, USA).

Results

No intraoperative or perioperative complications occurred as a result of adding AF ablation to AVR. There was a lower median Ambler score predictive of

Table V: Freedom from atrial fibrillation (AF), warfarin, and anti-arrhythmic drugs (AADs) by lesion set and AF type performed in patients undergoing AVR and AF ablation surgery.

Postoperative outcome	Lesion set			p-value†
	Cox-Maze (n = 9)	LA-maze (n = 14)	PVI (n = 48)	
Freedom from AF	9 (100)*	12 (86)	39 (81)*	0.471
Freedom from AF off AAD	8 (89)*	12 (86)*	38 (79)*	0.811
Freedom from warfarin	7 (78)	10 (71)	33 (69)*	0.926

Postoperative outcome	AF type			p-value†
	Paroxysmal (n = 46)	Persistent (n = 2)	Long-standing persistent (n = 23)	
Freedom from AF	42 (91)*	1 (50)	17 (74)	0.050
Freedom from AF off AAD	41 (89)*	1 (50)	16 (70)	0.074
Freedom from warfarin	36 (78)*	0 (0)	14 (61)	0.029

†Fisher's exact test.
*AF ablation subgroup significantly different from non-ablation group, p <0.05.
Values in parentheses are percentages.
LA: Left atrial; PVI: Pulmonary vein isolation.

Table VI: Unadjusted and propensity-adjusted p-values during follow up of patient characteristics between patients with (n = 71) and without (n = 22) AF ablation surgery.

Patient characteristic	Unadjusted p-value	Propensity-adjusted p-value
Age	0.376	0.879
Gender	0.464	0.877
Body mass index	0.910	0.758
Current smoker	0.714	0.819
NYHA class III/IV	0.002	0.942
Ejection fraction	0.070	0.961
Hypertension	0.194	0.876
COPD	0.002	0.938
Stroke	0.122	0.971
Cerebrovascular disease	0.088	0.963
Peripheral vascular disease	0.380	0.906
Coronary artery disease	0.672	0.905
Hyperlipidemia	0.181	0.617
Renal dialysis	0.368	0.285
Warfarin use	0.509	0.921
Prior PCI	0.750	0.808
Repeat sternotomy	<0.001	0.967
Operative indication	0.596	0.765
Left atrial size	0.513	0.969
Atrial fibrillation type	0.752	0.927
Logistic EuroSCORE	<0.001	0.833

COPD: Chronic obstructive pulmonary disease; PCI: Percutaneous coronary intervention.

in-hospital mortality in the AF ablation group as compared to the non-ablation group (6% versus 9%, p <0.001) (Table III). There was no significant difference in the observed in-hospital mortality, with two (3%) in the ablation group versus three (7%) in the non-ablation group. The median CPB and aortic cross-clamp times were longer in the AF ablation group by 12 and 6 min, respectively, but this difference did not reach statistical significance. Patients in the non-ablation group spent a significantly longer amount of time in the intensive care unit (ICU) (p = 0.012). AF ablation was associated with a shorter median length of stay in hospital (6 days versus 9 days in the non-ablation group; p = 0.005).

Fifty-seven patients (73%) in the AF ablation group were free from AF at the time of discharge compared to 15 (38%) in the non-ablation group (p <0.001). Prior to discharge, one stroke occurred in the non-ablation group, and one patient in the ablation group underwent placement of a permanent pacemaker. The level of discharge to home was similar between the two groups (60%).

During the follow up period (90 days to 15 months post surgery), 60 patients (85%) in the AF ablation group were free from AF when off AAD, compared to 11 (50%) in the non-ablation group (p <0.001) (Table IV). Fifty patients (70%) in the AF ablation group were free from warfarin compared to six (27%) in the non-ablation group (p <0.001). In the AF ablation group, freedom from AF whether the patient was on or off AAD occurred in 58 patients (82%), and did not differ between lesion sets (p = 0.471) (Table V). Time to freedom from warfarin in the ablation group was 237 days (median IQR 180-366 days). Two strokes occurred: one in the ablation group, and one in the non-ablation group.

Table VII: Propensity-adjusted multiple logistic regression model for freedom from atrial fibrillation (AF) after AVR in patients with follow up.

Predictor	Odds ratio	95% CI	p-value
AF ablation	0.09	0.02-0.50	0.006
Age	1.05	0.99-1.11	0.089
NYHA class III/IV	2.91	0.73-11.70	0.132
First CV surgery	0.76	0.13-4.31	0.753
AF type*	3.85	1.13-12.98	0.031

*Permanent versus paroxysmal.
CV: Cardiovascular.

Propensity scores were calculated based on the probability of undergoing a surgical AF ablation procedure for the 93 patients with valid follow up data. The covariates balance before and after propensity adjustment is shown in Table VI. All p-values after propensity score adjustment were not statistically significant, indicating a good balance after adjustment (Table VI).

In the univariate analysis, preoperative characteristics significantly associated with freedom from AF after AVR included AF ablation (p <0.001), age (p = 0.004), NYHA class (p = 0.008), repeat sternotomy (p = 0.003), and a trend towards AF type (p = 0.068). These variables were further entered into the propensity-adjusted multiple logistic regression model. AF ablation (p = 0.006), and paroxysmal AF (p = 0.031) were independent predictors of freedom from AF off AAD in the propensity-adjusted model (Table VII).

Freedom from AF at the last follow up examination yielded similar results when compared to that at the initial follow up. Final follow up information was available for 72 patients in the AF ablation group, and for 25 patients in the non-ablation group. Sixty patients (83%) in the AF ablation group were free from AF at the final follow up, compared to 10 (40%) in the non-ablation group (p <0.001). Freedom from AF at the final follow up did not differ between the lesion sets (p = 0.440). Variables were entered into a propensity-adjusted multiple logistic regression model to identify independent predictors for freedom from AF; thus, AF ablation (OR = 0.12, p = 0.012), younger age (OR = 1.06, p = 0.052), and paroxysmal AF (OR = 4.07, p = 0.022) were found to be predictors of freedom from AF in the propensity-adjusted model (data not shown).

Discussion

The addition of AF ablation in patients undergoing AVR led to a slight increase in the operative time, but was not associated with any added morbidity or mortality. The ablation of AF was associated with acceptable lengths of both ICU and hospital stays. Freedom from AF off AAD at discharge and at nine months in AF ablation patients was improved compared to non-ablation patients (82% in the ablation group and 35% in the non-ablation group at nine months). The average life expectancy for a 73-year-old patient is approximately 12 years (8), and freedom from structural valve deterioration for a bovine pericardial valve at 12 years in this age group is 93% (9). In addition, it was possible to avoid AF in 85% of cases and warfarin in 70%, which is associated with increased morbidity and mortality in elderly patients.

Current guidelines suggest that the use of a mechanical valve is favored in patients undergoing AVR if long-term oral anticoagulation with warfarin is already indicated. A class IIa guideline in the 2006 American Heart Association (AHA)/American College of Cardiology (ACC) guidelines states that "A bioprosthesis is reasonable for AVR in patients aged 65 years or older without risk factors for thromboembolism." (10). This guideline, therefore, implies that a mechanical valve is reasonable in patients with risk factors for thromboembolism. The 2007 European Society of Cardiology (ESC) guidelines state that "Patients already on anticoagulation because of high risk for thrombo-embolism..." have a class IIa guideline favoring a mechanical prosthesis (11).

These guidelines assume, however, that patients with pre-existing AF are not treated with AF ablation at the time of AVR. On the contrary, concomitant surgical AF ablation is currently being performed in more patients, with newer energy sources having made the AF ablation lesion set easier to perform, less time-consuming, and to be as effective as the standard Cox-Maze III (cut-and-sew) procedure (12). The STS database shows that concomitant AF ablation surgery is currently being performed in approximately 28% of AVR patients with AF (13). In the present study, concomitant surgical AF ablation was performed in 65% of patients undergoing AVR, which is likely reflective of surgical practice at other experienced, tertiary-care institutions.

Moreover, two studies have established the increased risk of pre-existing AF in patients requiring AVR. One study from the Oxford group (14) retrospectively analyzed 170 isolated AVR, 55 AVR/CABG, and 32 double-valve replacement (DVR) patients, using all mechanical valves. The overall mortality at 10 years was worse for patients with preoperative AF, as compared to those with preoperative NSR in all three groups: AVR (64% versus 19%, p <0.001), AVR/CABG (83% versus 21%, p <0.001), and DVR (80% versus 18%, p <0.001). In an earlier study conducted by the Mayo Clinic group (15), a retrospective analysis was performed of 321 patients having aortic valve surgery, but no significant difference was found in terms of long-term survival between patients with preoperative AF as compared to preoperative NSR. However, the preoperative AF group did have significantly more late morbidity, including congestive heart failure (25% versus 10%, p = 0.005) and stroke (16% versus 5%, p = 0.005).

Although several studies have established the efficacy of AF ablation in mitral valve surgery (16), few have examined AF ablation in AVR. The Osaka group (17) reported a case series of 16 AVR/maze and 77 DVR/maze patients, and found corresponding freedoms from AF at five years of 71% and 64%, respectively. The Hamburg group (18) described a case series of 30 AVR ± CABG patients with 'permanent' AF undergoing PVI with connecting box lesion sets only, and found a 74% freedom from AF at three months. Khargi et al. (19) examined 21 AVR patients also with 'permanent' AF undergoing a Cox-maze lesion set, and found freedom from AF at 12 months to be similar to that in mitral valve surgery patients undergoing AF ablation (79% versus 71%, p = 0.06).

The results of the present study extend the current literature by showing a significant improvement in freedom from AF off of AADs in AVR/AF ablation patients when compared to AVR/non-ablation patients. In this select group of ablation patients, 82% were free from AF off AADs, and even in the more sick non-ablation group 36% were free from AF off AADs. The difference remained significant in the propensity-adjusted multivariable model (AF ablation: OR = 0.09, p = 0.006). Pulmonary vein isolation was also found to be as effective as the left atrial-maze and Cox-maze procedures, and may be a valid choice for restoring NSR in AVR patients.

Study limitations

Among the limitations of the present study must be included its retrospective nature, and the fact that patient selection for AF ablation surgery was dependent on patient factors and surgeon judgment. Notably, 42 patients (95%) in the non-ablation group had either a repeat median sternotomy, minimally invasive AVR, or paroxysmal AF, and these were the most common reasons that these patients did not have AF ablation. Thin, friable tissue in elderly patients prevented a safe external closure of the left atrial appendage in some ablation patients. A second limitation was that the lesion sets were not standard, either by patient or surgical technique, although the energy source was limited to either bipolar radiofrequency ablation or cryothermy. A third point was that the assessment of

rhythm was not uniformly determined by continuous ECG monitoring; rather, in many patients it was determined by regular ECG. Finally, although the end-point of freedom from anticoagulation is reliably determined, the appropriateness of warfarin discontinuation could not be determined, as the majority of patients were managed by their local physicians.

In conclusion, surgical AF ablation is associated with an improved restoration of NSR in patients with pre-existing AF requiring AVR. Pulmonary vein isolation may be as effective as more extensive lesion sets, in particular for paroxysmal AF. Atrial fibrillation ablation reduced the need for oral anticoagulation in the majority of patients after AVR. Thus, in a patient with pre-existing AF who requires AVR, a bioprosthetic valve may be an acceptable choice when surgical AF ablation is performed.

Acknowledgements

The authors thank the Northwestern Bluhm Cardiovascular Institute Clinical Trials Unit for their support and use of the cardiovascular outcomes database.

References

1. Wolf PA, Mitchell JB, Baker CS, Kannel WB, D'Agostino RB. Impact of atrial fibrillation on mortality, stroke, and medical costs. Arch Intern Med 1998;158:229-234
2. Risk factors for stroke and efficacy of antithrombotic therapy in atrial fibrillation. Analysis of pooled data from five randomized controlled trials. Arch Intern Med 1994;154:1449-1457
3. Calkins H, Brugada J, Packer DL, et al. HRS/EHRA/ECAS expert Consensus Statement on catheter and surgical ablation of atrial fibrillation: Recommendations for personnel, policy, procedures and follow-up. A report of the Heart Rhythm Society (HRS) Task Force on catheter and surgical ablation of atrial fibrillation. Heart Rhythm 2007;4:816-861
4. Ambler G, Omar RZ, Royston P, Kinsman R, Keogh BE, Taylor KM. Generic, simple risk stratification model for heart valve surgery. Circulation 2005;112:224-231
5. Roques F, Michel P, Goldstone AR, Nashef SA. The logistic EuroSCORE. Eur Heart J 2003;24:881-882
6. Webb JG, Wood DA, Ye J, et al. Transcatheter valve-in-valve implantation for failed bioprosthetic heart valves. Circulation 2010;121:1848-1857
7. McCarthy PM, Kruse J, Shalli S, et al. Where does atrial fibrillation surgery fail? Implications for increasing effectiveness of ablation. J Thorac Cardiovasc Surg 2010;139:860-867
8. Xu JQ, Kochanek KD, Murphy SL, Tejada-Vera B. Deaths: Final data for 2007. National Vital Statistics Reports 2010;58:1-136
9. Banbury MK, Cosgrove DM, III, Lytle BW, Smedira NG, Sabik JF, Saunders CR. Long-term results of the Carpentier-Edwards pericardial aortic valve: A 12-year follow-up. Ann Thorac Surg 1998;66: S73-S76
10. Bonow RO, Carabello BA, Kanu C, et al. ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (writing committee to revise the 1998 Guidelines for the Management of Patients With Valvular Heart Disease): Developed in collaboration with the Society of Cardiovascular Anesthesiologists: Endorsed by the Society for Cardiovascular Angiography and Interventions and the Society of Thoracic Surgeons. Circulation 2006;114:e84-e231
11. Vahanian A, Baumgartner H, Bax J, et al. Guidelines on the management of valvular heart disease: The Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology. Eur Heart J 2007;28:230-268
12. Khargi K, Hutten BA, Lemke B, Deneke T. Surgical treatment of atrial fibrillation; a systematic review. Eur J Cardiothorac Surg 2005;27:258-265
13. Gammie JS, Haddad M, Milford-Beland S, et al. Atrial fibrillation correction surgery: Lessons from the Society of Thoracic Surgeons National Cardiac Database. Ann Thorac Surg 2008;85:909-914
14. Schulenberg R, Antonitsis P, Stroebel A, Westaby S. Chronic atrial fibrillation is associated with reduced survival after aortic and double valve replacement. Ann Thorac Surg 2010;89:738-744
15. Ngaage DL, Schaff HV, Barnes SA, et al. Prognostic implications of preoperative atrial fibrillation in patients undergoing aortic valve replacement: Is there an argument for concomitant arrhythmia surgery? Ann Thorac Surg 2006;82:1392-1399
16. Gillinov AM, Saltman AE. Ablation of atrial fibrillation with concomitant cardiac surgery. Semin Thorac Cardiovasc Surg 2007;19:25-32
17. Bando K, Kobayashi J, Sasako Y, Tagusari O, Niwaya K, Kitamura S. Effect of maze procedure in patients with atrial fibrillation undergoing valve replacement. J Heart Valve Dis 2002;11:719-724; discussion 725
18. Geidel S, Lass M, Ostermeyer J. A 5-year clinical experience with bipolar radiofrequency ablation for permanent atrial fibrillation concomitant to coronary artery bypass grafting and aortic valve surgery. Interact Cardiovasc Thorac Surg 2008;7:777-780
19. Khargi K, Lemke B, Deneke T. Concomitant antiarrhythmic procedures to treat permanent atrial fibrillation in CABG and AVR patients are as effective as in mitral valve patients. Eur J Cardiothorac Surg 2005;27:841-846