Rhythm outcome predictors after concomitant surgical ablation for atrial fibrillation: A 9-year, single-center experience

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Objectives: Concomitant surgical ablation is a safe and feasible procedure, recommended by the guidelines for patients with atrial fibrillation (AF) undergoing cardiac surgery. We performed a single-center data analysis to identify the predictors of rhythm outcome in such patients.

Methods: From January 2003 to January 2012, 503 patients with persistent (n = 296, 58.8%) or paroxysmal (n = 207, 41.2%) AF underwent concomitant surgical AF ablation. The lesions were limited to a pulmonary vein isolation (n = 76, 15.1%), a more complex left atrial lesion set (n = 353, 70.2%), or biatrial lesions (n = 74, 14.7%). Follow-up rhythm evaluations were based on either 24-hour Holter electrocardiograms or event recorder interrogation at 3, 6, and 12 months postoperatively. A sinus rhythm (SR) immediately postoperatively was defined as the first documented rhythm after weaning from extracorporeal circulation.

Results: The mean patient age was 68.0 ± 9.5 years, and 336 (66.8%) were men. No major ablation-related complications occurred. After 1 year of follow-up, 59.9% of all patients were in SR, with significantly better results in patients with paroxysmal AF than in those with persistent AF (67.3% vs 54.8%, $P = .0053$). Additional statistically significant factors influencing SR after 1 year were left atrial diameter ($P = .0019$), AF duration ($P = .018$), and immediate postoperative SR ($P < .001$). Regarding only patients with persistent or longstanding-persistent AF, those with biatrial lesions had significantly greater rates of conversion to SR than those with solitary left atrial ablation (SR, 64.9% vs 51.4%; $P = .044$) after 12 months.

Conclusions: The statistically significant predictors for SR after 1 year were left atrial diameter, AF duration, preoperative paroxysmal AF, immediate postoperative SR, and biatrial ablation for persistent AF. (J Thorac Cardiovasc Surg 2014;148:428-33)

Atrial fibrillation (AF) is the most common sustained arrhythmia in patients undergoing cardiac surgery, and its prevalence has been increasing with the aging of populations. AF can lead to heart failure, thromboembolic events, including stroke, and increased hospitalization, with a reduction in quality of life.[1,2] Therefore, the guidelines have recommended concomitant surgical ablation for patients with AF who are undergoing cardiac surgery.[3] Cox first reported his technique of surgical AF ablation using a cut-and-sew principle in 1987, later revised by him to a lesion pattern termed the "Cox maze III procedure." Because of its high success rate in the restoration of sinus rhythm (SR), it became the reference standard for AF surgery. However, owing to complexity of the procedure, only a few surgeons were performing it. To facilitate and simplify the procedure, the cut and sew principle was replaced by transmural atrial lesions generated by various thermal energy sources, such as radiofrequency, ultrasonography, or cryotherapy, resulting in the so-called Cox maze IV procedure. Various modified lesion sets, including isolated pulmonary vein ablation, left atrial ablation, and biatrial ablation, have been reported over the years. A meta-analysis by Barnett and Ad[4] showed that in randomized controlled trials and nonrandomized trials, statistically greater rates of conversion to SR occurred in patients who had undergone cardiac surgery with concomitant ablation compared with those who had undergone cardiac surgery alone. Prospective, randomized trials have resulted in rates of conversion to SR of 44% to 94% for patients undergoing concomitant AF ablation.[5-9] However, only a few studies with relatively small numbers of patients have investigated the influence of different lesion sets and energy sources on the outcomes of surgical AF ablation. Therefore, the aim of our study was to analyze the predictors of the 12-month outcome in patients with AF who had undergone concomitant surgical ablation and to determine the effect of different patient factors, energy sources, and lesion sets on the rates of conversion to SR in a large patient cohort with implementation of the current follow-up guidelines.

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Abbreviations and Acronyms

AF = atrial fibrillation
CABG = coronary artery bypass grafting
ECG = electrocardiogram
ER = event recorder
LA = left atrial
LVEF = left ventricular ejection fraction
PVI = pulmonary vein ablation
SR = sinus rhythm

METHODS

Patients

From January 2003 to October 2011, 503 patients underwent concomitant surgical ablation because of persistent (n = 296, 58.8%) or paroxysmal (n = 207, 41.2%) AF. The baseline patient characteristics are listed in Table 1. The mean patient age was 68.0 ± 9.5 years, and 66.8% were men. Of the 503 patients, 296 (58.8%) had preoperative persistent AF and 207 (41.2%) had paroxysmal AF. The mean left atrial (LA) diameter was enlarged to 51.0 mm, and the mean left ventricular ejection fraction (LVEF) showed a normal value of 53.5%. A moderate or more severely reduced LVEF of <40% was present in 61 patients (12.1%). The mean AF duration was 3.4 years, and 51 patients (10.2%) had a experienced a thromboembolic or ischemic stroke before surgery. The surgical procedures are listed in Table 2.

Ablation Methods

The ablation types are listed in Table 3. Isolated pulmonary vein ablation (PVI) was conducted in 76 patients (15.1%). This limited lesion set was used in patients with paroxysmal AF and without planned opening of the atria for the surgical procedure (eg, in patients undergoing coronary artery bypass grafting [CABG] and aortic valve replacement). Extended LA ablation was performed in 353 patients (70.2%) using the LA ablation lesion set of the Cox maze IV procedure, with pulmonary vein ablation, box lesion, LA appendage, and isthmus isolation. Since 2008, biatrial ablation was conducted in 74 patients (14.7%). This extended ablation regimen was only conducted in patients with persistent or longstanding-persistent AF. The decision of which patients underwent a biatrial or LA lesion set was determined by the surgeon performing the procedure. The right atrial lesion set consisted of intercaval line, isolation of the cavotricuspid isthmus, right atrial appendage, and terminal crest.

The energy sources were argon-based cryoablation in 114 patients (22.7%; CryoCath Surgical Ablation Probe, Medtronic, Inc, Minneapolis, Minn; and CryoICE Cryoablation probe, Atricure, Inc, West Chester, Ohio), unipolar radiofrequency ablation in 261 (51.8%; Cardioblate Unipolar RF Pen, Medtronic), and bipolar radiofrequency ablation in 128 (25.5%; Cardioblate BP2 device and Cardioblate Surgical Ablation System Generator, Medtronic; and Atricure Isolater Synergy Ablation Clamp, Atricure). From 2003 to 2009, epimyocardial cryoablation was used in patients receiving surgical AF ablation without opening the left atrium; all other patients received endomyocardial ablation using unipolar radiofrequency. Since 2009, after introduction of the bipolar radiofrequency clamp in our institution, it has become the preferred tool for all strategies of ablation. Since then, endomyocardial unipolar radiofrequency or cryoablation has only been used in patients requiring mitral valve treatment with either an open sternum transseptal or a minimally invasive thoracic-lateral approach.

Statistical Analysis

A retrospective, single-center data analysis was accomplished. All statistical analyses were performed using the Statistical Package for Social Sciences statistical software, version 18.0 (SPSS, Inc, Chicago, Ill). Continuous values are presented as mean ± standard deviation and were compared using the Student *t* test. Categorical variables are presented as the frequencies and percentages and were compared using the chi-square test or Fisher's exact test, as appropriate. $P < .05$ was considered statistically significant. The reported P values are 2-sided. Uni- and multivariate logistic regression analyses were used to identify independent predictors for SR after 12 months. The parameters considered for univariate analysis were age, gender, LA diameter, AF type and duration, LVEF, type of concomitant procedure, lesion set, energy source, and early AF recurrence. For multivariate logistic regression analysis, we included the significant covariates from the univariate analysis and the covariates that in our experience had been considered clinically relevant. These were age, gender, AF type and duration, surgical procedure, LVEF, and LA diameter.

Follow-up Protocol

Rhythm follow-up was accomplished after 3, 6, and 12 months in all patients using either 24-hour Holter electrocardiograms (ECGs) (n = 353) or event recorder (ER) interrogation (n = 149). In patients with ER, AF recurrence was defined as an AF burden > 0.5% and/or a duration of a single AF episode of >30 s. ER-documented AF episodes were manually validated. In patients without ER, a 24-hour Holter ECG was recorded at 3, 6, and 12 months postoperatively. In the latter group, any episode of AF with a duration >30 s was regarded as AF recurrence. Antiarrhythmic drugs and anticoagulation regimens were maintained for 3 months postoperatively in all patients and then adapted according to the ER or 24-hour ECG rhythm results. In patients without a contraindication, amiodarone was used as the first-line antiarrhythmic therapy. Otherwise, other class I or class III antiarrhythmic drugs were prescribed for ≥3 months postoperatively. Antiarrhythmic medical therapy was stopped when the patients were in SR at 3 months of follow-up. Electrical cardioversion was performed in patients with persistent AF at the follow-up examination. Patients with AF recurrence at 6 months postoperatively were considered for additional catheter-based ablation, if reasonable. Patients receiving additional catheter-based ablation were considered to have failure of surgical AF ablation for rhythm analysis after 12 months.

RESULTS

Perioperative Data and Outcomes

No major ablation-related complication occurred in any of the patients. A perforation of the posterior wall of the left atrium was present in 1 patient after cryoablation and was sutured without additional complications. No intraoperative deaths occurred. Five patients (0.9%) experienced perioperative stroke. The in-hospital mortality was 1.2%, and the 1-year survival rate was 94.9%. The stroke-free survival rate after 1 year was 97.2%.

Concomitant procedures and ablation type are listed in Table 2. Most procedures included mitral (n = 151, 30.0%) or aortic valve (n = 53, 10.5%) surgery. CABG was performed in 126 patients (25.1%), tricuspid valve replacement in 8 patients (1.6%), and aortic surgery in 14 patients (2.0%). Combined mitral valve replacement and tricuspid valve replacement was performed in 46 patients (9.2%), mitral valve replacement and aortic valve replacement in 25 (5.0%), and mitral valve replacement plus CABG in 58 (11.5%). Other procedures were conducted in 22 patients (4.4%).