Original research article

Surgical ablation for atrial fibrillation as a concomitant cardiac surgery procedure. A single-centre study with 1-year follow-up

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ABSTRACT

Introduction: Surgical ablation procedures have been shown to be effective in treatment of atrial fibrillation (AF), but convincing evidence showing relationship between clinical confounders, surgical technique and intermediate-to-long term outcomes is still lacking. Therefore we conducted a retrospective single-centre database study to identify predictors of sinus rhythm (SR) maintenance at 12 months after surgery with insights into standard medical care provided by general practitioners and/or outpatient cardiologists in the setting of a newly introduced method.

Methods: Data from consecutive 376 patients, who underwent heart surgery which included surgical left atrial (LA) ablation for AF between July 2006 and December 2010, were collected. Primary outcome was maintenance of SR at 12 months. A stepwise backward multivariate logistic regression analysis was used to identify predictors of the primary outcome.

Results: RF ablation was performed in 210 patients and 166 patients underwent cryoablation. In 273 subjects the 12-month follow-up data were available. The success rate in maintaining the sinus rhythm 1 year after surgery was 48.9% (63.1% for cryoablation, and 37.8% for RF (p < 0.0001)). None of the patients underwent repeated ablation procedure within the 12-month follow-up period. Paroxysmal AF, mitral valve surgery, and smaller LA diameter were associated with the primary endpoint; cryoablation was superior to RF ablation. Nevertheless, prescription rate of amiodarone/propafenone in patients with documented sinus rhythm at 12-month follow-up was 36.0%.

Conclusions: Using multivariate analysis of retrospective data we identified clinical confounders and technical aspects associated with better outcomes after surgical ablation for AF.

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Introduction

Surgical ablation procedures have been shown to be effective in treatment of atrial fibrillation (AF) and are considered a valuable option especially for patients requiring a cardiac surgery for other reasons such as valvular and/or ischaemic heart diseases [1-3]. Various lesion sets and energy sources have evolved and now have largely replaced the traditional cut-and-sew method [4,5], but convincing evidence about relationship between surgical technique, clinical confounders, and intermediate-to-long term outcomes is still lacking.

The ambiguity in comparing the individual approaches to the surgical ablations might be due to unclear, non-uniform criteria for heart rhythm outcome evaluation as seen in many studies [1,6,7]. Similarly, the intra- and inter-centre differences of patient populations undergoing these procedures influence interpretation of outcomes and limit power of conclusions [6]. Results of a single-centre retrospective database analysis are presented and discussed in this manuscript. The study was aimed to contribute to ongoing discussion regarding the surgical technique, and also the influence of left atrial (LA) diameter on sinus rhythm (SR) maintenance at 12 months after surgery.

Methods

All the patients who underwent heart surgery which included surgical left atrial (LA) ablation for AF between July 2006 and December 2010 in our centre were identified by procedure codes, and relevant data were collected from their electronic medical records in our institution. Patients who underwent bariatric ablation for AF were not included in this study since our institution had only a limited number of such cases in the study period. Primary outcome was maintenance of SR at 12 months after surgery validated by electrocardiogram and/or 24-h Holter monitoring.

Surgical technique

The energy sources used to create transmural lesions in the LA were either bipolar radiofrequency (RF) energy or cryotherapy. Isolator® SynergyTM Ablation System by AtriCure® was used to apply RF energy whereas cryotherapy was administered by Cardioblate® CryoFlex™ Argon-Powered Surgical Ablation System by Medtronic. The choice of energy source in each individual case was in competence of the operating cardiac surgeon.

Lesion set in the left atrium comprised of isolation lines around ostia of pulmonary veins bilaterally, a line connecting the left and right pulmonary veins, and a connecting lesion to the left atrial appendage which was resected. With the cryoablation technique a lesion to the mitral valve annulus was added. This was not performed in RF technique due to risk of damage of structures in the coronary sulcus [8,9]. Cryoaablation lesions in patients undergoing mitral valve surgery were performed from the endocardial approach while the other patients were ablated from the epicardial surface.

Unless postoperative bradycardia occurred the patients were commenced on amiodarone treatment after surgery and electrical cardioversion was added if necessary. A standard 3-month course of antiarrhythmic drug treatment therapy was recommended, but it was left to supervision of the referring cardiologist and/or GP. A follow-up scheme consisting of 3-month and 6-month consultations at the referring cardiologist office, and a 12-month check-up at our facility was proposed to the patients unless clinical circumstances required otherwise. Depending on outcome of the 12-month evaluation at our centre, most patients were recommended to continue with clinical ambulatory care by their referring cardiologist and/or GP.

Follow-up data

The primary outcome – restoration and maintenance of sinus rhythm at 12 months after surgery – was validated by physician’s office 12-lead electrocardiogram. 24-h Holter monitoring of ECG at 3 and 6 months was recommended in the follow-up instructions, but the decision whether or not to perform Holter monitoring was entirely in competence of the referring cardiologist/GP, prior to the follow-up consultation at our facility. The primary endpoint was met if the patient was free from AF, atrial flutter (AFL), and atrial tachycardia (AT) [1] and had not undergone pacemaker implantation by the time of the follow-up evaluation.

Echocardiographic assessment was performed in our facility on the occasion of 1-year post-operative check-up. In patients who did not present for follow-up evaluation we obtained ECG records through their primary care physician’s office. Information regarding patients’ follow-up medication was obtained by the same means. The mortality data were collected through the general medical insurance registry of the Czech Republic.

Since a significant portion of the postoperative care between the surgical intervention and the follow-up appointment was provided by outside facilities, we were unable to obtain detailed history to assess if the criteria for antiarrhythmic drug discontinuation as described in the HRS/EHRA/ECAS Expert Consensus Statement were met [1]. Therefore we opted to define our primary outcome as freedom from AF, AFL, and AT regardless of antiarrhythmic medication (AAM).

Statistical analysis

Pearson Chi-square test, Wilcoxon rank-sum test, and Student’s t test were used to compare categorical and continuous variables across the RF and cryoablation groups. For stepwise backward multivariate logistic regression analysis these clinical confounders were used: age, gender, type of surgery (mitral valve surgery, tricuspid valve surgery, aortic valve replacement, coronary artery bypass graft), type of LA ablation (cryotherapy vs. bipolar radiofrequency (RF)), surgical ablation approach (endocardial vs. epicardial approach), type of AF (paroxysmal vs. longstanding persistent) and LA size, and left ventricular ejection fraction. The study was approved by Ethics Committee of our centre and it waived the need for patient informed consent for this retrospective study.

Results

In total 376 patients were enrolled in the study. RF ablation was performed in 210 patients and 166 patients underwent
cryoablation. The preference of either of the two methods varied through the study period (Fig. 1). Surgical ablation for treatment of AF is not a primary indication for surgery in our centre, and it was added to one or more of the following surgical interventions: mitral valve replacement or repair \( n = 186, 49.6\% \), tricuspid valve replacement or repair \( n = 131, 35.0\% \), aortic valve replacement \( n = 152, 40.6\% \), and coronary artery bypass graft \( \text{CABG} \) \( n = 132, 35.3\% \). The most common combinations of surgical interventions to which the surgical ablation was added were: mitral valve + tricuspid valve surgery \( 70, 18.8\% \); isolated aortic valve replacement \( 64, 17.2\% \); isolated CABG \( 52, 14.0\% \); isolated mitral valve surgery \( 44, 11.8\% \); aortic valve replacement + CABG \( 33, 8.9\% \); mitral valve surgery + aortic valve replacement \( 21, 5.6\% \); mitral valve surgery + CABG \( 18, 4.8\% \); isolated tricuspid valve surgery \( 14, 3.8\% \); mitral valve + tricuspid valve surgery + CABG \( 14, 3.8\% \); and other procedures \( 42, 11.3\% \). The baseline preoperative patients’ characteristics are summarized in Table 1.

**Early postoperative outcomes**

Upon discharge from hospital, sinus rhythm was restored in 226 \( 60.1\% \) patients undergoing surgical ablation. Postoperative paroxysms of atrial flutter were reported in 31 \( 8.2\% \) patients. A 30-day post-operative mortality was 2.9\% \( 11 \) patients.

**Follow-up outcomes**

One-year survival after surgery was 88.3\% \( 332 \) patients. In 273 \( 82.2\% \) of the surviving patients the follow-up data were available. A major portion of the follow-up evaluations were performed in our facility, while 27 \( 9.9\% \) of the assessments were performed by patients’ primary care physicians and then reported to our centre.

The primary outcome, presence of sinus rhythm, was met in 48.9\% \( 136 \) of the surviving patients. Cryoablation showed 63.1\% success rate, while RF ablation 37.8\% \( p < 0.0001 \). Permanent electronic pacemaker was implanted in 19 patients \( 6.8\% \). All of the implants took place within 30 days after the operation and no pacemaker implantation was required later on. We did not identify any clinical variable which would predict occurrence of this adverse outcome. One patient operated for mitral valve replacement and RF ablation underwent a heart transplant 11 months after the initial surgery.

**Table 1 – Preoperative characteristics of all patients.**

<table>
<thead>
<tr>
<th>Patients’ characteristics</th>
<th>All patients ( n = 376 )</th>
<th>RF ( n = 210 )</th>
<th>Cryoablation ( n = 166 )</th>
<th>( p )-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (women)</td>
<td>161 (42.8%)</td>
<td>94 (44.8%)</td>
<td>67 (40.4%)</td>
<td>0.4031</td>
</tr>
<tr>
<td>Age (years)</td>
<td>69.8 (8.3)</td>
<td>70.6 (7.5)</td>
<td>68.8 (9.2)</td>
<td>0.0391</td>
</tr>
<tr>
<td>NYHA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>6 (1.8%)</td>
<td>3 (1.5%)</td>
<td>3 (2.0%)</td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td>101 (29.9%)</td>
<td>59 (31.2%)</td>
<td>42 (28.2%)</td>
<td>0.5525</td>
</tr>
<tr>
<td>III</td>
<td>211 (62.4%)</td>
<td>112 (59.3%)</td>
<td>99 (66.4%)</td>
<td>0.2134</td>
</tr>
<tr>
<td>IV</td>
<td>20 (5.9%)</td>
<td>15 (7.9%)</td>
<td>5 (3.4%)</td>
<td>0.1033</td>
</tr>
<tr>
<td>Endocardial ablation</td>
<td>99 (26.3%)</td>
<td>0</td>
<td>99 (59.6%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Type of surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitral valve surgery</td>
<td>186 (49.6%)</td>
<td>87 (41.6%)</td>
<td>99 (59.6%)</td>
<td>0.0005</td>
</tr>
<tr>
<td>Tricuspid valve surgery</td>
<td>131 (35.0%)</td>
<td>74 (35.6%)</td>
<td>57 (34.3%)</td>
<td>0.8279</td>
</tr>
<tr>
<td>Aortic valve replacement</td>
<td>152 (40.6%)</td>
<td>91 (43.8%)</td>
<td>61 (36.8%)</td>
<td>0.2035</td>
</tr>
<tr>
<td>Coronary artery bypass graft</td>
<td>132 (35.3%)</td>
<td>72 (34.6%)</td>
<td>60 (36.1%)</td>
<td>0.7585</td>
</tr>
<tr>
<td>Type of AF before surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paroxysmal</td>
<td>105 (27.9%)</td>
<td>49 (23.3%)</td>
<td>56 (33.7%)</td>
<td>0.0256</td>
</tr>
<tr>
<td>Longstanding persistent</td>
<td>271 (66.3%)</td>
<td>161 (76.7%)</td>
<td>110 (66.3%)</td>
<td></td>
</tr>
<tr>
<td>Baseline echocardiography</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left ventricular ejection fraction</td>
<td>52.5 (11.7)</td>
<td>53.1 (12.1)</td>
<td>51.8 (11.3)</td>
<td>0.2426</td>
</tr>
<tr>
<td>Left atrial diameter</td>
<td>49.1 (8.3)</td>
<td>49.3 (8.4)</td>
<td>49.0 (8.1)</td>
<td>0.7785</td>
</tr>
<tr>
<td>Antiarrhythmic medication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amiodarone</td>
<td>63 (16.9%)</td>
<td>37 (17.8%)</td>
<td>26 (15.8%)</td>
<td>0.6023</td>
</tr>
<tr>
<td>Propafenone</td>
<td>17 (4.6%)</td>
<td>11 (5.3%)</td>
<td>6 (3.6%)</td>
<td>0.4474</td>
</tr>
</tbody>
</table>
surgery (Table 2). Usage of AAM and oral anticoagulants at 12 months after surgery is described in Table 3.

**Predictors of success**

Stepwise backward multivariate logistic regression analysis was performed in order to identify clinical confounders associated with the primary endpoint (Fig. 2). Cryoablation was clearly superior to RF ablation with odds ratio of 2.41 (p = 0.0021). Larger left atrial diameters (AUC = 0.58) and longstanding persistent AF on the preoperative ECG tracing were independently and significantly associated with less freedom from AF/AFL/AT in the follow-up. Surgical procedures which included mitral valve replacement or repair were independently associated with greater benefit from the LA ablation, in terms of meeting the primary endpoint. Endocardial approach was not independently associated with the primary endpoint.

**Discussion**

We present a single-centre database study on patients undergoing surgical ablation procedure. Based on the results,
several previously disputed clinical confounders were shown important for the electrophysiological outcome of surgical left atrial ablation. The haemodynamic consequences of mitral valve replacement or repair were a likely cause of higher SR restoration and maintenance rate. Preoperative left atrial diameter measured by transthoracic echocardiography represented a significant determinant of surgical ablation success. Unfortunately, our data did not allow to determine a robust and clinically meaningful cut-off value which was a problem of most other studies as well [10]. Nonetheless, extremely large LA should detract from pursuing surgical LA ablations as these patients would unlikely benefit from the procedure which would needlessly prolong the extracorporeal circulation time with all adverse consequences [11]. The outcomes of adding surgical LA reduction to a surgical ablation for AF in patients with dilated LA remain inconclusive [12].

One of the most clinically relevant findings of this study was the superiority of cryoablation to the RF ablation technique. Even after adjusting for numerous clinical confounders the difference in success rate was statistically significant (OR = 2.41). The difference in type of ablation energy seemed to be an unlikely explanation for this phenomenon since both energies were previously proven to create transmural lesions [13,14]. However, it may be that the RF ablation technique was more prone to creating gaps between the individual ablation lines. We may also consider the possibility of higher rate of pulmonary vein reconnections with the RF technique occurring within one year after surgery.

The difference in lesion sets could possibly explain the lower SR maintenance rate at 12 months in patients after RF ablation. The connecting line to the mitral annulus in the cryoaablation procedure might have largely prevented occurrence of perimital flutter a common adverse outcome of a heart surgery and/or ablation for AF [15–17]. Nevertheless, clinical diagnosis of perimital flutter was not established in any of the patients. However, none of the patients in the present series underwent an electrophysiological study within the follow-up period and therefore the exact mechanisms of arrhythmias arising from failed ablation procedures in this cohort remain unclear. Furthermore, pathophysiology of AF is complex and therefore it may be that in certain patients, especially in those with recent onset of AF, ablation line across the mitral isthmus may not be required for achieving long-term freedom from AF/AFL/AT. Based on our experience supported by data published in the literature, a connecting line across the mitral isthmus by a cryoaablation probe has been added to the RF ablation in our institution. Furthermore, biatrial ablation procedures which have been introduced in our centre recently are expected to improve results in patients with dilated right atria and tricuspid valve insufficiency.

The general medical insurance registry of the Czech Republic is a highly accurate source of mortality data. The 1-year mortality rate (10.6%) was likely due to significant prevalence of serious comorbidities and high mean age of our patients. No randomized or matched controls were included in our study and therefore we cannot judge whether the surgical ablation procedure provided a survival benefit or not, but it was not the intended objective of this report.

Randomized controlled trials addressing the area of concomitant surgical ablations for AF are available, but most of them suffered from small sample sizes (15–120) as only two of them enrolled more than 45 surgical ablation patients [2]. A trial by Srivastava et al. (n = 120) compared 3 different ablation strategies and a control, no ablation group [18]. However, this study population included only young (<60 years) patients with chronic rheumatic atrial fibrillation undergoing valvular heart surgery ± surgical ablation and therefore had limited relevance to the practice in Europe and North America. The PRAGUE-12 randomized multicentre study (n = 117) confirmed superiority of heart surgery with surgical ablation to heart surgery only in terms of SR maintenance at 1 year, but it did not address the issue of optimal lesion set and energy source [19].

Most of the single-centre observational studies are limited to patients undergoing mitral valve surgery with a concomitant ablation for AF [20,21]. Stulak et al. presented a large single-centre retrospective analysis which included patients who underwent heart surgery for various congenital and adult-acquired cardiac diseases, and which compared several energy sources (cut and sew, cryothermy, radiofrequency, and combination), and lesion sets (biatrial, isolated pulmonary vein isolation, and isolated left atrial) used in their cohort [6]. Interestingly this study did not show larger LA diameter as an independent predictor of surgical AF ablation failure. This on the contrary came out statistically significant in our multivariate analysis.

**Study limitations**

The presented study is affected by limitations typical to protocols based on retrospective analysis of observational data. The patients were not randomized to either RF or cryoaablation, representing a potential selection bias. The strength of the presented study is a population count which allowed advanced statistical analysis including adjusting for numerous clinical confounders. The main limitation is the ambiguity regarding precise regimen of AAM in the postoperative management. Therefore, it was not feasible to secure evidence whether all of the patients in sinus rhythm still using AAM at 12 months had a trial of discontinuing AAM medication. In addition to the single-centre design there were other possible limitations. The absence of longer (e.g. 1 week) ECG Holter monitoring could have affected accuracy of the results. Also patient experienced symptoms without an ECG correlate were not consistently recorded in our database and were not used to define the primary outcome.

Relatively high prevalence of amiodarone/proprafenone prescription at 12 months after surgery could indicate need for improved physician awareness regarding outpatient care after surgical ablations for AF. Since the presented data were collected during the first years after the introduction of this technique, it is conceivable that this fact was the major reason of quality issues limiting the power of the results. Based on these facts the importance of close collaboration and professional interactions between specialized/academic centres and outpatient healthcare providers should not be underestimated especially in the scenario of newly introduced technique or procedure.
Conclusions

Based on the single-centre study from data collected shortly after the introduction of surgical ablation techniques in treatment of AF, these clinical confounders were proven to independently affect rhythm outcomes: type of ablation (superiority of cryoablation to the RF ablation technique), type of AF, LA diameter, and concomitant mitral valve surgery. It appears that these should be of paramount importance when considering adding surgical ablation to a heart surgery. Since postoperative outpatient management respecting current recommendations outside of a cardiothoracic centre in the early stages is critically important, a close collaboration and knowledge sharing among the healthcare professionals appear to be mandatory.

Conflict of interest

The authors have no conflicts of interest to disclose.

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Ethical statement

The study was approved by Ethics Committee of our centre.

Informed consent

The Ethics Committee of our centre waived the need for patient informed consent for this retrospective study.

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