Original research article

Clinical impact of left atrial appendage resection versus preservation during surgical ablation of atrial fibrillation

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\textbf{Abstract}

Introduction: Resection of left atrial appendage (LAA) during surgical ablation of atrial fibrillation may decrease the incidence of postoperative cerebrovascular events and increase the induction and maintenance of sinus rhythm (SR). This study evaluates the effect of LAA resection after the surgical ablation of atrial fibrillation.

Materials and methods: A retrospective analysis was made of 599 patients who underwent surgical myocardial revascularization and/or valve surgery with concomitant surgical ablation of atrial fibrillation. The LAA was resected in 140 patients and preserved in 459 patients. Postoperative, 1-month and 1-year results were compared between the groups in terms of TIA/CVA, maintenance of sinus rhythm, pacemaker dependence and mortality.

Results: The patients who underwent LAA resection were older, had more frequent persistent AF and underwent more frequently biatrial ablation set. In this group, longer times of extracorporeal circulation and longer cross-clamp times were observed. During the follow-up period, the resection group has shown lower incidence of TIA/CVA and the overall mortality was also lower in this group of patients.

Conclusion: The resection group in our study has shown the trend toward lower incidence of TIA/CVA and statistically significant decrease of overall mortality. This finding can support routine LAA resection during surgical ablation of atrial fibrillation.

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Introduction

LAA plays an important role in human physiology. It is a producer of atrial natriuretic peptide (ANP) in spite of the fact that the production in right atrial appendage is 40 times higher [1]. LAA has influence on induction of thirst [2] and affects the relationship between pressure and blood volume, and has the function of reservoir. Occlusion of the left atrial appendage leads to an increase in pressure and volume in the left atrium. It has positive effect on cardiac output [3,4], although this effect was not confirmed in elderly patients [5]. In patients with hypertension, LAAs were found bigger with depressed ejection velocity [6]. In patients with long-term atrial fibrillation (AF) LAAs with higher volume were identified as well as wall fibrosis and reduction of muscles pectinati.

LAA also plays an important role in pathogenesis of thromboembolism (TE) in patients with AF. The risk of TE is five times higher in patients with AF than without AF and the source of emboli is in 90% in LAA [7] in case of non-valvular AF. In actual guidelines of European Society of Cardiology, it is clearly declared that TE can have an alternative source of emboli to LAA in patients with AF, but the resection of LAA during the MAZE procedure is fully authorized [8].

On this count there are a few clinical studies that compare the clinical impact on LAA resection or preservation in terms of sinus rhythm maintenance, TE events, pacemaker dependence and mid-term mortality [9–11].

Materials and methods

Between January 2004 and December 2013, a total of 599 patients underwent cardiac surgery procedure with concomitant surgical ablation of atrial fibrillation at the Cardiac Surgery Department of Hospital of České Budějovice, Czech Republic. The decision to resect the LAA during the procedure was influenced by several factors such as presence of hypertension, diabetes mellitus, higher age, prevalent TE event and type of AF (paroxysmal, persistent). The decision was finally up to the attending surgeon and based on her/his view and experiences in LAA resection.

Surgical technique

A median sternotomy approach was regularly used in all patients and all procedures were performed on cardiopulmonary bypass. For the ablation of AF Cardioblate CryoFlex Surgical Ablation Probe (Medtronic, Minneapolis, USA) was used. In the beginning of the reported period, the left-sided ablation procedure was performed in patients with paroxysmal AF. It consisted of both-sided pulmonary veins isolation and possible LAA resection. The bilateral ablation procedure was performed in patients with persistent AF and in the latest period also for patients with paroxysmal AF. It consisted of bilateral vein isolation, as well as upper and lower box lesion that connected opposite pulmonary veins and lesion from lower box lesion to mitral isthmus. The bilateral ablation was finished with a right sided lesion set which consisted of an intercaval lesion and an isthmus line connecting the inferior vena cava with the cavitricuspidal isthmus.

Follow-up

All patients were monitored during the postoperative period with Holter monitoring till the discharge from the hospital. They were routinely administered warfarin for minimally 3 months postoperatively, with a target range of international normalized ration from 2 to 3. Patients who presented with AF events during the hospitalization, patients who underwent electrical cardioversion or patients with continuing AF at the discharge from hospital were given amiodarone for 1-month period.

Follow-up rhythm monitoring was performed with 24-h Holter monitoring at 1, 3, 6 and 12 months after the surgery and patients had a medical examination from the attending physician. AF events were defined as any AF episodes during the Holter monitoring that were recorded after the healing period (3 months after the surgery). Any symptoms suggestive of neurologic deficit were evaluated by attending neurologist and examined with imaging studies.

Statistical analysis

The obtained data set was evaluated using the following statistical parameters: medians (MD) with ranges or as means (M) with standard deviation (SD). The normal distribution was tested by the D’Agostino–Pearson omnibus K² tests and with the Shapiro–Wilk normality test.

The non-parametric Mann–Whitney test was used for comparing and studying the relationships between the continuous variables. Moreover, Fischer’s exact test was used for comparing the categorical variables. A confidence level of 95% was accepted as significant.

The statistical analysis was performed with MSExcel 2003 for Windows XP and the statistical analysis system GraphPad Prism version 5.01 (Graph-Pad Software, Inc., San Diego, CA, USA).

Results

The preoperative characteristics of the patients are listed in Table 1. The patients who underwent resection of the LAA were older than those who underwent LAA preservation (71.0 ± 7.0 vs. 69.1 ± 7.6 years). The group of patients who underwent LAA preservation had higher percentage of paroxysmal AF (45.3%); on the other hand the group of patients who underwent LAA resection had higher percentage of persistent AF (70.1%). These differences were found to be statistically significant. In the other variables (gender, diabetes, hypertension, renal insufficiency, preoperative TIA/CVA, COPD and ejection fraction) no differences reaching statistical significance were found.

The perioperative characteristics of the patients are listed in Table 2. The group of patients who underwent LAA resection had longer times of extracorporeal circulation (108.3 ± 38.2 vs. 99.7 ± 40.6 min) and aortic cross-clamp times (75.6 ± 28.6 vs. 66.6 ± 32.3 min). The left sided ablation set was more common in the preservation group (61.4%); otherwise the bialtrial ablation set was more common in the resection group (82.1%). The distribution of patients according to the type of surgery is listed in Table 2.
### Table 1 – Preoperative characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Resection group</th>
<th>Preservation group</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>140</td>
<td>459</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>71.0 ± 7.0</td>
<td>69.1 ± 7.6</td>
<td>0.0069</td>
</tr>
<tr>
<td>Male</td>
<td>90 (64.3)</td>
<td>273 (59.5)</td>
<td>0.3245</td>
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<tr>
<td>Diabetes mellitus</td>
<td>49 (35.0)</td>
<td>161 (35.1)</td>
<td>1.00</td>
</tr>
<tr>
<td>Hypertension</td>
<td>123 (87.9)</td>
<td>358 (78.0)</td>
<td>0.2835</td>
</tr>
<tr>
<td>Renal insufficiency</td>
<td>14 (10.0)</td>
<td>69 (15.0)</td>
<td>0.1619</td>
</tr>
<tr>
<td>Preoperative TIA/CVA</td>
<td>19 (13.6)</td>
<td>38 (8.3)</td>
<td>0.0705</td>
</tr>
<tr>
<td>COPD</td>
<td>22 (15.7)</td>
<td>79 (17.2)</td>
<td>0.7966</td>
</tr>
<tr>
<td>Ejection fraction (%)</td>
<td>56.2 ± 11.8</td>
<td>54.9 ± 13.5</td>
<td>0.3512</td>
</tr>
<tr>
<td>Paroxysmal AF</td>
<td>36 (25.7)</td>
<td>208 (45.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Persistent AF</td>
<td>99 (70.1)</td>
<td>231 (50.3)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Data are n (%) or mean ± SD, p-values ≤ 0.05 were considered statistically significant.

TIA, transitory ischemic attack; CVA, cerebrovascular accident; COPD, chronic obstructive pulmonary disease; AF, atrial fibrillation.

### Table 2 – Perioperative characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Resection group</th>
<th>Preservation group</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>140</td>
<td>459</td>
<td></td>
</tr>
<tr>
<td>CABG</td>
<td>49 (35)</td>
<td>145 (32)</td>
<td></td>
</tr>
<tr>
<td>CABG + valve procedure</td>
<td>38 (27)</td>
<td>121 (26)</td>
<td></td>
</tr>
<tr>
<td>Valve procedure</td>
<td>53 (38)</td>
<td>193 (42)</td>
<td></td>
</tr>
<tr>
<td>ECC time (min)</td>
<td>108.3 ± 38.2</td>
<td>99.7 ± 40.6</td>
<td>0.0179</td>
</tr>
<tr>
<td>Cx time (min)</td>
<td>75.6 ± 28.6</td>
<td>66.6 ± 32.3</td>
<td>0.0007</td>
</tr>
<tr>
<td>Left-sided ablation set</td>
<td>25 (17.9)</td>
<td>177 (38.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Bilateral ablation set</td>
<td>115 (82.1)</td>
<td>282 (61.4)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Data are n (%) or mean ± SD, p-values ≤ 0.05 were considered statistically significant.

CABG, coronary artery bypass grafting; ECC, extracorporeal circulation; Cx, aortic cross-clamp.

In the follow-up period four main clinical events were followed: the incidence of transitory ischemic attack/cerebrovascular event, the incidence and maintenance of sinus rhythm, need of implantation of pacemaker and death. Two out of these criteria reached the statistical significance in 1-year period – the lower incidence of sinus rhythm (p < 0.0001) and lower mortality (p = 0.0008) in the resection group. The distribution of these events is listed in Figs. 1–4.

**Discussion**

Resection of LAA during cardiac surgery leads to a significant reduction of thromboembolic risk. Although no randomized trials are presented anywhere that demonstrate this theory, we can find several clinical trials. Cox et al. published a study of 306 patients who underwent MAZE procedure with excision of both atrial appendages. The postoperative stroke rate was 0.7% and the stroke rate during 11 years of follow-up was only 0.4% [12]. The study of Johnson et al. [13] demonstrated that LAA removal brings a significant stroke risk reduction. On the other hand in their work, a higher number of perioperative cerebrovascular events (4.8%) were reported in the group of 435 patients. However, no new CVA occurred and no LAA thrombus was detected during the follow-up period. The fact that LAA removal/occlusion decreases the incidence of CVA can be also found in a

![Fig. 1 – Incidence of post-operative TIA/CVA in resection and preservation groups.](image1)

![Fig. 2 – Incidence of post-operative pacemaker dependence in resection and preservation groups.](image2)

![Fig. 3 – Incidence of post-operative sinus rhythm in resection and preservation groups.](image3)
randomized non-surgery study PROTECT AF. There were 707 patients with AF randomized 2:1 between the device (WATCHMAN) and warfarin. Nearly two thirds of the patients had CHADS2 score of 1 or 2. After the WATCHMAN implantation, there were 87% of patients who stopped warfarin at 45 days post-implantation. Stroke event rate was 2.6 patients-years in the WATCHMAN group versus 3.5 patients-years in the warfarin group [14]. That brings another argument for LAA resection, particularly in patients with long-standing AF. More than 20% of these patients stay in AF after the MAZE procedure [15] and this appreciable number of patients will stay in a high risk of CVA. Shirani and Alaeddini reported that the LAA remodeling process (dilation, stretching, reduction in pectinate muscle, volume and endocardial fibroelastosis) in chronic AF patients persists after the ablation in spite of successful AF intervention. This fact provides additional justification for routine LAA resection whether or not successful AF ablation is achieved [16].

The resection of the LAA should be taken into consideration also for the potential proarrhythmogenic role of LAA. In the work of Di Biase et al. [17] patients who failed after catheter ablation for AF underwent electrical mapping for trigger location. In almost 30% of patients the trigger of AF was found in LAA. A case report on the same topic was also presented by Takahashi et al. [18]. In our report, we did not find any increase in the number of patients in the resection group with sinus rhythm that was probably caused by higher incidence of persistent AF in this group of patients.

Several techniques of interventional [19,20] and surgical LAA exclusion are available, such as resection and use of a stapler or ligation. Although the principle of these three methods is same (to eliminate LAA from blood circuit) their efficiency shows remarkable differences. Kanderian et al. [21] have analyzed 137 patients after LAA resection, suture or stapling. The criterion of successful LAA occlusion was: no LAA communication under the suture or no LAA residue larger than 1 cm on TEE examination. Only 73% resections, 23% occlusions, and 0% staplers met the criteria. Gillinov et al. [22] reported a study with a group of 222 patients with LAA resection by using a stapler. Additional stitches due to bleeding under the stapler were required in 10% of patients, and 2% of patients experienced periprocedural CVA. Katz et al. [23] have demonstrated that endocardial suture can be frequently insufficient and is associated with residual leaks which were identified in 36% patients in the group of patients. For these reasons we find LAA resection optimal for patients undergoing MAZE procedure from conventional sternotomy.

This study is subject to the limitations inherent in retrospective work with observational data. The non-randomized design may have affected the results owing to patients selection bias. Other limitation can be found in shorter follow-up period (1 year). The advantage of LAA resection may by strengthened by longer follow-up. That would require prospective designs with long-term follow-up period (e.g. 5 years).

**Conclusion**

In our study, we had found the trend toward lower incidence of TIA/CVA and statistically significant decrease of overall mortality in the resection group in 1-year follow-up period. In the relationship with results of our study we can recommend routine LAA resection during ablation of AF.

**Conflict of interest**

None of the authors have conflict of interest regarding this manuscript.

**Ethical statement**

The study was approved by the local ethics committee.

**Informed consent**

One of the inclusion criteria of this study was the agreement to participate in the study and written informed consent. The informed consent was obtained from all the patients.

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**References**


