Safety and feasibility of concomitant surgical ablation of atrial fibrillation in patients with severely reduced left ventricular ejection fraction†

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Received 15 September 2013; received in revised form 4 November 2013; accepted 12 November 2013

Abstract

OBJECTIVES: Concomitant surgical ablation of atrial fibrillation (AF) is a safe and feasible procedure. However, many surgeons are reluctant to perform it in patients with heart failure. We investigated the safety and efficacy of AF ablation in patients with a severely reduced left ventricular ejection fraction (LVEF <35%).

METHODS: Between July 2003 and August 2011, 59 patients with severely reduced LVEF underwent concomitant surgical AF ablation, by either left atrial (LA) lesion set or bilateral pulmonary vein isolation in patients with paroxysmal AF, and biatrial lesion set in patients with persistent AF. Follow-up echocardiography (ECCG) was conducted after 12 months; rhythm monitoring was accomplished by either 24-h Holter echocardiography or event recorder monitoring.

RESULTS: The patients’ mean age was 68 ± 9 years (male patients, 71%). Paroxysmal AF was present in 24 (41%) and persistent AF in 35 (59%) patients. No ablation-related adverse events occurred. The one-year survival rate was 95% without differences in patients with and without restoration of sinus rhythm (SR). The overall rate of SR was 54% after 1 year, showing a superior result in patients with preoperative paroxysmal AF compared with those with preoperative persistent AF (70 vs 41%, P < 0.001). LVEF improved from 29 ± 8% preoperatively to 39 ± 7% after 12 months of follow-up. The improvement in LVEF was significantly higher in patients with restored SR than in those with AF (16 vs 5%; P < 0.001). Only patients with restoration of SR showed a statistically significant reduction in New York Heart Association functional class at the 12-month follow-up (P = 0.0013).

CONCLUSIONS: Surgical AF ablation was safe and feasible in patients with severely reduced LVEF. The restoration of SR led to a significantly higher improvement in LVEF and alleviation of clinical heart failure symptoms, not observed if AF persisted postoperatively.

Keywords: Surgical ablation • Atrial fibrillation • Heart failure

INTRODUCTION

Atrial fibrillation (AF) is the most common arrhythmia in patients undergoing cardiac surgery, and associated with an increased incidence of death, stroke and hospitalization, it is also known to reduce the quality of life [1, 2]. Therefore, the 2010 Guidelines for the management of AF issued by the European Society of Cardiology (ESC), European Association of Cardiothoracic Surgery (EACTS) and European Heart Rhythm Association (EHRA) recommend concomitant surgical AF ablation for symptomatic patients, as well as asymptomatic patients who have a low risk for an ablation procedure [3]. Cox first reported his technique of surgical AF ablation using the cut-and-sew principle in 1987. This technique was modified and resulted in the so-called Cox maze III procedure, which, because of its excellent results, with success rates >90%, remained the gold standard for surgical AF ablation for many years. However, only a few surgeons could perform this procedure owing to its complexity. When the cut-and-sew principle was replaced with the application of various energy sources to create trans-mural atrial lesions, the use of the procedure became widespread. Furthermore, recent studies have shown that a successful concomitant Cox maze procedure improves systolic ventricular function compared with patients who undergo heart surgery alone [4, 5]. Especially in patients with heart failure, who have a high incidence of AF, concomitant surgical AF ablation with restoration of sinus rhythm (SR) might be very beneficial. Heart failure patients with severely impaired left ventricular function may benefit especially from improved ventricular ejection fraction, not just from the surgical procedure but also from the...
restoration of SR after concomitant ablation. However, many surgeons are reluctant to perform concomitant surgical ablation procedures in this high-risk cohort of patients with heart failure as they consider extension of operative time as an additional risk factor, but there is little relevant information in the literature. Therefore, we aimed to investigate the safety and efficacy of concomitant surgical AF ablation in patients with a severely reduced left ventricular ejection fraction (LVEF; <35%).

**MATERIALS AND METHODS**

Between January 2003 and August 2011, 503 patients underwent concomitant surgical ablation due to persistent (n = 195, 39%), long-standing persistent (n = 101, 20%) or paroxysmal (n = 207 41%) AF. In 59 of these patients, a severely reduced LVEF (<35%) was observed on preoperative echocardiography (ECG). A retrospective single-centre data analysis was subsequently performed.

Complete left atrial (LA) ablation including pulmonary vein isolation, box lesions, and LA appendage and isthmus isolation was performed in 30 (51%) patients. Isolated bilateral pulmonary vein ablation was performed in 16 (27%) patients. Biaxial ablation was conducted in 13 (22%) cases, which included additional right atrial inter-caval lesion, isolation of the cavitricuspid isthmus, right atrial appendage and terminal crest. The energy sources applied included argon-based cryoablation (cryoICE cryo-ablation probe, AtriCure, Inc., West Chester, OH, USA; Cardioblate CryoFlex Surgical Ablation Probe, Medtronic, Inc., Minneapolis, MN, USA) in 14 patients, unipolar radiofrequency ablation (Cardioblate unipolar RF pen, Medtronic, Inc.) in 29 patients and bipolar ablation (Cardioblate BP2 device and Cardioblate Surgical Ablation System Generator, Medtronic, Inc.) in 16 patients.

**Statistical analysis**

All statistical analyses were performed using the SPSS statistical software, version 18.0 (SPSS, Inc., Chicago, IL, USA). Continuous values are expressed as mean ± standard deviation and were compared using Student’s t-test or the Mann–Whitney U-test, as appropriate. Categorical variables are displayed as frequencies, and percentages were compared using the χ² test or Fisher’s exact test, as appropriate. P < 0.05 was considered statistically significant. Reported P-values are two-sided. Cox regression analysis was used to determine survival rates.

**Follow-up**

All rhythm results were obtained by either event recorder (ER) interrogation or 24-h Holter ECG at the 3- and the 12-month follow-up. AF recurrence was defined as an AF burden >0.5% in ER interrogation or a single AF episode with duration >30 s on the 24-h Holter ECG. The postoperative and discharge rhythm results were obtained using a 12-lead ECG. The antiarrhythmic drugs and anticoagulation regimens were maintained for 3 months postoperatively in all patients and then adapted according to the rhythm results. In patients without contraindications, amiodarone was used as the first-line antiarrhythmic drug therapy; otherwise, other class I or III antiarrhythmic drugs were used for at least 3 months postoperatively. ECG was performed prior to the surgical procedure and 12 months postoperatively.

**RESULTS**

Baseline patient characteristics are shown in Table 1. The mean patient age was 68 ± 9 years. The mean preoperative LVEF was 29 ± 8%. The mean LA diameter was 54 ± 6 mm. The mean AF duration was 3.7 ± 2.1 years. Four (7%) patients had a history of stroke. Surgical procedures included isolated coronary artery bypass grafting (CABG) in 15 patients, aortic valve replacement in 7 and mitral valve repair or replacement in 14. A combined CABG and valve operation was performed in 16 patients; other surgical procedures made up the remaining 7 cases.

No major ablation-related complications occurred in any of the patients. One patient (1.7%) experienced perioperative stroke. The stroke-free survival rate after 1 year was 92%.

**Rhythm results**

SR was recorded by 12-lead ECG immediately after the procedure and at the time of discharge in 52 and 45% patients, respectively. All patients underwent either ER interrogation (n = 11) or 24-h Holter ECG monitoring (n = 48) at the 3- and 12-month follow-up. Thirty-one patients (52.5%) also attended a 6-month follow-up. At the 3- and 6-month follow-up, 48 and 51% patients, respectively, were in SR. At the 12-month follow-up, 54% of patients were in SR, with a statistically significantly higher success rate in patients who had preoperative paroxysmal AF, compared with those with persistent or long-standing persistent AF (70 vs 41%; P = 0.033; Fig. 1). The rate of freedom from AF at the 12-month follow-up was 60%.

**Survival**

There were no cases of intraoperative death. The in-hospital mortality rate was 1.8%, while the 30-day mortality rate was 2.7%. The 1-year survival rate was 95% for the entire patient population. Regarding only patients who were in SR at the 12-month follow-up, the survival rate was 97%. The 1-year survival rate in patients without successful ablation was 93%. Cox regression analysis did not display statistically significant differences in survival rates between the two groups (P = 0.38, Fig. 2).

<table>
<thead>
<tr>
<th>Table 1: Patient characteristics</th>
<th>Patients (n = 59)</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>68 ± 9</td>
</tr>
<tr>
<td>Gender (female/male)</td>
<td>42/17</td>
</tr>
<tr>
<td>AF duration (years)</td>
<td>4 ± 3</td>
</tr>
<tr>
<td>Paroxysmal AF, n (%)</td>
<td>24 (41)</td>
</tr>
<tr>
<td>Persistent AF, n (%)</td>
<td>35 (59)</td>
</tr>
<tr>
<td>Left atrial diameter (mm)</td>
<td>54 ± 6</td>
</tr>
<tr>
<td>Left ventricular ejection fraction (%)</td>
<td>28 ± 8</td>
</tr>
<tr>
<td>Prior stroke, n (%)</td>
<td>4 (7)</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>12 (20)</td>
</tr>
<tr>
<td>Renal insufficiency, n (%)</td>
<td>14 (24)</td>
</tr>
<tr>
<td>Peripheral arterial disease, n (%)</td>
<td>4 (7)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease, n (%)</td>
<td>5 (9)</td>
</tr>
<tr>
<td>Coronary artery disease, n (%)</td>
<td>32 (54)</td>
</tr>
<tr>
<td>Previous myocardial infarction, n (%)</td>
<td>8 (14)</td>
</tr>
</tbody>
</table>
Echocardiography

The LVEF improved from the baseline value of 28 ± 8 to 39 ± 7% at the 12-month follow-up in the overall cohort (P < 0.001). Regarding patients who were in SR at the 12-month follow-up alone, there was a statistically significant improvement in LVEF from 28 ± 8% at baseline ECG to 44 ± 9% at the 12-month follow-up (P < 0.001). In patients with unsuccessful ablation, LVEF improved from 30 ± 9 to 34 ± 9%, which did not reach statistical significance (P = 0.07, Fig. 3).

New York Heart Association classification

There was a statistically significant improvement in New York Heart Association (NYHA) classification from baseline to the 12-month follow-up (from 3.2 ± 1.8 to 2.4 ± 1.5, P = 0.009). Preoperatively, 20, 55, and 25% of the patients were in NYHA classes II, III, and IV, respectively. No patient was in NYHA class I. At the 12-month follow-up, 9, 50, 31, and 10% were in NYHA classes I, II, III, and IV, respectively. In patients with successful restoration of SR, the NYHA class was significantly improved from 3.2 ± 1.5 to 2.1 ± 1.7 (P = 0.0013), whereas improvement in patients with unsuccessful ablation did not reach statistical significance (3.1 ± 1.5 vs 2.4 ± 1.4, P = 0.08; Fig. 4).

**DISCUSSION**

This study investigates the impact of concomitant surgical AF ablation in a cohort of patients with heart failure and severely reduced LVEF (<35%). The prevalence of AF is high among this patient population [6]. Guglin et al. [7] reported a benefit from the restoration of SR, especially among patients with heart failure. In their study, they compared heart rate vs rhythm control in heart failure patients and found superior functional capacity in the group of...
patients who had restoration of SR. Furthermore, the number of heart failure symptoms was reduced in those patients. Similar results were published by Ad et al. [4] for a cohort of heart failure patients undergoing surgical AF ablation. In their series of 42 patients, they found a significant improvement in the health-related quality of life, as assessed by the SF 12v2 questionnaire, in patients who underwent successful ablation. In addition, the severity and frequency of heart failure symptoms were reduced and NYHA class was improved in patients who were converted to SR. In our study, a statistically significant improvement was observed in NYHA classification in patients who had successful ablation; this significance was not observed in patients with unsuccessful ablation. We also found a significant improvement in LVEF at the 12-month follow-up in patients who had successful ablation, which was not seen in patients who were in AF at this point in time. This finding is consistent with the published data by Ad et al. and Stulak et al. [4, 5]. Stulak et al. analysed the results from 434 patients undergoing the Cox maze procedure and reported a significant improvement in systolic function in patients who had restoration of SR. In addition, the RACE study, a large randomized trial comparing rate vs rhythm control in patients with persistent AF, showed an improvement in LVEF in patients who had restoration of SR at the 24-month follow-up [8].

In our patient population, surgical AF ablation was safe and feasible in this high-risk group. We had no ablation-related mortality or morbidity in any of our patients. These findings are consistent with the previously published data of Ad et al. They showed, in a propensity-score matched analysis of 178 high-risk patients with an additive EuroSCORE > 6, that there is no additional operative risk when performing AF ablation compared with a non-ablation group.

The effect of the restoration of SR on survival remains undefined. According to our data, survival rates did not differ significantly between patients with or without successful AF ablation. This finding is in conflict with a previous published study by Louagie et al., in which a successful Cox maze procedure with restoration of SR resulted in a higher survival rate in those patients [9]. The absence of a demonstrable significant survival benefit for patients who had SR restored in our study could be due to the relatively small number of patients and the limited follow-up time of 12 months. However, our data are in line with the results of the Prague-12 trial, a randomized multicentre study where patients with AF were randomized to cardiac surgery and AF ablation or cardiac surgery alone. In this study, the survival rates did not differ at the 1-year follow-up. However, the 5-year results of this trial, which are receivable, might give an answer to the question on the impact of AF ablation on long-term survival [10]. Also the AFFIRM study, a large randomized controlled trial, in which patients with AF were randomized to either rate or rhythm control did not show any difference in survival between patients with or without restoration of SR [11]. However, rhythm control was obtained by medical therapy in this study; therefore, further large prospective randomized trials comparing rate control and surgical ablation would be necessary to determine the impact of surgical ablation on the patients’ long-term survival.

In our patient population, 54.2% of patients were in SR after a 1-year follow-up. All rhythm results were obtained using 24-h Holter ECG or ER monitoring, according to the 2012 published ESC/EHRA/EACTS guidelines. This may be one of the reasons for the lower SR rates compared with previous published studies where the rhythm follow-up used only 12-lead ECG [12–15]. Another reason may be the fact that we were dealing with a high-risk population with a large number of comorbidities and structural heart disease, where the success rates of AF ablation tend to be lower. Given the potential long-term benefits of the restoration of SR, particularly in patients with a severely reduced LVEF, concomitant surgical ablation is worth considering even in this surgically high-risk population, in spite of potentially longer operative times.

Limitations of the study are the fact that we used a retrospective single-centre analysis with the potential risk of bias by unknown confounders. Furthermore, the ECG examinations were performed by different examiners with the potential risk of variability among the echo readings. Furthermore, our patient population consisted of a relatively small number of patients, and larger prospective randomized trials will be necessary to confirm these results.

CONCLUSION

In our study, surgical AF ablation was safe and feasible in patients with severely reduced LVEF. Furthermore, we could show that restoration of SR led to statistically significant improvement in NYHA class, LVEF and alleviation of clinical heart failure symptoms, not observed if AF persisted postoperatively. However, there was no survival benefit in patients with restoration of SR, which might be due to the relatively short follow-up and small patient cohort.

Conflict of interest: none declared.

REFERENCES

[3] Callkins H, Kuck KH, Cappato R, Brugada J, Camm AJ, Chen SA et al. Heart Rhythm Society Task Force on Catheter and Surgical Ablation of Atrial Fibrillation. 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. Developed in partnership with the European Heart Rhythm Association (EHRA), a registered branch of the European Society of Cardiology (ESC) and the European Cardiac Arrhythmia Society (ECAS); and in collaboration with the American College of Cardiology (ACC), American Heart Association (AHA), the Asia Pacific Heart Rhythm Society (APHRS), and the Society of Thoracic Surgeons (STS). Endorsed by the governing bodies of the American College of Cardiology Foundation, the American Heart Association, the European Cardiac Arrhythmia Society, the European Heart Rhythm Association, the Society of Thoracic Surgeons, the Asia Pacific Heart Rhythm Society, and the Heart Rhythm Society. Heart Rhythm 2012;9:632–696.e621.


APPENDIX. CONFERENCE DISCUSSION

Dr S. Benussi (Milan, Italy): The study confirms a very important spinoff of successful atrial fibrillation surgical ablation, which has also been reported in other studies. Sinus rhythm restoration favours an improvement in left ventricular ejection fraction. Now you confirm it with your data, and this is presumably due to a certain degree of tachyarrhythmopathy that plays a variable role in worsening left ventricular function by adding up to the amount of heart dysfunction related to organic valve disease.

So, if this is true, one would expect a more pronounced favourable effect of a successful ablation to occur in those patients undergoing surgery in a stable atrial fibrillation condition. Did you find any difference in left ventricular recovery between patients undergoing surgery with long-standing, persistent atrial fibrillation with respect to those operated on while in sinus rhythm because of paroxysmal atrial fibrillation before surgery?

And my main concern with your study is why was the rate of sinus rhythm recovery so poor in both paroxysmal and, especially, persistent patients? While the variable lesion sets may well have played a role here, I think a possible weak point in the reported experience is the wide variability of the utilized energy source. Why, in particular, did you utilize three different ablation platforms to operate on such a small series of particularly delicate patients?

Dr Pecha: To answer the first question, we did not look for differences between the two groups that were operated in paroxysmal AF or persistent AF due to the small patient numbers. So it was not possible to divide them into further subgroups and to get any results to answer that question. To address your second question, this is a retrospective study that has been performed over a long period of time. This is one of the reasons why we had different energy sources.

In the first years of this study, we used a unipolar pen, which is no longer used today. We nowadays use a bipolar clamp or the cryoablation tool. And I think the differences in the ablation tools and lesion sets used is a reflection of the long period of time which the study covers, and to the small number of patients. It is really difficult to collect data from many patients with a severely reduced ejection fraction that have been ablated.

Dr Benussi: In particular, don’t you find that basing everything on cryoenergy takes longer, with additional cross-clamp time in such patients with respect to bipolar radiofrequency? Even if we utilize cryoenergy for some of our patients, redo cases, mostly with a normal ejection fraction, in patients with a severely depressed left ventricular ejection fraction, that we find that basing everything on cryoenergy takes longer, and it increases cross-clamp time with respect to bipolar radiofrequency.

Dr Pecha: Yes, you’re absolutely right. But nowadays, we do not perform the whole lesion set with cryoablation. Formerly, when we had no bipolar clamp, we used cryoablation for the complete lesion set.

Dr F.M. Wagner (Hamburg, Germany): If I may just give you a quick comment on that, it has a lot to do with the historical development of A-Fib treatment at our hospital. Initially, our strategy was to use an epicardial approach in those patients where you do not need to open the left atrium, for example, mitral valve disease. For that reason, we started to use cryo in these patients because there, you can do a complete left lesion set, not just a PVI. This approach is going back to 2003. So for that reason, it is a more historical thing. Apart from that, I’m not that sure if cryo really is inferior in regard to transmural lesion quality. It might add some time, but if you take the newer devices that have a defrost mode, you do a lesion within, let’s say, two minutes and a few seconds. And if you do a complete setting with your clamp opening the left AA and all necessary steps included, I think the time is not that different at the end of the day.

Dr M.A. Mariani (Groningen, Netherlands): I have a very short, maybe provocative question. You have shown that the survival at one year doesn’t change, either the patient or AF or sinus rhythm. So my question is, why bother? I mean, you are adding operation time, different techniques, and you don’t see any improvement in the survival.

Dr Pecha: I think due to small patient numbers, this study does not have the power to display any survival differences. We just had a follow-up of one year. Probably a five-year follow-up would display differences. I think we need a longer follow-up and larger patient numbers to refer to that question.

Dr Mariani: Okay. Fair enough.

Dr S. Salzberg (Zürich, Switzerland): I have one last, short question. You have 24 patients with paroxysmal A-Fib, but you did only 16 pulmonary vein isolations. So in eight patients with paroxysmal AF, you did more lesions. Could you comment on that?

Dr Pecha: We had patients where we did extensive LA ablation. Those were patients where we opened the atria. And in some of them, we did additional lines in the left atrium.

Dr Salzberg: Okay.