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Institutional report - Cardiac general

A 5-year clinical experience with bipolar radiofrequency ablation for permanent atrial fibrillation concomitant to coronary artery bypass grafting and aortic valve surgery

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Abstract

This study analyses the 5-year results of permanent atrial fibrillation (pAF) bipolar radiofrequency (RF) ablation surgery concomitant to coronary artery bypass grafting (CABG) and/or aortic valve (AV) surgery. Eighty-five patients with pAF (0.5–30 years) underwent bipolar RF ablation procedure concomitant to CABG/AV surgery. All patients were restudied to assess survival, conversion rate to stable sinus rhythm (SR) and New York Heart Association (NYHA) class at 8 ± 1 days and at 3 ± 1 and 32 ± 15 months after surgery. Survival at time of re-examination was 100%, 98% and 96%, respectively (three non-cardiac deaths), SR could be documented in 61%, 74% and 78% of patients. Long-term AF before surgery and larger size of the left atrium (LA) were predictive for postoperative AF return ($P=0.005$, $P=0.03$); 88% of patients with small preoperative LA-size (<50 mm) and 85% with pAF-duration time <5 years had stable SR at late follow-up. Cardiac rhythm at three months was predictive for long-term rhythm-prognosis ($P<0.0001$). NYHA-class improved significantly after surgery ($P<0.0005$), particularly when SR was achieved ($P=0.046$). Permanent AF bipolar RF ablation surgery revealed excellent results in AV/CABG patients. It could be demonstrated that established SR remained stable over time. Preoperative pAF-duration time and LA-size are useful variables to predict the success rate of ablation.

Keywords: Aortic valve surgery; Arrhythmia surgery; Atrial fibrillation; Bipolar radiofrequency ablation; Coronary artery bypass grafting; Radiofrequency ablation

1. Introduction

Permanent atrial fibrillation (pAF) can be a serious concomitant problem in patients undergoing open heart surgery [1, 2]. It was the aim of this study to evaluate early and late results of a concept using bipolar radiofrequency (RF) ablation surgery in patients with concomitant pAF scheduled for coronary artery bypass grafting (CABG) and/or aortic valve (AV) replacement. Our data-analysis of a 5-year clinical experience with bipolar RF ablation surgery including late follow-up investigations is reported.

2. Patients and methods

The population of this investigation consisted of 85 consecutive patients with pAF for 0.5–30 years who were scheduled for combined pAF ablation and CABG and/or AV surgery in our institution between March 2003 and September 2007. Standardized bipolar RF ablation was perfomed in all 85 cases. Relevant data of patient characteristics are given in Table 1. Exclusion criteria: emergency operation, severely reduced left ventricular ejection fraction (LVEF $\leq$25%), acute endocarditis or myocardial infarction ($\leq$7 days), pAF $<$0.5 years, severe intracardiac thrombosis or left atrial (LA) size of $\geq$65 mm.

2.1. Bipolar radiofrequency ablation surgery

In all cases standardized bipolar RF ablation surgery was performed using the Atricure® device (Atricure Inc., Cincinnati, USA; Fig. 1) [2]. After initiation of cardiopulmonary bypass (CPB) isolation of the right/left pulmonary veins (RPVs, LPVs) was performed by impacting the atrial tissue between the jaws of the Atricure® hand piece and energy delivery with local temperature of 40–55 °C. The procedure was terminated when the ablation and sensing unit indicated tissue conductance below 2.5 Millisiemens for at least ten seconds. Then a purse-string suture was set at the posterior LA-wall and the distal jaw of the Atricure® inserted through a small incision in the direction of the LPVs and ablation was performed after clamp closure. Next the jaw was inserted in the direction of the RPVs and the connecting lesion between the PVs was completed (Fig. 1). After that CABG and/or AV surgery was performed.

2.2. Management of cardiac rhythm and follow-up

Transthoracic echocardiogram (TTE) and 12-lead electrocardiogram (ECG) and were routinely performed on admis-

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Table 1
Characteristics of 85 patients

Age, years	72±7 (52–85)
Gender, male/female	62/23 (73%/27%)
Significant CAD	65 (76%)
Severe AV disease	30 (35%)
NYHA-class	3.0±0.1 (2–4)
LVEF, %	57±14 (29–84)
Permanent AF-duration, years	6.3±6.9 (0.5–30; Median: 4.0 (IQR: 6.0)
LA-diameter*, mm	49±5 (36–60)
Anticoagulation (cumarine)	53 (62%)
History of failed interventional AF ablation	7 (8%)
History of failed DC cardioversion and/or antiarrhythmic medication	48 (56%)
EuroSCORE	6.6±2.4 (2–12)

AF, atrial fibrillation; AV, aortic valve; CAD, coronary artery disease; EuroSCORE, established score to evaluate the predicted risk of cardiac operations [low risk: 1–2 points; moderate risk: 3–5 points; high risk: ≥6 points]; LA, left atrium; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; *the LA-diameter at discharge (10±3 days after surgery) was 47±5 mm.

sion and before discharge. Assessment of LA-size was done by evaluating the LA-diameter (≥50 mm: large, <50 mm: small). Amiodarone administration was started with an intravenous bolus of 300 mg before the end of CPB, followed by an infusion of 900 mg/day for three days. Oral administration of 5×200 mg up to 7–10 g was begun after that, 1×200 mg/day followed for three months. In cases of contraindication for amiodarone administration, sotalol was given (bolus of 10 mg, then 1 mg/kg for 24 h; oral administration of 2–3×40–80 mg for 3 months); bradycardia for more than ten days led to amiodarone/sotalol termination (indication for permanent pacemaker implantation: 14 days bradycardia). In cases with early AF recurrence during hospital stay after saturation with amiodarone/sotalol and after exclusion of intracardiac thrombosis by TEE, DC cardioversion was recommended. All patients got cumarine for at least three months after surgery. Patients were restudied at 8±1 days (before discharge) and early/late (3±1/32±15 months) after surgery by clinical examination and standard 12-lead-ECG. One standard 24-h-ECG registry was performed in addition.

2.3. Statistical data analysis

The statistical analysis was performed with SPSS (SPSS Inc., Chicago, Illinois, USA) for Windows 11.5.2.1. Quantitative preoperative and operative data were described by arithmetic mean±S.D. or, if appropriate, by median and interquartile range (IQR). Qualitative distributed data were presented as absolute and relative frequencies. For data assessment an explorative data analysis was performed. No adjustments for multiple tests were calculated. Univariate logistic regression analysis was used to evaluate pAF recurrence and persistence after surgery. Continuous measurements as well as parameters grouped by clinical relevant values (e.g. LA-size: ≥50 mm vs. <50 mm, pAF-duration ≥5 years vs. <5 years, age: ≥70 years vs. <70 years) were included. Qualitative characteristics were compared using Fisher's exact test. Changes of NYHA-class were investigated using Friedman-test (Monte Carlo method; upper bound of 99% confidence interval given). All

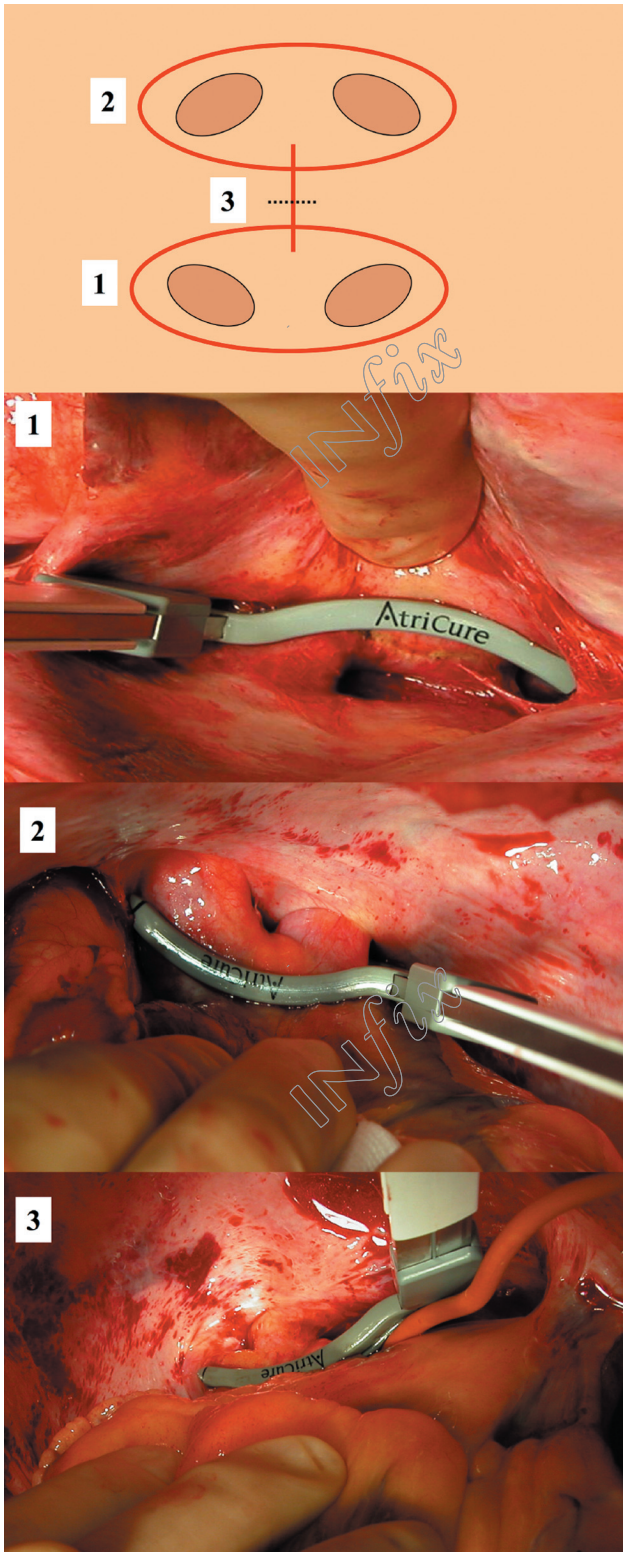

Fig. 1. Lesion pattern of bipolar radiofrequency ablation using the bipolar Atricure® device. (1) Ablation of the right pulmonary veins; (2) ablation of the left pulmonary veins; (3) connecting lesion through a small incision in the posterior left atrial wall.

P-values were two-tailed and not adjusted for multiple testing. *P*-values <0.05 were considered to be statistically significant.

3. Results

All relevant data of surgery are given in Table 2. No patient died within 30 days. During hospital stay, 42 of 58 patients with early AF recurrence had DC cardioversion (24 (57%) of them successful), one patient converted to sinus rhythm (SR) spontaneously. One patient had pacemaker implantation because of persisting bradycardia. No case of atrial flutter was observed. At 10 ± 3 days, 52 of 85 patients (61%) were discharged in SR.

Survival at mean 3 and 32 months was 96% (82 of 85 patients, 3 non-cardiac deaths). At three months the SR conversion rate was 74% (61/82), at 32 months 78% (64/82) of patients had stable SR (between early and late follow-up one survivor had pAF recurrence and persistence, 4 patients converted to stable SR spontaneously). With univariate logistic regression analysis the variables preoperative pAF-duration and preoperative LA-size were identified to be predictive for cardiac rhythm late after surgery ($P=0.005$, $P=0.018$). Permanent AF long-time duration at time of surgery was detected as an incremental risk factor for AF return after ablation [continuous measurement: $P=0.025$ (at time of discharge), $P=0.02$ (at 3 months), and $P=0.005$ (at 32 months)]. Larger LA-size was found as another risk factor [for grouped parameters at 3 and 32 months follow-up ($P=0.031$, $P=0.018$) and with continuous measurement at late follow-up ($P=0.03$)]. At early (late) follow-up 62% (67%) of patients with AF return had had LA-enlargement at time of surgery, whereas 66% of patients with SR had small LA-size ($P=0.04$, $P=0.028$). Whereas the cardiac rhythm at discharge was *not* predictive for the rhythm at 3 and 32 months ($P=1.00$), cardiac rhythm at 3 months was predictive for the situation of rhythm late after surgery ($P<0.0001$); 85% of cases with preoperative pAF-duration <5 years had stable SR late after surgery (≥5 years pAF-duration: only 69%) and 88% of patients with small LA-size of <50 mm (LA-size ≥50 mm: only 65%). For postoperative cardiac rhythm at discharge and early/late follow-up neither age ($P=0.97$, $P=0.37$, $P=0.23$), gender ($P=0.15$, $P=0.36$, $P=0.28$) nor the underlying cardiac disease (presence of AV disease: $P=0.44$, $P=0.66$, $P=0.63$) were predictive. However, 78% of patients with AF at late follow-up had been ≥70 years of age at time of surgery compared to only 62% of patients with SR at late follow-up ($P=0.27$). At 32 months, 58 of 82 patients (71%) did not need anticoagulation (all 18 patients with AF, and six cases with postoperative SR still had anticoagulation). NYHA-class improved significantly after surgery (decrease from NYHA 3.0 ± 0.5 to 1.4 ± 0.5; $P<0.0005$), particularly when stable SR was achieved [1.3 ± 0.5 (SR) vs. 1.9 ± 0.3 (pAF), with 72% of patients (46/64) in NYHA I and 28% (18/64) in NYHA II in the SR-group, and only 11% (2/18) in NYHA I and 89% (16/18) in NYHA II in the pAF-recurrence-group; $P=0.046$].

Table 2
Surgical data of 85 patients using the Atricure® device for bipolar ablation

Procedures	
*AV replacement	20 (24%)
*AV replacement + CABG	10 (12%)
CABG	55 (64%)
Operation time, min	178 ± 26
CPB-time, min	100 ± 31
ACC-time, min	53 ± 42
Cardioplegia (*Bretschneider*-solution;	30 (36%)
AV surgery alone or combined with CABG)	
Intermittent cross-clamping (CABG)	55 (64%)
Bipolar ablation time (min)	1.8 ± 0.5
Total bipolar procedure time (min)	11.5 ± 2.5

ACC, aortic cross-clamping; ASD, atrial septal defect; AV, aortic valve; CABG, coronary artery bypass grafting; CPB, cardiopulmonary bypass; CABG, coronary artery bypass grafting; *all patients with AV replacement got a bioprosthesis.

4. Discussion

It has been demonstrated that the initiation of atrial fibrillation originates from foci predominantly located in the LA-pulmonary vein junctional area and that AF is maintained by activation wave fronts of re-entrant circuits [3–6]. That is why surgeons, who used ablation techniques during open heart surgery, initially tried to follow more or less closely the principles of the Maze-procedure for AF ablation (including a combination of PV isolation and multiple lesions/incisions to interrupt re-entrant circuits [7, 8]), even if this concept was complex and invasive. As it was anticipated that the mechanisms of AF initiation and maintenance vary and are related with individual structural/electrophysiologic changes particularly when AF has become permanent [9–11], the configuration of lesion pattern became a relevant topic.

When we started with pAF ablation surgery, it was our intention to reduce the 'invasiveness' to a minimum, and we decided to perform 'only' a bilateral PV isolation and a connecting lesion between the ablated circles. Nevertheless, e.g. postoperative atrial flutter, which is expected to occur in some cases when a lesion to the mitral annulus is omitted, was absent in all cases. Instead, our data are in line with the experience of other researches (most groups used more complex lesions): a block of AF-wavelets sustained by foci predominantly located inside the PVs and additional rhythm protection including medical therapy results in stable SR in the majority of patients [12]. However, in the literature data of concomitant pAF ablation, surgery in the inhomogeneous group of 'non-mitral-valve' patients is limited and particularly the long-term effects on cardiac rhythm and survival among these patients are still incompletely understood.

Generally RF energy has become the most widely used energy source for AF ablation surgery, the use of cryo-application and microwave have been described as alternatives. Khargi et al. describe an SR conversion rate of almost 80% at one year after surgery in patients with AV replacement or CABG and concomitant monopolar endocardial RF ablation [13]. Other research has demonstrated the advantage of a bipolar RF ablation strategy (compared to a monopolar endocardial approach) in 'non-mitral-valve' cases because of significantly shorter ablation time (as the atrial tissue can be impacted during ablation) and total ablation procedure time (a left atriotomy does not have to be performed) [14].

Our data demonstrate that among CABG/AV patients with pAF apart from LA-size particularly the preoperative pAF-duration influences the probability to establish stable SR.

These findings confirm the 2006 data of Melo et al. from an international registry, who term the LA-size to be 'the best predictor of success' in a heterogeneous group of mitral patients with permanent or other forms of AF [15]. A significance of the variables larger LA-size and long-term AF-duration for bipolar RF ablation surgery failure among 'non-mitral-valve' patients has not been documented before. However, from our point of view it must be anticipated that the variable predictive for AF surgery failure as an independent risk factor most probably is not the LA-size or pAF-duration itself, but the cellular electrophysiological/morphologic damage (=atrial remodeling) correlated with progressive LA-enlargement or long-time pAF-duration: it is our theory that these factors are, in general, of significant relevance for the success of AF ablation surgery.

Particularly in cases with presumptively advanced myocardial damage (=electrical/structural changes), it would be of the greatest interest to enable the identification of highly diseased atrial myocardium also outside the PV-LA junctional area, perhaps on the basis of fibrillation electrograms or histological analysis and, with this information, selectively ablate or isolate 'all' potentially arrhythmia responsible structures. From our point of view, the concept of an individualized (=change from 'blind' to electrophysiologically directed) selective ablation/isolation of all diseased parts of the atria possibly might be an alternative to conventional surgical pAF therapy. However, even if remarkable regional differences (like pronounced interstitial fibrosis, distinct fragmentation) could be documented with postoperative analysis, a device that localizes specific relevant changes in the individual patient and enables ablation of all relevant regions also outside the PV-LA junctional area in real time is still not available. At present the described concept using 'blind' bipolar RF ablation enables to restore stable SR in the majority of pAF patients undergoing CABG/AV surgery, particularly when the LA is still small and pAF-duration time is short.

5. Limitations

The study consists of a heterogeneous group of patients regarding the type of cardiac pathology, which might have influenced the results. The study was not designed for patients with paroxysmal AF or pAF persisting for <0.5 years. The data were not evaluated under randomized conditions. For rhythm evaluation no 7-day Holter-monitoring and only one 24-h-ECG registry was performed. Further, the late follow-up did not include an echocardiographic investigation of LA function, which limits the completeness of the data.

6. Conclusion

The data allow to evaluate the results of a standardized bipolar RF ablation concept concomitant to CABG and/or AV surgery in patients with pAF-duration time of 0.5–30 years. It is demonstrated that an SR conversion rate of almost 80% in the total group and about 90% with 'good preconditions' (=small LA-size, short pAF-duration time) can be achieved and that SR remains stable over a time of about three years. Preoperative LA-size and pAF-duration were identified to be useful variables to predict the success rate of bipolar RF ablation in CABG/AV patients. It must be considered that preoperative long-term pAF and larger LA-size are risk factors for pAF ablation surgery failure.

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