Surgery for atrial fibrillation using radiofrequency catheter ablation

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Objective: We present the results obtained in 40 patients with chronic atrial fibrillation using direct intraoperative radiofrequency to perform atrial fibrillation surgery.

Methods: Between April 1995 and June 2002, 40 patients underwent surgery for atrial fibrillation using radiofrequency ablation and cardiac surgery at the Department of Cardiovascular Surgery of the University of Bologna. There were 8 men and 32 women with a mean age of 62 ± 11.6 years (range: 20 to 80 years).

Results: Concomitant surgical procedures were: mitral valve replacement (n = 13), mitral valve replacement plus tricuspid valvuloplasty (n = 11), combined mitral and aortic valve replacement (n = 8), and combined mitral and aortic valve replacement plus tricuspid valvuloplasty (n = 5). Moreover, 1 patient underwent tricuspid valvuloplasty plus atrial septal defect repair, another required aortic valve replacement plus coronary artery bypass graft, and a third underwent aortic valve replacement. After the mean follow-up time of 16.5 ± 2.5 months survival was 92.8% and the overall cumulative rate of sinus rhythm was 88.5%.

Conclusions: We conclude that the radiofrequency ablation procedure is a safe and effective means of curing atrial fibrillation with negligible technical and time requirements, allowing recovery of the sinus rhythm and atrial function in the great majority of patients with atrial fibrillation who underwent cardiac surgery (88.5% of our study population).

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Atrial fibrillation (AF) is a common arrhythmia present in 0.4% of the general population and in more than 1% of the population over 60 years of age. About 40% to 60% of patients undergoing mitral valve surgery have AF, thus compromising the clinical outcome. The detrimental sequelae of AF are irregular heartbeat, compromised hemodynamics due to the absence of a synchronous atrioventricular contraction, and the risk of systemic thromboembolic events.

Restoration of the sinus rhythm (SR) with atrioventricular resynchronization may be difficult in patients with lone or chronic AF. The procedure consists of the surgical approach described by James Cox, namely making linear lesions in the right and left atria to prevent the occurrence of multiple reentering circuits. This surgical

procedure is extensive and time-consuming and requires great surgical skill. More recently, Haissaguerre and colleagues[1] have demonstrated that radiofrequency (RF) ablation is able to confine the origin of paroxysmal AF to the rapidly firing foci in the pulmonary veins. The efficacy of RF ablation in patients with chronic AF undergoing cardiac surgery has been evaluated and the clinical outcome is presented here.

Methods

Operative Technique

Between April 1995 and June 2002, 40 patients with chronic AF underwent cardiac surgery and surgery to treat AF at the Department of Cardiovascular Surgery of the University of Bologna. The preoperative characteristics of the patients are shown in Table 1. All patients underwent cardiopulmonary bypass with bicaval and aortic cannulation under moderate hypothermia (32°C); myocardial protection was assured by antegrade crystalloid cardioplegia. The lesions were made by a Cobra Flex catheter (Boston Scientific, San Jose, Calif) at a temperature of 70°C to 80°C for a period of 2 minutes in the left atrium and 90 seconds in the right atrium. After a standard lateral left atriotomy, the probe was placed on the left atrial endocardium 5 to 10 mm medially from the right pulmonary vein orifices. The ablation probe was then used to create a circumferential lesion around the left pulmonary veins, at least 5 mm from their orifices. Connecting lesions were created from the left atrial appendage to the ablation line around the left pulmonary veins and from this lesion to the anteromedial commissure of the mitral valve. A final lesion connecting the 2 lesions encircling the pulmonary vein was created. The left atrial appendage was then excised and the stump of the left atrial appendage was closed with running polypropylene suture. We also performed the ablation in the right atrium to prevent the early postoperative onset of atrial flutter: a single lesion was created along the crista terminalis from the superior vena cava to the inferior vena cava. A connecting lesion was then created from the lower end of this lesion onto the atrioventricular groove, low down and opposite the orifice of the coronary sinus, to create a block in the cavotricuspid isthmus area (Figure 1). Two patients underwent aortic valve replacement and the probe was applied on the epicardium of the dome of the left atrium, connecting the pulmonary veins, which had previously been isolated.

Antiarrhythmic prophylactic treatment was carried out on a routine basis. Amiodarone was the drug of choice. Its administration was begun after induction of anesthesia: 300 mg intravenous bolus, followed by 1200 mg/24 hours intravenously until the end of the first postoperative day; beginning with the second postoperative day, oral administration of 200 mg/24 hours was begun. After discharge, a maintenance regimen of 200 mg/24 hours was continued. The pharmacological treatment was discontinued 6 months after the operation.

Follow-up

The mean follow-up time was 15.5 months (range: 2-74 months). Clinical history and 12-lead electrocardiogram (ECG) were taken during each follow-up visit. Sinus rhythm was defined as a supraventricular rhythm with P waves on the standard 12-lead ECG.

TABLE 1. Preoperative characteristics and surgical procedures

Variable	n = 40	*P* value
Age (years)	62 ± 11.6	NS
Sex (male)	8	NS
Sex (female)	32	NS
LA dimension (mm)	56.05 ± 7.6	NS
AF duration (months)	61.9	NS
Ejection fraction (%)	56.8 ± 13.3	NS
NYHA class	2.8 ± 0.5	NS
MVR	13	
MVR + TVP	11	
MVR + AVR	8	
MVR + AVR + TVP	5	
TVP + ASD and VSD repair	—	
TVP + ASD repair	1	
AVR	1	
AVR + CABG	1	
Redo	6 (15%)	NS

AF, Atrial fibrillation; *ASD,* atrial septal defect; *AVR,* aortic valve replacement; *CABG,* coronary artery bypass graft; *LA,* left atrial; *MVR,* mitral valve replacement; *NYHA,* New York Heart Association; *TVP,* tricuspid valveplasty; *VSD,* ventricular septal defect.

Six months after surgery, echocardiography was performed, including transmitral and transtricuspid Doppler echocardiography. E and A waves were detected to evaluate the atrial contraction. At least 1 Holter monitoring of rhythm was performed in each patient 6 months after hospital discharge.

Statistical Analysis

Continuous variables are expressed as the mean ± SD. Student *t* test for paired data was used to assess the statistical significance of differences between pre- and postoperative parameters. A *P* value $<.05$ was considered significant. The following preoperative variables were considered for any possible relationship with surgical results: AF duration, age, and left atrial diameters. Survival was calculated according to the Kaplan-Meier method.

Results

As a consequence of the ablation there were no local or general complications, namely atrial wounds. Concomitant surgical procedures were: mitral valve replacement (n = 13), mitral valve replacement plus tricuspid valvuloplasty (n = 11), combined mitral and aortic valve replacement (n = 8), and combined mitral and aortic valve replacement plus tricuspid valvuloplasty (n = 5). Moreover, 1 patient underwent tricuspid valvuloplasty plus atrial septal defect repair and 2 patients required aortic valve replacement, 1 of whom also required coronary artery bypass graft. The mean cardiopulmonary bypass time was 126.3 ± 33.4 minutes and the crossclamp time was 104.8 ± 31.5 minutes. The mean intensive care unit stay was 2.4 days. The cumulative in-hospital mortality was 7.5%: 1 patient died of sepsis, 1 of severe hepatic cirrhosis (of 20 years), and 1 of left ventricular disruption. Three patients (7%) needed permanent

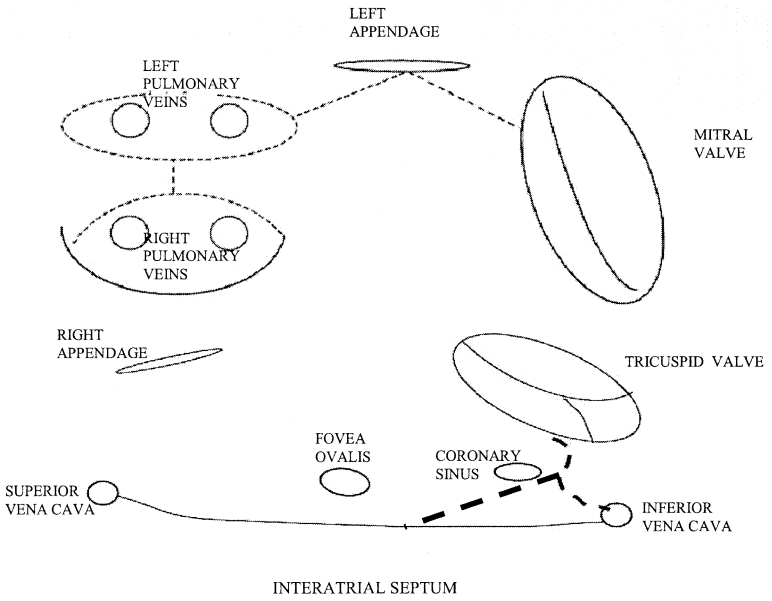

Figure 1. The surgical scheme of the RF ablation in the left and right atrium.

pacemakers implanted because of postoperative bradycardia. No patient had transitory neurologic symptoms after the surgical procedure. The cumulative rates of SR at discharge was 85%.

Follow-up

All 40 patients completed at least 6 months of follow-up. The duration of the follow-up ranged from 7 to 22 months (mean 16.5 ± 2.5). Cumulative survival was 92.8%. At the 12-lead ECG, the cumulative rate of SR was 88.5%. Biatrial contraction was documented during transthoracic Doppler echocardiography in 76.5% of the patients. Twenty-nine patients (72.5%) were under treatment with warfarin sodium and 9 patients (22.5%) were undergoing antiarrhythmic therapy (sotalol or amiodarone). We noted a significant improvement of the New York Heart Association (NYHA) functional class after surgery: 20 patients (50%) were in NYHA class I and 20 (50%) in NYHA class II.

Discussion

In 1991, Cox and colleagues[2-6] described a new procedure for the radical surgical treatment of atrial fibrillation: the maze procedure. Initially it was performed as an isolated cardiac procedure. However, as experience with this technique has grown, it has been performed concomitantly with other cardiac procedures.[7,8] It has been noted that the correction of the underlying cardiac pathology alone usually fails to abolish AF.[9] Kosakai and colleagues[10] have shown the advantage of the maze procedure for atrial fibrillation in patients undergoing simultaneous cardiac surgery. The negative effects of AF are widely known, particularly in combination with valve diseases. Therefore, a specific surgical intervention is needed to eliminate AF. Excellent results have been described for the surgical treatment of chronic AF associated with organic heart disease at the expense, however, of extensive atrial incisions and suturing and greater blood loss, as well as longer cardiac arrest.[11,12]

In an attempt to reduce the procedure time and to simplify the surgical technique, modifications of the original maze procedure have been developed,[13] including the application of RF energy.[14] Heat propagation is based on resistive and passive mechanisms. In the immediate proximity of the probe, tissue is heated to 50°C to 60°C with consequent coagulation and irreversible destruction of cell and collagen structures. Further away from the probe, the resistance offered by tissue decreases exponentially and the heart rate rapidly decreases. Thus, ablation of the peripheral portion of the lesion results from passive heating with the same effect of irreversible damage being reached over a longer period of time. Both resistive and passive heating propagate in all of the directions so that the tissue lesion is similar in depth and width. Once transmurality is achieved, the effects of RF lesions are the same as those of the other major techniques with effective ablation of atrial muscle, an antiarrhythmic effect, and no significant proarrhythmic activity from the scar tissue.[15]

The treatment of AF by the application of RF ablation in the atria is based on the concept of preventing functional macro-reentrant circuits[16] or eliminating anatomically determined circuits.[17] All the lesions are made in the endocardium and replace most of the surgical incisions of the

previous techniques. The RF ablation procedure requires 15 to 20 minutes of elective cardiac arrest time in contrast to at least 50 to 60 minutes of the Cox maze III procedure.[16,18] The importance of interrupting conduction along the coronary sinus to avoid the development of postsurgical atrial flutter has been recognized.[19] Therefore, we also performed RF ablation in the isthmus, between the tricuspid valve annulus and the inferior vena cava. In our study, patients had a long duration of AF (61.9 months) and large left atrial dimensions (56.05 ± 6 mm) but we did not find any statistically significant relationship between these preoperative data and the surgical results. Restoration of SR was demonstrated in 88.5% of patients at follow-up.

These data are comparable to the results documented by different groups,[20-25] who found restoration of SR between 70% and 98%, depending on patient preoperative characteristics (lone AF, concomitant heart diseases) and the surgical techniques. All our patients had chronic AF; 12.5% of the patients underwent combined mitral and aortic valve replacement plus tricuspid valvuloplasty and 15% (6 patients) of the previous patients were reoperations. Therefore, we believe that RF ablation should also be considered a safe and effective procedure in eliminating AF in patients suffering from a multiple valve disease and in those undergoing a reoperation.

An important aim of restoring SR is to produce the contraction of both atria, restoring an adequate electromechanical synchrony and decreasing the risk of thromboembolism. In our study, biatrial contraction was restored in 76.5% of the patients. Our data are equivalent to the data of other groups, reporting the occurrence of biatrial contraction in 66.7% to 99% of patients depending on the baseline characteristics.[26] RF ablation usually prolongs the cross-clamp time only of 10 to 15 minutes. This is a significant advantage in older patients with poor ventricular function and/or multiple valve disease, making it possible to enlarge the indications to restore sinus rhythm surgically.

In conclusion, we believe that the use of RF energy is safe and effective and simplifies the Cox maze III procedure in patients undergoing cardiac surgery, by restoring SR and atrial contraction in the majority of patients and also by reducing operating time.

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