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Radiofrequency Ablation for Treatment of Atrial Fibrillation

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ABSTRACT

Introduction: Atrial Fibrillation (AF) is the most common cardiac arrhythmia which represents a major public health problem. The main purpose of this research is to evaluate the Radiofrequency (RF) ablation effects in the patients with chronic AF scheduled for cardiac surgery because of different heart diseases. ***Methods:*** The descriptive and prospective study was conducted on 60 patients with AF scheduled for surgery along with RF ablation. The data were collected by questionnaire and included: patients' age, sex, NYHA class, operation type, past medical history, type and cause of valvular heart disease, preoperative ECG (electrocardiogram), duration of surgery, clamping time, cardiopulmonary bypass, and RF ablation time. RF ablation was followed by the main operation. The follow up examination, ECG, and echocardiography were performed 3 and 6 months after operation. ***Results:*** The mean age of patients was 48±10 years (18-71 years). Forty one patients had permanent AF and 19 had the persistent AF. The left ventricular ejection fraction was 48.27±9.75 percent before operation, and reached to 56.27±7.87 percent after the surgery (P<0.001). The mean NYHA class before the surgery was 2.83±0.68 which decreased to 1.34±0.46 6 months after the surgery with RF ablation (P<0.001). One patient (1.6%) died after surgery. Complete relief and freedom from AF recurrence was observed in 70% of patients in the mean follow up in 7 months after the surgery. The sinus rhythm with efficient atrial contraction was established in 100% of discharged patients. ***Conclusion:*** RF ablation is an effective procedure to cure atrial fibrillation in patients undergoing cardiac surgeries.

Introduction

Atrial Fibrillation (AF) is a supraventricular arrhythmia characterized by chaotic and uncoordinated contraction of the atrium (Chowdhury *et al.* 2009). AF is the most common cardiac arrhythmia and, therefore, represents a major public health problem (Mathew *et al.* 2009; Bonanno *et al.* 2009; Shamiss *et al.* 2009; Postma *et al.* 2009; Beukema *et al.* 2009) which has almost doubled each decade (Suzuki *et al.* 2009). The prevalence of AF is estimated at 0.4% in the general population, but it is higher in men and increases with age (Chen *et al.* 2008). It can be associated with hemodynamic impairment, reduced quality of life, and increased risks of systemic embolization, anticoagulant-related hemorrhage and mortality (Shamiss *et al.* 2009; Chen *et al.* 2008). AF is associated with valvular heart disease, especially with mitral valve (MV) lesions (Chen *et al.* 2008; Ferro *et al.* 2009; Kalavrouziotis *et al.* 2007). More than 40% of patients referred for mitral valve surgery have persistent AF, which was reported to have the potential risk to induce stroke (Funatsu *et al.* 2009; Kobayashi *et al.* 2002; Bando *et al.* 2002). It is also frequently seen in the postoperative period of cardiac surgery (Ferro *et al.* 2009).

The pathophysiology of AF is complex and likely has many possible mechanisms which may be interrelated (Mathew *et al.* 2009). In many patients, AF is thought to be triggered by ectopic activity originating in the pulmonary veins (figure 1a) and other specialized anatomic areas (Shamiss *et al.* 2009). AF involves a wide spectrum of arrhythmias from lone AF to paroxysmal to chronic AF. AF is an arrhythmia that may

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develop in several ways. Patients are older and have larger left atrial size and are more likely to have persistent/permanent AF. It is likely that AF comprises a spectrum of diseases with no single mechanism adequate enough to comprehensively explain AF and its variability (Mathew *et al.* 2009).

Treatment of AF is still widely debated due to the large variety of therapeutic options (Bonanno *et al.* 2009). Current therapeutic strategies include control of rate or rhythm, in combination with antiembolic treatment, in case of increased thromboembolic risk (Mathew *et al.* 2009; Shamiss *et al.* 2009; Postma *et al.* 2009). Cox maze III procedure is well known to be a reliable surgical option to eliminate AF (Funatsu *et al.* 2009; Cox *et al.* 2000). However, few surgeons have adopted the Cox maze III procedure, as it is a lengthy operation with extensive cutting, suturing and blood loss (Funatsu *et al.* 2009; Chen *et al.* 2008; Mokadam *et al.* 2004; Doukas *et al.* 2005). Several groups have successfully developed less invasive approaches using a number of different energy sources to create continuous lines of ablation to replace the surgical incisions (Shamiss *et al.* 2009; Chen *et al.* 2008; Kalarus *et al.* 2009; Burkhardt and Natale, 2009; Ehrlich and Hohnloser, 2009; Pappone and Santinelli, 2009; Lee *et al.* 2009).

Radiofrequency Catheter Ablation (RFCA), in which the pulmonary venous myocardium is isolated from the remainder of the left atrial myocardium (figure 1b), has become desirable in recent years (Postma *et al.* 2009; Bonanno *et al.* 2010). RFCA has emerged as an important treatment strategy for AF (Shamiss *et al.* 2009; Reynolds *et al.* 2009). Currently, the patient population undergoing AF ablation has greatly expanded (Mathew *et al.* 2009; Shamiss *et al.* 2009).

RFCA around pulmonary vein ostia and in the left atrium has been proposed as a technique to cure AF and is now performed with increasing success worldwide. However, few randomized controlled trials (RCTs) are available (Bonanno *et al.* 2009). The main purpose of this research is to evaluate the RFCA effects in the patients with chronic AF scheduled for cardiac surgery because of different heart diseases.

Materials and methods

This is a descriptive and prospective study, conducted on 60 patients referred to Shahid Madani Heart Hospital of Tabriz for cardiac operation from April 2006 to March 2008. Using simple randomized sampling, all patients with AF scheduled for surgery along with RF ablation (RF ablation) were enrolled in the study.

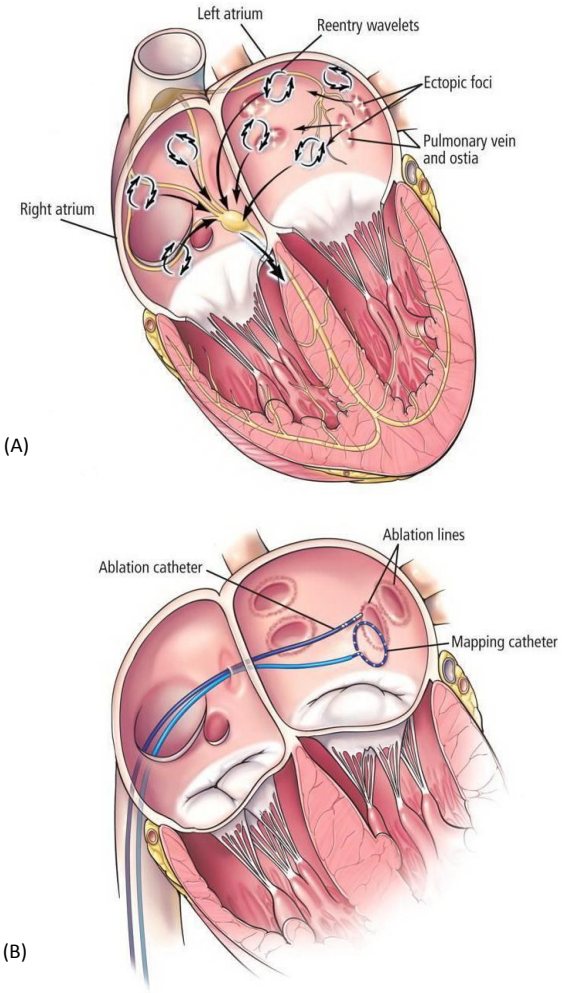

Fig. 1. Atrial fibrillation arising from ectopic foci, most of which are located in pulmonary veins (a); radiofrequency atrial ablation by creating lesions that electrically isolate the focal triggers of AF (b); by permission of medical illustrator: Joseph Pangrace.

The data were collected by questionnaire and included: patients' age, sex, NYHA class, operation type, and the information about coronary disease, the previous medical history, type and cause of valvular disease, preoperative ECG, duration of surgery, clamping time, CPB (cardiopulmonary bypass) time and the RF Ablation time during each operation. The patients were evaluated about the associated conditions such as the diabetes, hypertension, stroke or TIA (transient ischemic attack), and peripheral vascular disease as claudication, fatigue, foot sores, and numbness of extremities. All patients were evaluated about their activity tolerance and categorized based on the NYHA classification (grade I-IV). If the patients were receiving the anticoagulation warfarin, it was discontinued before operation and was replaced with heparin.

Paroxysmal AF was defined as at least two episodes that terminate spontaneously within 7 days. *Persistent AF*

was defined as lasting more than 7 days, or lasting less than 7 days but necessitating pharmacologic or electrical cardioversion. *Permanent AF* was defined as lasting more than 1 year (Chowdhury *et al.* 2009).

All patients were visited by an Anesthetic before the operation and received necessary premedications. The post-operation cares in the ICU was similar to those provided for other cardiac surgery patients. The temporary pace was inserted for all patients and used if necessary. The anti-arrhythmia and anti-coagulation drugs were not prescribed routinely for all patients. These drugs were used if the AF was recurrent or the prosthetic valve was used.

All operations were performed by an experienced surgeon and the anesthesia induction was performed according to the standard methods; CPB was established with bicaval technique after middle sternotomy in the presence of moderate hypothermia (Funatsu *et al.* 2009). The RF Ablation was performed before the main operation by USA made Cardioablator Modteronic. The contact time of unipolar electrode with atrium was maximally 120s, the goal temperature was 75°C, and the ablator output was 150W. The generator of RF ablator was controlling the tissue resistance, direction of voltage, and the ablation time during the surgery.

The resistance of contacting tissue was measured continuously every 200ms; and when the tissue resistance reached to a constant state, the monitor of ablator indicated that the tissue ablation has become complete. RF Ablation was followed by the main operation. Then, the patients were monitored for 4 days after the main surgery, daily ECGs were taken until their discharge from the hospital. The follow up examination, ECG, and echocardiography were performed 3 and 6 months after the surgery. The clinical follow up by the repeatedly visits was performed in the mentioned times. The mean follow up period was 7 months. In each follow up visit, the patients were evaluated for clinical condition and probable surgery complications, use of class III anti-arrhythmic drugs and warfarin. Ablation failure (relapsing AF during the 6 months after ablation surgery) was defined as presence of non-sinus rhythm as AF, atrial flutter and other irregular rhythms.

The echocardiography was performed by two experienced echocardiographists, and the patients LVEF (left Ventricular Ejection Fraction) and LV size was measured. Post-operative echocardiography and ECG were performed and recorded in ICU and in discharge time as well as 3 and 6 months after the surgery.

The collected data were analyzed by SPSS version 14.0 (SPSS Inc. Chicago, IL). Continuous data were reported as mean ± standard deviation. Categorical data were reported as frequency and percentage. Fisher's exact test was used to make statistical comparison between groups for categorical items. The Kaplan–Meier method was used to depict cumulative survival and freedom from the recurrence of permanent AF. Logistic regression was used to examine predictors of the recurrence of permanent AF and was reported as odds ratio and 95% confidence intervals. The P-values of less than 0.05 was considered as statistically significant (Funatsu *et al.* 2009; Aikawa *et al.* 2009).

Results

The mean age of studied patients was 48±10 years (range, 18 to 71 years). Forty one patients had the permanent AF and 19 patients had the persistent AF.

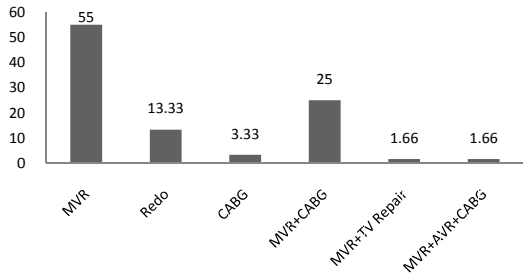

Fig. 2. Abundance of surgeries performed with the radiofrequency ablation.

The mean AF period before operation was 60±55 minutes in Permanent group and 26±23 minutes in Persistent group, and this difference was significant (P=0.03).

The LVEF was 48.27±9.75 percent before operation, and reached to 56.27±7.87 percent after the surgery, and this difference was significant (P<0.001). The LA Diameter before the surgery was 5.176±0.735cm and after 6 months decreased to 4.45±0.49cm (P=0.001). The surgery leads to clearing improvement of NYHA class patients. The mean NYHA class before the surgery was 2.83±0.68 which decreased to 1.34±0.46, 6 months after the surgery with RF ablation (P<0.0001). The patients' medical history is provided in Table 1.

Table 1. The patients' medical history

	Number
Hypertension controlled by drug	08
Diabetes	06
Cigarette smoking (>10 years)	06
Anti-arrhythmia drug use	60
Warfarin use	28
Transient ischemic attack (TIA)	03
Stroke	01
Non-cardiac surgery	11
The heart surgery	08
Myocardial infarction (MI)	04
Hospitalization because of non-cardiac disease	22
Family history of heart disease	10

All patients were under treatment of anti-arrhythmic drugs, amiodarone and Inderal because of chronic AF; also, most of them were using warfarin. The grade III and IV systolic murmur was heard in 58 patients in preoperative examination. Examination of lungs revealed diffused rales because of COPD in four patients.

Echocardiography was performed in all patients after the surgery and was compared with the preoperative echocardiography findings with regard to the LA Diameter, EF, and the left atrium contractility. Effective Atrial contraction was recognized in all patients who had the normal sinus rhythm during the follow up (70% of patients) period. The sinus rhythm with effective atrial contraction was observed in 100% of patients in 6 months after the surgery. The pump time was 32±142 minutes and the aorta clamping time was 24±120. The average usage of RF Ablation was 4±18 minutes.

Table 2. Causes of the patient's referral

Reason	Abundance	Percent
Mitral valve replacement	33	55
Mitral valve stenosis and regurgitation due to rheumatic cause	23	38
Mitral regurgitation	06	10

The hospitalized death following the surgery happened in ICU in one case (1.6%) which occurred suddenly. The patient was 40 years old women who underwent mitral valve replacement with RF ablation surgery because of mitral valve stenosis and insufficiency and chronic AF. She transferred to ICU with good hemodynamic status but an hour after entering ICU affected by sudden cardiac arrest and in spite of supportive measures and treatments expired 5 days after the operation. Three patients had hemodynamic disorder due to blood loss and decreased blood pressure, which reoperated for hemostasis and draining the clots.

Eight patients had ventricular tachycardia in whom the sinus rhythm reestablished by medical therapy and electrical shock in one case. Forty one patients had sinus rhythm in transferring from operation room to ICU. Five patients had flutter and others had AF. Fifty four patients conveyed to ward after 3 days of ICU stay, and 50 patients discharged after 9 days. Most of early recurrences occurred in hospital before discharge. Most of recurrences occurred during 2 weeks after the surgery, and then decreased. Complete relief and freedom from AF recurrence was observed in 70% of patients in the mean follow up in 7 months after the surgery. Of 18 uncured patients (30%), 15 patients (25%) had permanent AF before the surgery and 3 patients (5%) had redo surgery. Thirty-eight patients were evaluated by echocardiography, ECG and chest X-ray in 1 and 3 years after the surgery, of which 75% had sinus rhythm.

Eighteen patients who did not achieved reestablished sinus rhythm, had preoperative EF of 49±9 percent. Reversely, the preoperative EF in the group who achieved reestablished sinus rhythm was 51±8 percent ($p<0.04$). The sinus rhythm with efficient atrial contraction was established in 100% of patients. The anti-arrhythmic drug was stopped in 42% of patients after 6 mouths. The warfarin use continued regularly because of the presence of mechanical valve. The wound infection was diagnosed in 2 cases during examination at the clinic two weeks after the surgery, which both treated with conservative management. There was not any case of mediastinitis. The temporary pace was used for 3 days after surgery because of the block in 5 cases. Two patients had cardiac tamponade and underwent the reoperation for pericardial fluid drainage 30 days after the surgery. Four patients had transient stroke that cured. Two patients had need for insertion of permanent pacemaker after the surgery.

Discussion

In general, AF is associated with a doubling of cardiovascular mortality, an increased risk of systemic emboli and stroke (Beukema *et al.* 2009). The deleterious effects of AF include loss of effective atrial contraction and atrioventricular synchrony, which may compromise hemodynamic performance and cause stasis of blood flow within the atrium that leads to thrombus formation and systemic thromboembolic complications (Aikawa *et al.* 2009; Fujino *et al.* 2007).

The rationale for restoring sinus rhythm includes improving survival, lessening the risk of thromboembolism, eliminating the necessity for oral anticoagulation, preserving atrial contraction and improving cardiac output (Funatsu *et al.* 2009). So, the AF management involves three facets: rate control; prevention of thromboembolism; and the restoration of sinus rhythm. The data available on the clinical relationship between sinus node dysfunction and AF suggest that the sinoatrial (SA) node is probably passive during AF (Mathew *et al.* 2009; Nattel, S., 2002).

Pharmacologic treatment has been used for decades for conversion and prevention of recurrent AF (Lee, J., 2002). Attention must be directed to antithrombotic therapy for prevention of thromboembolism (Mathew *et al.* 2009; Fuster *et al.* 2006). AF investigators reported that warfarin reduced the risk of death by 33% and that warfarin is the only pharmacologic therapy that has been reported to improve survival in AF (Mathew *et al.* 2009). However, many patients with AF who are thought to be low risk for AF associated stroke do not substantially benefit from anticoagulation (Mathew *et al.* 2009). In our series, the anti-arrhythmia and anti-coagulation

drugs were not prescribed routinely for all patients. These drugs were used if the AF was recurrent or the prosthetic valve was used.

While the cornerstone of long-term AF management is usually anticoagulation with rate and/or rhythm control, there are several additional treatment options. It has been reported many management options available for AF with benefits and disadvantages of each (Mathew *et al.* 2009). The use of antiarrhythmic drugs is associated with substantial side effects and mortality in some patients. Accordingly, it is not surprising that non-pharmacologic techniques have been developed for the management of AF, including the use of atrial defibrillators, atrial pacing methods, and several surgical and RFCA procedures (Lee, J., 2002). The maze procedure for the surgical ablation of AF is a widely used adjunctive therapy (Aikawa *et al.* 2009) promoted by Cox *et al*. (Funatsu *et al.* 2009; Cox *et al.* 2000). Some major modifications, such as cryoablation, RF, and microwave were launched to minimize the invasive, time consuming and complicating aspects of the cut-and-sew technique (Funatsu *et al.* 2009; Kobayashi *et al.* 2002; Mokadam *et al.* 2004; Doukas *et al.* 2005; Nakajima *et al.* 2002; Izumoto *et al.* 2000; Knaut *et al.* 2002).

Since most of the triggers of AF are located within the pulmonary veins, one can use an empiric anatomic approach, creating a ring of ablation lesions around the outside of the ostium of each of the four pulmonary veins. The aim is to electrically isolate these veins (Chowdhury *et al.* 2009).

Meta-analyses suggest that a Maze surgical ablation procedure at the time of MV surgery is associated with a reduced postoperative AF risk. Economic model suggests that the surgical ablation strategy at the time of mitral valve surgery is likely a cost-effective intervention, provided patients have a good long-term postsurgical prognosis (Quenneville *et al.* 2009). Funatsu *et al*. showed that cryoablation based maze procedure for AF adjunct to mitral valve surgery is an effective and long-term promising solution for restoring sinus rhythm. Patient selection criterion concerning left atrial size, duration of AF and f-wave voltage might be reasonable to improve the results (Funatsu *et al.* 2009).

Since its earliest reports, little more than one decade ago, RFCA for AF has undergone rapid evolution in its techniques and emerged as an important option in the management of AF patients (Reynolds *et al.* 2009; Bevilacqua *et al.* 2009; Calkins *et al.* 2007). Today, RF ablation of AF has become a treatment option for younger and older patients as stand-alone therapy or as hybrid therapy with antiarrhythmic drugs (AADs). RFCA is associated with decreased healthcare resource utilization in all age groups (Kusumoto *et al.* 2009). Several small randomized studies have established that ablation reduces AF recurrence more effectively than AADs in patients who have failed previous AAD treatment, and yields superior improvements in symptoms and quality of life (Reynolds *et al.* 2009; Srivatsa U.N., 2010). Studies of RFCA for treatment of AF report higher efficacy rates than do studies of AAD therapy and a lower rate of complications (Calkins *et al.* 2009).

A 50-patient multicenter study demonstrated 80% short-term rate and 66% success rate at 20 months, with a low complication rate and a relatively short procedure time in patients with persistent AF using RF ablation (Scharf *et al.* 2009).

In a meta-analysis (2009), a total of eight randomized controlled trials (RCTs) were identified including 844 patients. Overall, 98 (23.2%) out of 421 patients in the treatment group and 324 (76.6%) outof 423 patients in the control group had atrial tachyarrhythmia recurrence. RFCA decreased atrial tachyarrhythmia recurrence by 71%. Fewer complications and adverse events were reported in the ablation group compared with the control group (Bonanno *et al.* 2009).

RFCA with/without AAD for symptomatic, drug-refractory paroxysmal AF appears to be reasonably cost-effective compared with AAD therapy alone from the perspective of the US health care system, based on improved quality of life and avoidance of future health care costs (Reynolds *et al.* 2009). In a prospective study, 100 patients with symptomatic paroxysmal, persistent or permanent AF were treated by RF in the left atrium. In the patients with paroxysmal AF, success was judged as complete in 21 out of the 35 (60%). The benefit was lower in patients with persistent arrhythmia (19 out of 42, 45%). In the 23 patients with permanent AF, there were 16 failures (69%) with recurrence of AF in 10 patients the day after the procedure. There were 13 patients (13%) with minor complications (Chevalier *et al.* 2009).

Many of our patients had the sinus rhythm at the discharging time. Our results indicate the progressive decreasing in the size of left atrium following the Ablation. The most important point of this study is the measurement of the left atrium size and its function by echocardiography before and after the surgery. Also, any type of atrial arrhythmia was considered in 3 months after the returning. Although the obtained results were not excellent, but were in favorable range and decreased the patient's drug use.

Complications of catheter-based treatment of AF were described by the expert consensus committee including: cardiac tamponade, pulmonary vein stenosis, phrenic nerve injury, esophageal injury, atrio-esophageal fistula, peri-esophageal vagal injury, thromboembolic events,

vascular complications, acute coronary artery occlusion, air emboli from catheters and sheath, catheter entrapment in the mitral valve, tachyarrhythmias, radiation exposure, and Mitral valve trauma (Chowdhury *et al*. 2009). In this study, we had one death and three cases of hemodynamic disorders; and there was not any dangerous and constant complication.

Conclusion

The results indicate that RF Ablation is an effective procedure in AF improvement in the patients undergoing cardiac surgery. RFCA established the constant sinus rhythm (in 70% of patients). The Redo operation, low LVEF before the surgery decreases its effectiveness. This procedure leads to returning the atrial contraction, increasing the cardiac output and improving the patients' NYHA class. It is concluded that in selected patients with AF, RFCA is a relatively effective and well-tolerated procedure to cure AF. Even though the results of our systematic review favor ablation therapy, large, well-designed RCTs are needed to confirm the efficacy and safety of RFCA for the management of AF.

Ethical issues

None to be declared.

Conflict of interests

No conflict of interest to be declared.

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