

## Mid-term results of surgical radiofrequency ablation for permanent atrial fibrillation

Erişkinlerdeki ventriküler septal defektlerin perkütan kapatılmasında ilk deneyimlerimiz

Ilker Mataracı, M.D., Adil Polat, M.D.,<sup>1</sup> Bulent Mert, M.D.,<sup>2</sup> Mehmet Aksut, M.D., Kaan Kirali, M.D.

Kartal Kosuyolu Yuksek Ihtisas Training and Research Hospital, Department of Cardiovascular Surgery, Istanbul;

<sup>1</sup>Elazig Military Hospital, Elazig; <sup>2</sup>Numune Hospital, Department of Cardiovascular Surgery, Sivas

**Objectives:** Atrial fibrillation (AF) is a common problem in cardiac surgery patients. We evaluated the mid-term results of patients who underwent open heart surgery and radiofrequency ablation (RFA).

**Study Design:** The study included 79 patients (53 females, 26 males; mean age 53±11 years; range 32 to 76 years) who underwent concomitant RFA for AF during open heart surgery under cardiopulmonary bypass. The majority of patients were in NYHA class III (n=68, 86.1%) and had rheumatic heart disease (n=67, 84.8%). The mean preoperative AF duration was 47±41 months. The most frequent procedure involved the mitral valve (64 replacements, 11 reconstructions). A unipolar probe was used in 60 patients (76%) and a bipolar probe in 19 patients (24.1%). The mean follow-up period was 20.8±14.7 months (range 1 to 59 months).

**Results:** The mean perfusion and cross-clamp times were 102.4±15.7 min (range 48 to 171 min) and 76.1±25.0 min (range 27 to 145 min), respectively. In-hospital mortality occurred in two patients (2.5%) and late mortality occurred in three patients (3.8%). One patient (1.3%) required implantation of a permanent pacemaker. During discharge, 58 patients (73.4%) were in sinus rhythm, of which nine (15.3%) developed recurrent AF within a mean of 5.3±4.4 months (range 2 to 12 months). Transient atrial flutter was seen in three patients (3.8%). Logistic regression analysis showed no risk factor to significantly affect early or late AF recurrence. Six- and 12-month rates of AF-free rhythm were 94.3±3.9% and 87.6±5.9% for operations performed by the year 2006 and 95.2±3.3% and 92.2±4.4 afterwards, respectively (p=0.0001). There was no significant difference with respect to survival between patients discharged with AF and in sinus rhythm (p>0.05).

**Conclusion:** Radiofrequency ablation is increasingly performed for the treatment of AF, yielding more successful results.

**Key words:** Aortic valve/surgery; atrial fibrillation/surgery; cardiopulmonary bypass; catheter ablation/methods; heart valve diseases/surgery.

**Amaç:** Atriyal fibrilasyon (AF) açık kalp cerrahisi uygulanan hastalarda sık karşılaşılan bir sorundur. Bu çalışmada açık kalp ameliyatına alınarak radyofrekans ablasyon (RFA) uygulanan hastaların orta dönem sonuçları incelendi.

**Çalışma planı:** Çalışmaya açık kalp cerrahisiyle birlikte kalıcı AF nedeniyle eşzamanlı olarak RFA uygulanan 79 hasta (53 kadın, 26 erkek; ort. yaş 53±11; dağılım 32-76) alındı. Hastaların büyük çoğunluğu (68 hasta, %86.1) NYHA sınıf III idi; 67 hastada (%84.8) romatizmal kalp hastalığı vardı. Ameliyat öncesi ortalama AF süresi 47±41 ay idi. Tüm hastalar kardiyopulmoner bypass kullanılarak ameliyat edildi. En sık uygulanan işlem mitral kapak işlemliydi (64 replasman 11 rekonstrüksiyon). Altmış hastada (%76) unipolar, 19 hastada (%24.1) bipolar prob kullanıldı. Ortalama takip süresi 20.8±14.7 ay (dağılım 1-59 ay) idi.

**Bulgular:** Ortalama perfüzyon ve kros-klamp süreleri sırasıyla 102.4±15.7 dk (dağılım 48-171 dk) ve 76.1±25.0 dk (dağılım 27-145 dk) bulundu. Hastane mortalitesi iki hastada (%2.5), geç dönem mortalite üç hastada (%3.8) görüldü. Ameliyat sonrası dönemde bir hastaya kalıcı yürek pili (%1.3) yerleştirildi. Taburculuk sırasında 58 hasta (%73.4) sinüs ritminde idi. Bu hastaların dokuzunda (%15.3) yeniden AF gelişti. Ortalama AF gelişme süresi 5.3±4.4 ay (dağılım 2-12 ay) idi. Üç hastada (%3.8) kısa süreli atriyal flutter görüldü. Lojistik regresyon analizinde erken ve geç dönemde AF gelişim riskini artıracak bir faktör saptanmadı. 2006 yılı öncesi ve sonrası yapılan ameliyatlarda 6. ve 12. aylarda sinüs ritminde seyir oranları ilk dönem için sırasıyla %94.3±3.9 ve %87.6±5.9, ikinci dönem için %95.2±3.3 ile %92.2±4.4 bulundu (p=0.0001). Atriyal fibrilasyon ve sinüs ritmi ile taburcu edilen hasta grupları arasında ortalama sağkalım açısından anlamlı fark bulunmadı (p>0.05).

**Sonuç:** Atriyal fibrilasyonun RFA ile tedavisi giderek artan sıklıkta kullanılmakta ve başarı oranları da gün geçtikçe artmaktadır.

**Anahtar sözcükler:** Aort kapağı/cerrahi; atriyal fibrilasyon/cerrahi; kardiyopulmoner paypas; kateter ablasyon; kalp kapağı hastalığı/cerrahi.

Received: 12.12.2008 Accepted: 16.04.2009

Corresponding address: Dr. İlker Mataracı, Kartal Koşuyolu Yüksek İhtisas Eğitim ve Araştırma Hastanesi, Kalp ve Damar Cerrahisi Kliniği, 34160 Cevizli, Kartal, İstanbul. Tel: +90 - 216 - 459 44 40 e-mail: imataraci@gmail.com

The prevalence of atrial fibrillation (AF) ranges from 1% to 4% and is observed to increase with age.<sup>[1]</sup> The prevalence is higher in patients with congestive heart failure and valvular heart disease and is more important for the patients undergoing open heart surgery. A total of 5% of the patients who present to the hospital due to cardiovascular diseases are observed to have atrial fibrillation.<sup>[2]</sup> Diseases and death due to AF has gained more importance in the treatment of atrial fibrillation particularly in recent years.

In this study, we evaluated the mid-term results of radiofrequency ablation (RFA) which has increasingly been in common use recently and factors which affect the post-operative mortality rate and maintenance of normal sinus rhythm.

### PATIENTS AND METHODS

Concomitant RFA for permanent AF was performed on a total of 79 patients (53 females, 26 males; mean age 53±11 years; range 32 to 76 years) who were hospitalized in our clinic and scheduled for open heart surgery under cardiopulmonary bypass. The mean AF time was 47±41 months (range 6 to 192 months).

Angiotensin converting enzymes (ACE) inhibitors were the most commonly used treatment preoperatively (n=76). Diuretics were used at various doses in 71 patients (NYHA class III-IV). A total of 22 patients used digitalis (0.25 mg/day), 21 patients used digitalis (0.25 mg/day) plus verapamil (120 mg/day), and 36 patients used metoprolol (100 mg/day), as antiarrhythmic therapy. A total of 57 patients with pulmonary hypertension used nitrate, while patients below the age of 60 (n=22) received warfarin for anticoagulation. Warfarin treatment was discontinued five days prior to surgery. Preoperative amiodarone use was avoided to minimize preoperative and postoperative side effects. Surgical indications of the patients are summarized in Table 1. Ascending aortic replacement was performed on one of the patients who underwent aortic valve replacement. Atrial septal defects and patent foramen ovale were detected in 2 patients and 1 patient, respectively, who were scheduled to undergo surgery due to rheumatic valvular disease (RVD). In addition to RFA, coronary

bypass (CABG) was performed on 2 patients who underwent surgery due to coronary artery disease, while concomitant valvular procedures were performed on six patients.

Majority of the patients (n=68, 86.1%) were in NYHA class III, while the rest were in NYHA class II (n=7, 8.9%), class IV (n=3, 3.8%) and class I (n=1, 1.3%). Eight of the patients (10.1%) had a history of prior open heart surgery. A total of 23 (29.1%) had a history of cigarette smoking, while 15 patients (19%) had a history of chronic obstructive pulmonary disease, 17 patients (21.5%) were hypertensive, and six patients (7.6%) were diabetics.

Preoperative mean size of the left atrium (LA) of the patients was 51.8±7.9 mm (range 28-65 mm), whereas 14 patients (17.7%) had a LA size of ≥60 mm. Mean ejection fraction (EF) was 56%±10 (range 25-70%), and was ≤40% in 10 patients (12.7%). The preoperative pulmonary artery pressure (PAP) was 50.7±15.2 mmHg (range 24-105 mmHg), whereas 57 patients (72.2%) had a PAP of ≥40 mmHg. The preoperative risk evaluation revealed a mean standard EuroSCORE value of 2.8±2.0 (range 0-8), and a logistic EuroSCORE value of 2.7±2.4% (range 0.9%-14.4%).

**Unipolar ablation.** Standard cardiopulmonary bypass (CPB) was instituted following median sternotomy. Left atriotomy was performed following cross-clamping. A Cardioblade surgical ablation pen with serum irrigation (Model 60813, Medtronic Inc, Minneapolis, MN, USA) was used for endocardial ablation. A 25-30-watt radiofrequency energy was applied over a period of 10-15 seconds. Thrombectomy and internal-external ligation of the left atrial appendage was performed on patients with a thrombus in the left atrium. Initially, the right pulmonary veins were isolated forming a half-moon shaped lesion and uniting the two ends by left atriotomy incision. The left pulmonary veins were then isolated forming ellipsoid lesions. These isolated islets were united by a smooth line. The procedure was completed by the formation of a linear lesion from the left pulmonary islet to the LA appendage and the posterior annulus of the mitral valve (Figure 1a). Mitral valve repair was performed following completion of the ablation to avoid possible thermal damage to suture materials.

**Bipolar ablation.** A Cardioblade surgical ablation pen with serum irrigation (Model 60813, Medtronic Inc, Minneapolis, MN, USA) was used for bipolar ablation. Standard cardiopulmonary bypass (CPB) was instituted following median sternotomy. The left pulmonary veins were explored and released; both pulmonary venous islets were isolated through the applicati-

**Table 1. Surgical indications**

	Number	Percentage
Rheumatic mitral valve disease	67	84.8
Degenerative mitral valve disease	8	10.1
Coronary artery disease	8	10.1
Congenital artery disease	3	3.8
Aortic valvular stenosis	16	20.3
Ascending aortic aneurysm	1	1.3

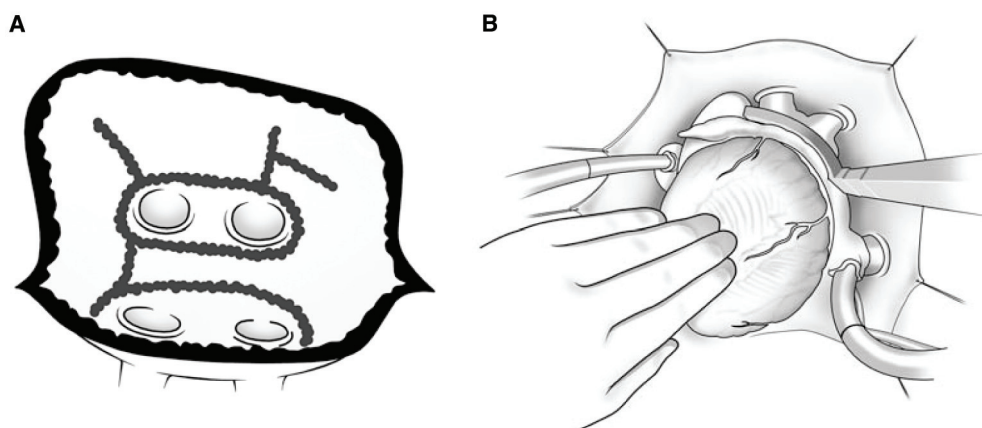


Figure 1. Ablation line: (A) unipolar, (B) bipolar.

on of epicardial bipolar ablation. The bipolar ablation technique was preferred when LA could not open during surgical procedures such as CAGB and aortic valve repair. The lesion was then formed on the LA appendage by epicardial ablation (Figure 1b).

Amiodarone infusion at the loading dose of 600-800 mg/day was initiated for all patients following cross-clamping and all patients were implanted with temporary epicardial pacemaker. Internal electromechanical cardioversion was performed on patients who developed AF following decannulation. All procedures performed are shown in Table 2.

All patients were closely monitored in the intensive care unit (ICU). A 12-lead electrocardiography was performed for rhythm control. Amiodarone administration which was All initiated in every patient during surgery was continued in the ICU after surgery. Amiodarone infusion was discontinued in two of the patients with decreased heart rate and a temporary pacemaker was implanted for support. The dose of amiodarone infusion was reduced in patients with electrocardiographically-confirmed (ECG) prolonged PR interval. Patients recei-

ving inotropes (at low dose or short-term) due to any reason were considered to have received inotropic support.

Following discharge, all patients were evaluated by routine examination in the outpatient clinic. Amiodarone was recommended as an antiarrhythmic agent for a minimum of three months. Patients were monitored by ECG in the first week and first month. A 24-hour Holter ECG monitoring was performed at 3 months in addition to following-up echocardiography and ECG after surgery. All antiarrhythmics were discontinued in patients who were in normal sinus rhythm during the three months follow-up. Patients were assessed biannually for 2 years and annually for the subsequent years.

Data were collected from the hospital medical records. Phone calls were made to all patients who were being followed up at the out-patients clinic in order to obtain information about their current conditions. All continuous variables were expressed as mean  $\pm$  standard deviation, while non-continuous variables were expressed as percentages. Continuous variables were also compared by the paired t-test, while logistic regression was used to analyze risk factors.  $P < 0.05$  was considered statistically significant. An independent t-test was used to assess data related to unipolar and bipolar ablation during surgery. In addition, the Kaplan-Meier test was used to estimate the survival rate and recurrence rate of AF, whereas Cox regression test was performed to assess the cumulative risks. Survival rates were expressed together with 95% confidence interval (CI). The SPSS 16.0 program was used for all statistical analysis.

## RESULTS

Mean perfusion time and cross-clamp time were  $102.4 \pm 15.7$  min (range 48 to 171 min) and  $76.1 \pm 25.0$

Table 2. Procedures performed on the patients

	Number	Percentage
Mitral valve replacement	64	81.0
Tricuspid reconstruction	29	36.7
Aortic valve replacement	16	20.3
Mitral reconstruction	11	13.9
Left atrial thrombectomy	8	10.1
Left atrial appendage ligation	8	10.1
Coronary artery bypass grafting	8	10.1
Atrial septal defect/patent foramen ovale repair	3	3.8
Ascending aortic replacement	1	1.3

**Table 3. Comparison of data in patients who underwent unipolar and bipolar ablation**

	Unipolar (n=60)	Bipolar (n=19)	p
Age	52.6±10.9	55.4±11.7	0.352
Left atrial diameter (mm)	53.0±6.96	48.0±9.4	<b>0.015</b>
Ejection fraction (%)	56.2±9.7	53.9±10.6	0.384
Pulmonary artery pressure (mmHg)	51.3±13.8	49.0±19.1	0.563
EuroSCORE (Standard)	2.8±2.0	2.7±2.2	0.981
EuroSCORE (Logistic %)	2.7±2.3	2.7±3.0	0.996
Atrial fibrillation duration (month)	34.3±27.0	51.0±31.0	<b>0.038</b>
Aortic cross-clamping time (min)	71.8±20.0	89.5±33.9	<b>0.042</b>
Total perfusion time (min)	97.1±24.6	119.4±36.5	<b>0.020</b>
Duration of surgery (min)	181.5±48.1	199.2±70.3	0.218
Length of stay in the intensive care unit (days)	2.5±1.1	3.5±2.8	0.155
Length of hospitalization (days)	8.5±3.1	9.1±5.3	0.680
Follow-up duration for sinus rhythm (patients/month)	15.5±16.5	10.5±12.4	0.166
Total follow-up duration (patients/month)	22.3±15.1	13.7±12.4	<b>0.026</b>

min (range 27 to 145 min), respectively. The mean length of stay in the ICU and hospital were  $2.8 \pm 1.6$  days (range 1-24 days) and  $8.9 \pm 3.5$  days (range 10-14 days), respectively.

All data related to unipolar and bipolar ablation are shown in Table 3. Postoperative morbidity rate is given in Table 4. The follow-up echocardiography at 6 months after discharge revealed LA and EF values as  $45.6 \pm 14.4$  mm and  $51.0\% \pm 14.0\%$ , respectively. The LA diameter was not significantly different from the preoperative values ( $p=0.592$ ), whereas the EF values were found to be significantly decreased ( $p=0.0001$ ).

All patients who were in normal sinus rhythm following surgery were transferred to the ICU. Twenty seven patients (34.2%) developed early AF, six of whom returned to normal sinus rhythm following amiodarone infusion. Cardioversion was performed on the remaining 21 patients; however normal sinus rhythm was not restored.

A total of 58 patients (73.4%) were in normal sinus rhythm at discharge, of which nine (15.3%) developed recurrent AF within a mean period of  $5.3 \pm 4.4$  months (range 2 to 12 months). A 24-hour Holter ECG monitoring performed at three months after surgery revealed

that two of the patients (3.5%) who were discharged on normal sinus rhythm developed AF and three of the patients (3.8%) who developed atrial flutter within a short period of time continued to receive antiarrhythmic treatment. No other treatment protocol was scheduled for patients who developed atrial flutter. Antiarrhythmic treatment was repeated every three months until the Holter-ECG monitoring revealed normal sinus rhythm.

Evaluation of factors which affected recurrent AF following discharge, including sex, NYHA class, EF of  $\leq 40\%$ , LA diameter of  $>60$  mm, pulmonary hypertension (PHT) (PAP of  $\geq 40$  mmHg), presence of RVD, preoperative AF duration, radiofrequency probe used during the surgery, and any postoperative morbidity demonstrated that there was no significant effect on the development of AF ( $p>0.05$ ).

The mean sinus rhythm follow-up period of the patients was  $19.1 \pm 15.4$  months (range 1-59 months) (cumulative 94 patients/year). Rate of prognosis without AF for patients discharged with normal sinus rhythm was  $96.1\% \pm 2.7\%$  at 6 months,  $93.7\% \pm 3.6\%$  at 12 months,  $91.1\% \pm 4.3\%$  at 18 months and  $82.8\% \pm 6.0\%$  at 24 months. Based on Kaplan-Meier test, mean survival was found to be  $34.8 \pm 2.9$  months (95% CI 29.1-40.4) in patients with normal sinus rhythm. Factors which might affect survival independently from AF (sex, preoperative LA of  $>60$  mm, PHT, RVD, preoperative AF duration, previous isolated CABG and previous CABG + valvular intervention) were assessed by the log-rank (Mantel-Cox) test and no significant effect of any of these factors was recorded ( $p>0.05$ ).

In order to evaluate our experience on patients who underwent surgery, we compared the patients based on the surgical intervention date. The survival rate was thus found to be different in patients with normal sinus

**Table 4. Postoperative morbidities**

	Number	Percentage
Inotropic support	33	41.8
Prolonged mechanical ventilatory support	3	3.8
Atrial flutter	3	3.8
Renal failure	2	2.5
Congestive heart failure	2	2.5
Bleeding requiring reoperation	1	1.3
Pacemaker implantation	1	1.3
Multiple organ failure	1	1.3

rhythm. When surgical intervention performed between 2003-2006 and 2006-2008 (September) were compared, we found survival rate to be  $94.3\% \pm 3.9\%$  and  $87.6\% \pm 5.9\%$  at 6 and 12 months, respectively for the first period in patients who were discharged with normal sinus rhythm. This rate was found to be  $95.2\% \pm 3.3\%$  and  $92.2\% \pm 4.4\%$  at 6 and 12 months, respectively for the second period. The difference was also found to be significant by log-rank (Mantel-Cox) test ( $p=0.0001$ ).

Overall follow-up period was  $20.8 \pm 14.7$  months (range 1-59 months) (cumulative 133.3 patients/year). Early in-hospital mortality was seen in 2 of the patients (2.5%), while late mortality was seen in 3 patients (3.8%) who underwent surgery due to rheumatic mitral valve disease. The patients including two males and one female were 45, 54 and 70 years old. The 70 year-old patient was in NYHA class IV preoperatively and had a history of low EF, PHT, and chronic obstructive pulmonary disease. At the 4th postoperative month the patient died in spite of being discharged with AF rhythm. The other two patients with history of previous cardiac surgery had improved cardiac functions (EF 50% and 55%). Their only need was postoperative low dose inotropic support. One of the patients discharged with normal sinus rhythm developed AF 12 months after surgery and died four months following an embolic cerebral event. The other patient who was discharged with AF rhythm also died due to stroke at 9 months.

The survival rate was  $94.4\% \pm 5.4\%$  and  $87.2\% \pm 8.6\%$  at 6 months and 12 months, respectively (estimated mean survival was  $45.3 \pm 3.8$ , 95% CI 38.0-52.7) in patients discharged with AF rhythm. On the other hand, the survival rate was found to be 100% and  $97.2\% \pm 2.7\%$  at 12 months and 18 months, respectively (estimated mean survival  $57.8 \pm 1.2$ , 95% CI 55.5-60.1) in patients discharged with normal sinus rhythm. However, no significant difference was found between patients discharged with AF and sinus rhythm with regards to the mean survival through comparison made by the log-rank (Mantel-Cox) test ( $p=0.101$ ).

## DISCUSSION

There are two important reasons for permanent AF therapy in patients undergoing cardiac surgery: (i) These patients are already going to undergo surgery due to some other reason and (ii) their morbidity and mortality rates are higher than those observed in other patients with normal sinus rhythm.<sup>[3]</sup> So far, many studies have been conducted to investigate the prevalence of AF and association between the prevalence of the disease and its relation with age in Turkey.<sup>[1]</sup> Morbidity and

mortality due to atrial fibrillation can be prevented by early interventions.

Permanent AF results from an atrial substrate containing multi-reentry waves. Although several ectopic foci can be found in the superior vena cava, crista terminalis, coronary sinus, Marshall vein, interatrial septum or in the left atrial posterior wall, the disease mainly originates from pulmonary veins (PV).<sup>[4]</sup> In the early years, isolation of this site has long commonly been performed by the Cox-Maze procedure which is not normally preferred due to the high rate of comorbidity and complexity of use.<sup>[5]</sup> On the other hand, developments in the catheter ablation technique pioneered by Haïssaguerre et al.<sup>[6,7]</sup> is on the increase in interventional cardiology. The major aim of these techniques is to prevent stimulation of an AF wave which can result from the isolated PV site and other possible non-PV sources.<sup>[8,9]</sup> Radiofrequency ablation is becoming widely used since meets such needs, can be performed at the same time with other procedures and does not lead to any additional morbidity as seen in Cox-Maze procedure.<sup>[10]</sup>

RFA performed during surgery may cause thermal damage to the endocardium, subendocardium and adjacent atrial tissues up to a certain depth. Histological studies have reported transmural lesion formation in only 75% of the patients.<sup>[11]</sup> In addition, normal sinus rhythm was also reported to be present at discharge in 73.4% of the patients. Guang et al.<sup>[10]</sup> also reported a similar rate and emphasized that this approach was more successful in cases where the underlying pathologies were corrected without ablation. Surgical ablation is also superior to catheter ablation since it can provide a complete conduction blockade. The importance of this is emphasized in the development of recurrence and flutter following catheter ablation.<sup>[7,12]</sup>

Factors which affect the outcomes of surgery have been the subject of many studies. The left atrial size was reported to influence postoperative success rate.<sup>[13]</sup> Duran et al.<sup>[14]</sup> also reported that LA diameter as well as female sex, concomitant mitral stenosis and advanced age was a strong predictor for AF and the threshold value was 5.5 cm. Consistent with other references, we did not find any significant result when investigating the effect of LA diameter of  $\geq 60$  mm. However, decrease in LA size and restoration of the tissue following ablation suggest that LA size is a variable that should be taken into consideration.<sup>[15]</sup> In another study, an enlarged atrium has been reported to facilitate the presence of several reentry circuits.<sup>[16]</sup> In our study, we did not find a significant difference in terms of LA sizes, however there was a significant reduction in the EF which seems to be consistent with the correction of mitral valve regurgita-

tion. We did not also find any significant effect of gender on the results. No consensus seems to have been arrived at on this issue.<sup>[17]</sup> Preoperative AF duration can also be another factor masking the effect of LA diameter. Long preoperative AF duration may lead to irreversible changes in LA tissue. Atrial muscle deformity and fibrosis have been reported in patients with AF.<sup>[16]</sup> The reversibility of this condition is controversial. Chua et al.<sup>[18]</sup> reported that a 3-month preoperative AF duration might be effective in the postoperative AF duration.

The choice of probe is another issue of controversy. Although unipolar probes have a high rate of side effects and despite some challenges in the formation of transmural lesion,<sup>[19]</sup> we did not find any significant difference when compared to bipolar probes. Comparison of unipolar and bipolar ablation data (Table 3) demonstrated that preoperative AF duration, CPB and the duration of cross-clamping were longer in the group using bipolar probes, yielding a significant difference. We concluded that logistic regression analysis did not produce a significant difference since the mean AF duration was not very long in both groups. Lack of a difference between the total duration of operation suggested that the difference between cross-clamping and CPB may have been associated with the surgical operation itself rather than the ablation procedure. The total follow-up duration was longer in the majority of our patients since they underwent unipolar ablation.

These were discussed in detail in our previous article where the unipolar-bipolar ablation techniques were evaluated.<sup>[20]</sup> The unipolar ablation technique focuses mainly on the left atrium, whereas biatrial intervention is performed when opening the right atrium. As a result, the unipolar approach is often used in patients with mitral valve disease with a higher prevalence of AF.<sup>[21]</sup> On the other hand, the bipolar technique is used in cases where the atria can not be opened. Models with serum irrigation are used in both techniques. A similar learning curve and experience are important for both techniques with respect to the surgical approach. The main advantages of bipolar ablation are the avoidance of CPB and intervention on a functioning heart.<sup>[22]</sup> As a result, the unipolar ablation technique was more commonly used in our patient group with mitral valve disease.

Preoperative AF duration has been reported to be a risk for recurrent AF.<sup>[23]</sup> There was no such finding in our study; however, all patients were in AF rhythm for a duration of  $\geq 12$  months, except for one patient with a 6-month AF history. The AF duration should be taken into consideration while deciding on surgical indications and we believe that early surgical intervention may yield more productive results.

In our study, one of the most interesting results is the prolonged survival rate as of 2007 with normal sinus rhythm. This may be explained by learning curve which is generally accepted for every surgical technique. We expect the success rate to increase as the number of surgeries performed increase in our center.

The major limitation of our study may be the inadequate elaboration of electrophysiological studies. Prevalence of atrial flutter was lower in our patient group, producing characteristic complaints. This may partially be associated to changes in the perception of postoperative AF<sup>[24]</sup> and the related complaints reported. In addition, postoperative Holter monitoring is a method also used in other centers.<sup>[25]</sup> Atrial flutter was reported in three of the patients, who were reported to continue with antiarrhythmics. Focal catheter ablation and identification of the origin of these flutter-like arrhythmias has been reported to increase the rate of sinus rhythm through further studies.<sup>[25]</sup> Williams *et al.*<sup>[25]</sup> reported the utilization of catheter ablation in patients who developed postoperative flutter during follow-up. Considering our study sample size and prevalence of AF particularly in patients who underwent cardiac surgery, further studies with a greater sample size are expected to produce more accurate results.<sup>[26]</sup>

In conclusion, RFA can successfully be performed for the treatment of AF in patients scheduled for open heart surgery, with a low rate of morbidity and mortality. More positive results are expected as surgical experience and the number of the procedures increases.

## REFERENCES

1. Uyarel H, Onat A, Yüksel H, Can G, Ordu S, Dursunoğlu D. Incidence, prevalence, and mortality estimates for chronic atrial fibrillation in Turkish adults. [Article in Turkish] *Türk Kardiyol Dern Arş* 2008;36:214-22.
2. Bahar I, Akgül A, Babaroğlu S, Ozatik MA, Turhan H, Göl MK ve ark. Kronik atriyal fibrilasyonda mekanik mitral kapak replasmanı ile birlikte radyofrekans atriyal ablasyonun etkinliği. *Anadolu Kardiyol Derg* 2006; 6:41-8.
3. Geidel S, Lass M, Boczor S, Kuck KH, Ostermeyer J. Surgical treatment of permanent atrial fibrillation during heart valve surgery. *Interact Cardiovasc Thorac Surg* 2003;2:160-5.
4. Chen SA, Tai CT. Catheter ablation of paroxysmal atrial fibrillation. *Cardiol Rev* 2005;13:87-94.
5. Ad N. The maze procedure: past, present and future. In: Sie HT, D'Ancona G, Bartolozzi F, Beukema W, Doty DB, editors. *Manual of surgical treatment of atrial fibrillation*. Massachusetts: Blackwell Publishing; 2008. p. 102-12.

6. Haïssaguerre M, Shah DC, Jaïs P, Hocini M, Yamane T, Deisenhofer I, et al. Electrophysiological breakthroughs from the left atrium to the pulmonary veins. *Circulation* 2000;102:2463-5.
7. Haïssaguerre M, Hocini M, Sanders P, Takahashi Y, Rotter M, Sacher F, et al. Localized sources maintaining atrial fibrillation organized by prior ablation. *Circulation* 2006;113:616-25.
8. Nanthakumar K, Lau YR, Plumb VJ, Epstein AE, Kay GN. Electrophysiological findings in adolescents with atrial fibrillation who have structurally normal hearts. *Circulation* 2004;110:117-23.
9. Todd DM, Skanes AC, Guiraudon G, Guiraudon C, Krahn AD, Yee R, et al. Role of the posterior left atrium and pulmonary veins in human lone atrial fibrillation: electrophysiological and pathological data from patients undergoing atrial fibrillation surgery. *Circulation* 2003;108:3108-14.
10. Guang Y, Zhen-jie C, Yong LW, Tong L, Ying L. Evaluation of clinical treatment of atrial fibrillation associated with rheumatic mitral valve disease by radiofrequency ablation. *Eur J Cardiothorac Surg* 2002;21:249-54.
11. Deneke T, Khargi K, Müller KM, Lemke B, Mügge A, Laczkovics A, et al. Histopathology of intraoperatively induced linear radiofrequency ablation lesions in patients with chronic atrial fibrillation. *Eur Heart J* 2005;26:1797-803.
12. Laurent G, De Chillou C, Bertaux G, Poull IM, Martel A, Andronache M, et al. Simple and efficient identification of conduction gaps in post-ablation recurring atrial flutters. *Europace* 2006;8:7-15.
13. Chen MC, Chang JP, Chang HW. Preoperative atrial size predicts the success of radiofrequency maze procedure for permanent atrial fibrillation in patients undergoing concomitant valvular surgery. *Chest* 2004;125:2129-34.
14. Duran NE, Duran I, Sönmez K, Gençbay M, Akçay A, Turan F. İleri mitral yetersizliğinde atriyal fibrilasyonun sıklığı ve öngördürücüleri. *Anadolu Kardiyol Derg* 2003;3:129-34.
15. Beukema WP, Elvan A, Sie HT, Misier AR, Wellens HJ. Successful radiofrequency ablation in patients with previous atrial fibrillation results in a significant decrease in left atrial size. *Circulation* 2005;112:2089-95.
16. Aslan O, Güneri S. Atriyal fibrilasyonun elektrofizyolojik temelleri. *Anadolu Kardiyol Derg* 2002;2:244-52.
17. Forleo GB, Tondo C, De Luca L, Dello Russo A, Casella M, De Sanctis V, et al. Gender-related differences in catheter ablation of atrial fibrillation. *Europace* 2007;9:613-20.
18. Chua YL, Schaff HV, Orszulak TA, Morris JJ. Outcome of mitral valve repair in patients with preoperative atrial fibrillation. Should the maze procedure be combined with mitral valvuloplasty? *J Thorac Cardiovasc Surg* 1994;107:408-15.
19. Martin-Suárez S, Claysset B, Botta L, Ferlito M, Pacini D, Savini C, et al. Surgery for atrial fibrillation with radiofrequency ablation: four years experience. *Interact Cardiovasc Thorac Surg* 2007;6:71-6.
20. Kırallı K. Cerrahi ablasyon teknikleri: intraoperatif radyofrekans kateter ablasyon (mono-bipolar). *Türkiye Klinikleri J Cardiovasc Surg-Special Topics* 2008;1:45-8.
21. Kırallı K. Atriyal fibrilasyonun tanımlanması. *Türkiye Klinikleri J Cardiovasc Surg-Special Topics* 2008;1:4-6.
22. Akpınar B, Sağbaş E, Güden M, Sanisoğlu I. Atriyal fibrilasyonun cerrahi tedavisi. *Anadolu Kardiyol Derg* 2007;7:65-73.
23. Geidel S, Lass M, Ostermeyer J. A 5-year clinical experience with bipolar radiofrequency ablation for permanent atrial fibrillation concomitant to coronary artery bypass grafting and aortic valve surgery. *Interact Cardiovasc Thorac Surg* 2008;7:777-80.
24. Hindricks G, Piorkowski C, Tanner H, Kobza R, Gerds-Li JH, Carbucicchio C, et al. Perception of atrial fibrillation before and after radiofrequency catheter ablation: relevance of asymptomatic arrhythmia recurrence. *Circulation* 2005;112:307-13.
25. Williams MR, Stewart JR, Bolling SF, Freeman S, Anderson JT, Argenziano M, et al. Surgical treatment of atrial fibrillation using radiofrequency energy. *Ann Thorac Surg* 2001;71:1939-43.
26. Demirkiliç U. Mitral kapak cerrahisinde atriyal fibrilasyonu da tedavi edelim. *Editöryel Yorum. Anadolu Kardiyol Derg* 2005;5:49-50.