ORIGINAL ARTICLE

Braz J Cardiovasc Surg 2004; 19(3): 301-308

Results of the intraoperative radiofrequency ablation of chronic atrial fibrillation

Resultados da ablação cirúrgica por radiofreqüência da fibrilação atrial crônica

Carlos Alberto Cordeiro de ABREU FILHO, Luís Alberto Oliveira DALLAN, Luiz Augusto Ferreira LISBOA, Guilherme Sobreira SPINA, Maurício SCANAVACCA, Max GRINBERG, Eduardo Argentino SOSA, Sérgio Almeida de OLIVEIRA

RBCCV 44205-698

Abstract

Objective: **The "Cox-Maze III" operation is very effective in the treatment of chronic atrial fibrillation, but many surgeons do not use this technique because of its high complexity. In order to simplify the procedure, new alternatives that involve the use of different energy sources, such as radiofrequency, to create transmural lesions that substitute the atrial incisions of the Cox technique have been developed. The purpose of this study is to evaluate the results of intraoperative radiofrequency ablation in the treatment of chronic atrial fibrillation in patients with associated cardiac diseases.**

Method: **Between February 2002 and March 2003, 35 consecutive patients with chronic atrial fibrillation were submitted to intraoperative radiofrequency ablation, associated with other surgical procedures. The ages of the patients ranged from 16 to 69 years old (mean 55.4 years old); there were 23 (65.7%) female patients.**

Results: **Radiofrequency ablation was associated with surgical treatment of the mitral valve in 29 (82.9%) patients and with treatment of atrial septal defect in 6 (17.1%). There was 1 (2.8%) in-hospital death; at the time of hospital discharge 26 patients (76.4%) were in sinus rhythm. After a mean follow-up of 11.7 ± 2.8 months, the overall survival rate was 94.2 % and 24 (72.7%) patients were in sinus rhythm.**

Conclusion: **Intraoperative radiofrequency ablation is a safe and effective technique for the treatment of chronic atrial fibrillation, with satisfactory midterm results in terms of conversion to sinus rhythm.**

Descriptors: **Catheter ablation. Catheter ablation, radiofrequency, Atrial fibrillation. Intraoperative ablation.**

Resumo

Objetivo: **A operação de "Cox-Maze III" apresenta alta efetividade para o tratamento da fibrilação atrial (FA) crônica, porém, devido a sua alta complexidade, não é amplamente utilizada. Novas alternativas, que envolvem o uso de fontes de energia, como a radiofreqüência, para criação de lesões transmurais, que substituem as linhas de secção e sutura da técnica de Cox, foram desenvolvidas visando simplificar o procedimento. O objetivo deste estudo é avaliar os resultados do emprego da radiofreqüência intra-operatória para**

Work performed in the Heart Institute, Hospital das Clínicas Medicine School, University of São Paulo (InCor HC – FMUSP), São Paulo, SP, Brazil.

Presented at the 30th National Congress of Heart Surgery in Goiânia, April 2003

Correspondence address: Carlos Alberto Cordeiro de Abreu Filho. Rua Tangará, 304, Ap. 222, São Paulo, SP, Brazil. CEP: 04019-030. Tel/Fax: 11- 5904-3080
E-mail: carlosabreu@incor.com.br

Article received on October, 2003
Article accepted on March, 2004

tratamento da FA crônica em pacientes com cardiopatias associadas com indicação de tratamento cirúrgico.

Método: **Entre fevereiro de 2002 e março de 2003, 35 pacientes consecutivos portadores de FA crônica foram submetidos à ablação com radiofreqüência intra-operatória, associada a outros procedimentos cirúrgicos. A idade variou de 16 a 69 anos (média = 55,4 anos), sendo 23 (65,7%) pacientes do sexo feminino.**

Resultados: **A ablação foi associada ao tratamento cirúrgico da valva mitral em 29 (82,9%) pacientes e à atriosseptoplastia em seis (17,1%) pacientes. A mortalidade hospitalar foi de 2,8%; vinte e seis (76,4%) pacientes apresentavam-se em ritmo sinusal no momento da alta hospitalar. Após seguimento médio de 11,7 ± 2,8 meses, a sobrevida foi de 94,2% e 24 (72,7%) pacientes apresentavam-se em ritmo sinusal.**

Conclusão: **A ablação por radiofreqüência intra-operatória demonstrou ser uma técnica segura e eficiente para o tratamento da FA crônica, apresentando índices satisfatórios de reversão para o ritmo sinusal em médio prazo.**

Descritores: **Ablação por cateter. Ablação por cateter de radiofreqüência. Fibrilação atrial. Ablação intra-operatória.**

INTRODUCTION

Atrial fibrillation (AF) is a sustained arrhythmia highly prevalent among patients with mitral valve diseases with indication for surgical treatment. Up to 60% of these patients suffer from chronic AF [1]. In this group of patients, the surgical treatment in isolation, presents with unsatisfactory results in respect to reversal to sinusal rhythm. SCHMIDLIN et al. [2] observed that among patients with mitral stenosis and AF submitted to mitral valve surgery in isolation, the reversal rate to sinusal rhythm was only 38.5%.

Data such as this justifies the necessity to develop an efficient technique for patients indicated for surgical treatment suffering from chronic AF and associated heart diseases.

The Cox-Maze III operation described by COX et al. [3] consists of a surgical procedure to treat chronic AF, which results in almost 100% reversal to sinusal rhythm [4,5]. However, in spite of this high rate, it is a highly complex procedure, with a high risk of bleeding through the various atrial sutures, as well as other possible complications relative to the technique such as: the reoccurrence of perioperative atrial arrhythmias, loss of atrial transport function, dysfunction of the sinoatrial node, with a risk of the need of a definitive pacemaker in the postoperative period [6].

New alternatives have been developed with the aim of simplifying the operative technique and reproducing the results of the Maze operation in a less invasive manner. Among these we can highlight: isolation of the left atrium, the mini-Maze operation and the utilization of energy sources to perform the transmural lesions that substitute the sectioning and suture lines of the technique originally proposed by Cox.

The good results obtained by radiofrequency with the utilization of catheters for the treatment of AF [7,8] motivated surgeons to introduce its application in the intraoperative phase to ablate this arrhythmia in patients with associated heart diseases and indication for surgical treatment [9,10].

The aim of this study was to evaluate the efficacy over the mid-term, of surgical radiofrequency ablation for the treatment of chronic AF, in patients with associated heart diseases and indication for surgical treatment.

METHOD

Between February 2002 and March 2003, 35 consecutive patients with chronic AF were submitted to intra-operative ablation by radiofrequency associated to other surgical procedures. The preoperative characteristics of the patients are described in Table 1 and the diagnoses that motivated surgical indication are detailed in Table 2. In the postoperative period the patients were prospectively assessed.

The respective protocol was approved by the Scientific and Ethics Committee of the Heart Institute of the Hospital das Clinicas, Medicine School, University of São Paulo, Brazil. All the patients agreed to participate in the study and gave their written informed consent.

Table 1. Preoperative characteristics of the patients (n = 35).

	Number of patients (%)
Women	23 (65.7%)
Age (years)	16 a 69 (mean 55.4)
Chronic AF	35 (100)
Duration of permanent AF (months)	8 a 264 (mean 64.2)
Functional Class (NYHA)	
III	25 (71.4%)
IV	10 (28.6%)

Legend: AF – atrial fibrillation; CHI – congestive heart insufficiency; NYHA - New York Heart Association.

Table 2. Indications for surgical treatment

	Number of patients (%)
MiS	13 (37,2%)
MiS + TI	4 (11,5%)
MiI	9 (25,8%)
MiI + TI	3 (8,5 %)
IAC	5 (14,2%)
IAC + COI	1 (2,8%)

Legend: MiS - mitral stenosis; TI - tricuspid insufficiency; MiI - mitral insufficiency;
IAC - interatrial connection; COI - coronary insufficiency

Inclusion criteria

- Permanent AF of at least 12 months
- At least one failed previous attempt at cardioversion (chemical or electrical)
- Associated heart disease with indication for heart surgery

Exclusion criteria

- Incapacity or lack of cooperation to participate in the study and solicitation of clinical follow-up
- Previous radiofrequency ablation by catheter for correction of AF
- Necessity of emergency heart surgery
- Confirmed pregnancy during tests of eligibility of the patient
- Contra-indication for anticoagulant therapy
- Diagnosis of active infectious endocarditis

Radiofrequency ablation system

The system of radiofrequency utilized constituted of an energy generator and a unipolar pen probe (Cardioblate, Medtronic Inc, Minneapolis, MN). The system was irrigated with 0.9% saline solution by a continuous infusion pump to cool the point of the electrode that entered in contact with the atrial myocardium, in order to reduce the risk of injury to adjacent tissue. The energy generator operated in the range of 20 to 30 W with impedance greater than 500 ohms.

Operative technique

All the operations were performed by the same surgeon. The approach was by median sternotomy followed by longitudinal pericardiotomy to expose the heart and the great vessels.

After systemic heparinization, the ascending aorta and the inferior and superior vena cavae were cannulated to establish cardiopulmonary bypass, maintaining the patient at moderate hypothermia of 32 ºC.

Before clamping the ascending aorta with the heart still beating, the modified Cox-Maze III procedure was initiated using radiofrequency. Resection of the right auricle was performed followed by two incisions in the lateral wall of the right atrium, one lengthwise toward the inferior vena cava and the other transversal. The radiofrequency was applied externally on the epicardium of the right atrium from the site of the cannulation of the superior vena cava to the inferior vena cava (Figure 1).

In succession, radiofrequency was applied to the endocardium of the right atrium starting from the base of

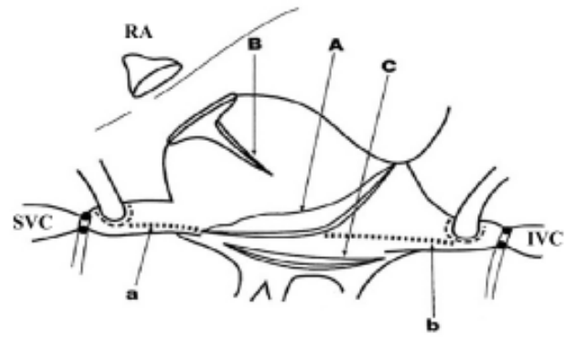

Fig. 1 – diagram showing the atrial incisions: across the right atrium (A); lengthwise in the right atrium (B); lengthwise in the left atrium (C); amputation of the right auricle (RA); application of radiofrequency in the epicardium of the right atrium (lines a and b) continuing to the site of cannulation of the superior vena cava (SVC) to the inferior vena cava (IVC).

the resection of the right auricle along to the upper margin of the tricuspid valve, then to the lower margin of the tricuspid valve toward the posterior longitudinal right atriotomy on the atrioventricular groove. In the interatrial septum, application was performed passing by the fossa ovalis to the caudal region of the ostium of the coronary sinus, toward the inferior vena cava (Figure 2).

Consequently, clamping of the ascending aorta was performed and sanguineous cardioplegia solution (4:1) at 4 ºC was intermittently injected via anterograde every 20 minutes. A left lateral atriotomy was performed to expose the inside of the left atrium followed by resection of the left auricle.

Radiofrequency was applied to the endocardium of the left atrium, beginning from the site of the resection of the left auricle to the orifice of the left superior pulmonary vein. Radiofrequency was applied around the orifices of the left and right pulmonary veins. In patients with greatly enlarged left atria (greater than 6 cm on the longest axis), radiofrequency was applied along a lengthwise line between the right and left pulmonary vein orifices. The procedure was completed with the application of radiofrequency between the left inferior pulmonary vein and the margin of the mitral valve annulus (Figure 3).

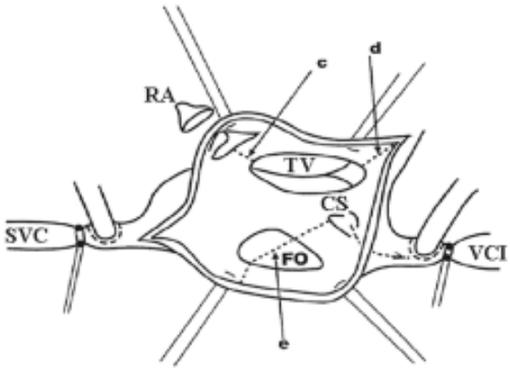

Fig. 2 – Diagram showing the application of radiofrequency inside the right atrium between the base of the amputation of the right auricle (RA) and the upper margin of the tricuspid valve (TV) annulus – (line c); from the lower margin of the tricuspid valve annulus toward to posterior longitudinal right atriotomy in the atrioventricular groove (line d); starting from the inferior vena cava (IVC), passing through the coronary sinus (CS), following the inter-atrial septum passing by the fossa ovalis (FO) – (line e).

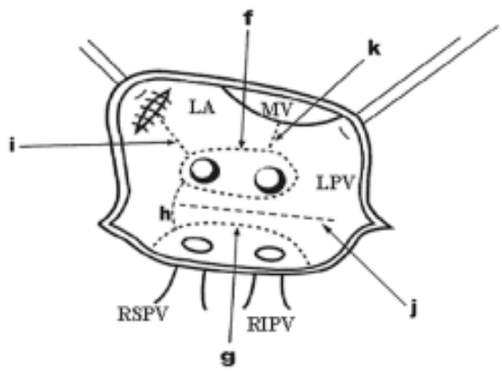

Fig. 3 – Diagram showing the application of radiofrequency inside the left atrium, around the orifices of the left pulmonary veins (LPV) – (line f); around the orifices of the right pulmonary veins (LPR) – (line g); uniting the right and left pulmonary veins (line h), between the orifice of the left superior pulmonary vein and the base of the amputation of the left auricle (LA) – (line i); lengthwise between the left and right pulmonary veins (line j); between the orifice of the left inferior pulmonary vein and the margin of the mitral valve annulus (MV) – (line k).

Figures 4 and 5 are photographs of the operation with the application of radiofrequency on the right and left atria.

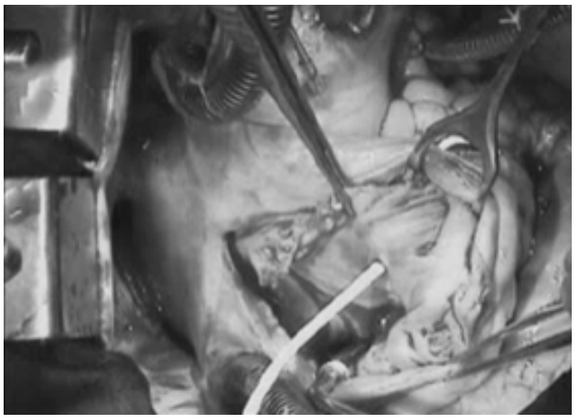

Fig. 4 - Photograph showing the ablation by radiofrequency using a unipolar probe on the endocardium of the right atrium

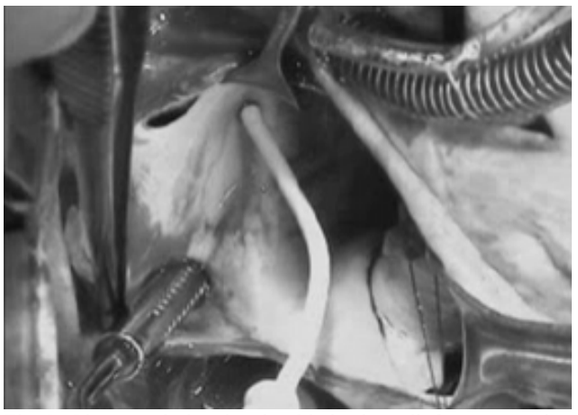

Fig. 5 – Photograph showing the ablation by radiofrequency using a unipolar probe on the endocardium of the left atrium

Postoperative follow-up

All the patients were followed-up in the postoperative period at the following time intervals: Before being released from hospital, one, three and 12 postoperative months. At each clinical follow-up, the following points were analyzed: heart rhythm, functional class of congestive heart insufficiency (ICC) according to the classification of the New York Heart Association (NYHA) and evaluation of adverse events such as complications and deaths.

All the patients received endovenous maintenance doses of amiodarone (900 mg/day) during the postoperative intensive care unit stay, followed by oral administration (doses greater than or equal to 200 mg/day) continued up to at least the sixth postoperative month after release from hospital. This is because of the possibility of relapse of AF episodes in the postoperative period and does not signify failure of the procedure.

Complimentary diagnostic examinations were performed during the postoperative follow-up included 12-lead electrocardiogram, transthoracic echocardiogram and 24-hour continuous electrocardiogram (Holter).

The atrial contractility was evaluated in patients suffering from sinusal rhythm using transthoracic echocardiogram, with measurement of the velocity of the E and A waves, as well as the ratio between them in the right and left atria.

RESULTS

Surgical procedures

The surgical procedures performed are listed in Table 3. Among them, six (17.1%) were reoperations including five mitral valve replacements using biological prostheses and one re-plasty also of this valve.

Table 3. Surgical procedures

Modified Cox Maze III operation using radiofrequency and associated procedures	Number of patients (%)
MiVRe (BP)	18 (51.5%)
MiVRe (BP) and TrV	6 (17.2%)
MiV	4 (11.5%)
MiV, TrV and Atrioseptoplasty	1 (2.8%)
Atrioseptoplasty	5 (14.2%)
Atrioseptoplasty and CABG	1 (2.8%)

MiVRe (BP) - Mitral valve replacement for biological prosthesis; MiV - Mitral valvuloplasty; TrV - tricuspid valvuloplasty; CABG – Coronary artery bypass grafting (saphenous vein graft between anterior interventricular branch and left coronary artery).

The mean cardiopulmonary bypass and aortic clamping times were 107.2 ± 21.1 and 57.5 ± 13.5 minutes respectively and the times for application of the radiofrequency on the right and left atria were 14.2 ± 5.1 and 12.3 ± 4.2 minutes respectively.

After releasing the clamp from the ascending aorta, with the return of the heart beats, sinusal rhythm was observed in 29 (82.9%) of the patients, four (11.4%) presented with junctional rhythm and two (5.7%) continued with AF.

Hospital morbid-mortality

There were no intra-operative deaths. There was one (2.8%) intra-hospital death of a 67-year-old female patient with mitral stenosis of rheumatic etiology and with secondary tricuspid insufficiency. She was submitted to mitral valve replacement with a biological prosthesis, de Vega plasty of the tricuspid valve and ablation for AF by radiofrequency. She required a temporary pacemaker for total atrioventricular block on the first postoperative day and presented with sudden death on the forth postoperative day.

The intra-hospital complications observed were: bronchopneumonia in three patients (8.5%), pneumothorax in one (2.8%) and infection of the operative wound in three (8.5%).

Heart rhythm

At hospital release, among the 34 surviving patients (97.1%), 26 (76.4%) presented with sinusal rhythm, six (17.6%) with AF and two (6%) in junctional rhythm.

Three months after the procedure, 16 patients (47.1%) presented with sinusal rhythm, 12 (35.3%) presented with AF with low ventricular response, four (11.8%) presented with atrial tachycardia and two (5.8%) presented with atrial flutter.

After a mean follow-up of 11.7 ± 2.8 months, among the 33 patients being accompanied, 24 (72.7%) presented with sinusal rhythm, eight (24.2%) with AF with low ventricular response and one (3.1%) presented with atrial tachycardia. No patients required hospitalization for treatment of relapsed arrhythmias.

Atrial contractility

Twelve months after the procedure, among the patients who had sinusal rhythm, 22 (91.6%) presented with right atrial contractility and 20 (83.3%) presented with left atrial contractility demonstrated by transthoracic echocardiogram.

Congestive heart insufficiency

At hospital release, among the 34 surviving patients, 27 (79.4%) were in functional class I and seven (20.6%) in functional class II. This result was similar after the third postoperative month. In the twelfth postoperative month, among the 33 surviving patients, 23 (69.6%) presented in functional class I and 10 (30.4%) in functional class II.

Mid-term morbid-mortality

No complications related to the surgical procedure occurred over the mid-term of 11.7 ± 2.8 months. The survival rate was 94.2%, one late death, a 28-year-old female patient submitted to mitral valve replacement using a biological prosthesis and ablation for AF, occurred. She died due to puerperal septicemia in the tenth postoperative month.

COMMENTS

The main objectives of AF treatment are to relieve symptoms propitiate to the reestablishing of a sinusal rhythm, the reestablishing of the atrioventricular synchronism and of the atrial contractility, improvement of the hemodynamic performance and the reduction of the risk of thromboembolic events [11].

The Cox-Maze III operation presents with good results in terms of reestablishing sinusal rhythm and has become the gold standard treatment for chronic AF.

There are Brazilian authors with experience in performing the Cox operation. JATENE et al. [12] compared two groups of patients, Group I in which mitral valve operation and the Cox operation were made and Group II in which only a mitral valve operation was performed. After a mean follow-up of 37 months, the AF was present in 76.5% of the Group II patients and in 5.3% of the Group I patients (p-value = 0.0001).

KALIL et al. [13] performed a study that confirmed that the results of the Cox operation in respect to reversal to a sinusal rhythm are similar among patients with rheumatic or degenerative mitral valve diseases. In the postoperative period, the sinusal rhythm was confirmed in 71% of rheumatic disease patients and in 75% of degenerative mitral valve disease patients.

Owing to the high complexity of the Cox operation, it is not widely used; new alternatives have been developed with the aim of simplifying the treatment for AF.

Observing the physiopathologic basis of AF, it was confirmed that only some of the atrial incisions of the Cox operation were necessary and considered essential. These include incisions around the pulmonary veins and in the left atrium isthmus, that is, between the inferior pulmonary veins and the mitral valve annulus in the left atrium and in the cavo-tricuspid isthmus, that is, between the annulus of the tricuspid valve, the coronary sinus and the orifice of the inferior vena cava of the right atrium. Thus, the reduced Cox operation, designated the mini-Maze technique, started to be performed, which included the utilization of cryoablation.

The anatomic region corresponding to the orifices of the pulmonary veins and to the bottom of the left atrium, presents a strong correlation with the physiopathology of AF. Several authors praised the operation that isolates the left atrium for the treatment of chronic AF.

KALIL et al. [14] presented a study that demonstrated similar results in respect to reversal to sinusal rhythm among patients operated by the simplified technique for left atrium isolation and those operated by the classic Cox-Maze III technique.

Technological development gave other simpler options for the Cox operation, using energy sources to cause the transmural atrial lesions. The main energy sources employed are cryoablation, already utilized in the mini-Maze, microwaves, ultrasound and radiofrequency [15].

SCHUETZ et al. [16] performed a study of 43 patients with chronic AF and associated heart diseases. The patients were randomly allocated to two groups. The first consisted of 24 patients who underwent endocardial ablation by microwaves and the second group consisted of 19 patients who were submitted to valvar or coronary operations only. After 12 months of postoperative follow-up, 80% of the treated group patients and 33.3% of the control group presented with sinusal rhythm (p-value = 0.036).

BRICK et al. [17] performed intra-operative ablation with ultrasound for the treatment of chronic AF. Twenty-seven patients were submitted to ablation associated with other surgical procedures with the ablation lines following the Cox-Maze III technique. At release from hospital, the reversal rate to sinusal rhythm was 81.4%. The same authors presented an experiment utilizing intra-operative radiofrequency [18].

SIE et al. [1] utilized radiofrequency for intra-operative ablation for AF. In a study of 122 patients they obtained, after 39 months of follow-up, a 90% survival rate with 78.5% ± 5.1% of the patients free of fibrillation or atrial flutter. Among these patients, 83% presented with right atrial transport function and 77% with left atrial transport function, evidenced by transthoracic echocardiogram.

CHIAPPINI et al. [19] performed a comparative study of ablation by radiofrequency with the conventional Cox-Maze III operation. The authors confirmed that the reversal rate to sinusal rhythm, after a mean follow-up of 73.2 months, was similar between the two techniques.

The varying energy sources employed to achieve the transmural lesions in the atrial walls presented with similar reversal rates to sinusal rhythm, varying from 70 to 80%. In our study, using radiofrequency, after a mean follow-up of 12.7 ± 2.8 months, 72.7% of the patients presented with sinusal rhythm.

The prolonged time used to perform the Cox-Maze III operation was one of the reasons that led to the search for new alternatives for the original procedure. In a study analyzing five years of experience with the Maze operation, COX et al. [20] evaluated 49 patients submitted only to this operation. The mean cardiopulmonary bypass time was 184 minutes and mean aortic clamping time was 69 minutes.

To perform ablation by radiofrequency and associated operations, SIE et al. [21] presented mean times of cardiopulmonary bypass and aortic clamping of 195 and 94 minutes respectively. In our series, which also included the Maze procedure with radiofrequency and associated operations, the mean time of cardiopulmonary bypass time was 107 minutes and of aortic clamping it was 57 minutes.

Operations for the treatment of chronic AF can present complications caused by the surgical procedure, such as sinus node artery injury or lesions of other coronary arteries and perforation of the left atrium and the esophagus with the development of an atrio-esophageal fistula [22]. These complications are rare but very serious. In our experience we have not observed any complications due to the surgical technique.

JATENE et al. [23] performed an important study related to coronary atrial circulation and its correlation to the Cox procedure. The authors analyzed 30 hearts of individuals without prior heart disease. After a macroscopic evaluation, seven distinct patterns of the artery of the sinus node emerged in relation to its origin, position, distance from the coronary ostium, its route and the area of irrigation. This work is of great importance as it helps to direct atrial incisions in the Cox procedure, as well as the application of alternative energy sources to create transmural lesions.

The future perspectives for the surgical treatment of chronic AF with the use of radiofrequency, or other energy sources, point to progressively less invasive techniques, performed through smaller accesses, such as the right lateral mini-thoracotomy, applied to the epicardium without the use of cardiopulmonary bypass and possibly, with minimally invasive techniques such as videothoracoscopy [24]. Thus, the indication of this type of treatment may include patients with only chronic AF, without associated heart disease.

The limitations of this work were the small sample size and the heterogeneous group of patients, in relation to the surgical indication and the presence of associated heart diseases. This is the first report of our experience but the study continues with more cases, stratification of the patients in distinct groups and the introduction of a control group composed of patients suffering from chronic AF and associated heart diseases, who will be submitted to only surgical correction of the heart diseases.

CONCLUSION

Intra-operative ablation by radiofrequency for chronic atrial fibrillation presented with satisfactory results in the mid-term and with reversal rates to sinusal rhythm comparative to other currently available energy sources for the surgical treatment of atrial fibrillation.

BIBLIOGRAPHIC REFERENCES

1. Sie HT, Beukema WP, Misier AR, Elvan A, Ennema JJ, Haalebos MM et al. Radiofrequency modified maze in patients with atrial fibrillation undergoing concomitant cardiac surgery. J Thorac Cardiovasc Surg 2001;122:249-56.

2. Schmidlin CA, Loures DRR, Carvalho RG, Mulinari LA, Silva Jr. AZ, Brommelstroet M et al. Efeitos da correção cirúrgica de estenose mitral sobre o ritmo cardíaco. Rev Bras Cir Cardiovasc 2001;16:128-35.

3. Cox JL, Schuessler RB, D'Agostino Jr. HJ, Stone CM, Chang BC, Cain ME et al. The surgical treatment of atrial fibrillation: III. Development of a definitive surgical procedures. J Thorac Cardiovasc Surg 1991;101:569-83.

4. Cox JL, Ad N. New surgical and catheter-based modifications of the Maze procedure. Semin Thorac Cardiovasc Surg 2000;12:68-73.

5. Cox JL. Intraoperative options for treating atrial fibrillation associated with mitral valve disease. J Thorac Cardiovasc Surg 2001;122:212-5.

6. Cox JL, Ad N, Palazzo NAT, Fitzpatrick S, Suyderhoud JP, DeGroot KW et al. Current status of the Maze procedure for the treatment of atrial fibrillation. Semin Thorac Cardiovasc Surg 2000;12:15-9.

7. Haissaguerre M, Jais P, Shah DC, Gencel L, Pradeau V, Garrigues S et al. Right and left atrial radiofrequency catheter therapy of paroxysmal atrial fibrillation. J Cardiovasc Electrophysiol 1996;7:1132-44.

8. Gaita F, Riccardi R, Calo L, Scaglione M, Garberoglio M, Antolini R et al. Atrial mapping and radiofrequency catheter ablation in patients with idiopathic atrial fibrillation. Electrophysiological findings and ablation results. Circulation 1998;97:2136-45.

9. Guden M, Akpinar B, Sanisoglu I, Sagbas E, Bayindir O. Intraoperative saline–irrigated radiofrequency modified maze procedure for atrial fibrillation. Ann Thorac Surg 2002; 74:S1301-6.

10. Viola N, Williams MR, Oz MC, Ad N. The technology in use for the surgical ablation of atrial fibrillation. Semin Thorac Cardiovasc Surg 2002;14:198-205.

11. Deneke T, Khargi K, Grewe PH, Laczkovics A, von Dryander S, Lawo T et al. Efficacy of an additional MAZE procedure using cooled-tip radiofrequency ablation in patients with chronic atrial fibrillation and mitral valve disease: a randomized, prospective trial. Eur Heart J 2002;23:558-66.

12. Jatene MB, Barbero-Marcial M, Tarasoutchi F, Cardoso RA, Pomerantzeff PMA, Jatene AD. Influência da operação de Cox no tratamento da fibrilação atrial em valvopatia mitral reumática: análise comparativa de resultados imediatos e tardios. Rev Bras Cir Cardiovasc 1998;13:105-19

13. Kalil RAK, Cunha B, Albrecht AS, Moreno P, Abrahão R, Prates PR et al. Análise comparativa dos resultados da cirurgia do labirinto (Cox-maze) para fibrilação atrial crônica em pacientes com doença valvar reumática ou degenerativa. Rev Bras Cir Cardiovasc 1999;14:191-9.

14. Kalil RAK, Lima GG, Abrahão R, Stürmer ML, Albrecht A, Moreno P et al. Técnica cirúrgica simplificada pode ser eficaz no tratamento da fibrilação atrial crônica secundária à lesão valvar mitral? Rev Bras Cir Cardiovasc 2000;15:129-35.

15. Gillinov AM, Blackstone EH, McCarthy PM. Atrial fibrillation: current surgical options and their assessment. Ann Thorac Surg 2002;74:2210-7.

16. Schuetz A, Shuelze CJ, Sarvanakis KK, Mair H, Plazer H, Kilger E et al. Surgical treatment of permanent atrial fibrillation using microwave energy ablation: a prospective randomized clinical trial. Eur J Cardiothorac Surg 2003;24:475-80.

17. Brick AV, Seixas T, Portilho C, Peres AK, Vieira Jr. JJ, Melo Neto R at al. Tratamento intra-operatório da fibrilação atrial crônica com ultra-som. Rev Bras Cir Cardiovasc 2001;16:337-49.

18. Brick AV, Seixas T, Peres A, Vieira Jr. JJ, Mattos JV, Mesquita A et al. Reversão da fibrilação atrial crônica pela técnica do labirinto com aplicação de radiofreqüência e ultra-som transoperatórios. Rev Bras Cir Cardiovasc 1999;14:290-7.

19. Chiappini B, Martìn-Suàrez S, LoForte A, Arpesella G, Di Bartolomeo R, Marinelli G. Cox/Maze III operation versus radiofrequency ablation for the surgical treatment of atrial fibrillation: a comparative study. Ann Thorac Surg 2004;77: 87-92.

20. Cox JL, Boineau JP, Schuessler RB, Kater KM, Lappas DG. Five-year experience with the maze procedure for atrial fibrillation. Ann Thorac Surg 1993:56:814-24.

21. Sie HT, Beukema WP, Misier AR, Elvan A, Ennema JJ, Wellens HJ. The radiofrequency modified maze procedure: a less invasive surgical approach to atrial fibrillation during open-heart surgery. Eur J Cardiothorac Surg 2001;19:443-7.

22. Mohr FW, Fabricius AM, Falk V, Autschbach R, Doll N, von Oppell U et al. Curative treatment of atrial fibrillation with intraoperative radiofrequency ablation: short-term and midterm results. J Thorac Cardiovasc Surg 2002;123:919-27.

23. Jatene MB, Hervoso CM, Terra RM, Guimarães MH, Monteiro R, Jatene FB et al. Importância da anatomia da circulação coronária atrial na operação de Cox para o tratamento da fibrilação atrial. Rev Bras Cir Cardiovasc 1999;14:32-8.

24. Cox JL. Atrial fibrillation I: a new classification system. J Thorac Cardiovasc Surg 2003;126:1686-92.