Results of the Surgical Treatment of Chronic Atrial Fibrillation

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Objective *– Report clinical experience in surgical treatment of atrial fibrillation (AF) by Cox-maze procedure.*

Methods *– 61 patients underwent surgical treatment for AF. Two had primary AF and 59 AF secondary to heart disease (2 atrial septal defects, 57 mitral). Ages ranged from 20 to 74 years (mean = 49). There were 44 females (72%). The surgical technique employed was Cox 3 without cryoablation. The patients were follow-up in specific at patient clinics and underwent periodical ECG, exercise tests, echocardiogram and Holter monitoring.*

Results *– In-hospital mortality was 4.9% and late mortality 1.6%. A temporary pacemaker was used in 28 (46%) and a definitive in 7 patients (11.4%). On hospital discharge, AF remained in 17%; 63.9% had sinus rhythm, 6.9% atrial rhythm, 1.7% junctional rhythm, and 10.3% had pacemaker rhythm. In the last evaluation, AF was present in 19.5%; (70.5% sinus rhythm, 4% atrial rhythm, 2% atrial tachycardia, and 4% pacemaker rhythm). There was no report of thromboembolic episodes. Chronotropic response was considered adequate in 19%, intermediate in 29%, and inadequate in 42%. In Holter monitoring, the mean heart rate was 82±8 bpm, with a minimum of 57±7 bpm and maximum of 126±23 bpm, with supraventricular extrasystoles in 2.3±5.5% of the total heartbeats and ventricular extrasystoles in 0.8±0.5%. In the echocardiogram, the A wave was present in the left atrium in 87.5%.*

Conclusion *– Maze procedure is effective and has acceptable surgical risk. Atrial or sinus rhythms remain stable with a small but remarkable frequency of atrial and ventricular arrhythmias. Left atrial contraction is present, although attenuated, as well as the chronotropic response to exercise.*

Key words: atrial fibrillation, surgery, arrhythmias

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Atrial fibrillation (AF) has been treated traditionally with methods established decades ago, whose objectives are the recovery of the sinus rhythm or, when this is not feasible, the control of the ventricular rate associated with anticoagulation [1]. This arrhythmia was considered benign, and there were few efforts to study it in greater detail. Since the last decade, however, AF has become more and more frequently investigated and treated.

Establishment of an adequate therapy for AF is considered one of the major challenges for cardiologists in the near future.

The understanding of AF as a nonbenign entity with a clear increase in morbidity and mortality in its presence, especially when associated with risk factors, such as structural heart disease, hypertension, etc [2,3], has led to efforts to reverse it. In addition, pharmacological methods through interventional catheterization [4-7], implantable defibrillators [7,8], and surgery [9-13] have also been developed.

Since 1991, we have been studying the surgical treatment of AF. Initially, we used the maze procedure proposed by Cox[12], with modifications, in a series of patients with surgical indication due to mitral valve lesion. Later, we extended the series, including other lesions and primary AF. This study aims to report this experience.

Methods

Between May 94 and June 98, 61 patients underwent the maze procedure. Fifty-nine patients had organic lesions, among which were 57 isolated or associated mitral lesions and 2 atrial septal defects (ASD). The lesions associated with the mitral valve lesion were one aortic lesion and one case of ischemic heart disease. In 2 patients, who had previously undergone catheter ablation without success, the AF was primary and refractory to the medicamentous treatment.

Age ranged from 20 to 74 years (mean age = 49 years) at the time of surgery. There were 44 females (72% of the patients).

The patients referred for surgery included those with

chronic AF for more than 6 months, who were considered refractory to clinical treatment and without reversion to sinus rhythm during this period. These patients did not have severe left ventricular dysfunction, i.e., ejection fraction ≤ 20% on the echocardiogram and there was no previous heart surgery and no pericardial adhesions of any other origin. These patients would be treated with surgery due to their basic lesion, except those with primary AF. The criteria for surgical indication were those of the main organic lesion, except in the 2 patients with primary AF, where the criterion was refractoriness to previous treatment. During the study, all patients with chronic AF referred for surgery and who did not fulfill all the exclusion criteria cited above underwent the maze procedure.

The most employed surgical technique was the third modification of the maze procedure, known as Cox 3[14]. In some of the first cases, the septal incisions were longitudinal instead of oblique-transversal, as in the Cox 3 technique, and the longitudinal incision in the inferior vena cava was omitted. After becoming acquainted with the procedure, we began to use all the original incisions proposed by the author. Cryoablation of the extremities of the atrioventricular incisions, as well as of the posterior coronary sinus, was not performed because adequate equipment was not available. To replace cryoablation, a broader dissection of the site was performed as was electrocoagulation of the adjacent tissues.

In the postoperative period (POP), we tried to maintain the atrial frequency above 80 bpm, activating a temporary atrial pacemaker, when necessary. Spironolactone was routinely administered to prevent water retention consequent to temporary reduction of the atrial natriuretic factor[13].

All patients were followed in specific ambulatory clinics or by their attending physicians. The patients periodically underwent a clinical assessment and also electrocardiogram, ergometric test, echocardiogram, and 24-hour Holter monitoring, to determine their functional condition, basic heart rhythm, arrhythmias, chronotropic response to exercise, and left and right atrial contraction.

Quantitative data were expressed in percentages or mean ± standard deviation. Statistical analyses were performed through the SPSS and EPI-INFO software in computers with the operating system Windows 95. The results are shown in tables and charts as indicated.

Results

The global mortality rate was 6.5% (4 patients), of which 3 (4.9%) were in-hospital deaths and one (1.6%) was a late death. The causes of the early deaths were the following: 1) neurologic damage due to a previous carotid lesion, followed by multiple-organ failure in a 72-year-old female patient in functional class IV referred for surgery due to severe mitral regurgitation accompanied by moderate ventricular dysfunction; 2) immediate postoperative endocarditis in mitral bioprosthesis, treated with an initially successful reoperation that was followed by pulmonary embolism and death in the early POP of the second surgery; 3) ventricular failure after two redo operations to correct postoperative bleeding. The cause of the late death was not clarified, and sudden death may have been due to arrhythmia at the 14th month of POP because the Holter monitoring in this patient showed ventricular arrhythmias.

In the early POP, a temporary pacemaker necessitated by atrial bradycardia was employed for hours or days, 14 days being the longest period, in 28 patients. Definitive stimulation was used in 7 (11.4%) patients, with the DDD system in 6 patients and the VVI-R system in one patient. Of these patients, 3 had total atrioventricular block (AVB) in the early POP, 2 had junctional bradycardia in the early POP, one patient had brady-tachyarrhythmia syndrome with syncope in the late POP, and one patient had third-grade AVB in the early POP, which later disappeared, returning to the sinus rhythm. During this period, there was infection at the site of the pacemaker generator in one patient, and the system was removed without another implant. AF evolved in this patient. At the last evaluation, there were 6 (9.8%) patients with definitive pacemakers implanted.

Temporary atrial arrhythmias were frequent and were the major cause of prolonged hospital stay. Episodes of fibrillation and flutter were treated with electrical cardioversion or chemical cardioversion with intravenous amiodarone followed by oral maintenance doses, whenever possible, at the same hospital stay. These episodes occurred in 6 (10%) patients.

The most significant early surgical complications were the following: 2 patients with stroke and no sequela on hospital discharge; one anaphylactic reaction to protamine; withdrawal of foreign body fixed to the superior vena cava through venous catheter; perioperative aortic dissection; acute cholecystitis; two re-operations due to excessive bleeding; and one case of acute pulmonary edema during the operation.

In regard to the lengths of surgery and hospitalization, they varied as follows: the mean time of extracorporeal circulation was 91 minutes, varying from 41 to 151 minutes; the mean time of myocardial ischemia was 63 minutes, varying from 43 to 116 minutes; the time of hospital stay varied from 8 to 37 days (mean = 14 days and mode = 8 days).

On hospital discharge, 63.9% of the patients had sinus rhythm. Atrial rhythm was found in 6.9% of the patients, the junctional rhythm in 1.7% of the patients, and the pacemaker rhythm in 10.3%. Atrial fibrillation was present in 17.2% of the operated patients (Fig. 1).

At least one postoperative evaluation was carried out in 51 patients, and the last one was performed at a mean time of 14.7 months after the surgery (1 to 36 months). At the last evaluation, 36 (70.5%) out of 51 patients had sinus rhythm, 2 patients (4%) had atrial rhythm, one patient (2%) had paroxysmal atrial tachycardia (PAT) with AVB 2:1, and 2 patients (4%) had a rhythm of DDD pacemaker. AF rhythm was present in 10 patients (19.5%) (Fig. 2). There was no report of systemic or pulmonary thromboembolic episode in the patients during follow-up.

From the 31 patients undergoing the ergometric test, 3

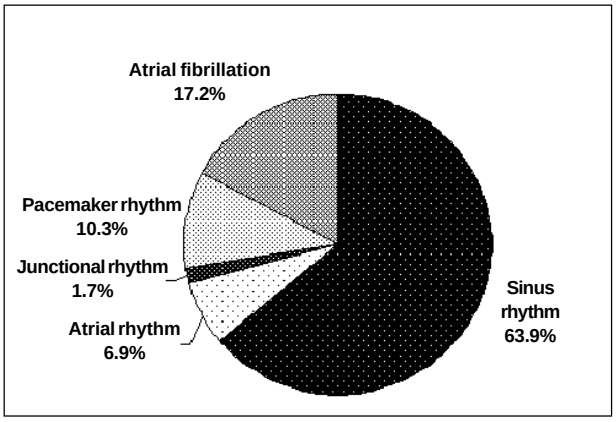

Fig. 1 – Pie-chart representing the cardiac rhythms on hospital discharge.

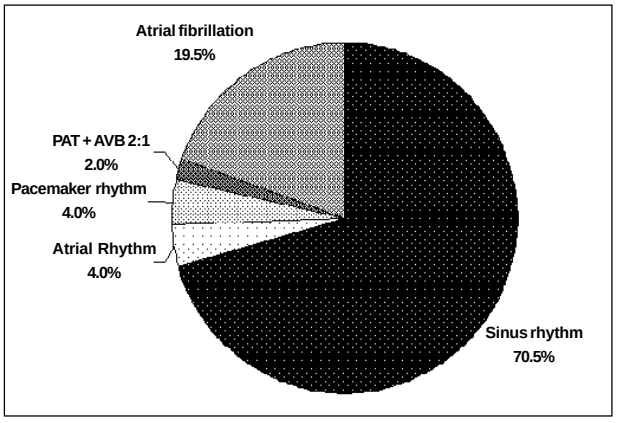

Fig. 2 - Pie-chart representing the cardiac rhythm at the last postoperative evaluation (1 to 36 months, mean = 14.7 months).

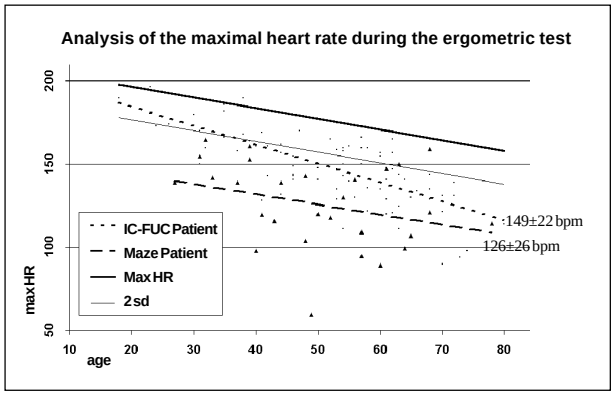

Fig. 3 – Maximal heart rate (HR) during the ergometric test of part of the series studied (Maze patient) compared with a random sample of healthy patients of the same laboratory (IC/FUC patient) and the maximal HR calculated for the test (maximal HR), distributed in regard to age. The patients of the series studied show maximal HR inferior to that of the healthy population of the laboratory ($p<0.01$).

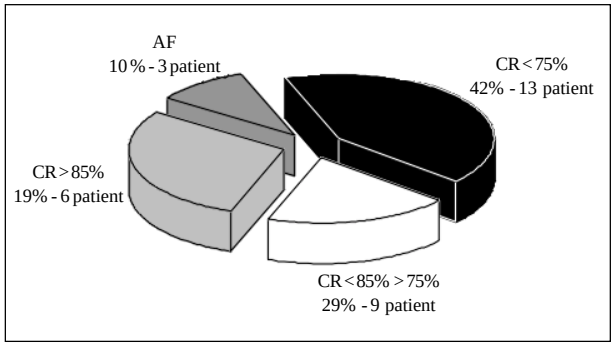

Fig. 4 – Graphic representation of the chronotropic response (CR) to exercise, evaluated through the ergometric test in a sample of 31 patients of the series. 13 patients (42%) had a HR below 75% of the heart rate calculated; 9 patients (29%) had HR between 75% and 85% of the heart rate calculated; and 6 patients (19%) showed chronotropic response of 85% or more.

developed AF during the test. In the remaining 28 patients, the chronotropic response to exercise was considered adequate (> 85% of the maximal heart rate (HR) calculated) in 19% of the patients, intermediate (between 75% and 85% of the maximal HR) in 29% of the patients, and inadequate (< 75% of the maximal HR) in 42% of the patients. The mean maximal HR reached in this group of patients was 126±26 bpm. The mean HR of a random sample of patients with similar characteristics regarding sex and age who underwent the ergometric test at the same service was 149±22 bpm ($p<0.01$) (Figs. 3 and 4). This sample comprised randomly chosen patients, who came to the ergometry laboratory for distinct reasons, at the same time of the study.

Twenty-four hour Holter monitoring was performed in 17 patients chosen among those with atrial rhythm at clinical evaluation. There were 12 females (70%) and 5 males (30%). The mean age was 51±12 years. From these patients, 9 were receiving medication (digitalis or beta-blockers). ECG-Holter was performed at a mean time of 12±7 months of the POP. The mean HR was 82±8 bpm, the maximal was 126±23 bpm and the minimal was 57±7 bpm. Supraventricular extrasystoles accounted for 2.3±5.5% of the total heartbeats and the ventricular extrasystoles for 0.8±0.5%. Chronotropic competence was interpreted as normal in 9 (53%) patients and altered in 8 (47%) patients. Atrioventricular conduction was normal in 13 (76%) patients and there was first degree AVB in 4 (24%) patients.

On echocardiogram, the mean diameter of the left atrium (LA) was 61.5 mm in the POP and 51.5 mm 12 months after the surgery ($p<0.01$). The A wave of the LA was present in 87.5% of the tests performed at the third month of the POP and, in 88% of the tests performed at the 12th month of the POP. The E/A wave ratio was 1.9±1.2 at the third month of the POP and 2.37±0.80 at the 12th month of the POP. The mean velocity of the A wave was 89.3 cm/s at the third month of the POP and 70.3 cm/s at the 12th month of the POP.

Discussion

Absence of an ideal treatment for chronic AF has compelled researchers to look for advanced treatment options. Procedures that restore atrial contraction and AV synchronism have been sought to reestablish atrial transportation and to reduce the risk of thromboembolism, through the elimination of its cause, i.e. blood stasis inside the atria. Among the surgical procedures, the corridor procedure of Guiraudon et al[10] and the electrical isolation of the left atrium[9] (or right atrium, depending on the disease) have sig-

nificant rates of success, although inferior to the maze procedure proposed by James Cox et al[11-13] who performed it for the first time in 1987.

The most recent series described by Cox et al[15] reports 178 patients who underwent surgery. Out of these 178 patients, 118 were operated upon according to the current technique (Cox-maze 3) with an early mortality rate of 2%. Intolerance to arrhythmia, intolerance to drugs, and thromboembolism were the indications for surgery. There were 26 patients with mitral lesions. There was success (atrial or sinus rhythm) in 96% of the patients, atrial flutter in 1%, and persistence of AF in 3%. A definitive DDD pacemaker was implanted in 22% of the patients due mostly to sinus dysfunction and to total AVB in some patients. Patients with primary or secondary, paroxysmal and chronic AF were operated upon. In the POP follow-up, there was evidence of right atrial contraction in 98% and left atrial contraction in 94%. The patients did not receive anticoagulants.

Our experience reported in this study shows a surgical risk similar to that of other series in the literature (Table I). The surgical success was slightly inferior to that of Cox, but yet within the expectations of others, because it involved a group of patients with another basic lesion, where the atrial lesion may have become irreversible. In addition, failures due to the learning process of the procedure and the selection of the patients should also be considered. The use of dissection and electrocoagulation instead of cryoablation could have also contributed to some failures. Comparison with a series of patients treated only for the valvular lesion showed no increase in surgical risk[16]. On the other hand, the analysis of a precedent setting series at our institution, in which only the mitral lesion was treated, showed reversion to sinus rhythm in only 26% of the patients[17]. Therefore, the benefits of the Cox method are unequivocally demonstrated by the results obtained.

Kobayashi et al[18] reported a series of 42 patients who underwent the maze procedure and the redo of the mitral valve operation, with no early deaths. Sinus rhythm was restored in 67% of the patients, suggesting that selected patients may benefit from the procedure, even in re-operations.

Other series of patients have been reported, and their results are shown in table I[15,16,19-23]. Usually, atrial or sinus rhythm is restored 85% to 90% of the time. An atrial pacemaker is necessary in 10% to 22% of the cases, depending on the previous disease. There seems to be no increase in mortality when the procedure is associated with the correction of structural lesions, even though the hospital stay and the early mortality rate may be higher with the maze procedure.

On the other hand, in our case series and in others, there is an attenuation of the chronotropic response due to partial denervation of the heart in the first months of the POP[24,25]. This response improves in a more prolonged follow-up[26]. Late occurrence of incessant atrial tachycardia has been described, emphasizing the need for the clinical observation of the patients[27].

The issue of efficacy of atrial contraction frequently arises. Several serial studies[28-31] show the restoration of effective atrial contraction and reduction of the size of the atria in most patients. Contraction is more intense in the right atrium and seems to improve with time. Giant atria tend to remain without contraction, despite the restoration of atrial electrical activity[32]. Comparison between groups treated and those that underwent only mitral valve surgery shows a decrease in the incidence of thromboembolism after the maze surgery[16].

At first sight, the surgical treatment for primary AF may seem strange. However, considering what has been reported, the evidence in the literature and the reproducibility of the results, surgery should be considered when patients of an active age are limited by arrhythmia and at the constant risk of systemic thromboembolism. Comparing the surgical risk of 2% with the already known risk of embolism or hemorrhage, we can assume that through the restoration of atrioventricular synchronism the patients operated upon will benefit within one or two years of the POP. Atrial thrombi, previous thromboembolism, hypertension, diabetes, recent heart failure, intolerance to drugs, severe symptomatology, or evidence of tachycardiomyopathy can help with the surgical indication. On the other hand, the tendency toward less invasive procedures, through smaller thoracotomies, can reduce the impact of the surgical aggression and turn this procedure into a more attractive option.

In conclusion, the maze procedure (Cox-maze) to correct chronic AF is efficient and effective in most patients. There was no increase in mortality when it was associated with the correction of other cardiac defects. Morbidi-

Table I - Results of the surgical treatment of atrial fibrillation through the maze procedure (Cox-maze)

Author/year	n	Primary	Secondary	Early Mortality (%)	Sinus/Atrial Rhythm (%)	With Pacemaker (%)
Cox, 1996 [15]	178	152	26	2	97	22
Kosakai, 1995 [19]	101	-	101	2	86	-
Gregori, 1995 [20]	20	-	20	0	90	-
Jatene, 1998 [16]	20	-	20	5	95	-
Sandoval, 1996 [21]	21	-	21	5	85	-
Melo, 1997 [22]	12	-	12	0	75	-
Kawaguchi, 1996 [23]	51	-	51	0	88	-
Kalil, 1999	61	2	59	4,9	76,5	4

ty and the duration of the intervention slightly increased. Atrial rhythm is maintained at medium-term and there is a small but remarkable frequency of atrial and ventricular arrhythmias, which deserve observation. Left atrial contraction is present, although attenuated, in the patients with atrial rhythm. The chronotropic response is slight in comparison with that in the healthy population, but the mean HR remains within an acceptable range. Use of the maze procedure to correct cardiac lesions to treat secondary chronic AF is beneficial in the short- and medium-term. As in other studies, our findings support the use of the surgical treatment of primary AF in selected patients.

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