v. 3, n. 26, 2023

International Journal of Health Science

SURGICAL ABLATION OF ATRIAL FIBRILLATION USING ENERGY SOURCES

Alexandre Visconti Brick
Professor of the Surgery Department of the Faculty of Medicine at Brasília University (UnB)

Domingo Marcolino Braile
Emeritus Professor of the São José do Rio Preto Medical School (FAMERP) and Federal University of Campinas (UNICAMP)

All content in this magazine is licensed under a Creative Commons Attribution License. Attribution-Non-Commercial-Non-Derivatives 4.0 International (CC BY-NC-ND 4.0).

Abstract: Surgical ablation, concomitant with other operations, is an option for treatment in patients with chronic atrial fibrillation (CAF). The aim of this study is to present literature review on surgical ablation of atrial fibrillation in patients undergoing cardiac surgery considering energy sources and return to sinus rhythm. Comprehensive survey was performed in the literature on surgical ablation of atrial fibrillation considering energy sources, sample size, study type, outcome (early and late) and return to sinus rhythm. Analyzing studies with immediate results (5), the percentage of return to sinus rhythm ranged 73-96%, while in those of long-term results (20) (from 12 months) the range was from 62 to 97.7%. In both, there was consequent clinical improvement of patients who underwent ablation, regardless of the energy source used. Surgical ablation of atrial fibrillation is essential in the treatment of this arrhythmia. With current technology, it may be minimally invasive, making it mandatory to perform some procedure in an attempt to revert to sinus rhythm in patients requiring heart surgery.
Keywords: Atrial fibrillation, Arrhythmias/ cardiac Ablation techniques, Energy-Generating Resources, surgery.

INTRODUCTION

Atrial fibrillation is the most common and complex supraventricular arrhythmia with loss of atrial contraction, occurring in about 0.4% of the population and 10% of patients over 60 years. Very often, it is associated with mitral valve disease and constant cause of thromboembolic events, especially cerebrovascular[1].

There are several studies demonstrating that pharmacological means to control the rhythm do not reduce morbidity and mortality rate and does not protect against thromboembolism. The atrial fibrillation that does not respond to medicines has several consequences by maintaining the irregular rhythm (palpitations and discomfort), loss of atrioventricular synchrony, causing heart failure, atrial thrombosis with thromboembolic episodes, being cause of stroke and pulmonary embolism in 33% of cases[2,3].

Often, anticoagulation, in addition to risks of bleeding, does not protect against thromboembolism and antiarrhythmic agents are not tolerated in many patients, causing potentially lethal side effects[4].

As a result, there is great interest in developing operative and interventional techniques using catheter that, through experimental and clinical studies have brought important advances in the treatment of arrhythmias.

Techniques developed over the years and studies of intraoperative mapping enabled knowledge on the electrophysiological mechanisms of this arrhythmia. Catheter ablation has an outstanding position in the treatment of atrial fibrillation, but surgery is an effective therapeutic method for treatment of CAF in patients who require heart surgery for other reasons.

The most accepted theory to explain the electrophysiological mechanism for maintenance of atrial fibrillation (AF) is multiple waves described by Moe[5] and confirmed by studies by Alessie et al.[6] and Cox et al.[7]. Subsequently, it was shown that AF is initiated by automatic foci with high frequency of triggering[8,9]. The endocardial mapping revealed that these foci are located in the pulmonary veins and the creation of multi-shaped lesions with radiofrequency energy in place of originating foci interrupts AF[10]. Whereas the cardiac electrical stimulation does not propagate where there is lesion with scarring, requiring normal

myocardium to progress, the injury caused by ablation with energy sources interrupts the reentry circuit[8-10].

The International Consensus on Catheter Ablation for Atrial Fibrillation Surgery defined the following indications for surgical ablation of AF[11]: 1-symptomatic patients undergoing surgical procedures; 2- selected asymptomatic patients undergoing another surgical procedure in which ablation can be performed with minimal risk; and 3- surgery for primary AF, to be considered for symptomatic patients who opt for surgery in which one or more attempts of catheter ablation have failed or who are not candidates for catheter ablation.

Also, the Brazilian Guidelines for Treatment of AF indicate the following[12]:

Class I: patients with symptomatic AF undergoing mitral valve surgery;

Class II B: surgery for treatment of AF in patients with symptomatic AF in which catheter ablation can not be performed or has failed.

The first non-pharmacological treatment of atrial fibrillation includes: 1) electrical cardioversion with a high recurrence rate[13]; 2) techniques using intraoperative cryoablation of the bundle of His and the atrioventricular junction[14]; 3) isolation of the left atrium[15]; 4) catheter ablation of the atrioventricular junction and permanent pacemaker implantation[16]; 5) catheter ablation of the bundle of His and definitive pacemaker implant and 6) "Corridor Operation[17]".

These procedures, although regularizing the heart rate, maintain the atria, or part of them, fibrillating, not eliminating the risk of complications such as hemodynamic compromise and the occurrence of thromboembolic events.

Based on the electrophysiological mechanisms of atrial fibrillation, analyzed in experimental studies, it has been described in the "Cox operation", which consists of making incisions and sutures of the atrial wall, enabling the spread of electrical stimulation in the atria within a labyrinth, ordering atrial contraction[18]. Changes have been performed, evolving to the "Cox Operation", simpler and also propitiating the return of sinusal rhythm[19]. Studies reporting the success of this technique were published, considered the reference standard for the surgical treatment of atrial fibrillation[20,21], mainly in patients with mitral valve disease[22].

The wide dissection of cardiac structures and performing extensive lines of section and suturing of the atrial wall, however, significantly increased the operative time and the time of cardiopulmonary bypass and aortic clamping, increasing postoperative morbidity, making it difficult the wide application of the procedure.

In order to increase the applicability and reduce the complexity of "Cox operation", several technical modifications were introduced as the change in the location of the atrial incisions[23]; reduction of section lines and suturing of the atrial wall, known as "Mini Cox[24]", and unilateral procedure, only in the left atrium, called "Cox at Left"[25].

The use of catheter ablation for the treatment of supraventricular arrhythmias stimulated the use of energy sources (cryoablation, radiofrequency, microwave, ultrasound and laser) to cause linear ablative lesions with application for endocardial or epicardial via or both replacing the cutting and suturing of the atrial wall[26-29].

Techniques of atrial ablation based on clinical studies and basic sciences, which elucidated the electrophysiology of arrhythmias, allowed high rate of success in controlling atrial arrhythmias. The association between electrophysiologists and surgeons

enabled the development of surgical methods for the treatment of CAF, especially when associated with valvular disease.

The Maze procedure developed by Cox I employed section, suture and cryoablation[30]. Changes in techniques, including the dismissal of cryoablation have been introduced, such as Jazbik et al.[31], Gregori Jr. et al.[32] and Batista et al.[33].

Grimberg et al.[34] and Maratia et al.[35] demonstrated that the simple surgical repair of the valve, or even its replacement does not guarantee a return to sinus rhythm. It has been shown that in patients with chronic atrial fibrillation and valvular heart disease, the combination of valve repair with the completion of the Maze technique allows the return to sinus rhythm.

Kalil et al.[36], performing simplified surgical technique with single incision around all four pulmonary vein ostia in patients with mitral valve disease, found that this technique was effective in treating AF secondary to mitral valve disease.

Several authors have developed and improved techniques to eliminate chronic atrial fibrillation and return to sinus rhythm in patients undergoing cardiac surgery, especially in patients with mitral valve disease, using various sources of energy capable of causing permanent blocking lines such as microwaves[37], ultrasound[38], cryoablation[24], radiofrequency[39] and laser[28].

The most widely used energy source is currently the frequency, an alternating current, released in the form of continuous sine wave, unmodulated, which may be unipolar or bipolar, irrigated or not, being able to promote ablation of the entire tissue. The driving of the energy can be measured, demonstrating the transmural lesion, an important factor to eliminate arrhythmia[40]. After the use of radio as a form of energy most commonly used in catheter ablation, results of experimental studies have been published[41,42] with new sources of energy to surgical ablation. Radiofrequency ablation for treatment of AF was described by Hindricks[43].

Regarding the cryoablation, there are two energy sources available: nitrogen oxides and argon, with a difference in the ability to freeze the tissue. The size and depth of the lesion will depend on factors such as temperature of the ablation catheter, tissue temperature, size of the catheter, duration and number of ablation lines, and the type of source[21]. The disadvantage involves the long time of application of that source and limited use in minimally invasive technique.

In an experimental study, Manasse et al.[44] used radiofrequency and cryoablation for endocardial and epicardial routes and/or video-assisted thoracoscopy, demonstrating the importance of the pulmonary veins and the presence of transmural lesions created quickly.

The micro-wave energy uses electro-magnetic field generated by oscillation of the tissue molecules, producing heat, with uniform penetration without burning the tissues around[29]. There is also a limitation on its use in minimally invasive surgery, and complications and concerns about possible esophageal perforation.

The laser, despite being a promising form of energy, has been tested only in experimental studies[28].

The effect of ultrasound to treat AF is produced by tissue damage resulting from hyperthermia in tissue necrosis, being able to produce transmural lesion that can be used by both endocardial and epicardial via, a minimally invasive manner. Considering the experience in the use of ultrasound scalpel (*UltraCision*®), often used in videolaparoscopic procedures[45], in surgery for treatment of refractory ventricular

tachycardia, Brick at al.[27,46] devised new approach to form lines of lesion, which would determine the partitioning of the left and right atria, less surgical time and cardiopulmonary bypass with consequent reflection in postoperative complications.

The aim of this study is to present literature review on surgical ablation of atrial fibrillation in patients undergoing cardiac surgery considering energy sources and return to sinus rhythm.

METHODS

This study was based on review of literature on surgery of chronic atrial fibrillation using energy sources available in databases Latin American and Caribbean Health Sciences (LILACS), *Medical Literature Analysis and Retrieval System Online* (Medline) and The Scientific Electronic Library Online (SciELO) in Portuguese and English, with respect to the theme presented in the last 20 years. The keywords used included: atrial fibrillation, ablation techniques, energy sources and results of surgical treatment.

The analysis of the studies was performed descriptively in order to present current knowledge about surgical ablation of atrial fibrillation in patients undergoing cardiac surgery[47].

Studies were analyzed on the development of surgical ablation of atrial fibrillation with energy sources associated with cardiac surgery, experimental, randomized and non-randomized studies.

Catheter ablation studies and surgical treatment of atrial fibrillation alone were excluded.

RESULTS

In this literature review we identified 75 studies on evolution and improvement of surgery of arrhythmias, divided into epidemiology and clinics (7), techniques and theories of surgery (16), experimental surgery (5), pioneering surgery (6), guidelines (3) surgeries without ablation (13) and energy sources (25) (Table 1).

19 articles were identified from the first surgery to eliminate fibrillation, through pioneering surgery performed by Cox, known as the Maze procedure until the early use of energy sources for ablation of arrhythmia.

Regarding the use of energy sources, Table 2 presents 25 articles focusing on the sample

Article	Amount
Epidemiology and Clinical	7
Techniques and Theories	16
Experimental surgery	5
Pioneering surgery	6
Guidelines	3
Surgery without ablation	13
Radiofrequency	11
Cryoablation	11
Ultrasound	4
Microwave	3
Electrocautery	1
Total of Selected Studies	75

Table 1. Classification of articles according to the clinical and surgical characteristics.

AUTHOR / YEAR	ENERGY SOURCE / Reference	SAMPLE	TYPE OF STUDY	OUTCOME*	CONCLUSION** (%)
	Radiofrequency				
Breda et al./2010	57	15	prospective	Immediate	96.0
Beukema et al./2008	59	258	retrospective	late	69.0
Williams et al./2001	60	48	prospective	late	81.0
Kottkamp et al./2002	61	70	prospective	late	93.0
Benussi et al./2002	62	132	prospective	late	76.9
Canale et al./2011	63	53	retrospective	late	68.0
Canale et al./2011	64	47	prospective	Immediate	73.0
Huang et al./2014	65	81	retrospective	late	76.0
Dong et al./2013	66	191	retrospective	late	79.1
Phan et al./2014	67	62 studies	meta-analysis of randomized controlled trials	late	67.9
Colafranceschi et al./2009	68	10	prospective	immediate	80.0
	Ultrasound				
Brick et al./2001	71	27	prospective	Immediate	81.4
Ninet et al./2005	72	103	prospective	late	85.0
Lins et al./2010	73	44	prospective randomized	late	86.4
Groh et al./2008	74	98	prospective	late	84.0
	Cryoablation				
Fukada et al./1998	51	29	prospective	late	65.5
Lee et al./2001	52	83	prospective randomized	late	95.7
Lee et al./2003	53	129	prospective randomized	late	97.7
Cox et al./2000	54	346	prospective	late	93.0
Blomström et al./2007	55	69	prospective randomized double-blind	late	73.3
Johansson et al./2012	56	65	randomized	late	73.0
	Microwave				
Gillinov et al./2002	29	20	prospective	Immediate	75.0
MacDonald et al./2012	69	12 studies	meta-analysis	late	62.0
Lin et al/2011	70	94	Prospective randomized	late	87.0
	Electrocautery				
Gomes et al./2008	44	23	prospective	late	76.4

late results correspond to those obtained from 6 months of follow-up ** Percentage of return to sinus rhythm.

Table 2.- Summary of literature on surgery of chronic atrial fibrillation using energy sources.

size, type of study, result (early and late) and completion (percentage of return to sinus rhythm). Of these, six randomized trials (484 patients), 17 non-randomized (1,551 patients) and two meta-analyzes (74 studies). A total of 19 studies were prospective and 4 retrospective.

Analyzing studies with immediate results (5) the percentage of return to sinus rhythm ranged 73-96%, while in the long-term results (20) (from 12 months) the range was from 62 to 97.7%. In both, there was consequent clinical improvement of patients who underwent ablation, regardless of the energy source used.

DISCUSSION

With research on the origin of atrial fibrillation and with the experience of electrophysiologists and surgeons, new approaches have emerged from the classic Maze surgery (COX-Maze)[7,18,19], which brings inconvenience to the extensive manipulation of the atria, with consequent peri- and postoperative repercussions. For this reason, there has been a demand for less invasive procedures, such as: manipulation only in the pulmonary veins and intraoperative ablation of atrial walls with alternative energy sources (cryoablation, microwave, radiofrequency, laser and ultrasound), and thoracoscopy procedures using radiofrequency and ultrasound catheters, from the epicardium in on-pump surgeries.

Atrial ablation can be obtained from traditional cutting technique and suture until the simplified technique for pulmonary vein isolation, as demonstrated by Albrecht et al.[48] in randomized controlled prospective study.

Gomes et al.[49], using electrocautery in mitral valve surgery, found that this source of energy reversed arrhythmia in a significant number of patients. Brick (personal communication) had the opportunity, in the absence of ultrasound equipment, to use electrocautery in small numbers of patients, not recommending routine use for causing charring with the release of small emboli inside the atrium.

In the following paragraphs, the energy sources are reviewed with data in the literature.

In relation to cryoablation, Gallagher et al.[50] described the use of cryoablation initially in the treatment of accessory bundles as method of p*re-excitation syndrome* correction.

Fukada et al.[51] investigated the indication of "Cox operation" in patients with mitral valve disease with atrial fibrillation using cryoablation for replacement of some atrial incisions. They observed that the ideal cases were patients with disease of non-rheumatic origin, especially those undergoing valve repair.

Lee et al.[52] used cryoablation to replace the section and suture lines, dividing the patients into two groups: in the first, the lines described in the "Cox operation" were used; in the second, the left and right pulmonary veins were isolated separately. Thus, they studied the improvement of atrial contraction in 83 patients undergoing surgical treatment of atrial fibrillation and other heart diseases. They demonstrated in the early evolution and following six months that the restoration of sinus rhythm and recovery of atrial contraction were significantly more evident in the second group. Later, Lee et al.[53] studied 86 patients with mitral valve disease of rheumatic origin compared to 43 patients with mitral disease of degenerative etiology, and similar results in both groups have been demonstrated, following six months, with conversion to sinus rhythm in 95.3% and 97.7% and recovery of atrial contraction in 90.4% and 91.9%, respectively.

Cox et al.[54] described minimally invasive technique for performing the "Cox operation III", with access by right inframammary thoracotomy of about 7 cm, cannulation of artery and right femoral vein and superior vena cava, for installation of cardiopulmonary bypass system and endocardial application of cryoablation to replace the section and suture lines.

In 2007, Blomström-Lundqvist et al.[55] concluded for the benefit of cryoablation in the reversion and maintenance of sinus rhythm in patients undergoing mitral valve surgery. They analyzed 69 patients who underwent isolated valve operation and in combination with cryoablation and published prospective multicenter randomized study to assess the efficacy of cryoablation applied to the epicardium of the left atrium in patients undergoing mitral valve surgery. During follow-up, the heart rate was set at 6 and 12 months, sinus rhythm rate in patients undergoing ablation was 73.3% (in both periods) and without ablation group was 45.7% (6 months) and 42.9% (12 months); with a significant difference between the groups in the two follow-up periods.

Johansson et al.[56] used the epicardial cryoablation in randomized study with 65 patients with mitral valve surgery, concluding that the ablation group had better results. This source of energy, originally used by Cox et al.[54], represents an effective and safe therapeutic option. However, the main drawback in minimally invasive surgery (off-pump) is that the freezing of the blood produces coagulation with risk of thromboembolism[55].

Another source of energy, the radiofrequency, was the first alternative energy source applied in the surgical treatment of AF and has been widely used. The irrigated unipolar device, applying the "point to point" energy source, produces tissue linear lesion. Bipolar catheter is able to promote ablation of all tissue involved by the electrodes quickly (usually less than 10 seconds). Breda et al.[57] reported the initial assessment of surgical biatrial ablation by radiofrequency. An energy driving can be measured during ablation and this can be correlated with proven transmural lesion[58].

In 2008, Beukema et al.[59] published medium and long term follow-up after radiofrequency ablation associated with other cardiac surgery and demonstrated maintenance of sinus rhythm in 69% of cases treated in follow-up of 1 year, 56% in 3 years, 52% in five years, and 57% in later periods. Treatment with antiarrhythmic drugs was maintained in 64% of patients alive who were free of AF and only 1% was under oral anticoagulation regimen.

Williams et al.[60] described the experience of three centers with the use of flexible catheter for application of radiofrequency in the pulmonary vein isolation using the endocardial via, similar to the "Cox operation", or separately, of the right and left sides, with lesions communicating the two blocs. The procedure was performed in 48 patients undergoing other procedures associated, and in eight cases lesions were performed in the right atrium. It was found survival rates of 87.5% and 81% of sinus rhythm cases in the average follow-up of four months.

Kottkamp et al.[61], through access with anterolateral right mini-thoracotomy and video-assisted cardiopulmonary bypass, performed continuous linear lesions with application of radiofrequency by endocardial via in the left atrium, involving the mitral annulus and the pulmonary veins after anatomical definition of reentrant circuits with electrophysiological mapping. The procedure was performed in 70 patients with persistent or paroxysmal atrial fibrillation.

After six months, 93% of patients were in sinus rhythm; after 12 months, 95% of patients with persistent atrial fibrillation and 97% of patients with paroxysmal atrial fibrillation were in sinus rhythm. Complications from the procedure: an esophageal perforation case and a case of development of stenosis of the circumflex coronary artery.

Benussie et al.[62] described the application of radiofrequency with multipolar catheter for performing lesions by epicardial via in 40 patients with valve disease mitral. The procedure was performed around the right and left pulmonary veins, connecting them to the left atrial appendage. After the left atriotomy, endocardial application joined the lesions of the pulmonary veins with the mitral valve, with the exclusion, in the end, of the left atrial appendage. In the mean follow-up of 11.6 months 76.9% were in sinus rhythm, with a significant reduction in the diameter of the left atrium and recovery of right and left atrial contraction. In the medium term, the results of the experience with radiofrequency ablation for atrial fibrillation in 132 patients were presented, being performed through epicardial via in 107 patients. The lesions in the left atrium were performed prior to cardiopulmonary bypass, used for correction of associated heart diseases. The operative mortality was 0.8%. After three years of development, 77% of the patients were free of atrial fibrillation and 98% free of stroke, with a survival rate of 94%.

In 2011, Canale et al.[63,64] performed retrospective studies demonstrating that the use of bipolar radiofrequency led to the reversal of arrhythmia in 68% of patients after 14 months in one study and 73% of patients in the other in the period of 7 months. The author's experience with the use of bipolar radiofrequency was more efficient than with unipolar.

In 2014, Huang et al.[65], after comparing the use of monopolar and bipolar radiofrequency, concluded that both are effective for the treatment of chronic atrial fibrillation, however, ablation with bipolar radiofrequency is more convenient in practice. Dong et al.[66] in 2013, analyzed the concomitant valve replacement and radiofrequency ablation in 191 patients with rheumatic disease. 158 patients were followed-up for a year and sinus rhythm was maintained at 79.11%.

In 2014, Phan et al.[67], after performing cumulative meta-analysis of randomized clinical trials of surgeries with and without AF ablation in six databases, identified sixteen randomized trials and concluded that surgical ablation concomitant with cardiac surgery was effective and safe to restore sinus rhythm, after 12 months of follow-up.

Colafranceschi et al.[68] performed video-assisted thoracoscopic surgery in 2009, concluding that it is safe and reproducible, especially in patients with paroxysmal fibrillation and refractory to drug therapy and did not require concomitant surgery. This technique opens new paths for patients who have not adequately responded to catheter treatment.

In Brazil, Brick et al.[27] started experience with unipolar radiofrequency catheter performing ablation of the left atrium point to point. The development of bipolar ablation devices with irrigated catheter contributed to technical improvement of the procedure with consequent less operative time and postoperative results with satisfactory success rate for reversal of sinus rhythm of 96%[57].

Using microwaves as an energy source, Gillinov et al.[29] described their experience with ablation in 10 patients undergoing surgery for mitral valve and pulmonary vein and isolation for epicardial application. After opening the left atrium, the lesions were

observed by endocardial via, proving to be transmural.

MacDonald et al.[69] in 2012, concluded that the energy by microwave in concomitant surgery in the long-term outcome assessment was not as effective when compared to radiofrequency ablation.

Lin et al.[70] in 2011, compared the use of microwave in 94 patients and bipolar radiofrequency in 93 patients undergoing valve surgery, for three months, concluding that radiofrequency ablation is superior to ablation with microwaves.

The use of ultrasound in the treatment of AF promotes tissue damage by hyperthermia. The use of this technology is attracting interest because it allows the ablation in a less invasive way, without damaging adjacent structures. Brick et al.[71] began their experience with the use of radiofrequency, using the unipolar endocardial catheter ablation, and three patients underwent surgery with reversion to sinus rhythm.

The performance of intraoperative ablation using this technique, in addition to facilitate and reduce the operative time, allowed greater understanding of the role of the left atrium and pulmonary veins in chronic fibrillation[27,41].

Additional procedures were performed: exclusion of the right and left atrial appendages, reduction of the left atrium, where necessary, and ablation of the right atrium to eliminate the possibility of occurrence of atrial flutter.

Ninet et al.[72] in a multicenter study, analyzed prospectively 103 patients between September 2002 and February 2004, using ultrasound for epicardial ablation of atrial fibrillation. Ablation was performed through epicardial via using a high-frequency ultrasound, EpiCor® (St Jude Medical Inc). In this analysis, after six months, 85% of patients were in sinus rhythm. They demonstrated the advantage of using the energy of ultrasound, creating a transmural lesion around the left atrium, without the use of cardiopulmonary bypass.

Lins et al.[73] show an improvement in functional class in the treated group versus the control group in a comparative study in patients with mitral valve disease, using ultrasound scalpel (*UltraCision®*). The groups presented homogeneous characteristics preoperatively and no significant difference considering the cardiopulmonary bypass times, anoxia and ICU stay postoperatively in both groups, which concludes that the use of ultrasonic scalpel for ablation of AF does not act as fact to worsen patient outcomes. Comparing patients undergoing ultrasound ablation than those who received no recent ultrasound ablation it was not found more complications or deaths in the recent or late postoperative. The results observed in this study show that the application of the ultrasound technique ablation can be applied to patients who have surgical indication for mitral valve disease correction.

In addition to the endocardial application, ultrasound with other devices like the EpiCor® can be used in off-pump surgery, through epicardial via in patients with isolated fibrillation, as well as in patients with ischemic heart disease undergoing CABG[74]. The Consensus of the International Society of Minimally Invasive Cardiothoracic Surgery (ISMICS)[75], whose objective was to determine whether surgical ablation of AF during associated cardiac procedures improved postoperative clinical outcomes. The group involved in the study analyzed the best available evidence, with systematic data review, including randomized-controlled studies or not, always in descending order of importance. A systematic review and meta-analysis identified 10 randomized trials (650 patients) and 23 non-randomized (3997

patients), the great majority was published in English and performed in the United States.

The authors of the consensus defined the following recommendations: in patients with persistent and permanent AF, the surgical ablation is recommended to increase the incidence of sinus rhythm in the short- and long-term (Class 1, Level A); reduce the risk of stroke and thromboembolic events (Class 2a, level A); increase the exercise tolerance and improve ventricular function (Class 2a, level A) and increase survival (Class 2a, level B)[75].

CONCLUSION

From classical labyrinth surgery (Cox-Maze), changes in demand for less invasive procedures have occurred using alternative sources of energy.

The results of the surgical ablation of atrial fibrillation in patients undergoing cardiac surgery depend on the energy source used; the lesion produced is transmural and applied in the two atria.

We conclude that surgical ablation of atrial fibrillation is essential in the treatment of this arrhythmia. With current technology, it may be minimally invasive, making it mandatory to perform some procedure in an attempt to revert to sinus rhythm in patients requiring heart surgery.

Situations involving the primary fibrillation surgery indication should include a multidisciplinary team approach involving cardiologists, electrophysiologists and surgeons to the correct choice of patients and the most appropriate procedure.

REFERENCES

1. Go AS, Hylek EM, Phillips KA, Chag Y, Henault LE, SELBY JV, et al. Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the Anticoagulation and Risk Factors In Atrial Fibrillation (ATRIA) Study. JAMA. 2001;285;2370-5.

2. Kannel WB, Abbot RD, Savage DD, McNamara PM. Epidemiological features of chronic atrial fibrillation: The Framingham Study. N Engl J Med 1982; 306:1018-22.

3. Wolf PA, Abbot RD, Kannel WB. Atrial fibrillation: a major contributor to stroke in the elderly: The Framinghan Study. Arch Intern Med 1987; 147:1561-4.

4. Hart RG, Halperin JL, Pearce LA, et al. Lessons from the stroke prevention in atrial fibrillation trials. Ann Intern Med 2003;138(10):831-8.

5. Moe FK. On the multiple wavelet hypothesis of atrial fibrillation, Arch Int Pharmacodyn Ther 1962; 140:183-8.

6. Alessie M, Bonke FIM, Schopman JG. Circus movement in rabbit atrial muscle as a mechanism of tachycardia. III- The "Leading Circle" concept: a new model of circus movement in cardiac tissue without the involvement of an anatomical obstacle. Circ Res 1977; 41:9-18.

7. Cox JL, Schussler RB, Boineau JP. The surgical treatment of atrial fibrillation: I – Summary of the current concepts of the mechanisms of atrial flutter and atrial fibrillation. J Thorac Cardiovasc Surg 1991; 101:402-5.

8. Haissagüerre M, Jaïs P, Shah DC, Takahashi A, Hocini M, Quiniou G, et al. Spontaneous initiation of atrial fibrillation by ectopic beats originating in the pulmonary veins. N Engl J Med 1998; 339:659-66.

9. Scheinman M, Morady F, Hess DS, Gonzalez R. Catheter-induced ablation of the atrioventricular junction to control refractory supraventricular arrhythmias. JAMA 1982; 248:851-5.

10. Gallagher JJ, Svenson RH, Kasel JH, German LD, Bardy GH, Broughton A, etal. Catheter technique for closed-chest ablation of the atrioventricular conduction system: A therapeutic alternative for the treatment of refractory supraventricular tachycardia. N Engl J Med 1982; 306:194-200.

11. Calkins H, Brugada J, Packer DL, Cappato R, Chen SA, Crijins HJ,et al.HRS/EHRA/ECAS expert Consensus Statement on catheter and surgical ablation of atrial fibrillation: recommendations for personnel, policy, procedures and follow-up. A report of the Heart Rhythm Society (HRS)Task Force on catheter and surgical ablation of atrial fibrillation. Heart Rhythm. 2007;4:816-61.

12. Diretrizes Brasileiras de Fibrilação Atrial. Arq Bras Cardiol. 2009;92(Supl.1):1-

13. Van Noord T, Van Gelder IC, Schoonderwoord BA, Crijns HJ. Immediate reinitiation of atrial fibrillation after electrical cardioversion predicts subsequent pharmacologic and electrical conversion to sinus rhythm on amiodarone. Am J Cardiol 2000; 86:1384-5.

14. Harrison L, Gallagher JJ, Kasell J, Anderson RH, Mikat E, Hackel DB, etal. Cryosurgical ablation of the AV node-His bundle: A new method for producing AV block. Circulation 1977; 55:463-70.

15. Williams JM, Ungerleider RM, Lofland GK, Cox JL. Left atrial isolation. New technique for the treatment of supraventricular arrhythmias. J Thorac Cardiovasc Surg 1980; 80:373-80.

16. Scheinman M, Morady F, Hess DS, Gonzalez R. Catheter-induced ablation of the atrioventricular junction to control refractory supraventricular arrhythmias. JAMA 1982; 248:851-5.

17. Guiraudon GM, Klein GL, Yee R, Leitch JW, Kaushik RR, McLellan DG. Surgery for atrial tachycardia. Pace 1990; 13:1996-9.

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

19. Cox JL, Jaquiss RDB, Schuessler RB, Boineau JP. Modification of the Maze procedure for atrial flutter and atrial fibrillation. II. Surgical technique of the maze III procedure. J Thorac Cardiovasc Surg 1995; 110:485-95.

20. Jatene AD, Sosa E, Tarasoutchi F, Jatene MB, Pomerantzeff PMA. Tratamento cirúrgico da fibrilação atrial. Procedimento do "labirinto": experiência inicial. Rev Bras Cir Cardiovasc 1992; 7:107-11.

21. 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.

22. Jatene MB, Sosa E, Jatene FB, Tarasoutchi F, Monteiro AC, Salerno PR, et al. Evolução tardia da operação de Cox para fibrilação atrial em valvopatia mitral. Rev Bras Cir Cardiovasc 1995; 10:18-24.

23. Kim KB, Huh JH, Kang CH, Ahn H, Sohn DW. Modifications of the Cox-Maze III procedure. Ann Thorac Surg 2001; 71:816-22.

24. Szalay ZA, Skwara W, Pitschner HF, Faude I, Klövekorn WP, Bauer EP. Midterm results after the mini-maze procedure. Eur J Cardiothorac Surg 1999; 16:306-11.

25. Sueda T, Nagata H, Shikata H, Orihashi K, Morita S, Sueshiro M, et al.Simple left atrial procedure for chronic atrial fibrillation associated with mitral valve disease. Ann Thorac Surg 1996; 62:1796-800.

26. Haïssaguerre M, Marcus FI, Fischer B, Clémenty J. Radiofrequency catheter ablation in unusual mechanisms of atrial fibrillation: Report of three cases. J Cardiovasc Electrophysiol 1994; 5:743-51.

27. Brick AV, Seixas TN, Portilho CF, Vieira Jr JJ, Mattos JV, Peres AK. Reversão da fibrilação atrial crônica pela técnica do labirinto com aplicação de radiofreqüência e ultrassom transoperatório. Rev Bras Cir Cardiovasc 1999; 14:290-7.

28. Williams M, Klein K, Sanchez J, D'Alessandro D, Di Giorgi P, Mutrie C, et al. Linear atrial ablation using laser energy. Division of Cardiothoracic Surgery Columbia University College of Physicians and Surgeons 2002.

29. Gillinov AM, Smedira NG, Cosgrove III DM. Microwave ablation of atrial fibrillation during mitral valve operations. Ann Thorac Surg 2002; 74:1259-61.

30. Cox JL, Schuessler RB, Boineau JP et al. Modification of the maze procedure for atrial flutter and atrial fibrillation: II. Surgical technique of the maze – III procedure. J Thorac Cardiovasc Surg. 1995; 110:485-495.

31. Jazbik JC, Coutinho JH, Amar MR, Silva SL, Jazbik AT, Rodrigues J, et al. Tratamento cirúrgico da fibrilação atrial em pacientes com insuficiência mitral: proposta inicial de uma nova abordagem cirúrgica. Rev SOCERJ. 1993; 6(3):142-5.

32. Gregori Jr F, Cordeiro e Goulart MAet al. Técnica de Cox sem crioablação para tratamento cirúrgico da fibrilação atrial. Rev Bras Cir Cardiovasc. 1993; 8:220-4.

33. Batista RJV, Franzoni M, Precoma DV et al. Autotransplante Cardíaco: um novo método no tratamento de problemas cardíacos complexos. 1995; 10:90-100.

34. Grimberg M, Solimene MC, Belotti G et al.Estenose mitral calcificada: aspectos clínicos e cirúrgicos. Arq Bras Cardiol. 1975; 28:17-24.

35. Maratia C, Kalil RAK, Santanna et al. Fatores preditivos de reversão a ritmo sinusal após intervenção na valva mitral em pacientes com fibrilação atrial crônica. Rev Bras Cir Cardiovasc. 1977; 12:17-23.

36. Kalil RAK, Lima GG, Abrahão R, Sturmer 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(2):129-35.

37. Krum D, Shetty S, Mare J et al. Characteristics of myocardial lesions created using microwave energy: optimization of antenna design (Abstr). Circulation. 1994; 90:1271.

38. He DS, Simmons WN, Zimmer et al. Comparison of several ultrasonic frequencies for cardiac ablation (Abstr). Circulation. 1994; 90: I-271.

39. Hindricks F, Mohr W, Autschbach R and Kottkamp H. Antiarrhytmic surgery for treatment of atrial fibrillation – new concepts. Thorac Cardiovasc Surg. 1999; 47 (supply) 365-369.

40. Taylor GW, Kay GN, Zheng X, Bishop S, Ideker RE. Pathological effects of extensive radiofrequency energy applications in the pulmonary veins in dogs. Circulation 2000; 101:1736-42.

41. Santos, MA.Estudo experimental comparativo entre ultra-som e radiofreqüência na realização de linhas de ablação atriais por via epicárdica.(Tese). São Paulo; Universidade Federal de São Paulo; 2003. XV, 106f.

42. Caccitolo JA, Stulak JM, Schaff HV, Francischelli D, Jensen DN, Mehra R. Open-heart endocardial radiofrequency ablattion: an alternative to incisions in maze surgery. J.Surg Research 2001; 97:27-33.

43. Hindricks F Mohr W, Autschback R and Kottkamp H – Antiarrhytmic Surgery for Treatment of Arial Fibrillation – New Concepts. Thorac Cardiovas Surg 1999, 47(supply)365-369.

44. Manasse E, Infante M, Ghiselli S, Cariboni U, Alloisio M, Barbone A, et al.A vídeo-assisted thoracoscopic technique to encircle the four pulmonar veins: a new surgical intervention for atrial fibrillation ablation. Heart Surg Forum 2002;5:337-9.

45. Amaral JF. Laparoscopic Application of a ultrasonically activated scalpel. G I Endoscopy Clinics of North Am. 1993; 3:381-391.

46. Brick AV, Seixas TN, Portilho CF, Vieira Jr JJ, Mattos JV, Peres AK. Tratamento cirúrgico da taquicardia ventricular refratária: nova proposta técnica. Rev Bras Cir Cardiovasc. 1997; 12(3): 269-73.

47. Souza MT, Silva MD, Carvalho R. Bento, A. Revisão integrativa: o que é e como fazer. Eintein 2010;8:102-6.

48. Albrecht A, Kalil RAK, Schuch L, Abrahão R, Sant'Anna JRM, de Lima GG, et al. Randomized study of surgical isolation of the pulmonary veins for correction of permanent atrial fibrillation associated with mitral valve disease. J Thorac Cardiovasc Surg 2009; 138:454-9.

49. Gomes JR, et al. Tratamento cirúrgico da fibrilação atrial crônica com eletrocautério convencional em cirurgia valvar mitral. Rev Bras Cir Cardiovasc 2008; 23(3): 365-371

50. Gallagher JJ, Sealy WC, Anderson RW, Kasell J, Millar R, Campbell RWF, et al. Cryosurgical ablation of accessory atrioventricular connections: a method for correction of the pre-excitation syndrome. Circulation 1977; 55:471-9.

51. Fukada J, Morishita K, Komatsu K, Sato H, Shiiku C, Muraki S, et al. Is atrial fibrillation resulting from rheumatic mitral valve disease a proper indication for the maze procedure? Ann Thorac Surg 1998; 65:1566-70.

52. Lee JW, Choo SJ, Kim KI, Song JK, Kang DH, Song JM, et al. Atrial fibrillation surgery simplified with cryoablation to improve left atrial function. Ann Thorac Surg 2001; 72:1479-83.

53. Lee JW, Park NH, Choo SJ, Jo MS, Song H, Song MG. Surgical outcome of the maze procedure for atrial fibrillation in mitral valve disease: rheumatic versus degenerative. Ann Thorac Surg 2003; 75:57-61.

54. Cox JL, Ad N, Palazzo T, 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(1):15-9.

55. Blomström-Lundqvist C, Johansson B, Berglin E, Nilsson L, Jensen SM, Thelin S, et al. A randomized double-blind study of epicardial left atrial cryoablation for permanent atrial fibrillation in patients undergoing mitral valve surgery: the SWEDish Multicentre Atrial Fibrillation study (SWEDMAF). Eur Heart J. 2007;28(23):2902-8.

56. Johansson B1, Bech-Hanssen O, Berglin E, Blomström P, Holmgren A, Jensen SM, et al. Atrial function after left atrial epicardial cryoablation for atrial fibrillation in patientsundergoing mitral valve surgery.J Interv Card Electrophysiol. 2012;33(1):85-91.

57. Breda JR, Ragognette RG, Breda ASCR, Gurian DB, Horiuti L, Machado LN, etal. Avaliação inicial da ablação operatória biatrial por radiofrequência de fibrilação atrial. Rev Bras Cir Cardiovasc. 2010;25(1):45-50.

58. 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(3):198-205.

59. Beukema WP, Sie HT, Misier AR, Delnoy PP, Wellens HJ, Elvan A. Intermediate to long-term results of radiofrequency modified Maze procedure as an adjunct to open-heart surgery. Ann Thorac Surg. 2008;86(5):1409-14.

60. 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; 71:1939-44.

61. Kottkamp H, Hindricks G, Autschbach R, Krauss B, Strasser B, Schirdewahn P, et al. Specific linear left atrial lesions in atrial fibrillation: intraoperative radiofrequency ablation using minimally invasive surgical techniques. J Am Coll Cardiol 2002; 40:475-80.

62. Benussi S, Nascimbene S, Agricola E, Calori G, Calvi S, Caldarola A, etal.Surgical ablation of atrial fibrillation using the epicardial radiofrequency approach: mid-term results and risk analysis. Ann Thorac Surg 2002; 74:1050-7.

63. Canale, Leonardo Secchin; Colafranceschi, Alexandre Siciliano; Monteiro, Andrey José Oliveira; Fernando Eugênio dos Santos; et al. Tratamento cirúrgico de fibrilação atrial utilizando ablação com radiofrequência bipolar em doença mitral reumática. Rev. bras. cir. cardiovasc;26(4):565-572, out.-dez. 2011. ilus, tab.

64. Canale, Leonardo Secchin; Colafranceschi, Alexandre Siciliano; Monteiro, Andrey José; Coimbra, Marialda; et al. Uso da radiofrequência bipolar para o tratamento da fibrilação atrial durante cirurgia cardíaca. Arq. bras. cardiol;96(6):456-464, jun. 2011.

65. Huang WZ, Wu YM, Ye HY, Jiang HM. Comparison of the outcomes of monopolar and bipolar radiofrequency ablation insurgical treatment of atrial fibrillation. Chin Med Sci J. 2014;29(1):28-32.

66. Dong L, Fu B, Teng X, Yuan HS, Zhao SL, Ren L. Clinical analysis of concomitant valve replacement and bipolar radiofrequency ablation in 191 patients.J Thorac Cardiovasc Surg. 2013;145(4):1013-7.

67. Phan K, Xie A, Tian DH, Shaikhrezai K, Yan TD. Systematic review and meta-analysis of surgical ablation for atrial fibrillation during mitral valve surgery. Ann Cardiothorac Surg. 2014;3(1):3-14.

68. Colafranceschi, Alexandre Siciliano; Monteiro, Andrey José de Oliveira; Botelho, Eduardo Souza Leal; Canale, Leonardo Secchin; Rabischoffsky, Arnaldo; et al. Cirurgia vídeo-assistida para a ablação da fibrilação atrial isolada por radiofrequência bipolar. Arq. bras. cardiol;93(4):334-42.

69. MacDonald DR, Maruthappu M, Nagendran M. How effective is microwave ablation for atrial fibrillation during concomitant cardiacsurgery?Interact Cardiovasc Thorac Surg. 2012;15(1):122-7.

70. Lin Z, Shan ZG, Liao CX, Chen LW. The effect of microwave and bipolar radio-frequency ablation in the surgicaltreatment of permanent atrial fibrillation during valve surgery.Thorac Cardiovasc Surg. 2011;59(8):460-4.

71. Brick AV, Seixas T, Portilho C, Peres A K, Vieira Jr J J, Melo Neto R, Araújo J M. Tratamento intra-operatório da fibrilação atrial crônica com ultra-som. Rev Bras Cir Cardiovasc 2001; 16(4): 337-49.

72. Ninet J, Roques X, Seitelberger R, Deville C, Pomar JL, Robin J, et al. Surgical ablation of atrial fibrillation with offpump, epicardial, high-intensity focused ultrasound: results of a multicenter trial. J Thorac Cardiovasc Surg. 2005;130(3):803-9.

73. Lins RMM, Lima RC, Silva FPV, Menezes AM, Salerno PR, Thé EC, et al. Tratamento da fibrilação atrial com ablação por ultrassom, durante correção cirúrgica de doença valvar cardíaca. Rev Bras Cir Cardiovasc. 2010;25(3):326-32.

74. Groh MA, Binns OA, Burton HG 3rd, Champsaur GL, Ely SW, Johnson AM. Epicardial ultrasonic ablation of atrial fibrillation during concomitant cardiac surgery is a valid option in patients with ischemic heart disease. Circulation. 2008;118(14 Suppl):S78-82.

75. Ad N, Cheng DCH, Martin J, Berglin EE, Chang BC, Doukas G. Surgical Ablation for atrial fibrillation in cardiac surgery: a consensus statement of the International Society of Minimally Invasive Cardiothoracic Surgery (ISMICS) 2009. Innovations. 2010;5(2):74-83.