

## EFFECTIVENESS OF UNIPOLAR RADIOFREQUENCY SURGICAL ABLATION FOR ATRIAL FIBRILLATION

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**Aim.** To verify the effectiveness of surgical ablation for atrial fibrillation by irrigated unipolar radiofrequency, applied to both atria, for the reversal and maintenance of the sinus rhythm in the short and medium term in patients undergoing concomitant cardiac surgery.

**Material and methods.** Between February 2008 and March 2012 a total of 35 consecutive patients with persistent and permanent paroxysmal AF underwent surgical tachyarrhythmia ablation by irrigated unipolar radiofrequency applied biatrially with concomitant cardiac surgery. All cases were diagnosed at least 12 months before the procedure and the group consisted of 15 (42,8%) male and 20 female (51,2%) patients, aged 25-78 years (52,23±12,82).

**Results.** There were 24 (68,5%) patients with rheumatic mitral valve disease with 25,8% with degenerative disease. The left atrial diameter measured by transthoracic echocardiography ranged from 44 to 70 millimeters (mm) (55,31±18,10). There were two hospital deaths in this series. Upon discharge, we observed the following rhythms and percentages: 24 (68,5%) — sinus rhythm, 7 (20%) — AF and 4 (11,5%) — junctional rhythm. At medium term follow-up we obtained the following results: 11 (73,3%) — sinus rhythm, 2 (13,35%) — junctional rhythm and 2 (13,35%) — AF.

**Conclusion.** Surgical ablation by irrigated unipolar radiofrequency applied to both atria is effective in the reversal and maintenance of sinus rhythm during short and medium term follow-up.

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**Key words:** atrial fibrillation, unipolar radiofrequency, heart failure.

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## ЭФФЕКТИВНОСТЬ ОДНОПОЛЯРНОЙ РАДИОЧАСТОТНОЙ ХИРУРГИЧЕСКОЙ АБЛАЦИИ ПРИ ФИБРИЛЛЯЦИИ ПРЕДСЕРДИЙ

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**Цель.** Проверить эффективность хирургической абляции при фибрилляции предсердий однополярным методом, применяемым для обоих предсердий, для реверсирования и поддержания синусового ритма в краткосрочной и среднесрочной перспективе у пациентов, подвергнутых сочетанной сердечно-сосудистой хирургии.

**Материал и методы.** В период с февраля 2008 г и в март 2012 г всего 35 пациентов с персистирующей и постоянной ФП были подвергнуты хирургической абляции тахикардии однополярным методом, примененным билатерально с сопутствующей сердечно-сосудистой хирургией. Все случаи были диагностированы по крайней мере 12 месяцев перед процедурой, в группе было 15 (42,8%) мужчин и 20 женщин (51,2%) больных, в возрасте 25-78 лет (52,23±12,82).

**Результаты.** У 24 (68,5%) больных был диагностирован ревматический митральный порок сердца, из которых у 25,8% — с дегенеративным заболеванием. Диаметр левого ушка предсердия, измеренный трансторакальной эхокардиографии колебался от 44 до 70 миллиметров (мм) (55,31±18,10). Были констатированы два смертельных случая в этой группе. После выписки мы наблюдали следующие ритмы и проценты:

24 (68,5%) — синусовый ритм, 7 (20%) — ФП и 4 (11,5%) — сочетанный ритм. В среднесрочной перспективе последующих получены следующие результаты: 11 (73,3%) — синусовый ритм, 2 (13,35%) — сочетанный ритм и 2 (13,35%) — ФП.

**Заключение.** Хирургическая радиочастотная абляция однополярным методом применяется для обоих предсердий и является эффективным для восстановления и поддержания синусового ритма при коротких и средних сроках наблюдения.

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**Ключевые слова:** фибрилляция предсердий, радиочастотная униполярный, сердечная недостаточность.

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Atrial fibrillation (AF), whose prevalence increases with age, represents the most common sustained disturbance of cardiac rhythm in the presence or absence of structural heart diseases. Its occurrence is associated with not only increased morbidity and mortality rates, which are related to hemodynamic deterioration and complications owing to the use of anticoagulants, but also with increased hospital costs [1].

The Cox-Maze III operation represents the most effective method for treatment of AF. However, despite the

fact it is considered the gold standard of therapy; its effectiveness is inversely proportional to its applicability [2]. Thus, several alternative energy sources (cryoablation, microwave, radiofrequency) have been used in an attempt to create a lesion similar to that obtained by the “cut and suture” technique [3-5].

The use of radiofrequency in surgical treatments of AF has been reported with good results and few complications in several studies. This radiofrequency, either uni- or bipolar, was initially used in the electrophysiology laboratory. It

was the first alternative energy source applied in such treatments and has been widely tested in recent years [6, 7]. The irrigated unipolar device produces a linear lesion of the tissue when the point-to-point power source is applied.

In our method, unipolar radiofrequency is the most often widely used energy source in the surgical treatment of AF with structural heart disease. However, some authors suggest that the effectiveness of this unipolar source is lower when compared with other methods in the restoration of normal sinus rhythm [8, 9]. Therefore, we adopt the AF ablation by irrigated unipolar radiofrequency, biatrially applied, for the treatment of AF (paroxysmal, persistent or permanent), with concomitant cardiac surgery [10].

The aim of this study is to verify the effectiveness of surgical ablation for atrial fibrillation by irrigated unipolar radiofrequency, applied to both atria, for the reversal and maintenance of sinus rhythm in the short and medium term in patients undergoing concomitant cardiac surgery.

### Material and methods

**Patients and Study Design.** A total of 35 consecutive patients with paroxysmal, persistent and permanent AF, diagnosed 12 months before the surgical procedure, were screened between February 2008 and March 2012.

Patients had indication to surgery when signs of cardiac congestion were apparent. About 51.4% of the patients were in New York Heart Association (NYHA) Heart Failure functional class (FC) II and 48.6% in class III. The follow-up period after surgery ranged from 1 to 60 months (mean of  $9 \pm 4$ ).

They underwent surgical ablation of tachyarrhythmia by irrigated unipolar radiofrequency applied biatrially, with concomitant cardiac surgery. The study protocol was approved by the local ethics and research committee of Faculdade de Medicina do ABC (ABC Medical School) and the Federal University of São Paulo (UNIFESP). Patients were included after signing a term of informed consent.

Left ventricular ejection fraction (LVEF) below 35%, the presence of infectious endocarditis, contra-indication to anticoagulant therapy or unstable arrhythmia defined as non-controlled heart rate were considered exclusion criteria.

**Surgical Technique.** The operation began with the performance of hemodynamic monitoring by measuring the mean arterial pressure, the central venous pressure and urine output. In addition, respiratory rate was verified by pulse oximetry.

The surgery was carried out in the usual way, with median sternotomy as access, cannulation of the aorta and the superior and inferior vena cava after intravenous administration of heparin (400 IU/kg) and moderate hypothermia at 32°C.

The myocardial protection method used was hypothermic antegrade blood cardioplegia (approximately 18°C)

with added potassium (15 mEq/L) in induction. In the subsequent doses, at intervals of 15 minutes, perfused blood was administered at 32°C without adding any other substance.

The mitral valve approach was made transeptally, followed by valve repair or replacement (using a biological or metal prosthesis).

After the valve procedure, patients underwent surgical treatment for atrial fibrillation, with excision of the right and left atrial appendage (RAA and LAA) and an incision of 4 centimeters (cm) from the middle portion of the RAA removed towards the superior vena cava orifice. Thereafter, irrigated radiofrequency was applied in the endocardium of both atria following the procedures described in a previous publication. The Medtronic Cardioblate® Unipolar Surgical Ablation Pen was the instrument of choice (Medtronic Inc., Minneapolis, MN)<sup>10</sup>.

At the end of the operation, patients in normothermia were taken to the postoperative unit, where electrocardiography was carried out every 12 hours and they were clinically monitored throughout their stay. They were then discharged, and one month after the surgery follow-up was done with ECG, echocardiography and 24-hour Holter monitoring. During the course of treatment all subjects were accompanied by a single member of the surgical team, who filled out a protocol form for the sake of pre- and postoperative data comparison.

**Post-surgery drug protocol.** The treatment protocol after the application of irrigated radiofrequency initially involved the use of amiodarone (100-400 mg daily) in order to control atrioventricular nodal conduction and for atrial stabilization before discharge. It was prescribed individually, taking into account the potential side effects of this medication.

Moreover, we administered oral anticoagulants to maintain INR (International Normalized Ratio) between 2.0 and 3.0. In the event of reversal and maintenance of sinus rhythm, anticoagulant therapy was maintained for at least four weeks. On the other hand, whenever there was no reversion of the sinus rhythm, two attempts at electrical cardioversion (ECV) were scheduled, with an interval of 4 to 6 weeks between both attempts. In the case of failure, the use of oral anticoagulants and drugs was maintained, with referral of the patient for electrophysiological study (after gradual discontinuation of amiodarone).

### Results

In Table 1 the clinical and demographical data of the patients can be observed. The group consisted of 15 (42,8%) male and 20 female (51,2%) patients. The mean age for men was  $52,23 \pm 12,82$  years. In 24 (68,5%) patients the mitral valve disease was rheumatic, in 9 (25,8%) it was degenerative, 1 (2,85%) was ischemic and 1 (2,85%) had mitral stenosis after repair with a ring. The mean left atrial diameter measured by transthoracic echocardiography was  $55,31 \pm 18,10$  mm.

There were two hospital deaths in this series: one patient who went into cardiogenic arrest and another from sepsis due to pulmonary infection.

In Table 2 the surgical data is shown. Mitral repair was performed in 6 cases (17,1%), a biological prosthesis was implanted in 19 cases (54,2%) and a metallic prosthesis in 10 cases (28,7%). The mean CPB time was  $128 \pm 26,32$  minutes and the anoxia time was  $88,60 \pm 17,30$  minutes. The average time for performing ablation was  $8,72 \pm 1,91$  minutes.

Table 3 shows the data of the immediate postoperative period, with 26 (74,3%) patients in sinus rhythm, 4 (11,4%) in AF, 4 (11,4%) in junctional rhythm and 1 (2,9%) with total atrioventricular blockage (TAVB) requiring artificial cardiac stimulation with a temporary pacemaker.

During the postoperative follow-up until hospital discharge, 3 patients showed AF, including the case that reverted to TAVB. Thus, at discharge, we observed the following rhythms and percentages: 24 (68,5%) — sinus rhythm, 7 (20%) — AF, and 4 (11,5%) — junctional rhythm.

Also during postoperative follow-up 50% of the AF patients had reversion to sinus rhythm after electrical cardioversion. At the mean follow-up time we obtained the following results: 11 patients (73,3%) with sinus rhythm, 2 (13,35%) with junctional rhythm and 2 (13,35%) with AF. Among the patients who remained in AF, left atrial diameters were greater than 65 mm.

### Discussion

In experimental studies, achieving transmural with unipolar radiofrequency requires prolonged application time (over two minutes). During the mitral valve surgery it was observed that after two minutes of unipolar endocardial ablation only 20% of the lesions were transmural [11]. This finding plays an important role in the success of the procedure once transmural is a fundamental requirement in association with the ablation lines employed. Thus, due to the difficulty in confirming whether the lesion produced by the application of unipolar radiofrequency was actually transmural, it is advisable to apply energy to the endocardium slowly (preferably between 8 and 10 minutes of ablation or at a rate of 10 to 15 cm/second).

In 2008 Myrdko et al published a prospective study involving 100 patients with permanent AF and mitral valve disease, with surgical indication for replacement or valvuloplasty. The patients had similar demographic and clinical characteristics and were divided into two groups: one for isolated mitral valve replacement and the other for concomitant treatment of arrhythmia with unipolar radiofrequency. At hospital discharge 56% of the patients undergoing unipolar ablation were in normal sinus rhythm, compared with only 22% of the isolated mitral group. After a one-year follow-up, the percentage of patients in sinus rhythm was 54 versus 16% (unipolar ablation group and

Table 1

Preoperative clinical and demographic data

Variables	Frequency
Gender	
– Female	57,2
– Male	42,8
Age (years)	52,23±12,82
NYHA	
– II	51,4
– III	48,6
History of thromboembolism	16,7
Left Atrium Diameter (mm)	55,31±18,10

Results expressed as percentage for categorical variables and mean and standard deviation for continuous variables.

Table 2

Surgical data

Procedure	Unipolar radiofrequency
Mitral valve replacement	82,9
Mitral valve repair	17,1
Anoxia time (min)	88,60±17,30
Perfusion time (min)	128±26,32
Ablation time (min)	8,72±1,9

Results expressed as percentages for categorical data and mean and standard deviation for continuous variables.

Table 3

Post-operative (PO) Unipolar radiofrequency patients data and follow-up

Rhythm	PO	Discharged	PO follow-up
Sinus rhythm	74,3	68,5	73,3
AF	11,4	20	13,35
Junctional rhythm	11,4	11,5	13,35
Pacemaker	2,9	-	-

Results expressed as percentages.

control respectively). Both groups received pharmacological treatment with amiodarone for three months, followed by electrical cardioversion in the event of persistence of the tachyarrhythmia. The main factors identified by the failure of the unipolar ablation in this study were the left atrial diameter over 60 millimeters (mm) and the presence of severe left ventricular dysfunction [12].

Johansson et al showed similar results in patients undergoing coronary artery bypass grafting and unipolar ablation in a longer follow-up period ( $32 \pm 11$  months) and with assessments at 3 and 6 months post-operatively. The success rate obtained was of 62% versus 33% (ablation versus control group). Furthermore, the authors demonstrated improved quality of life after restoration of sinus rhythm [13].

In this consecutive series we observed results similar to those previously reported in the literature, with mean follow-up times of nine months. Just like other studies, the rhythm monitoring was performed essentially by the sur-

face electrocardiogram and 24-hour Holter recording, which obviously may limit the diagnosis of asymptomatic events. For the next patients, continuous monitoring of the cardiac rhythm by ECG telemetry is suggested in order to solve this issue.

A different approach to analyze the effect of radiofrequency ablation for AF was published by Zangrillo et al, evaluating the changes in troponin levels in 142 patients. The researchers found no significant change in this marker when comparing unipolar ablation with isolated mitral valve surgery groups ( $p=0,7$ ), concluding that the method is safe with little interference in cardiac structure [14].

Despite the advances in understanding the mechanisms that generate AF, surgical treatment should ideally be individualized according to each case. The flaw in the application of unipolar radiofrequency can be directly related to either ablation lines or the fact that the generating focus of the arrhythmia is not in the left atrium. The performance of the bi-atrial technique corroborates the best results. Between 9 and 19% of cases have the origin of arrhythmia in the right atrium, and such cases additionally benefit from the application of bi-atrial lines. Another important factor is the time of application of the endocardial unipolar radiofrequency because, unlike bipolar devices, the transmural of the lesion is more difficult to obtain. We conclude that standardization of the surgical technique in the application of unipolar radiofrequency is directly related to higher success rates [15-17].

In 2012, Chen Y et al, reviewing the effectiveness of unipolar radiofrequency, observed success rates in restoring sinus rhythm ranging from 54 to 83% in a mean period of

12 months. The procedure is safe and effective, especially in patients with paroxysmal or persistent AF, young individuals with a left atrial diameter less than 60 mm, regardless of the type of heart surgery performed [12, 13, 18, 19]. It is noteworthy that all these works lack a monitor capable of identifying asymptomatic episodes of tachyarrhythmia, since in most cases the follow-up is done with surface electrocardiograms and 24-hour Holter monitoring.

Thus, the irrigated unipolar radiofrequency technique for treatment of atrial fibrillation can achieve a success rate of 80% in late follow-up work. This success rate, however, is often not obtained before 3 to 6 months post-operatively. Therefore, patients that remain in AF before this time should not be considered as a failure of the procedure.

Most patients undergoing this ablation technique leave the operating room in sinus rhythm. However, about 70% of the cases have episodes of AF in the immediate postoperative period. The main factors involved are the likely neurohormonal imbalance and the inflammation of the pericardium [20-22]. The expected result is that about 50% of patients undergoing irrigated radiofrequency ablation receive hospital discharge in sinus rhythm whereas the remaining cases will probably be in the process of "reverse atrial remodeling", which will facilitate possible spontaneous or medical (pharmacological or electrical) reversion to the normal rhythm during the post-operative follow-up.

In conclusion, the results of this study suggest that surgical ablation by irrigated unipolar radiofrequency for atrial fibrillation, applied to both atria, is effective in the reversal and maintenance of sinus rhythm during short and medium term follow-up.

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