

# Pulmonary Vein Isolation for Treatment of Atrial Fibrillation

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## SUMMARY

Between March 2009 and December 2010, 94 consecutive procedures of pulmonary vein isolation were performed for treatment of paroxysmal and persistent atrial fibrillation. These interventions constitute the initial experience of the Instituto Cardiovascular de Buenos Aires, where 260 procedures are currently performed each year.

Our population consisted mainly of men with an average age of 55.58 years; 71.9% had no history of cardiovascular disease. Paroxysmal atrial fibrillation occurred in 65.3% of cases over an average of 7 years. All patients had received three different antiarrhythmic agents excluding beta blockers or calcium channel antagonists. The average number of episodes of atrial fibrillation was 6 per year.

The success rate during the procedure was 97.87%. The primary success rate at 12 months was 84.04%, 88.32% for the group without heart disease and 64.8% for the group with heart disease. Mean follow-up was 18±6 months. In our experience, pulmonary vein isolation is a treatment strategy for very selective cases with an acceptable primary success rate.

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**Key words** > Atrial Fibrillation - Ablation - Arrhythmias

**Abbreviations** > 

<b>AVA</b>	Atrial fibrillation	<b>INR</b>	International normalized ratio
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## BACKGROUND

We present our initial experience with radiofrequency pulmonary vein isolation for the treatment of atrial fibrillation performed in Argentina at the Instituto Cardiovascular de Buenos Aires (ICBA). Our electrophysiology laboratory counts with three staff electrophysiologists and one fellow. Nowadays, an average of 260 catheter ablation procedures for treatment of arrhythmias are performed each year.

We analyzed 94 consecutive procedures of pulmonary vein isolation performed between March 2009 and December 2010 for the treatment of paroxysmal or persistent AF. In all the cases the patients had been referred by their primary physicians and were evaluated in our clinic before including them in the study for the analysis of each particular case.

## MATERIAL AND METHODS

After the clinical evaluation, those patients who fulfilled the eligibility criteria were included in the study (Table 1).

Our population (Table 2) consisted mainly of men with an average age of 55.58 ± 10.53 years. The percentage of patients with no history of cardiovascular disease was 71.9%; 28.1% had hypertension, diabetes, dyslipemia or ischemic

heart disease. Only 4.25% presented severe left ventricular dysfunction and the remaining 10.63% had valvular heart disease other than mitral valve prolapse or history of myocardial revascularization surgery. The population was divided into two groups depending on the presence or absence of heart disease: lone AF or AF with heart disease. Atrial fibrillation was also classified in paroxysmal (self-limited episodes of arrhythmia) and persistent (episodes of sustained AF that required either pharmacologic or electrical cardioversion to terminate). Patients with both types of arrhythmia were classified according to the most prevalent pattern. Paroxysmal atrial fibrillation occurred in 65.3% of cases over an average of 7 years. All patients had received three different antiarrhythmic agents excluding beta blockers or calcium channel antagonists due to the limited effect of these agents which were only used to control heart rate in case of recurrent AF. Thus, we used a very specific criteria of recurrence. Interestingly, 84.5% of the population was or had been receiving amiodarone. The average number of episodes of AF was 6 per year.

Before undergoing the procedure, INR (international normalized ratio) was determined once a week during three consecutive weeks; one of these determinations should be in the therapeutic range (INR 2-3) under treatment with warfarin or acenocoumarol. The characteristics of the study population are described in Table 3.

Paroxysmal AF was more common in patients with lone AF, while patients with heart disease had more prevalence of persistent AF, larger left atrium and lower ejection fraction. The percentage of women was higher.

Transesophageal echocardiography was performed at the moment of admission to verify the absence of thrombi. Two days before the procedure, all patients underwent 64-row multislice computed tomography to identify the anatomy of the pulmonary veins (absence of veins, presence of accessory pulmonary veins or common ostia) and of other essential structures at the moment of catheter ablation (the crista terminalis, atrial appendage, left atrial roof and mitral isthmus, and three-dimensional reconstruction of the esophagus). The presence of spontaneous contrast was not a contraindication to perform the study. Anticoagulation therapy was stopped two days before the procedure and was replaced by low-molecular-weight heparin.

The procedure was performed under general anesthesia and an arterial line was inserted for continuous blood pressure monitoring.

After skin antiseptis, both femoral veins were punctured using the modified Seldinger technique. A decapolar catheter was positioned in the coronary sinus and a quadripolar catheter in the region of the tricuspid valve in order to record bundle of His electrograms. Two transseptal punctures were performed in the left anterior oblique projection under fluoroscopic guidance. Continuous monitoring of the left atrial pressure was achieved using a standard Brockenbrough needle to guide the procedure. Then, two long SL1 and SL2 preshaped sheaths (St. Jude Medical)

were positioned. A Lasso catheter and a ThermoCool (Biosense) irrigated tip catheter were advanced to deliver radiofrequency energy. The anatomical reconstruction was performed using the circular Lasso mapping catheter which is capable of simultaneously recording from multiple points. The ablation catheter was used to identify the ostia and the antrum of the pulmonary vein. Anticoagulation was given to maintain an activated clotting time of between 250 and 350 s throughout the study.

A nonfluoroscopic mapping system EnSite NaVx version 7.0 (St.Jude Medical Inc.) was used for electroanatomic reconstruction and navigation.

The electric activity of each pulmonary vein was obtained using a duodecapolar circular catheter (Optima, St.Jude Medical Inc.). When the action potentials were identified in more than one pulmonary vein, radiofrequency energy was subsequently applied to the left superior, left inferior, right superior and right inferior pulmonary veins. Radiofrequency energy was delivered at the anterior and posterior aspect of each pulmonary vein with a power output of 35 to 40 W and of 30 W, respectively. The lesions were applied to the antrum but not the ostia of the veins. High-frequency fractionated electrograms recorded by the ablation catheter before and after applying the ablation lesion were analyzed in each patient. The target was reduction of the potential amplitude by 75% or the suppression of the action potential. Impedance was continuously monitored during radiofrequency energy delivery to ensure the catheter was correctly positioned in the antrum and thus prevent lesions inside the pulmonary vein. The activation sequence around the pulmonary vein

Inclusion criteria	Exclusion criteria
Recurrent PAF under treatment with two different drugs (class I-III)	Contraindications for anticoagulation
Absence of treatment with beta blockers or calcium antagonists	Valvular heart disease (excluding mitral valve prolapse)
Having received amiodarone	Left atrium > 55 mm
Intolerance of antiarrhythmic drug therapy	Thrombus in the left atrial appendage
Age between 18 and 75 years	
Having signed an informed consent form	

Table 1. Selection of patients

	Total population (n = 94)	Lone AF (n = 77)	AF with heart disease (n = 17)	p
Age	55 ± 10	55 ± 10	56 ± 11	0.7
Women (%)	15 (15.95%)	11 (14.28%)	4 (23.5%)	0.05
Paroxysmal AF	62 (65.95%)	57 (74.02%)	5 (29.41%)	0.001
Persistent AF	32 (34.05%)	20 (25.95%)	12 (70.58%)	0.001
LA (cm)	4.5 ± 2.0	4.5 ± 0.2	4.7 ± 1.8	0.006
EF (%)	55 ± 4	58 ± 4	49 ± 12	0.001
Atypical AFL (n)	3	3	3	0.6
History of AF (years)	6.4 ± 6	6 ± 4	7 ± 7	0.6

Table 2. Clinical characteristics of the population

\*Differences are established between the groups with AF without and with heart disease.

	Success n (%)	Recurrence n (%)	Reinterventions n (%)	Total
Lone AF	68 (88.3)	9 (11.6)	7 (9.0)	77
AF with heart disease	11 (64.8)	6 (35.2)	5 (29.4)	17
Total	79 (84.0)	15 (15.9)	12 (12.8)	94

Table 3. Clinical characteristics of the population

ostium was verified to determine the activation pattern before starting with pulmonary vein isolation (Figure 1). If the conduction pattern changed during radiofrequency energy delivery, the region showing the new shortest conduction by the Lasso catheter was targeted. Persistent pulmonary vein isolation was confirmed 30 minutes after the initial documentation of isolation. If necessary, ablation was repeated around the antrum to consolidate the block. We used all the methods available to discriminate local or remote electrical activity. In all the cases the procedure was completed with an ablation line at the cavotricuspid isthmus to achieve bidirectional conduction block. Patients with persistent AF ultimately required a linear ablation at the left atrial roof and mitral isthmus. Finally, complex fractionated atrial electrograms were eliminated.

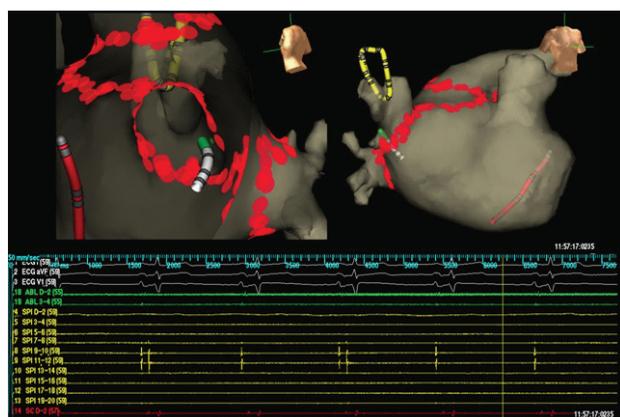
The catheters and the sheaths were removed and compression was applied to the puncture sites for hemostasis. Patients underwent neurological examination after recovery from anesthesia at the electrophysiology laboratory and 24 hours after. All patients restarted treatment with warfarin adjusted to achieve an INR of 2 to 3 and were discharged the following day after undergoing echocardiographic evaluation to verify the absence of pericardial effusion. Antiarrhythmic therapy was continued for three months if there were no contraindications.

Follow-up included an interview and 24-hour Holter monitoring at 3, 6, 9 and 12 months. Antiarrhythmic agents and anticoagulation treatment were stopped after 3 months. Patients with palpitations during followed-up consulted at the emergency room for evaluation and underwent the necessary studies. The presence of recurrence three months after the procedure was an indication for a second ablation to treat AF or atrial arrhythmias that had not been documented previously (atypical atrial flutter, atrial tachycardia, or isthmus-dependent atrial flutter.)

### Statistical Analysis

The results are expressed as mean  $\pm$  standard deviation or percentages of patients. The efficacy of the procedure was evaluated as success, absence of arrhythmia and failure, and symptomatic or asymptomatic recurrent AF.

Fisher's exact test was used to analyze discrete variables ( $\alpha = 0.05$ ).



**Fig. 1.** Isolation of the right superior pulmonary vein during radiofrequency delivery. See the conduction pattern 2:1 before pulmonary vein isolation.

## RESULTS

The results obtained in both groups were compared. Table 4 shows the results in 94 patients with a follow-up of  $18 \pm 6$  months. The isolation of the pulmonary veins was achieved in 97.87% patients. The right inferior pulmonary vein was more difficult to isolate. Mean ablation time was 20 minutes for isolation of each pulmonary vein. Total fluoroscopy time was  $23 \pm 10$  minutes and mean total duration of the procedure was  $3.2 \pm 0.5$  hours. No major complications as mortality, atrio-esophageal fistula or pulmonary vein stenosis occurred. The absence of atrio-esophageal fistulas reported in the first series might be related to the use of power output and temperature of 40 W and 50 °C in the anterior aspect and 30 W and 50 °C in the posterior aspect of the vein to avoid damage of the surrounding structures. Another significant difference between our approach and the circumferential isolation of the pulmonary veins, a technique developed by Dr. Pappone in Milan, is that our technique avoids superimposition of the ablation lines which is the main cause of this complication as the authors have reported. (1)

The complications are summarized in Table 4. Four patients presented cardiac tamponade which resolved with pericardial drainage and hemostasis control (administration of protamine during the procedure). None of them required surgery. All these patients completed the procedure. Transseptal puncture was the cause of cardiac tamponade in these patients. This complication occurred in patients with small left atrium. Two cases of transient ischemic attack were evaluated and treated by neurologists and evolved without neurological deficits. There were no cases of symptomatic pulmonary stenosis. This complication was clinically evaluated in all the patients.

Recurrent AF occurred in 15.95% of patients after 3 months of follow-up: there was a significant difference between the group with heart disease and those without heart disease (11.68% vs. 35.2%).

In patients undergoing a second procedure, the reconnection of at least two pulmonary veins was the most common finding. The conduction gap was more frequent in the region between the left atrial appendage and the anterior aspect of the left superior pulmonary vein, where the catheter is unstable due to the presence of a ridge between both structures. Ablation of the mitral isthmus or the left atrial roof was performed only in those cases with persistent isolation of the pulmonary veins in which recurrent AF could not be explained by reconnection (Figure 2). In case of persistent AF, activation mapping was performed to identify fractionated atrial potentials with subsequent radiofrequency ablation.

The primary success rate at 12 months was 84.04%, 88.32% for the group without heart disease and 64.8% for the group with heart disease. We did not analyze other variables as functional class, left atrial remodeling and recurrence rate, among others.

Nine of the 15 patients with recurrence at the

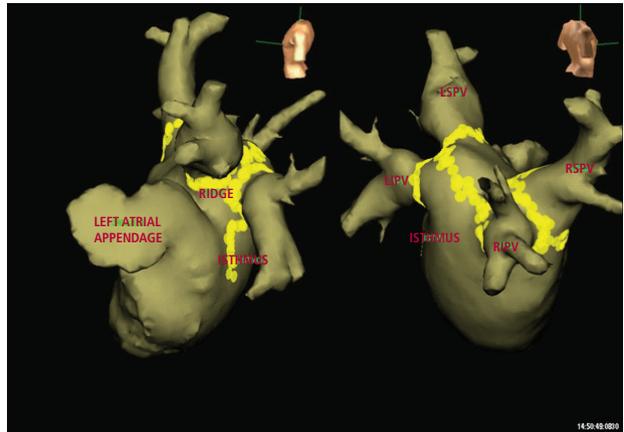
**Table 4.** Complications

	Lone AF (n = 77)	AF with heart disease (n = 17)
Stroke	0	0
TIA	2	1
Cardiac tamponade	3	1
PV stenosis	0	0
CABGS (urgency)	0	0
Fistula	0	0
Hematoma	4	3

end of the follow-up period required treatment with class I or III antiarrhythmic agents. The remaining patients received beta blockers for heart rate control during the episodes and oral anticoagulant agents were administered to all the patients. Paroxysmal AF and atypical atrial flutter were the most common findings. Interestingly, more than 50% of the episodes were asymptomatic.

## DISCUSSION

Atrial fibrillation is the most common sustained arrhythmia. (2) Atrial fibrillation can cause considerable impairment of quality of life, is associated with comorbidities and is a condition difficult to treat. (3-5) In our experience, pulmonary vein isolation is a treatment strategy for very selective cases with an acceptable primary success rate. Ablation of AF is quite different from other radiofrequency ablation procedures for the treatment of other arrhythmias. Standard electrophysiological criteria (8) are not used for pulmonary vein isolation (1, 6.,7), where anatomy plays a key role. (9) This procedure is long, difficult and has a high recurrence rate compared to ablation of supraventricular arrhythmias. We still do not have immediate standardized endpoints, and the definite result of the procedure depends on patient's outcomes (10) after three months (11). Several factors, such as edema and remodeling, are important in immediate recurrence which is not related with the presence of the arrhythmia at the long-term. Since first published by Dr. Haïssaguerre, (12) , the technique has evolved favorably. The incidence of complications is currently low due to the implementation of novel technologies, (13) as irrigated-tip catheter, (14, 15) three-dimensional reconstruction, (16), high resolution computed tomography (17) and absence of ablation lesions to the pulmonary veins ostia. As with any new technique a learning curve has to be overcome by a highly trained staff. The best results are obtained in those centers performing between 90 and 120 procedures per year as mentioned by an updated worldwide database. (18) Our results are similar to those of these centers. The constant development of technology will probably improve the outcomes and reduce the complexity of the procedure. Recently,



**Fig. 2.** Ablation lesions in recurrent AF after pulmonary vein isolation; additional ablation lines were created in the left atrial roof and mitral isthmus.

The European Society of Cardiology has modified the guidelines for the management of atrial fibrillation, prioritizing catheter ablation versus treatment with amiodarone in the group of patients with paroxysmal AF. This modification is of considerable importance in our environment in which the use of amiodarone is deeply rooted. Our experience in a specialized tertiary care center is consistent with these favorable outcomes in selected cases.

## CONCLUSIONS

In our experience, pulmonary vein isolation is a treatment strategy for very selective cases in specialized tertiary care centers with an acceptable primary success rate.

## RESUMEN

### Análisis de los criterios de autoría en los artículos publicados en la Revista Argentina de Cardiología

Entre marzo de 2009 y diciembre de 2010 se realizaron en forma consecutiva 94 procedimientos de aislamiento de las venas pulmonares como tratamiento de la fibrilación auricular paroxística y persistente, que constituyen la experiencia inicial del Instituto Cardiovascular de Buenos Aires y cuya casuística actual asciende a aproximadamente 180 por año. Nuestra población estuvo constituida mayoritariamente por hombres, con una edad promedio de 55 años. El 71,9% de la población no tenía antecedentes de enfermedad cardiovascular. La forma de presentación fue paroxística en el 65,3% de los casos, con una historia de arritmia de 7 años en promedio y habiendo cumplido tratamiento con tres fármacos antiarrítmicos diferentes que no incluían betabloqueantes ni bloqueantes cálcicos. El número de episodios de fibrilación auricular fue en promedio de 6 por año. La tasa de éxito durante el procedimiento fue del 97,87%. La tasa de éxito primario a los 12 meses fue del 84,04%, del 88,32% para el grupo sin cardiopata y del 64,8% para el grupo con cardiopatía. El seguimiento promedio fue de 18 ± 6 meses. En nuestra experiencia, el aislamiento de las venas pulmonares es una modalidad de tratamiento con una aceptable tasa de éxito primario en casos muy selectos.

**Palabras clave** > Fibrilación auricular - Ablación - Arritmias

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