

# The First-Pass Isolation Effect in High-Power Short-Duration Compared to Low-Power Long-Duration Atrial Fibrillation Ablation: a Predictor of Success

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## ABSTRACT

**Introduction:** Different results are described after atrial fibrillation ablation and multiples predictors of recurrence are well established.

**Objective:** Evaluate and analyze if first-pass isolation effect (FPI) during first atrial fibrillation (AF) ablation with high-power short-duration (HPSD) comparing to low-power long-duration (LPLD) can impact on late outcome. **Methods:** Observational, retrospective study, 144 patients submitted to HPSD and LPLD ablation. HPSD: 71 patients, 50 (70.42%) males, mean age 59.73 years, 52 (73.24%) hypertension, 44 (61.97%) obstructive apnea, 23 (32.39%) arterial disease, 20 (28.17%) diabetes, and 10 (14.08%) stroke. CHADS<sub>2</sub>VASC<sub>2</sub> 2.57. CT: 73 patients, 50 (68.49%) males, mean age 60.7 years, 53 (72.60%) hypertension, 41 (56.16%) obstructive apnea, 28 (38.36%) arterial disease, 14 (19.17%) diabetes and 8 (10.96%) stroke. CHAD<sub>2</sub>SVASC<sub>2</sub> 2.22. **Results:** Recurrence occurred in 33 patients (22.92%) at 12 months follow-up, HPSD with 9 patients and LPLD with 24 patients. Higher rate of bilateral FPI were observed in HPSD patients with 62 of 71 patients comparing to 17 of 73 patients in LPLD ( $P < 0.00001$ ). At the end of study 62 (87.32%) of 71 HPSD patients were in sinus rhythm comparing to 49 (67.12%) of 73 patients in LPLD ( $P 0.0039$ ). **Conclusion:** HPSD ablation produced higher rates of FPI comparing to LPLD. HPSD compared to LPLD showed a superiority in maintaining sinus rhythm at 12 months. At patients submitted to HPSD protocol ablation, FPI could predict higher rate of sinus rhythm at 12 months follow-up.

**KEYWORDS:** Atrial fibrillation; Atrial tachyarrhythmias; Recurrence rate; First-pass isolation; Atrial fibrillation ablation.

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## INTRODUCTION

More than two decades ago, Haïssaguerre et al.<sup>1</sup> concluded that ectopic beats from pulmonary veins were atrial fibrillation (AF) triggers and showed that ablation can be a treatment for these triggers. Since then, the electrophysiology community has discovered factors that limit the success of this procedure in conventional supraventricular tachycardias<sup>2,3</sup>. For example, as a central objective of AF treatment interventions, the left atrial anatomy and its surrounding organs are a limiting factor during pulmonary vein isolation (PVI)<sup>4-7</sup>. In addition to anatomical limitations, questions have been raised regarding the biophysics of lesions induced by radiofrequency<sup>8,9</sup>. One of the solutions for these limitations and to achieve better results is the adoption of new technologies, such as irrigated catheters and, more recently, catheters containing sensors that measure real-time contact force<sup>10-14</sup> using higher power settings in the radiofrequency generators associated with short application times.

## OBJECTIVES

The objective of the present study was to define whether there is a correlation between the first-pass isolation effect (FPI), which is the electrical isolation of the pulmonary veins antrum in the first attempt of radiofrequency application, in the long-term success rate with the maintenance of sinus rhythm in patients after AF high-power short-duration (HPSD) ablation compared to patients submitted to conventional low-power long-duration (LPLD) ablation.

## METHODS

### Study population

One hundred forty-four consecutive first catheter AF ablations with the LPLD and HPSD techniques were performed. This post-hoc analysis was performed with the last patients submitted to LPLD and the first one with HPSD, and data were collected between January 2016 and January 2019. Patients were divided into two groups, patients using HPSD and patients submitted to LPLD ablation (Tab. 1).

Table 1. Clinical features.

Clinical features	HPSD	LPLD	Statistical analysis
Medium age (years)	59.73	60.70	NS
Males (%)	50 (70.42)	50 (68.49)	NS
Hypertension (%)	52 (73.24)	53 (72.60)	NS
Obstructive apnea (%)	44 (61.97)	41 (56.16)	NS
Arterial disease (%)	23 (32.39)	28 (38.34)	NS
Diabetes (%)	20 (28.17)	14 (19.17)	NS
Stroke (%)	10 (14.08)	8 (10.96)	NS
Medium chads <sub>2</sub> vasc <sub>2</sub> (min-max)	2.57 (0-8)	2.22 (0-7)	NS
Paroxysmal af (%)	39 (54.93)	52 (71.23)	NS
Medium time (months): diagnosis to ablation (min-max)	23 (4-144)	25.63 (3-144)	NS

Among the 71 HPSD patients, with mean age of 59.73 years, 50 (70.42%) were males, 52 (73.24%) had hypertension, 44 (61.97%) had obstructive sleep apnea, 23 (32.39%) arterial disease, 20 (28.17%) diabetes, and 10 (14.08%) strokes. Mean CHADS<sub>2</sub>VASC<sub>2</sub> 2.57 (0-8). Mean left atrial diameter of 40.40mm (33-62), paroxysmal AF in 39 (54.93%) patients and the mean time from diagnosis to catheter ablation (CA) was 23 (4 to 144) months.

Among the 73 LPLD patients, with mean age of 60.7 years, 50 (68.49%) were males, 53 (72.60%) had hypertension, 41 (56.16%) had obstructive sleep apnea, 28 (38.36%) arterial disease, 14 (19.17%) diabetes, and 8 (10.96%) strokes. Mean CHADS<sub>2</sub>VASC<sub>2</sub> 2.22 (0-7). Mean left atrium diameter of paroxysmal AF in 52 (71.23%) patients and the mean time for AF diagnosis to ablation was, in Group A, 25.63 (3-144) months.

## Pre-ablation investigation for thrombus exclusion

Patients underwent a transesophageal echocardiogram (TEE) and/or angiotomography of the left atrium and pulmonary veins prior to the procedure. Both tests for thrombus exclusion, left atrium diameter, and other measurements were performed on the day of the procedure or up to 48 hours before ablation.

## First-pass isolation effect definition

FPI is defined as the electrical isolation of the veins before radiofrequency is applied in the entire pulmonary antrum circumference leaving a visual gap between the first and last radiofrequency application that achieved the objective of no electrical activity inside de pulmonary Veins (PVs). In cases of doubt we performed stimulations inside an outside the veins to document the presence of entry and exit blocks.

## Catheter ablation

All patients underwent ablation using an uninterrupted oral anticoagulation protocol (OAC). Patients also had their antiarrhythmic drugs suspended for 5 half-lives prior to the procedure, with the exception of amiodarone, which was maintained for the procedure. The main objective was to isolate the antral portion of the pulmonary veins<sup>2,15</sup>. In cases of patients with previously diagnosed atrial flutter, tachyarrhythmia was also ablated at the end of the PVI, the times for this ablation and radiofrequency were not included in the data. Procedures were performed in sinus rhythm, and patients in atrial fibrillation or flutter underwent electrical cardioversion immediately before ablation.

For all patients, the EnSite Velocity mapping system version 5.0 was used with a TactiCath™ contact force sensing catheter, Agilis™ deflectable sheath, Viewflex™ intracardiac echocardiography probe, and Ampere™ radio frequency generator (St Jude Medical – USA/Abbott – USA).

In the HPSD ablation technique, on the posterior wall, atrial roof, and atrial flutter (if indicated), the power of radiofrequency generator is set to 45 Watts for no more than 6 seconds. On the anterior wall, the power was increased to 50 Watts with an estimated pressure of 10–20 grams of contact force for short periods of time<sup>16</sup>. The irrigation pump was always programmed for 35mL/min regardless of the power setting. For LPLD, the radiofrequency (RF) applications lasted no more than 30 seconds, an irrigation set of 17mL/min was use for pump flow, a contact force between 10 to 30 grams and 20 Watts were applied in the posterior wall and 30 Watts elsewhere including in cases of atrial flutter. At the end of the procedure, all patients were given a challenge of 12 mg of adenosine for each antrum of the pulmonary veins in order to unmask any dormant veins and assess the need for re-ablation of their reconnection<sup>17,18</sup>.

In addition to analyzing the real-time contact force values across all radiofrequency applications, we evaluated the impedance measurements in the electrophysiology recording system looking for gradual falls that might indicate lesion formation<sup>8-11</sup>. The dragging technique for CA was performed and all efforts were made to avoid catheter jumps. If a catheter jump did occur, the radiofrequency application was immediately interrupted, and the ablation would continue from the spot before the jump occurred<sup>19-23</sup>.

We did not use other features provided by the contact force catheter, such as the lesion index (LSI) and force-time integral (FTI)<sup>24</sup>. All patients received esophageal temperature monitoring, as previously described<sup>25</sup>.

## Informed consent and ethical considerations

All patients signed the informed consent form according to the standards of ours Institutions, which follows national and international standards<sup>26,27</sup>. The study was approved by the Research Ethics Committee of the Institution.

## Post-ablation follow-up protocol

Patients aged over 75 years old or who had multiple comorbidities remained in the intensive care unit after ablation for one day, those without these characteristics stayed at an apartment and were discharged from the hospital on the day after the procedure only if clinical evaluation, vascular punctures, chest X-ray, and electrocardiogram (ECG) were normal. Patients were prescribed 2 g of Sucralfate per day and 40 mg of Pantoprazole twice a day for 4 weeks after the procedure. Same antiarrhythmic drugs were reintroduced after the procedure.

Antiarrhythmics were maintained for 60 days and then suspended. Anticoagulants were discontinued at this time for patients with a CHADS<sub>2</sub>VASC<sub>2</sub> score less than or equal to 3<sup>28</sup>, with the exception of patients who had a previous stroke and/or were aged 75 years old. In cases of atrial arrhythmia, amiodarone was the drug of choice to reestablish the normal sinus rhythm. If this approach was successful, the drug was used for 30 more days and then suspended. Direct current cardioversion (DC) was performed in patients after the amiodarone challenge or if they reached the 60th day with atrial tachyarrhythmias.

All patients were evaluated after 7 days, and 1, 2, 3, 6, and 12 months with a medical appointment and ECG. After 3, 6, and 12 months, they also underwent 24 hours of Holter monitoring.

## Statistical analysis

All tests were performed using BioStat statistical software (AnalystSoft Walnut, CA, USA). Continuous variables were expressed as mean-standard deviation. A result was considered significant if the *p*-value < 0.05. Continuous variables were compared using the  $\chi^2$  test.

## RESULTS

Among the 144 patients evaluated in this study, we obtained bilateral FPI in 62 (87.32%) of 71 patients in the HPSD group compared to 17 (23.29%) of 73 patients in the LPLD group, with a *p*-value < 0.00001 (Fig. 1). In the 12-month analysis, 62 (87.32%) of 71 HPSD patients were in sinus rhythm comparing to 49 (67.12%) of 73 patients in LPLD, demonstrating a significant *p*-value 0.0039, suggesting that when FPI is achieved during the procedure patients had better outcomes with a much lower rate of recurrences (Fig. 2). Of the 9 recurrent patients in HPSD ablation, 6 (66.67%) were in AF and 3 (33.33%) in atypical atrial flutter/tachycardia, while in the LPLD patients, 17 (70.83%) were in AF and only 7 (29.17%) in regular tachyarrhythmias (Tab. 2).

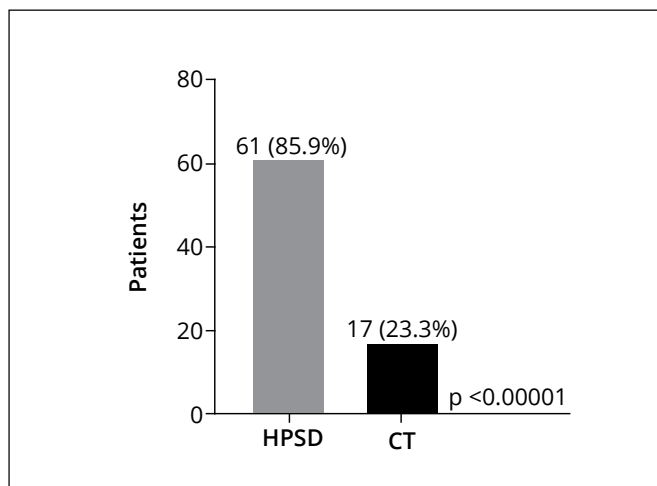


Figure 1. First-pass isolation effect in HPSD an CT (LPLD) ablations.

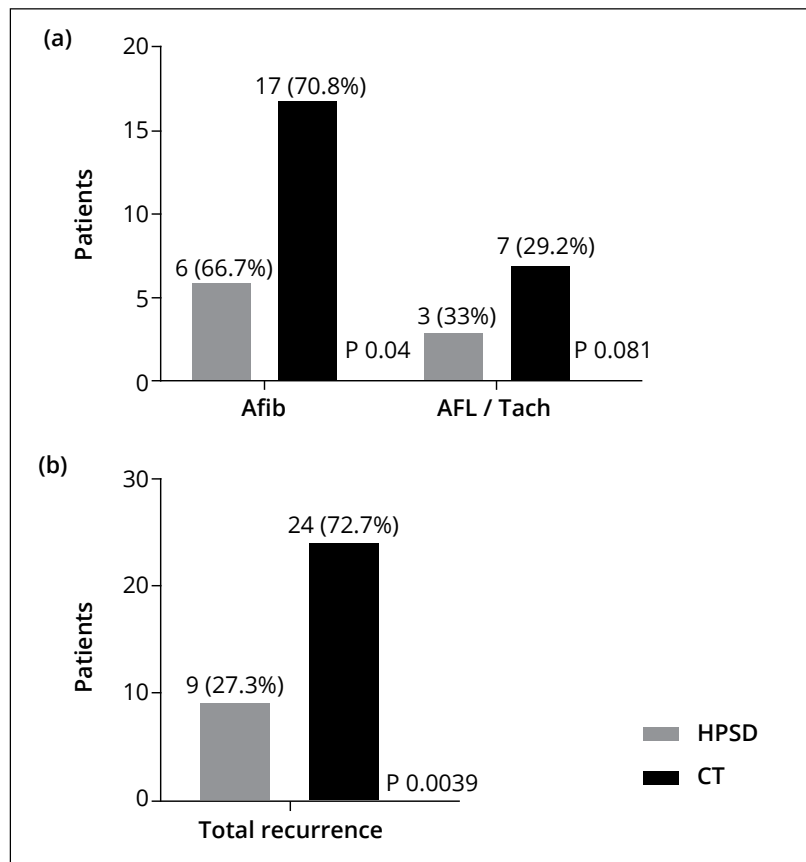


Figure 2. Types of atrial tachyarrhythmias recurrences at the top and the total recurrence rate at the bottom in HPSD and CT (LPLD) ablations.

Table 2. Recurrence characteristics at 12 Months in HPSD and CT (Conventional Technique with Low-Power Long Duration) patients.

Recurrence rate 12 months	HPSD	LPLD	Statistical analysis
Atrial arrhythmias at ecg and/or holter (total: 33 pts)	9 (27.27%)	24 (72.73%)	0.0039
Atrial fibrillation	6 (66.67%)	17 (70.83%)	0.04
Atrial flutter / tachycardia	3 (33.33%)	7 (29.17%)	0.081

The present study only evaluated patients with FPI achieved in both sides of pulmonary veins antrum. A redo procedure was not performed in this group of patients.

Analyzing more data from other findings of this study, it was possible to observe some differences in the results between the two techniques:

- lower rate of esophageal heating in HPSD with 34 of 71 patients showing elevation in esophageal temperature in comparison to 52 of 73 patients in LPLD with a significant *p*-value 0.0019;
- equal left atrium time between the techniques, with a *p*-value 0.0839;
- lower total ablation time, with 94.54 minutes in HPSD and 113.55 minutes in LPLD, achieving a significant *p*-value 0.0059; and
- a major difference in the RF time RF, with HPSD protocol showing 1964.84 seconds and LPLD with 5017.80 seconds, as well as a remarkable *p*-value < 0.00001 (Tab. 3).

Another interesting finding of our data was a small number of reconnections spontaneously or after a challenge of 12mg of Adenosine. In this series of patients, HPSD ablation showed a total of 4 (5.63%) left PV reconnections and 3 (4.23%) right ones and LPLD ablation, 5 (6.85%) in left PV and 3 (4.11%) in right ones, with a non-significant *p*-value.

**Table 3.** Ablation features in HPSD and CT (Conventional Technique with Low-Power Long Duration).

Ablation features	HPSD 71 patients	LPLD 73 patients	Statistical analysis
Mean left atrial time (min)	76.16	92.79	NS
Mean total ablation time (min)	96.54	113.55	0.0059
Mean 3d map collecting time (min)	8.32	7.28	NS
Mean rf time (sec)	1961.25	5,017.80	< 0.00001
Mean fluoroscopy time (min)	7.6	13.37	NS
First-pass isolation	61 (85.92%)	17 (23.29%)	< 0.00001
Esophageal heating	34 (47.89%)	52 (71.23%)	0.0019
Success rate (sinus rhythm at 12 months follow-up)	62 (87.32%)	49 (67.12%)	0.0039

NS= non-significant with P value of > 0.05.

## DISCUSSION

In this retrospective, observational study, high rates of 62 (87.32%) HPSD patients with bilateral FPI were identified, showing that RF lesions done by this technique are effective. In the opposite way, a very low rate of FPI was shown in patients submitted to the LPLD approach with only 17 (23.29%) patients achieving this effect.

When we compare the results of FPI in both groups we saw a better outcome in patients submitted to HPSD protocol. These are the same results presented by Ninomiya et al.<sup>29</sup> last year during the American Heart Association sessions, which included 446 patients submitted to PVI with an open-irrigated contact force catheter. They divided the study population into first-pass group (383 patients, 86%) and no first-pass group (63 patients, 14%), based on the presence or absence of first-pass PVI in at least one of two ipsilateral PV and followed them for 859±211 days after the index PVI procedure. The 2-year recurrence-free rate was significantly better in the FPI group than in the no-FPI one (75 vs. 59%, log rank *p*-value 0.032). Cox proportional hazards regression analysis indicated that the total number of PV with first-pass PVI was an independent predictor for AF recurrence after CA (hazard ratio: 0.77, 95% confidence interval: 0.62 to 0.97, *p*-value 0.028). Furthermore, PV reconnection rate in the second procedures (n=78) was significantly lower in the PV that had achieved FPI in the first procedures than that in others (34 vs. 73%, *p* < 0.0001).

As in another series of cases, there was a small number of reconnections spontaneously or after a challenge of 12mg of Adenosine. In our series, in HPSD ablation we had a total of 4 (5.63%) left PV reconnections and 3 (4.23%) right ones, and in LPLD ablation, 5 (6.85%) in left PV and 3 (4.11%) in right ones, with a non-significant *p* value. In the work by Okamatsu et al.<sup>30</sup> in which 20 patients submitted to HPSD ablation had no cases of reconnection, and in the paper by Berte et al.<sup>31</sup>, the rate of reconnections in two different groups with different approaches varied from 21 to 33%. In these two studies using HPSD ablation the rate of PV reconnections varied from 33 to 0%, showing a huge variation in this type of technique.

As a matter of additional information, 4 HPSD patients went back to the electrophysiology lab for a redo procedure since they had symptomatic tachyarrhythmias that failed to medical therapy, 2 patients were on AF and 2 in atypical atrial flutter. The electrophysiologic findings were 3 patients without PV reconnection and 1 patient with reconnected left PV. Of the LPLD patients, 16 of the 24 recurrent patients were submitted to a redo procedure, 11 of which showing AF and 5 atypical atrial flutters. Of these 16, at least 1 PV was reconnected in 12 patients and, in the other 4 patients, there were no records of any PV reconnection, with the ablation procedure directed to treat left atrial flutters.

Our results suggest, in a retrospective analysis of these 144 patients, that the FPI effect can be used as a prediction factor for long-term success since 85.92% of patients submitted to HPSD ablation reached this objective and had, at 12 months, 87.32% of patients maintained sinus rhythm, while in LPLD patients, 23.29% of them achieved FPI and 67.12% were in sinus rhythm, a condition for long-term success with high rates of sinus rhythm patients.

## Study limitations

This was a retrospective, observational, small sampled study, which practiced non-continuous cardiac rhythm monitoring through the use of ECG and 24-hour Holter monitoring to document the recurrence of atrial tachyarrhythmias. A larger sample size or continuous monitoring may produce different findings in the future.

As we did not perform redo procedures and this is the only way to investigate PV reconnections at each or both sides, this might be another limitation, since we were unable to correlate PV reconnection as the real cause of recurrence and since we know that other foci may be the trigger of AF.

## CONCLUSION

This study showed a high success rate of sinus rhythm maintenance for HPSD compared to LPLD. We documented a high rate of first-pass isolation effect and a low-recurrence rate at 12 months in HPSD comparing to the LPLD technique. The first-pass isolation effect demonstrated a positive influence on long-term outcome predicting that success rate is higher in this group of patients.

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