Received: 20 December 2019 | Revised: 10 February 2020 | Accepted: 2 March 2020

DOI: 10.1111/jce.14438



ORIGINAL - ELECTROPHYSIOLOGY

WILEY

# Evaluation of higher power delivery during RF pulmonary vein isolation using optimized and contiguous lesions

Maria Kyriakopoulou MD[1,2] | Jean-Yves Wielandts MD, MSc, PhD[1] | Teresa Strisciuglio MD[1] | Milad El Haddad MSc, PhD[1] | Jan De Pooter MD, PhD[3] | Alexandre Almorad MD[1] | Gabriela Hilfiker MD[1] | Thomas Phlips MD[1] | Philippe Unger MD, PhD[4] | Michelle Lycke MSc, PhD[1] | Yves Vandekerckhove MD[1] | Rene Tavernier MD, PhD[1] | Mattias Duytschaever MD, PhD[1] | Sebastien Knecht MD, PhD[1]

[1]Department of Cardiology, AZ Sint-Jan Hospital, Bruges, Belgium

[2]Department of Cardiology, Universite Libre de Bruxelles (ULB), Brussels, Belgium

[3]Department of Cardiology, UZ Gent, Gent, Belgium

[4]Department of Cardiology, CHU Saint-Pierre, Brussels, Belgium

**Correspondence**
Sebastien Knecht, MD, PhD, Department of Cardiology, Sint-Jan Hospital Bruges, Ruddershove 10, 8000 Bruges, Belgium.
Email: sebastien.knecht@azsintjan.be

**Disclosures:** None.

**Funding information**
European Society for Cardiology; Cardiopath PhD Program

## Abstract

**Aims:** "CLOSE"-guided pulmonary vein isolation (PVI) is based on contiguous (≤6 mm) and optimized radiofrequency (RF) ablation lesions (ablation index [AI] ≥ 400 posteriorly and ≥ 550 anteriorly]. However, the optimal RF power to reach the desired AI is unknown. Therefore we evaluated the efficiency of an ablation strategy using higher power (40 W) during a first "CLOSE"-guided PVI.

**Methods:** Eighty consecutive patients undergoing "CLOSE"-guided PVI for symptomatic paroxysmal atrial fibrillation were ablated with 40 W (group A). Results were compared with 105 consecutive patients enrolled in the "CLOSE to CURE"-study and were ablated using the same protocol with 35 W (group B).

**Results:** In group A, ablation was associated with shorter ablation procedure time (91 vs 111 minutes; $P < .001$), shorter fluoroscopy time (5 vs 11 minutes; $P < .001$), shorter PVI time (48 vs 64 minutes; $P < .001$), shorter RF time (20 vs 28 minutes; $P < .001$), lower RF time per application (22 vs 29 seconds; $P < .001$), less RF applications (52 vs 58; $P < .001$), and less catheter dislocations (1 vs 2; $P = .002$). The impedance drop (12 vs 13 Ω; $P = .192$), first-pass isolation rate (99% vs 93%; $P = .141$) and acute reconnection rate (6% vs 4%; $P > .733$) were similar in both groups (groups A and B, respectively). No complications occurred. In group A, a gastroscopy—performed in five patients with esophageal temperature rise more than 42°C—did not reveal any esophageal lesion. Postprocedural recurrence of atrial tachyarrhythmia at 1 year was not significantly different between both groups.

**Conclusions:** Using the "CLOSE"-protocol, increased power increases the efficiency of PVI without compromising patients' safety.

KEYWORDS

atrial fibrillation, contact force, high power ablation, pulmonary vein isolation

Maria Kyriakopoulou and Jean-Yves Wielandts contributed equally to this study.

  

## 1 | INTRODUCTION

Recent publications concerning point-by-point radiofrequency (RF) pulmonary vein isolation (PVI) have shown promising results using the so-called "CLOSE" protocol.[1] The "CLOSE" protocol consists of contact force (CF)-guided delivery of closely spaced (interlesion distance ≤ 6 mm) and optimized lesions (ablation index (AI) ≥ 400 posteriorly and ≥550 anteriorly) close to the pulmonary vein (PV) ostia. It has been associated with a high rate of the first-pass PVI, a lower rate of acute PV reconnection and a high rate of single-procedure freedom of atrial fibrillation (AF).[1,2]

The AI formula has shown its correlation with lesion depth and combines RF power, CF between the catheter and the atrial wall and the duration of each RF application.[3] Nonetheless, the optimal RF power to reach the desired AI target according to the "CLOSE" protocol for PVI remains unknown.[4] Increased power theoretically results in reduced RF application duration when there is a similar CF.[5-9] However, the use of higher power could also potentially increase the complication rate, the risk of steam pop or esophageal injury.[10] While historically the power was set below 35 W (mostly ≤ 25 W at the posterior wall),[1,11,12] recent studies using AI as targeted endpoint have shown promising results with a power ≥35 W.[9,13,14] In all three of these studies, STSF catheters were used (SmartTouch Surround Flow; Biosense Webster Inc, Irvine, CA)

The aim of the present study was to evaluate the efficiency and safety of an ablation strategy using higher power (40 W) as compared with the patients enrolled in the "CLOSE to Cure" study[15] who were treated with a more conventional approach (35 W) during a first time "CLOSE"-guided PVI for paroxysmal AF, using an ST open-tip irrigation catheter (ThermocoolSmartTouch; Biosense Webster Inc).

## 2 | METHODS

### 2.1 | Study population

From January 2018 to September 2018, 80 consecutive patients undergoing "CLOSE"-guided PVI for symptomatic paroxysmal AF were ablated with 40 W (group A). Results were compared to the 105 patients enrolled in the "CLOSE to CURE" study, ablated with 35 W (group B).[15] All procedures were performed by experienced operators in a single center. All patients provided written informed consent before undergoing the ablation procedure.

### 2.2 | Ablation procedure

All procedures were performed under general anesthesia and under novel anticoagulants (last dose >12 hours before the procedure) or uninterrupted antivitamin K.[16] Esophageal temperature was monitored in all patients (SensiTherm; St Jude Medical Inc, Saint Paul, MN). Intravenous heparin was administered after femoral vein access to achieve an activated clotting time of more than 300 seconds. A decapolar coronary sinus catheter was introduced via the right femoral vein and double transseptal puncture was performed with conventional long sheaths (SL0; St Jude Medical Inc). A decapolar circular mapping catheter (Lasso; Biosense Webster Inc, Diamond Bar, CA) and an 8F open-tip irrigated RF catheter with tip-integrated CF sensor (ThermocoolSmartTouch; Biosense Webster Inc) were positioned in the left atrium (LA). Then calibration of the CF catheter, respiratory gating and three-dimensional (3D) geometry (fast anatomical mapping) of the LA (Carto System; Biosense Webster Inc) were performed.

All patients underwent "CLOSE"-guided PVI.[1] Briefly, point-by-point RF delivery was performed aiming for a contiguous circle enclosing both ipsilateral veins. Real-time automated display of RF applications (VISITAG; Biosense Webster Inc) was used with predefined settings of catheter stability (3 mm for 4 seconds with 40 W) and minimum CF (30% of time >4 g). RF was delivered (EP Shuttle ST-3077; Stockert GmbH, Freiburg, Germany) in a power-controlled mode (without ramping) using 40 W (irrigation rate at 30 mL/min). RF was delivered until an AI of ≥400 was reached at the posterior wall/roof/south pole and AI ≥ 550 at the anterior wall. In the case of a dislocation, that is, an interruption of the VISITAG generation process for stability reasons, a new RF application reaching the AI target was applied.[1] Maximal intertag distance between two neighboring lesions was 6 mm. In case of intraesophageal temperature rise more than 38.5°C during posterior wall ablation, RF delivery was stopped at an AI of 300 and CF was decreased. In the absence of first-pass isolation (ie, no isolation after completing the PV circle), touch-up ablation was applied until PVI. After PVI, adenosine (dose resulting in atrioventricular block) was given for each PV (with the Lasso in its corresponding position). In the case of reconnection during the waiting time or during the adenosine test, the site of reconnection was located and treated with touch-up ablation until PVI resistant to subsequent adenosine challenge. In the case of (pre-) procedural documentation of typical flutter, cavotricuspid isthmus (CTI) ablation was performed

### 2.3 | Control group from the "CLOSE to CURE" study

Briefly, the "CLOSE to CURE" study aimed at performing PVI using the "CLOSE" protocol in patients with paroxysmal AF receiving an implantable loop recorder 3 months before the procedure (Reveal LINQ; Medtronic, Dublin, Ireland).[15] In the "CLOSE to CURE" patients (105 patients, control group), ablation was performed using the same anesthesia protocol, transseptal access, and catheters.[15] The calibration of the CF catheter, respiratory gating, 3D reconstruction of the LA geometry, the predefined nephroid RF circle, and RF generator was identical.[2,3,15] Only two parameters were different: the RF power (35 W) and the predefined catheter stability VISITAG settings (3 mm for 8 seconds).[15] The ablation procedure time was defined as the effective time calculated from groin to groin (femoral vein puncture until pulling out the catheters

of the patient's body) excluding the time of the additional LA voltage map and pacing maneuvers that were specific parts of the "CLOSE to CURE" study protocol.[15]

## 2.4 | Clinical follow-up

A 1-month follow-up was conducted in all of the patients to exclude any short-term procedural complications.

One-year clinical follow-up data for both groups were also analyzed. This data consisted of procedure-related complications, arrhythmia recurrence, and antiarrhythmic drug treatment continued up to 1 year after the ablation procedure.

Arrhythmia recurrence in group A was defined as any atrial tachyarrhythmia (ATA) > 30 seconds on Holter at 1 year or earlier on the anamnestic indication. This was put in comparison to the data from the "CLOSE to CURE" population-based on internal loop recorder (ILR) data for the duration of 1 year. Both groups respected a postprocedural arrhythmia recurrence blanking period of 3 months.

Antiarrhythmic drug therapy (ADT; class I or class III) continuation was left at the discretion of the treating physician in group A. In group B, ADT was stopped after the 3-month blanking period and only reinstated at the discretion of the treating physician at ATA recurrence.

## 2.5 | Statistical analysis

Continuous variables were presented as mean ± SD or median. Categorical variables were presented as percentages (%) and counts. Two-group comparisons of continuous variables were performed by Student *t* tests if normally distributed or with Wilcoxon rank-sum tests if the normality assumption was violated according to Shapiro-Wilk tests. Categorical variables were compared using the Fisher exact test. Two-tailed *P* values less than .05 were considered to indicate statistical significance. Statistical analyses were performed using SPSS 25.0 (IBM, Armonk, NY).

# 3 | RESULTS

## 3.1 | Population characteristics

Both groups showed similar characteristics concerning the number of male patients (59% vs 62%; $P = .762$), body mass index (28 ± 5 vs 27 ± 4 kg/m$^2$; $P = .032$), $CHA_2DS_2VASc$ score (2 [interquartile range (IQR): 1-3] vs 2 [IQR: 1-2]; $P = .091$), the diameter of the LA (43 ± 8 vs 44 ± 6 mm; $P = .784$), left ventricle ejection fraction (LVEF) (60% [IQR: 60%-60%] vs 60% [IQR: 60%-60%]; $P > .999$), in group A (40 W) and group B (35 W), respectively. In group A, the European Heart Rhythm Association score was lower (2 [IQR: 2-2] vs 3 [IQR: 2-3]; $P < .001$) and the age was slightly higher (67 years [IQR: 58-73] vs 64 years [IQR: 56-69]; $P = .039$) (Table 1).

**TABLE 1** Clinical characteristics of the study population

| | Group A (40 W) (n = 80) | Group B (35 W) (n = 105) | *P* value |
|---|---|---|---|
| Mean age, y | 67 (IQR: 58-73) | 64 (IQR: 56-69) | **.039** |
| Male patients | 47 (59%) | 65 (62%) | .762 |
| BMI, kg/m$^2$ | 28 ± 5 | 27 ± 4 | **.032** |
| $CHA_2DS_2VASc$ | 2 (IQR: 1-3) | 2 (IQR: 1-2) | .091 |
| LA diameter, mm | 43 ± 8 | 44 ± 6 | .784 |
| EHRA | 2 (IQR: 2-2) | 3 (IQR: 2-3) | **<.001** |

*Note:* Results are presented as median (interquartile range), mean ± SD or n (%). Bold values indicate a significance level of $P < .05$.
Abbreviation: BMI, body mass index; EHRA, European Heart Rhythm Association; IQR, interquartile range; LA, left atrium.

## 3.2 | Global procedural results

When using an RF power of 40 W (group A), there was a shorter ablation procedure time (91 minutes [IQR: 80-103] vs 111 minutes [IQR: 94-162]; $P < .001$), a shorter fluoroscopy time (5 minutes [IQR: 3-9] vs 11 minutes [IQR: 8-14]; $P < .001$), less radiation (air Kerma: [9 mGy (IQR: 4-13) vs 18 mGy (IQR: 12-29); $P < .001$]); lower dose area product ([1638 mGy/cm$^2$ (IQR: 905-2666) vs 4040 mGy/cm$^2$ (IQR: 2552-6393); $P < .001$]) in groups A and B, respectively, despite the fact that there were more CTI ablations in group A (20/80 [25%] vs 6/105 [6%]; $P < .001$) (Table 2 and Figure 1).

## 3.3 | PVI characteristics

In group A, the total RF time was shorter (20 minutes [IQR: 16-22] vs 28 minutes [IQR: 24-32]; $P < .001$), the time to isolate the PVs was shorter (48 minutes [IQR: 37-57] vs 64 minutes [IQR: 55-77]; $P < .001$), the number of RF applications was lower (52 [IQR: 46-58] vs 58 [IQR: 52-64]; $P < .001$], the RF time per application was shorter (22 seconds [IQR: 21-24] vs 29 seconds [IQR: 27-30]; $P < .001$) and the number of dislocations was lower (1 [IQR: 0-3] vs 2 [IQR: 1-4]; $P = .002$]) (Table 2 and Figure 2). In group A, the median CF (13 g [IQR: 12-15] vs 14 g [IQR: 12-15]; $P = .035$) and force-time integral (FTI) were lower (283 gs [IQR: 258-314] vs 365 gs [IQR: 339-402]; $P < .001$) when compared with group B. The impedance drop was similar in both groups (12 Ω [IQR: 11-13] vs 13 Ω [IQR: 11-14]; $P = .192$), in group A and group B, respectively (Table 2 and Figure 2).

### 3.3.1 | Anterior wall and posterior walls

In group A, the RF time per RF application was shorter (anterior wall: 34 seconds [IQR: 28-40] vs 42 seconds [IQR: 35-51]; $P < .001$ and posterior wall: 16 seconds [IQR: 14-19] vs 20 seconds [IQR: 16-25]; $P < .001$), as well as the FTI (anterior wall: 426 gs [IQR: 383-501] vs 540 gs [IQR: 479-629]; $P < .001$ and posterior wall: 177 gs [IQR: 149-225] vs 240 gs [IQR: 197-304]; $P < .001$). The average

**TABLE 2** Procedural characteristics of the study population

| | Group A (40 W) (n = 80) | Group B (35 W) (n = 105) | *P* value |
|---|---|---|---|
| Total RF time, min | 20 (IQR: 16-22) | 28 (IQR: 24-32) | **<.001** |
| Amount of RF applications, (n) | 52 (IQR: 46-58) | 58 (IQR: 52-64) | **<.001** |
| Median RF time per application, s | 22 (IQR: 21-24) | 29 (IQR: 27-30) | **<.001** |
| Median CF, g | 13 (IQR: 12-15) | 14 (IQR: 12-15) | **.035** |
| Median T, °C | 39 (IQR: 37-40) | 39 (IQR: 39-40) | **.039** |
| Median power, W | 39 (IQR: 38-40) | 34 (IQR: 34-35) | **<.001** |
| Median FTI, gs | 283 (IQR: 258-314) | 365 (IQR: 339-402) | **<.001** |
| Median impedance drop, Ω | 12 (IQR: 11-13) | 13 (IQR: 11-14) | .192 |
| Ablation index | 466 (IQR: 459-474) | 470 (IQR: 459-481) | .085 |
| First-pass isolation, (n) | 79/80 (99%) | 98/105 (93%) | .141 |
| Reconnection rate after adenosine, (n) | 5/80 (6%) | 4/97 (4%)[a] | .733 |
| Dislocation points, (n) | 1 (IQR: 0-3) | 2 (IQR: 1-4) | **.002** |
| PVI time, min | 48 (IQR: 37-57) | 64 (IQR: 55-77) | **<.001** |
| Ablation procedure time, min | 91 (IQR: 80-103) | 111 (IQR: 94-162) | **<.001** |
| Fluoroscopy time, min | 5 (IQR: 3-9) | 11 (IQR: 8-14) | **<.001** |
| Air kerma (AK), mGy | 9 (IQR: 4-13) | 18 (IQR: 12-29) | **<.001** |
| Dose area product (DAP), mGy/cm$^2$ | 1638 (IQR: 905-2666) | 4040 (IQR: 2552-6393) | **<.001** |

*Note:* Results are presented as median (interquartile range) or n(%). Bold values indicate a significance level of $P < .05$.

Abbreviations: CF, contact force; FTI, force-time integral; IQR, interquartile range; PVI, pulmonary vein isolation; RF, radiofrequency.

[a]Adenosine test performed in 97 out of 105 patients.

CF was lower at the posterior wall in group A (11 g [IQR: 8-14] vs 12 g [IQR: 9-17]; $P < .001$), but it was similar at the anterior wall in both groups (13 g [IQR: 10-18] vs 13 g [IQR: 10-18]; $P = .196$, group A and Group B, respectively). Finally, the impedance drop was lower at the posterior wall in group A (11 Ω [IQR: 7-15] vs 11 Ω [IQR: 8-16]; $P < .001$), but it was similar at the anterior wall in both groups (12 Ω [IQR: 9-16] vs 12 Ω [IQR: 9-17]; $P = .778$), group A and group B, respectively (Tables 3 and 4).

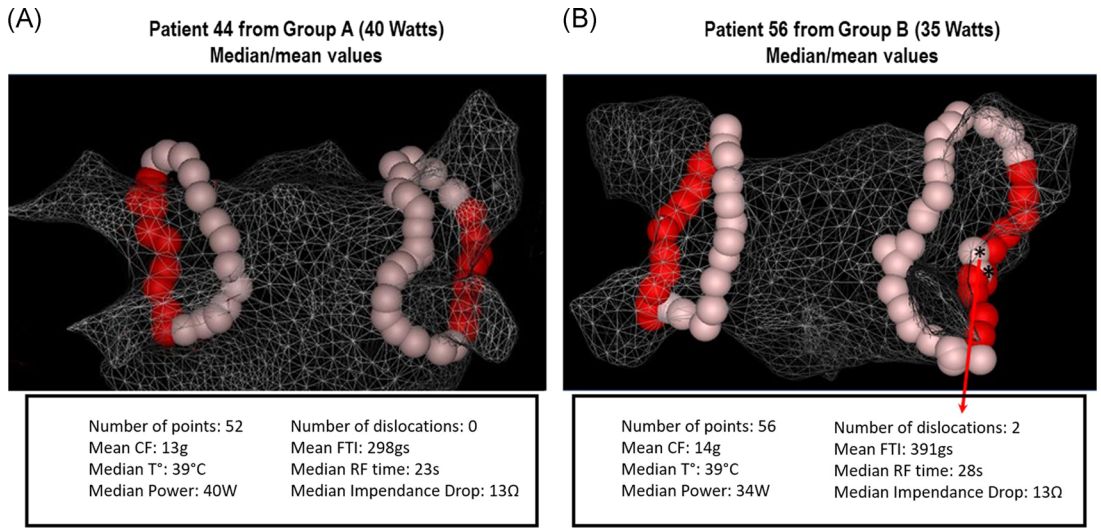


**FIGURE 1** Two representative examples of "CLOSE"-guided encirclement of the pulmonary veins (PV) and the radiofrequency parameters (median/median value) of all VISITAG points in one patient from group A (40 W; A) and one patient from group B (35 W; B). Posteroanterior view. Red VISITAG points with ablation index (AI) > 550 and pink VISITAG points with AI > 400. Asterisk (*) on two dislocation points in group B (35 W)

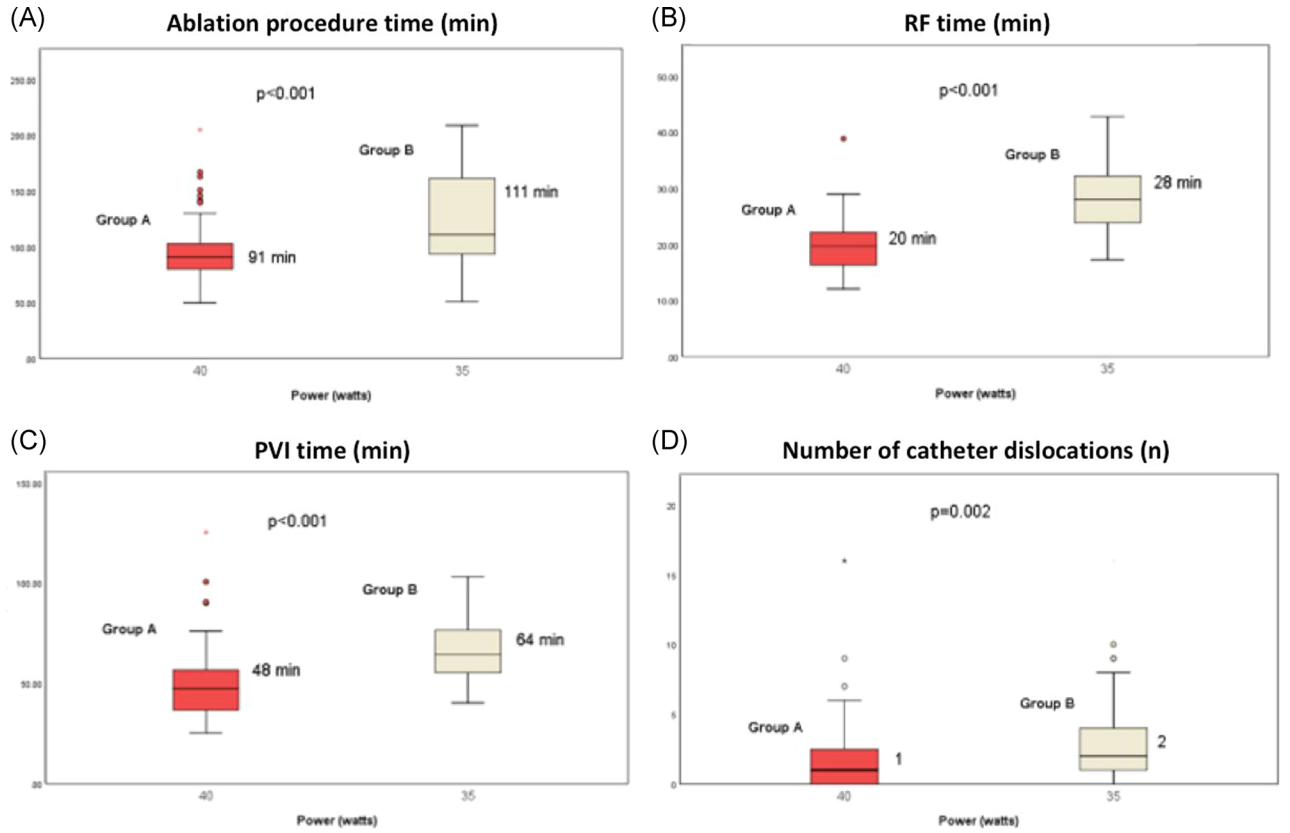


**FIGURE 2** Comparison between group A (40 W) and group B (35 W) concerning (A) ablation procedure time, (B) total radiofrequency (RF) time, (C) time for pulmonary vein isolation (PVI) time, and (D) amount of dislocations (n)

## 3.4 | Procedural outcome and complications

The first-pass isolation rate was similar (79/80 patients [99%] vs 98/105 patients [93%]; $P = .1414$), as well as the reconnection rate after adenosine test (5/80 patients [6%] vs 4/97 patients [4%]; $P = .733$], in group A and group B, respectively (Table 2).

No procedural complication, especially no steam pop, no cardiac perforation, no stroke, and no death occurred in both groups. In group A, a gastroscopy was performed in five patients with esophageal temperature rise more than 42°C during PVI after a median of 10 days (range 7-13) after ablation and did not reveal any esophageal injury. None of the patients developed esophageal fistula at a 1-month clinical follow-up.

## 3.5 | One-year follow-up

ATA recurrence within the first year was not significantly different between both groups (8/80 patients [10%] vs 14/105 patients [13.3%]; $P = .647$).

**TABLE 3** RF applications characteristics at the anterior wall of pulmonary veins

| Anterior wall median (IQR) | Group A (40 W) (n = 1326 RF applications) | Group B (35 W) (n = 2182 RF application) | *P* value |
|---|---|---|---|
| RF time per application, s | 34 (IQR: 28-40) | 42 (IQR: 35-51) | **<.001** |
| Average CF, g | 13 (IQR: 10-18) | 13 (IQR: 10-18) | .196 |
| Maximum T, °C | 39 (IQR: 37-41) | 40 (IQR: 39-41) | **<.001** |
| Maximum power, W | 40 (IQR: 40-40) | 35 (IQR: 35-35) | **<.001** |
| Force-time integral, gs | 426 (IQR: 383-501) | 540 (IQR: 479-629) | **<.001** |
| Impedance drop, Ω | 12 (IQR: 9-16) | 12 (IQR: 9-17) | .778 |
| Ablation index | 560 (IQR: 558-564) | 566 (IQR: 560-574) | **<.001** |

Abbreviations: CF, contact force; IQR, interquartile range; RF, radiofrequency. Bold values indicate a significance level of $P < .05$.

**TABLE 4** RF applications characteristics at the posterior wall of pulmonary veins

| Posterior wall median (IQR) | Group A (40 W) (n = 2697 RF applications) | Group B (35 W) (n = 3940 RF application) | *P* value |
|---|---|---|---|
| RF time per application, s | 16 (IQR: 14-19) | 20 (IQR: 16-25) | **<.001** |
| Average CF, g | 11 (IQR: 8-14) | 12 (IQR: 9-17) | **<.001** |
| Maximum T,°C | 38 (IQR: 36-40) | 39 (IQR: 38-40) | **<.001** |
| Maximum power, W | 40 (IQR: 38-40) | 35 (IQR: 35-35) | **<.001** |
| Force-time integral, gs | 177 (IQR: 149-225) | 240 (IQR: 197-304) | **<.001** |
| Impedance drop, Ω | 11 (IQR: 7-15) | 11 (IQR: 8-16) | **<.001** |
| Ablation index | 420 (IQR: 413-431) | 424 (IQR: 412-440) | **<.001** |

Abbreviations: CF, contact force; IQR, interquartile range; RF, radiofrequency. Bold values indicate a significance level of $P < .05$.

Use of ADT after 3 months blanking period was 19 of 80 in group A and 5 of 105 in group B (this was left at the discretion of the treating physician in group A and only reinstated in case of ATA recurrence after 3 months blanking period in group B). ADT used were Flecainide (8 vs 2), Sotalol (8 vs 3), and Amiodarone (3 vs 0) in groups A and B, respectively.

By considering both ATA recurrence or continued use of antiarrhythmic drugs at 1 year postprocedure as a failure, 1-year failure was not significantly different in both groups either (20/80 patients [25%] vs 14/105 patients [13.3%]; $P = .06$).

Moreover, no esophageal injury or atrioesophageal fistula was noted during the follow-up.

## 4 | DISCUSSION

### 4.1 | Main findings

This study suggests that increased power improves the efficiency of ablation by reducing the RF duration, the number of dislocations and the ablation procedure time, without compromising the safety.

### 4.2 | Biophysics of RF catheter ablation: effect of increased power

In addition to catheter stability, the lesion formation will mostly be determined by three parameters included in the AI formula: the contact between the tip electrode and the tissue, the power used, and the duration of the application.[17-19] Experimental work has shown that the AI formula predicts lesion depth with high accuracy and that power had the greater contribution (over CF) at the initial time of ablation.[3] It was already shown that the RF lesion mostly grows during the initial period of RF application.[17] We also know that, for different RF durations, the lesion size invariably increases with increasing power.[17] In our study, the median RF time per application was significantly shorter when using 40 W (22 vs 29 seconds) despite a slightly reduced contact at the posterior portion of the PVs, and this was associated with a reduction of the total RF time and procedural time.

RF current delivery causes resistive heating of the tissue in contact with the electrode and irreversible tissue damage is created by a temperature greater than approximately 50°C.[17] Excessive thermal injury may result in steam pops and unfortunately, they cannot be accurately predicted as there is no reliable method to monitor the tissue temperature during RF application.[17] The best approximation of tissue temperature comes from the thermistor located inside the ablation catheter. However, this is influenced by the catheter-tissue orientation, the blood environment and the electrode cooling from the saline irrigation itself which could sometimes give a false impression of safety.[17] In our study, increased power did not result in any steam pop occurrence nor esophageal lesion in the five patients with an increased esophageal temperature more than 42°C. These encouraging results should obviously be confirmed in larger randomized trials.

### 4.3 | High power RF ablation during PVI

Several studies have compared different power RF ablation strategies for PV isolation, mostly without relying on the AI formula.[5-10,19,20] Higher power ablation has been shown to be associated with a reduction in the duration of the procedural parameters (ablation procedure time, PV isolation time, fluoroscopy time, and radiation dose),[5-10] reduced AF recurrence,[10] and PV reconnection,[9] but sometimes with an increased risk of steam pops along with a higher incidence of pericardial effusion and gastrointestinal symptoms (especially during longer RF application).[10]

Using the AI formula, the power used in previous studies typically ranges from 25 W (at the posterior wall) to 35 W (overall or at the anterior wall only).[1,11,12] A recent multicenter registry compared two different RF power setups and two different irrigated catheters.[9]

As compared to the conventional group (25-30 W), the high power group (30-40 W) was associated with better efficiency, lower acute PV reconnection, without increased side effects.[9] Our study confirmed these data as all procedural parameters were improved without esophageal injury in the few patients with significantly increased esophageal temperature who received a gastroscopy. Also, the postprocedural recurrence of ATA at 1 year was not significantly different in the high power group of this study. However, long-term results should be put in perspective considering the differences in use of long-term ADT in both groups.

### 4.4 | Clinical implications

The so-called "CLOSE" protocol has already been shown to be a very efficient ablation strategy for the treatment of low-risk patients with paroxysmal AF. Previous publications using a power of 35 W showed an absence of any recurrence lasting more than 2 minutes in 78% of the patients after 2-year follow-up and a reduction of the AF burden from 2.68% (IQR: 0.09-15.02) to 0% (IQR: 0-0).[13] However, in some patients, there still remain some practical issues to easily complete the CLOSE protocol. These issues are mostly related to the problems encountered to stabilize the ablation catheter (mostly during long RF applications), with therefore potential problems to acquire contiguous ablation points or risk of dislocation and/or overshooting.

This study emphasizes that, in addition to a subjective feeling of increased easiness, the use of an increased power during PVI increases the efficiency of the procedure, most probably by reducing the RF time per application, resulting in shorter ablation procedure and shorter fluoroscopy, PVI and RF times, without impact on the procedural efficacy (at the time of the procedure and during the follow-up) and without compromising safety (in particular no steam pop and no esophageal damage in the patients receiving a gastroscopy). However, this was a monocentric nonrandomized study with a limited amount of patients, and therefore caution has to be taken regarding the risk of complications. In particular, the risk of atrioesophageal fistula, a very uncommon but life-threatening complication, will have to be evaluated in larger cohorts with systematic gastroscopic evaluation.

## 5 | LIMITATIONS

This single-center pilot comparison was retrospective and had implicit limitations with respect to relatively low patient volume. However, it seemed for us to be a necessary step towards an adequately powered randomized study. Gastroscopy was not systematically performed in each patient, but it was carried out in the five patients with esophageal temperature rise more than 42°C, since we already demonstrated that the number of esophageal lesions was not significant when respecting an AI of 400 at the posterior wall.[21] Moreover, catheter stability duration settings were reduced in comparison to the original "CLOSE to CURE" protocol to accelerate VISITAG feedback with respect to the AI. However, it remains important to emphasize carefulness with respect to posterior wall energy delivery. This needs to be further addressed in a larger study.

Holter was performed in the 80 patients of the high power group instead of an ILR (as in the "CLOSE to CURE" study), as the emphasis of this study was initially on procedural efficacy and safety and not on the long-term evaluation of efficacy.

Also both groups cannot be adequately compared at long term considering ADT strategy was different and not part of the study design, which was mostly focused on procedural efficiency rather than long-term efficacy. This needs to be addressed in a prospective randomized study.

## 6 | CONCLUSION

High power during "CLOSE"-guided AF ablation increases the efficiency of PVI, mostly by reducing RF duration, the time to isolate the PVs, the amount of dislocations and the ablation procedure time, without compromising patient's safety. These results still have to be confirmed by a randomized prospective study.

### ACKNOWLEDGMENTS

Maria Kyriakopoulou received an ESC Training Grant from the European Society for Cardiology and Teresa Strisciuglio received a grant from the Cardiopath PhD program.

### ORCID

*Teresa Strisciuglio* http://orcid.org/0000-0001-5928-1669
*Sebastien Knecht* http://orcid.org/0000-0003-4500-0146

### REFERENCES

1. Taghji P, El Haddad M, Phlips T, et al. Evaluation of a strategy aiming to enclose the pulmonary veins with contiguous and optimized radiofrequency lesions in paroxysmal atrial fibrillation: a pilot study. *JACC Clin Electrophysiol*. 2018;4(1):99-108.
2. Phlips T, Taghji P, El Haddad M, et al. Improving procedural and one-year outcome after contact force-guided pulmonary vein isolation: the role of interlesion distance, ablation index, and contact force variability in the 'CLOSE'-protocol. *Europace*. 2018;20(FI_3):f419-f427.
3. Nakagawa H, Ikeda A, Constantine G, et al. Controlling lesion size and incidence of steam pop by controlling contact force, radiofrequency power and application time (force-power-time index) in canine beating heart. *Heart Rhythm*. 2012;9(s5).
4. Yuyun MF, Stafford PJ, Sandilands AJ, Samani NJ, Andréng G. The impact of power output during Percutaneous catheter radiofrequency ablation for atrial fibrillation on efficacy and safety outcomes: a systematic review. *J Cardiovasc Electrophysiol*. 2013;24(11):1216-1223.
5. Nilsson B, Chen X, Pehrson S, Svendsen JH. The effectiveness of a high output/short duration radiofrequency current application technique in segmental pulmonary vein isolation for atrial fibrillation. *Europace*. 2006;8(11):962-965.
6. Winkle RA, Mohanty S, Patrawala RA, et al. Low complication rates using high power (45-50 W) for short duration for atrial fibrillation ablations. *Heart Rhythm*. 2019;16(2):165-169.
7. Barkagan M, Contreras-Valdes FM, Leshem E, Buxton AE, Nakagawa H, Anter E. High-power and short-duration ablation for pulmonary vein isolation: safety, efficacy, and long-term durability. *J Cardiovasc Electrophysiol*. 2018;29(9):1287-1296.

8. Baher A, Kheirkhahan M, Rechenmacher SJ, et al. High-power radiofrequency catheter ablation of atrial fibrillation. *JACC Clin Electrophysiol*. 2018;4(12):1583-1594.
9. Dhillon G, Ahsan S, Honarbakhsh S, et al. A multicentered evaluation of ablation at higher power guided by ablation index: establishing ablation targets for pulmonary vein isolation. *J Cardiovasc Electrophysiol*. 2019;30:357-365.
10. Kanj MH, Wazni O, Fahmy T, et al. Pulmonary vein antral isolation using an open irrigation ablation catheter for the treatment of atrial fibrillation: a randomized pilot study. *J Am Coll Cardiol*. 2007;49(15):1634-1641.
11. Das M, Loveday JJ, Wynn GJ, et al. Ablation index, a novel marker of ablation lesion quality: prediction of pulmonary vein reconnection at repeat electrophysiology study and regional differences in target values. *Europace*. 2017;19(5):775-783.
12. Hussein A, Das M, Chaturvedi V, et al. Prospective use of ablation index targets improves clinical outcomes following ablation for atrial fibrillation. *J Cardiovasc Electrophysiol*. 2017;28(9):1037-1047.
13. Berte B, Hilfiker G, Russi I, et al. Pulmonary vein isolation using a higher power shorter duration CLOSE protocol with a surround flow ablation catheter. *J Cardiovasc Electrophysiol*. 2019;30(11):2199-2204.
14. Chen S, Schmidt B, Bordignon S, et al. Ablation index guided 50 Watts ablation for pulmonary vein isolation in patients with atrial fibrillation: procedural data, lesion analysis and initial results from the FAFA AI high power study. *J Cardiovasc Electrophysiol*. 2019;30(12):2724-2731.
15. Duytschaever M. Successful 1-year outcome of catheter ablation of lone paroxysmal atrial fibrillation assessed by insertable cardiac monitors: the CLOSE to CURE study. 2019;Late-breaking trials 1. 17 March 2019 EHRA, Lisbon.
16. Calkins H, Hindricks G, Cappato R, et al. 2017 HRS/EHRA/ECAS/APHRS/SOLAECE expert consensus statement on catheter and surgical ablation of atrial fibrillation: executive summary. *Europace*. 2017;20(1):157-208.
17. Wittkampf FHM, Nakagawa H. RF catheter ablation: lessons on lesions. *Pacing Clin Electrophysiol*. 2006;29(11):1285-1297.
18. Nakagawa H, Jackman WM. The role of contact force in atrial fibrillation ablation. *J Atr Fibrillation*. 2014;7:1027.
19. Bhaskaran A, Chik W, Pouliopoulos J, et al. Five seconds of 50-60 W radio frequency atrial ablations were transmural and safe: an in vitro mechanistic assessment and force-controlled in vivo validation. *Europace*. 2017;19(5):874-880.
20. Bunch TJ, Day JD. Novel ablative approach for atrial fibrillation to decrease risk of esophageal injury. *Heart Rhythm*. 2008;5(4):624-627.
21. Wolf M, El Haddad M, De Wilde V, et al. Endoscopic evaluation of the esophagus after catheter ablation of atrial fibrillation using contiguous and optimized radiofrequency applications. *Heart Rhythm*. 2019;16(7):1013-1020.

**How to cite this article:** Kyriakopoulou M, Wielandts J-Y, Strisciuglio T, et al. Evaluation of higher power delivery during RF pulmonary vein isolation using optimized and contiguous lesions. *J Cardiovasc Electrophysiol*. 2020;31:1091–1098. https://doi.org/10.1111/jce.14438