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ORIGINAL ARTICLE
Arrhythmia and electrophysiology

Procedural performance and outcome after pulsed field ablation for pulmonary vein isolation: comparison with a reference radiofrequency database

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Aims Pulsed field ablation (PFA) is a promising ablation technique for pulmonary vein isolation (PVI) with appealing advantages over radiofrequency (RF) including speed, tissue selectivity, and the promise of enhanced durability. In this study, we determine the procedural performance, efficacy, safety, and durability of PFA and compare its performance with a dataset of optimized RF ablation.

Methods and results After propensity score matching, we compared 161 patients who received optimized RF-guided PVI in the PowerPlus study (CLOSE protocol) with 161 patients undergoing PFA-guided PVI for paroxysmal or persistent atrial fibrillation (AF; pentaspline basket catheter). The median age was 65 years with 78% paroxysmal AF in the PFA group (comparable characteristics in the RF group). Pulsed field ablation–guided PVI was obtained in all patients with a procedure time of 47 min (vs. 71 min in RF, $P < 0.0001$) and a fluoroscopy time of 15 min (vs. 11 min in RF, $P < 0.0001$). One serious adverse event [transient ischaemic attack] occurred in a patient with thrombocytosis (0.6 vs. 0% in RF). During the 6-month follow-up, 24 and 27 patients experienced a recurrence with 20 and 11 repeat procedures in the PFA and the RF groups, respectively ($P = 0.6$ and 0.09). High-density mapping revealed a status of 4 isolated veins in 7/20 patients in the PFA group and in 2/11 patients in the RF group (35 vs. 18%, $P = 0.3$).

Conclusion Pulsed field ablation fulfils the promise of offering a short and safe PVI procedure, even when compared with optimized RF in experienced hands. Pulmonary vein reconnection is the dominant cause of recurrence and tempers the expectation of a high durability rate with PFA.

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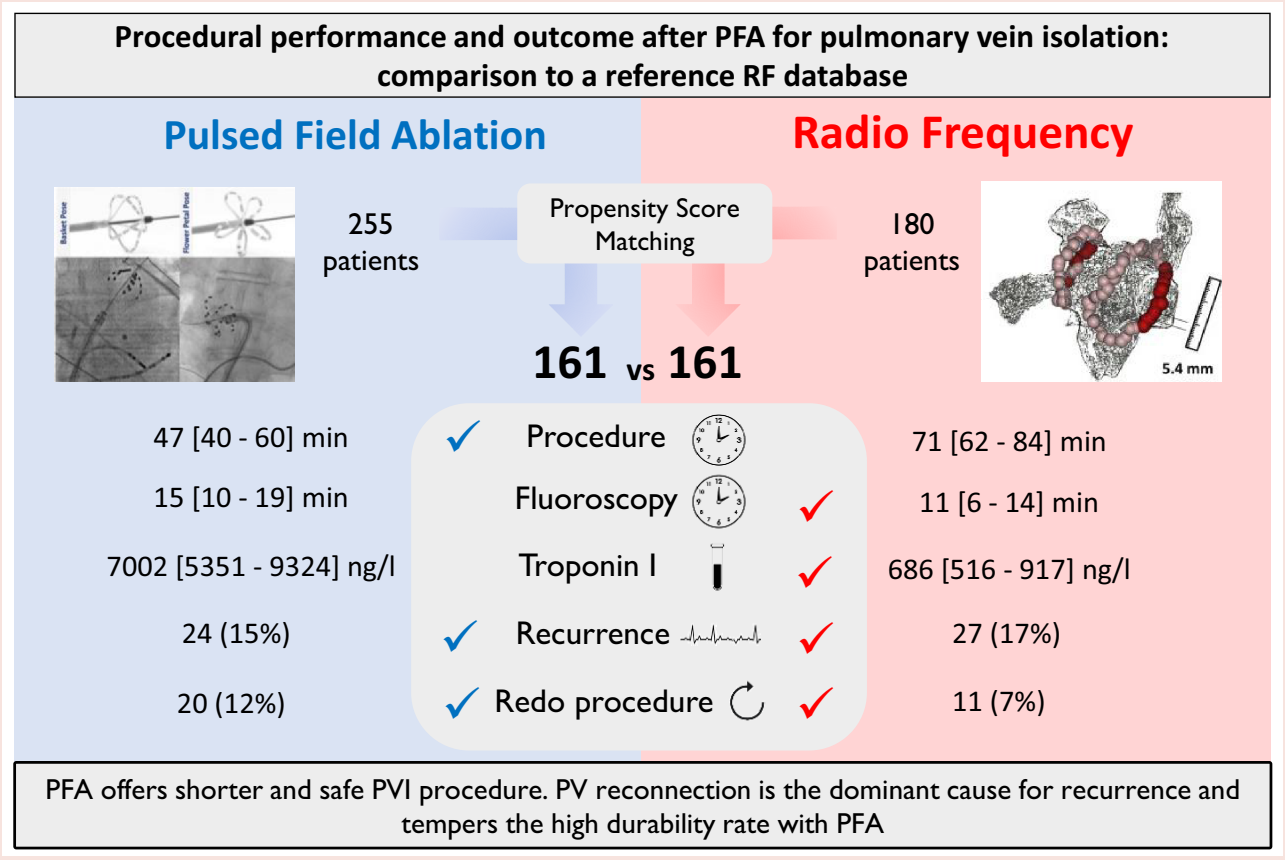
Graphical Abstract



Keywords Atrial fibrillation • Pulsed field ablation • Radiofrequency • Efficacy • Safety • Durability

Introduction

Pulmonary vein isolation (PVI) is the cornerstone treatment for rhythm management of atrial fibrillation (AF), the most common arrhythmia worldwide.[1] Ablation techniques mainly rely on thermal ablation such as radiofrequency (RF) and cryoablation, with many improvements in protocols and energy delivery control maximizing the efficiency and efficacy of the procedure.[2] However, thermal ablation may result in collateral damage such as PV stenosis, phrenic nerve, and oesophageal injuries.

Recently, a non-thermal energy technique known as pulsed field ablation (PFA) has re-emerged, offering several advantages, including speed, tissue selectivity, safety, and a promising high durability rate, as observed in initial pilot studies.[3] Pulsed field ablation energy induces a selective electroporation of cardiomyocytes leading to apoptosis without damaging the collateral tissues.[3,4] Initial studies, based on protocol-mandated repeat studies after PFA for paroxysmal AF, were associated with high durability rates after the optimization of energy delivery.[3] The 1-year freedom from atrial tachyarrhythmia (ATA) reached ~80% for paroxysmal AF.[5] Many safety endpoints were evaluated and no long-term phrenic nerve palsy, PV stenosis, and oesophageal lesions were found.[6,7] Some case reports referred to coronary spasm following PFA applications on the cavotricuspid isthmus, recently demonstrated to be avoided through nitroglycerin infusion.[8]

In a recent retrospective study conducted by Urbanek *et al.*,[9] a comparison between cryoballoon ablation and PFA revealed a shorter procedure time using PFA, with a similar efficacy and safety profile [three persistent phrenic nerve palsy, one stroke or transient ischaemic attack (TIA), and one oesophageal injury in the cryoablation group and one tamponade in the PFA group]. The ADVENT trial marked the first randomized comparison of PFA with conventional ablation methods (RF or cryoablation). Once again, the procedure time was found to be shorter for PFA, with a similar safety and efficacy profile.[10]

In our present study, we evaluated the procedural performance, safety, and efficacy at a 6-month follow-up of PFA for PVI and compared it with a dataset of PVI performed with stable, contiguous, and optimized RF applications (the CLOSE protocol in the PowerPlus study).[11]

Methods

Study population

We performed a propensity score matching between 180 patients from the PowerPlus study on the one hand and 255 patients from our PFA registry with a 6-month follow-up on the other hand (out of 450 patients from our PFA registry). For 161 patients in the PowerPlus group, there was a matched patient in the PFA group. The PowerPlus study, a prospective,

multi-centre, unblinded, randomized controlled trial (ClinicalTrials.gov: NCT04784013), originally enrolled 180 consecutive patients with symptomatic paroxysmal or persistent AF, all scheduled for their initial PVI procedure. These patients were prospectively recruited across four distinguished European centres: AZ Sint-Jan in Bruges, Belgium; Luzerner Kantonsspital in Luzern, Switzerland; Medical University of Graz in Graz, Austria; and Leiden University Medical Center in Leiden, Netherlands. Exclusion criteria included long-standing persistent AF, prior ablation for AF, and a left atrial diameter >50 mm measured by echocardiography in a parasternal long axis. In parallel, the PFA registry comprised 255 consecutive patients with symptomatic paroxysmal or persistent AF undergoing a first-time PVI at the AZ Sint-Jan Hospital (Bruges, Belgium), all of whom had also undergone a 6-month follow-up period.

Ablation procedure

Pulsed field ablation

All procedures were performed under general anaesthesia and on direct oral anticoagulation (OAC) or uninterrupted vitamin K antagonists. Ultrasound-guided femoral venous puncture and transoesophageal echocardiography were used. The PFA system consists of a PFA generator (Farapulse, Boston Scientific) that delivers high-voltage, high-frequency pulses over multiple channels; an over-the-wire 12 Fr multi-electrode PFA catheter (Farawave, Farapulse); and a 13 Fr steerable sheath (Faradrive, Farapulse). After transseptal access, the standard transseptal sheath was exchanged for the 13 Fr steerable sheath (Faradrive). The angiography of the pulmonary veins was performed before ablation. The generator output was 2000 V in biphasic mode. Pulmonary vein isolation was performed with eight applications per vein with a 31 or 35 mm catheter at the discretion of the operator (four basket and four flower applications with rotation for every two applications). Contact was evaluated by fluoroscopy and slight deformation of the spline before each application. Additional PFA applications were delivered in case of subsidiary PVs, large carina of permanent PV signals. Pulmonary vein isolation was assessed at the end of ablation using the Farawave catheter.

Radiofrequency

All procedures were performed under general anaesthesia (Bruges and Luzern) or sedation (Graz and Leiden) and on direct OAC or uninterrupted vitamin K antagonists. Three centres (Bruges, Luzern, and Leiden) used ultrasound-guided femoral venous puncture, transoesophageal (or intracardiac) echocardiography, and oesophageal temperature monitoring. The CARTO-3, three-dimensional (3D) mapping system, and nMARQ RF generator (Biosense Webster, Diamond Bar, CA, USA) were used in all cases. Point-by-point PVI was performed as per the CLOSE protocol using the QDOT catheter in two modes (90 W over 4 s in temperature-controlled—Q MODE+ or 35/50 W in temperature and flow-controlled modes—Q MODE). Pulmonary vein isolation was confirmed with the lasso catheter (Biosense Webster) positioned in each circle, both at the end of the encirclement and during adenosine challenge.

Post-procedure management and follow-up

In the PFA group, none of the patients received a proton pump inhibitor or endoscopic oesophageal evaluation. In the RF group, all patients were treated with a proton pump inhibitor for 1-month post-ablation. Post-procedure endoscopic oesophageal evaluation was carried out in all patients in Bruges, in the event of intra-procedural oesophageal temperature rise (Luzern) or in the presence of symptoms (Graz and Leiden).

Clinical follow-up consisting of physical examination and electrocardiogram (ECG) was performed at 1, 3, and 6 months post-procedure. A 24 h Holter was performed at 3 months and a 2–6 days Holter at 6 months' post-procedure or in the case of symptoms. A 3-month blanking period was applied after which anti-arrhythmic drugs (AADs) were discontinued (if still ongoing).

Study endpoints

The primary endpoint was procedural time, defined as the duration from femoral venous puncture to the extraction of catheters from the left atrium.

Secondary endpoints included measures of procedural efficiency, clinical efficacy at 6 months, safety, and the durability of the lesions in patients undergoing repeat procedures.

Procedural efficiency was assessed based on fluoroscopy dose and high-sensitivity troponin I level on Day 1 (Atellica® IM TnIH assay on lithium–heparin plasma, Siemens Healthcare Diagnostics Inc., Tarrytown, NY, USA), while clinical efficacy was defined as the freedom from ATA following a single procedure during the 6-month follow-up period.

Safety outcomes were determined by evaluating the incidence of primary adverse events occurring within the first 7 days post-ablation. These adverse events included, but were not limited to, death, cerebrovascular accident, myocardial infarct, atrio-oesophageal fistula, cardiac tamponade or perforation, and PV stenosis. The occurrence of PV stenosis or atrio-oesophageal fistula beyond 7 days was also considered a primary adverse event.

The durability of the lesions was evaluated in patients with recurrence who underwent repeat procedures.

Statistical analysis

The data analysis was conducted using SPSS Statistics (IBM, version 24). Propensity scores were calculated through binary logistic regression with the following covariates: age, body mass index, sex, left atrium diameter, CHA_2DS_2VASC score, type of AF, AAD before PVI, and time to ablation. Matching scores were determined using a nearest neighbour algorithm with a maximum distance of fifth standard deviation of pairwise distances between each patient in the PFA group and each patient in the PowerPlus group. For 161 patients in the PowerPlus group, there was a matched patient in the PFA group. The normality of data was assessed using the Shapiro–Wilk test. Continuous variables were presented as mean ± standard deviation or median (inter-quartile range). Group means were compared using the independent samples *t*-test for normally distributed data and Mann–Whitney *U* test for non-uniformly distributed data. The χ^2 test was employed for percentage and other categorical data. Event-free survival was estimated using the Kaplan–Meier method and compared using the log-rank test and Cox regression test. A *P*-value of <0.05 was considered statistically significant.

Results

Patient demographics

A total of 322 patients were included in the analysis: 161 patients treated with PFA [median age 65 (59; 71) years, 36% women] and 161 patients from the PowerPlus study [median age 65 (59; 72) years, 37% women]. Baseline demographics are presented in *Table 1*. Most of the patients in both groups had paroxysmal AF (78 vs. 76%, $P = 0.8$). The left atrium diameter was similar between groups [41 (36; 44) vs. 40 (36; 43) mm, $P = 0.2$], and more patients were treated with OAC before the procedure in the PFA group than in the RF group (93 vs. 83%, $P = 0.01$). Otherwise, there were no differences in clinical characteristics between the groups.

Procedural characteristics

Procedural results are summarized in *Table 2* and *Figure 1*. The procedural time was shorter in the PFA group than in the RF group [47 (40–60) vs. 71 (62–84) min, $P < 0.0001$]. The fluoroscopy time and doses were higher in the PFA group than in the RF group [15 (10; 19) vs. 11 (6; 14) min, $P < 0.0001$ and 4198 (2766; 7586) vs. 2848 (1770; 4856) mGy cm^2, $P < 0.0001$, respectively]. High-sensitivity troponin I level on Day 1 was higher in the PFA group vs. the RF group [7002 (5351; 9324) vs. 686 (516; 917) ng/L, $P < 0.0001$]. No acute procedural complications were reported, and no catheter char was detected in either group.

Follow-up

One patient from the RF group died from COVID-19 4 months' post-procedure and another patient from this group was lost to follow-up at 6 months. All other patients completed the 6-month follow-up.

Table 1 Clinical characteristics

Baseline characteristics	PFA (N = 161)	PowerPlus (N = 161)	P-value
Woman, *n* (%)	58 (36)	60 (37)	0.8
Age, median (IQR), years	65 (59; 71)	65 (59; 72)	0.9
Hypertension, *n* (%)	80 (50)	77 (48)	0.7
SHD, *n* (%)	27 (17)	28 (17)	0.9
Diabetes, *n* (%)	14 (9)	15 (9)	0.9
Normal LVEF, *n* (%)	151 (94)	146 (91)	0.3
BMI, median (IQR), kg/m^2	26 (25; 30)	27 (25; 29)	0.7
LA diameter (parasternal long axis), median (IQR), mm	41 (36; 44)	40 (36; 43)	0.2
$CHA_2DS_2VAS_C$	2 (1; 3)	2 (1; 3)	0.7
Paroxysmal AF, *n* (%)	125 (78)	123 (76)	0.8
Persistent AF, *n* (%)	36 (22)	38 (24)	0.6
Diagnosis to ablation time, median (IQR), months	12 (4; 36)	12 (4; 36)	0.7
OAC before the procedure	150 (93)	133 (83)	0.01
AAD before the procedure	103 (64)	87 (54)	0.07

SHD, structural heart disease; LVEF, left ventricular ejection fraction; BMI, body mass index; LA, left atrium; OAC, oral anticoagulation; AAD, anti-arrhythmic drug; IQR, inter-quartile range.

Table 2 Procedural characteristics

Procedural characteristics	PFA (N = 161)	PowerPlus (N = 161)	P-value
Sinus rhythm at baseline, *n* (%)	131 (82)	133 (83)	0.3
Procedure time, median (IQR), min	47 (40; 60)	71 (62; 84)	<0.0001
Fluoroscopy time, median (IQR), min	15 (10; 19)	11 (6; 14)	<0.0001
DAP, median (IQR), mGy.cm^2	4198 (2766; 7586)	2848 (1770; 4856)	<0.0001
High-sensitivity Troponin I level on Day 1, median (IQR), ng/L	7002 (5351; 9324)	686 (516; 917)	<0.0001

DAP, dose area product; IQR, inter-quartile range.

Arrhythmia recurrence and repeat procedures

Efficacy and safety results are summarized in *Table 3* and *Figure 2*.

At the end of the 6-month follow-up, 24 patients (15%) of the PFA group and 27 patients (17%) of the RF group experienced recurrent tachyarrhythmia ($P = 0.6$, *Figure 2A*). The Kaplan–Meier analysis showed 85 and 83% ATA-free survival in the PFA and the RF groups, respectively (hazard ratio 1.138, 95% confidence interval 0.656–1.971, $P = 0.646$, *Figure 3*).

In the PFA group, 20 patients (12%) underwent repeat procedures compared with 11 patients (7%) in the RF group ($P = 0.09$, *Figure 2B*). A status of four isolated veins was met in seven (35%) and two (18%) patients in the PFA and the RF groups, respectively ($P = 0.3$). Reconnection of the right veins was noted in 10/20 (50%) patients in the PFA group and in 5/11 (45%) patients in the RF group and of the left veins in 8/20 (40%) patients in the PFA group and in 4/11 (36%) patients in the RF group (both $P = 0.8$, *Figure 2C*). After RF-guided PVI procedures, a status of non-isolation at repeat was predominantly attributed to gap-related reconnections at regions of the carina. After PFA-guided PVI, non-isolation was either due to gap-related reconnection or the apparent lack of isolation at the proximal part of the circle. Two examples of high-density activation maps obtained during repeat procedures, both after index PFA and index RF procedures, are depicted in *Figure 4*. In *Figure 4A* (repeat after PFA), high-density mapping (Octaray, Biosense Webster) showed the gap-related reconnection of both superior veins, whereas the right inferior pulmonary vein appeared non-isolated all around its proximal portion. In *Figure 4B* (repeat after RF), high-density mapping (Pentaray, Biosense Webster) showed the reconnection of the left pulmonary veins through gaps located at the anterior and posterior carinas.

Safety

In the RF group, one patient developed an acute Dressler's syndrome, which was successfully managed with colchicine and corticosteroid, and one patient presented with moderate dyspnoea at 3 months' post-ablation due to pulmonary embolism (possibly related to COVID vaccination 12 days previously, together with a premature discontinuation of OAC post-ablation).

In the PFA group, one patient presented a transient ischaemic visual accident a few hours after the procedure. This patient was known to suffer from thrombocytosis. No other major procedural complications were reported.

Discussion

Our study aimed to compare a PFA strategy with PVI performed with stable, contiguous, and optimized RF applications (CLOSE protocol). This observational study was performed in a well-balanced population with a predominantly paroxysmal AF without major exclusion criteria. The main findings are that PFA ablation offers (i) a significant reduction in the procedure time with higher fluoroscopy time and dose, (ii) an equally safe procedure, and (iii) similar 6-month outcomes compared with RF-guided ablation.

Evidence on safety and efficacy of pulsed field ablation

Successful ablation for AF relies on the creation of a transmural, contiguous scar capable of electrically isolating the pulmonary veins while also carrying a low risk of damage to collateral tissue. During PFA applications, ultrarapid electric fields (<1 s) create microscopic pores in cell membranes, leading to increased permeability for ion transport and massive cell death.[12] The mechanism of cell death is predominantly apoptotic, although other studies suggest that necrosis or necroptosis may also play a role.[12] The electroporation affects cardiomyocytes without affecting other collateral structures, avoiding side effects such as phrenic palsy, PV stenosis, and oesophageal lesions, commonly found with thermal techniques. The absence of coagulative necrosis prevents PV stenosis. The tissue specificity is determined by the threshold sensitivity to the electric field, with cardiomyocytes having the lowest threshold (400 V/cm).[12] Among the recently developed PFA catheters, Farapulse (Boston Scientific) was the first to receive approval in Europe and is currently the most widely used worldwide. Even if the promised durability with optimized bipolar applications was very high, the long-term follow-up of IMPULSE, PEFCAT, and PEFCAT II using

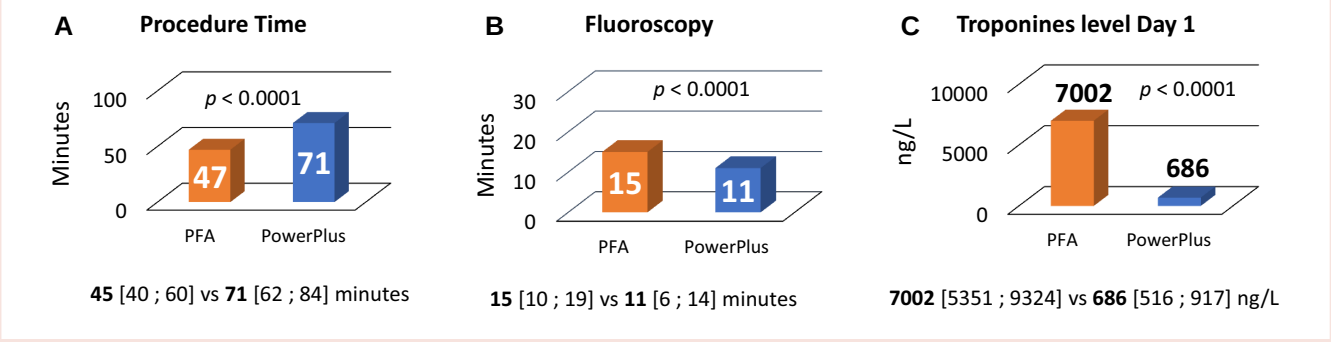


Figure 1 Procedural characteristics. (*A*) Procedure time. (*B*) Fluoroscopy time. (*C*) High-sensitivity troponin I levels on Day 1 after procedure.

Table 3 Efficacy and safety outcomes

Efficacy and safety	PFA (*N* = 161)	PowerPlus (*N* = 161)	*P*-value
Recurrence at 6 months, *n* (%)	24 (15)	27 (17)	0.6
Repeat ablation, *n* (%)	20 (12)	11 (7)	0.09
Four isolated veins status, *n* (%)	7 (35)	2 (18)	0.3
Serious adverse events			
None, *n* (%)	160 (99.5)	161 (99)	
Vascular, *n* (%)	0 (0)	0 (0)	
Tamponade, *n* (%)	0 (0)	0 (0)	
TIA/stroke, *n* (%)	1 (0.5)	0 (0)	
Other complications			
Pericarditis, *n* (%)	0 (0)	1 (0.5)	
Oesophageal injury, *n* (%)	0 (0)	1 (0.5)[a]	

TIA, transient ischaemic attack.
[a]Ulcer.

Farapulse on 121 patients showed a 1 year freedom from AF of 81% and ATA of 78.5%.[3] The 5S Study investigated this technology in 191 patients (62% had paroxysmal AF).[13] Each patient underwent transthoracic echocardiography, while endoscopy and brain magnetic resonance imaging were only performed in 52 and 53 patients, respectively. Recurrence was observed in only nine patients. Regarding complications, the study reported 2 strokes, 1 tamponade, and 19% of asymptomatic cerebral injury. Another real-world scenario involving 138 patients with AF (62% persistent) showed freedom from ATA in 90% of paroxysmal AF and 60% of persistent AF patients.[14] No PV stenosis, oesophageal lesion, or permanent phrenic nerve injury was reported in these studies. Complications such as coronary spasm during PVI with PFA (Farapulse catheter) have been reported.[8] Pulsed field ablation applications targeting PVs and posterior wall did not induce coronary spasm, conversely to applications on the cavotricuspid isthmus. Intravenous or intracoronary nitroglycerin administration before PFA application has been shown to prevent severe coronary spasm.[8] Recently, the MANIFEST-PF registry, involving 1568 patients (65% paroxysmal AF), demonstrated a good safety profile with 1.9% major adverse events (1.1% tamponade, 0.4% stroke) and good efficacy with 12-month freedom from AF/atrial flutter/atrial tachycardia of 78.1% (81.6% for paroxysmal AF and 71.5% for persistent AF).[15]

The very high-power short-duration RF ablation has shown a safe and efficient profile with pre-clinical studies and PowerPlus study with a high rate of contiguity and transmurality.[11]

Procedural efficiency of pulsed field ablation

In this study, procedural times were significantly shorter in the PFA group than in the RF group, showing a 34% reduction. It is important to note that we compared 161 patients from the first 255 patients undergoing PFA (with operators lacking experience in the new technique) with the last 161 patients undergoing RF ablation following the CLOSE protocol. In contrast, the fluoroscopy time and dose were higher in the PFA group (27 and 32% increase, respectively). The short procedure time with PFA is mainly attributed to fast and short applications with a high rate of single-shot isolation (no PV signals after the first application) and a short waiting time between applications. Moreover, continuous applications can be performed without fearing oesophageal injury, in contrast with RF where rising temperature might require the operator to change position for the next application. These findings align with Urbanek *et al.*[9] who compared PFA and cryoablation and reported similar procedure times. On the other hand, the MANIFEST-PF registry and ADVENT trial showed longer procedure times (60 min), potentially related to protocol-dependent differences in waiting time and/or additional 3D mapping.[10,15] Regarding fluoroscopy time, our results align with the MANIFEST-PF registry (11 min)[15] but are shorter compared with the ADVENT trial (21 min)[10] and longer compared with the study by Urbanek *et al.*[9] (7 min).

High-sensitivity troponin I levels on Day 1 were 10 times higher after PFA than RF ablation, albeit without any clinical complaints or ECG changes. Although prior studies could not confirm a relation between post-procedural high-sensitivity troponin I elevation and outcomes after PVI, the current observation might suggest a large amount of affected tissue with PFA.[16]

Clinical safety of pulsed field ablation

An excellent safety profile was observed in both groups without major complications. The complete absence of vascular complications and transseptal-related tamponade is likely attributable to operator experience and crucially the use of ultrasound.

In the PFA group, a TIA occurred in a patient known to have thrombocytosis. The absence of overt stroke or TIA in the 90 W group aligns with prior studies using very high-power short-duration RF applications.[17] Our results are consistent with the excellent safety profile described in the MANIFEST-PF registry and in the study by Urbanek *et al.*[9,15] However, the ADVENT trial addressed a safety concern with one reported death.[10]

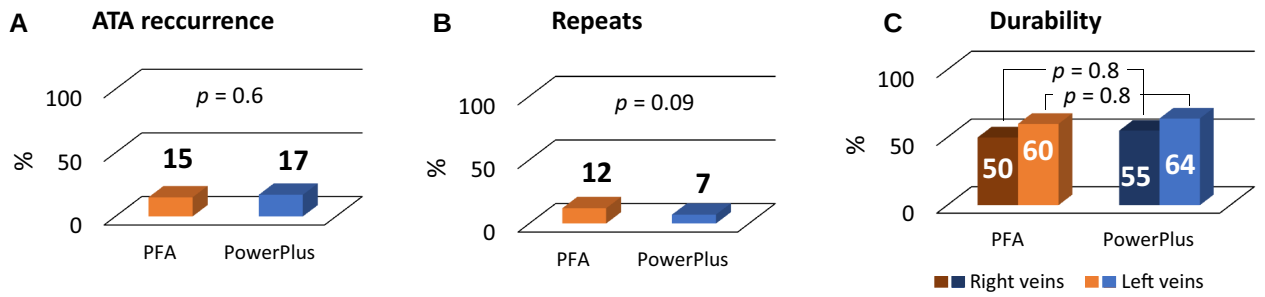


Figure 2 Pulsed field ablation and radiofrequency efficacy. (*A*) The percentage of ATA recurrence at 6 months. (*B*) The percentage of repeat procedures. (*C*) The durability of the pulmonary vein isolation.

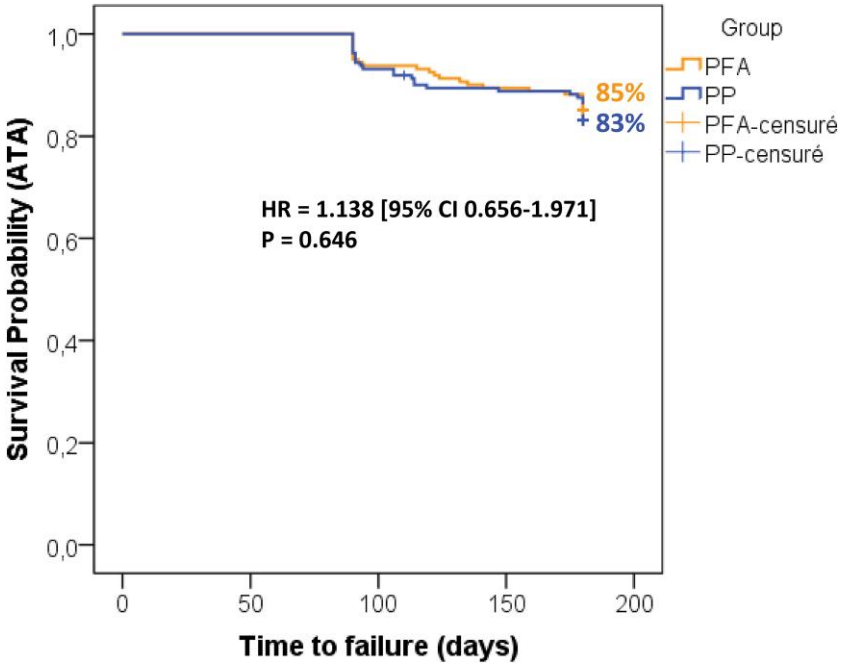


Figure 3 Six-month outcomes. Kaplan–Meier curve of freedom from recurrence of ATA at the 6-month follow-up.

Despite these encouraging clinical findings, further studies are needed to explore the incidence of silent ischaemic lesions. Brain MRI analysis in the 5S Study revealed up to 19% of silent brain injuries after PFA,[13] whereas brain imaging studies have reported an incidence of 25% after catheter RF ablation.[18,19] On the other hand, silent lesions were observed in 12–24% of patients undergoing imaging after 90 W/4 s PVI.[20]

Finally, concerning oesophageal and phrenic nerve safety, no evaluation was conducted in the PFA group. A very low rate of thermal injury was observed in the RF group, consistent with previous studies.[21]

Clinical effectiveness and durability of pulsed field ablation

No differences were observed at 6 months regarding effectiveness with high rates of freedom from recurrent ATA of ~84% in both groups. These results were obtained in a predominantly paroxysmal AF population with limited structural heart disease and a relatively short time from diagnosis to ablation. The reported efficacy rates align with prior CLOSE studies that used conventional power for contiguous PV encirclement (both in power-controlled or temperature-controlled mode)[22,23] and with recent clinical studies using PFA.[5,13,14] These findings are in line with the study by Urbanek *et al.*[9] and the MANIFEST-PF registry but differ from the ADVENT trial, which reported a lower success rate at 6 months (79.7% in the PFA group).[10,15]

In the present study, we observed a similar isolation durability rate in both groups. High-density activation maps obtained during repeat procedures indicated typical gap-related reconnections (mostly located on the carina) after the RF procedure, whereas after PFA, non-isolation was also characterized by the circumferential presence of antral potentials in the presence of durable distal isolation. This last finding could

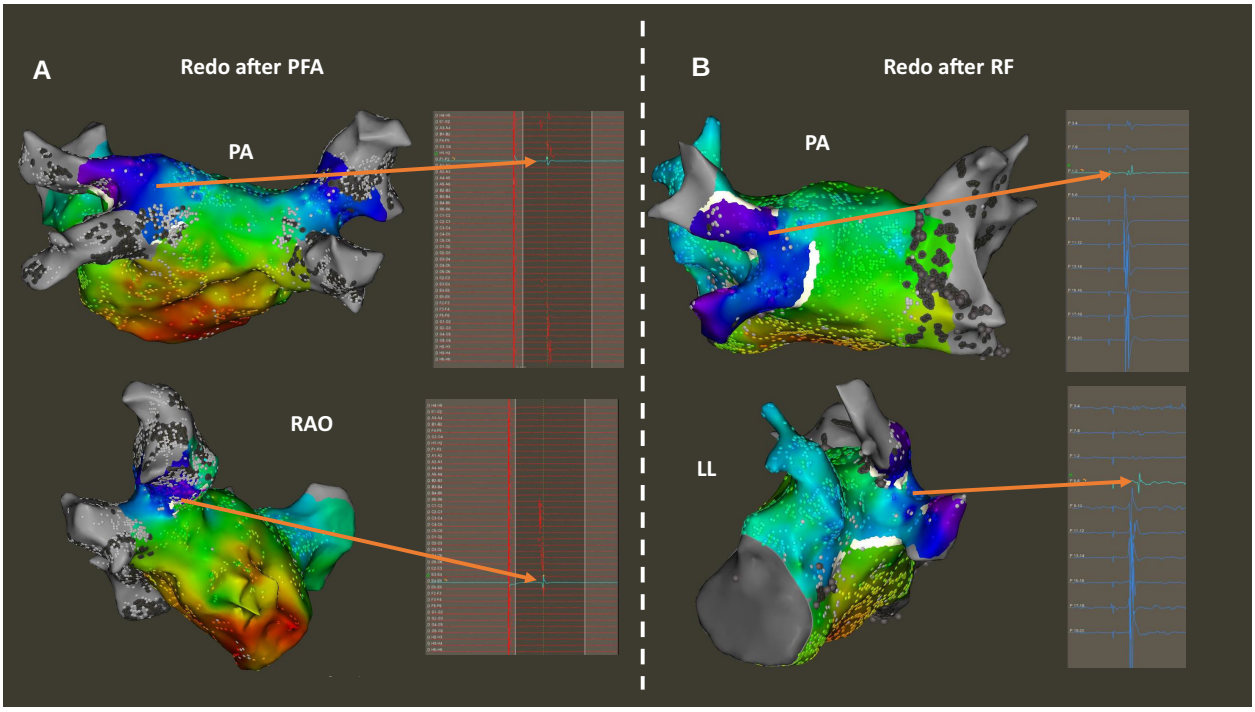


Figure 4 Redo procedures after pulsed field ablation–guided and radiofrequency-guided pulmonary vein isolation. (*A*) Redo procedure (posterior anterior and right anterior oblique views) after pulsed field ablation-guided pulmonary vein isolation ablation using Octaray catheter (Biosense Webster) for high-density mapping. We observed the gap-related reconnection of both superior veins, whereas the RIPV appeared non-isolated all around its proximal portion. (*B*) Redo procedure (posterior anterior and left lateral views) after radiofrequency-guided pulmonary vein isolation ablation using Pentaray catheter (Biosense Webster) for high-density mapping. We observed the reconnection of the left pulmonary veins through gaps located at the anterior and posterior carinas.

indicate either non-isolation of the antrum at the index procedure (i.e. no PFA applications at that region) or the reconnection of priorly targeted regions (which would imply lower lesion quality of 'flower' PFA applications at the antrum). Further studies are required to investigate the types of reconnections after PFA. Of note, the carina has previously been reported to be the preferential site of reconnection after PVI, and this uses different energy sources. This is most likely due to the increased instability of the catheter and/or the presence of thick muscular connections with the potential of epicardial connections in this region.

Clinical and research implications

The very low complication rate, absence of collateral damage, no need for specific monitoring, short learning curve, and short procedural times (<1 h) illustrate how PFA ablation for PVI seems a promising alternative to RF, especially for patients undergoing a first procedure directed at PVI-only. However, we must await the results of more randomized controlled trials (like BEAT-AF) comparing the performance, efficacy, and safety of PFA vs. RF or cryo-energy in larger patient cohorts, with specific emphasis on silent adverse events such as silent brain injury. Finally, we need to await the results of studies evaluating new PFA catheter designs and dosing recipes, long-term outcomes after ablation, and cost-effectiveness.

Limitations

Despite the use of propensity matching, this study is limited by its single-centre, retrospective design without randomization. Moreover, we did not perform post-procedural brain MRI or systematic remapping.

Conclusions

Pulsed field ablation demonstrates shorter procedure times with comparable efficacy, performance, and safety profiles when compared with RF ablation in experienced hands. The primary advantages of the energy lie in its short learning curve and tissue selectivity. The development of new catheters with contact force information, coupled with integration into 3D mapping systems, will further help in the mapping of other complex arrhythmias.

Lead author biography

Dr Benjamin De Becker is an electrophysiology and pacing fellow in the Department of Cardiology, AZ Sint-Jan Hospital, Bruges, Belgium.

Data availability

The data supporting the findings of this study are available from the corresponding author on request.

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