

Left atrial substrate modification in addition to pulmonary vein isolation using a novel circular variable loop pulsed field ablation catheter

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Background

Pulsed field ablation (PFA) is a recently developed technology that causes tissue necrosis through electroporation and has been employed and validated for pulmonary vein isolation (PVI) in atrial fibrillation (AF) ablation. Only few devices have received a CE mark for this use and the Varipulse™ catheter (Varipulse™, Biosense Webster, Irvine, USA), a variable loop PFA catheter, has been recently approved. Despite the growing experience with PVI, evidence is lacking about the use of PFA catheters and linear ablation lesions, which could potentially be performed with PFA catheters, reducing procedure related costs and time.

Case summary

A 73-year-old Caucasian woman with multiple cardiovascular risk factors presented with highly symptomatic paroxysmal AF and was scheduled to undergo PFA AF ablation using the new Varipulse catheter. The procedure was performed under deep sedation and the catheters were advanced through trans-septal puncture. 3D electroanatomic mapping of the left atrium showed significant anterior wall fibrosis. After PVI, substrate modification through an anterior mitral line (AML) approach was pursued. The AML was performed with additional PFA applications and successful bidirectional block was confirmed by pacing maneuvers without any procedural complications. The patient was discharged the following day, asymptomatic and in a state of well-being.

Conclusion

Individual LA substrate modification, including linear lesion sets, can be delivered in addition to PVI using the novel Varipulse PFA catheter in patients with AF.

Keywords

Pulsed field ablation • Anterior mitral line • Pulmonary vein isolation • Atrial fibrillation • Case report

ESC curriculum

5.3 Atrial fibrillation • 6.3 Heart failure with preserved ejection fraction

Learning points

- Linear ablation lesions can be performed with PFA catheters, such as the Varipulse PFA catheter, when pursuing a substrate modification approach.
- The use of new technologies and emerging devices can pose challenges when employed in different-than-usual clinical scenarios.

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Introduction

Pulsed field ablation (PFA) is an energy approach that relies on ultra-short (microsecond-range) high-voltage electrical discharges that induce irreversible electroporation, a process that results in tissue necrosis. PFA has been demonstrated to be a safe and effective treatment for atrial fibrillation (AF).^{1,2} A novel circular catheter (Varipulse™, Biosense Webster, Irvine, USA), with a variable loop structure has been specifically designed for PFA procedures targeting the pulmonary veins (PVs). The catheter obtained the CE mark in February 2024 and has been successfully used in first AF ablation procedures under routine clinical conditions. There is only very little experience focusing on the use of this novel PFA device beyond the PVs and only a few case reports have been published describing the use of different PFA catheters for linear atrial lesions, with high rates of acute bidirectional block across ablation lines. This report describes the first reported clinical experience with left atrial (LA) anterior mitral line (AML) ablation using the novel Varipulse catheter in a patient with paroxysmal AF and severe atrial fibrosis affecting the anterior LA wall.

Summary figure

At outpatient clinic (one month before ablation)	Severe symptoms related to atrial fibrillation (AF), multiple cardiovascular risk factors
Procedure planning	Patient scheduled for interventional AF treatment with pulsed field ablation (PFA), employing the new Varipulse catheter
Procedure day—mapping	Evidence of anterior wall fibrosis during left atrial 3D electroanatomic mapping
Procedure day—ablation	After pulmonary vein isolation, successful and uncomplicated substrate-guided anterior mitral line ablation with PFA
Post-operative period (one day after ablation)	No complications—discharge

Case presentation

A 73-year-old Caucasian female patient, with multiple cardiovascular risk factors (including diabetes, hypertension, dyslipidaemia, history of multiple urgent coronary revascularizations and heart failure with preserved ejection fraction) presented with symptomatic paroxysmal AF (European Heart Rhythm Association—EHRA IIB), reporting daily arrhythmia related symptoms lasting for several months despite medical therapy, and was referred for AF ablation to our centre. Upon arrival, the patient was in AF with a normal ventricular rate, clinical examination revealed no signs of acute heart failure and cardiac ultrasound showed a non-dilated left ventricle with normal wall thickness, preserved ejection fraction, and a slightly dilated left atrium (left atrial volume index 37 mL/m²) with diastolic dysfunction. Blood testing was significant for an elevated NT-proBNP level of 1120 pg/mL. The patient was then scheduled to undergo PFA-guided AF ablation using the Varipulse™ catheter (Varipulse™, Biosense Webster, Irvine, USA). Catheter ablation was performed under deep sedation with a bolus of midazolam and fentanyl and a continuous infusion of propofol. A 6F diagnostic catheter was inserted distal into the coronary sinus via the right femoral vein. Trans-septal puncture (TSP) using a steerable 8.5 F sheath (Vizigo) was performed in a modified Brockenbrough technique.³ Unfractionated heparin was administered according to the patient's weight to maintain an activated clotting time ≥ 300 s. Electrical cardioversion was then performed to allow a better estimate of low-voltage areas. After TSP, a multipolar mapping catheter (Pentaray, Biosense Webster, Irvine,

USA) was positioned in the LA and 3D mapping of the LA (Carto V8®, Biosense Webster, Irvine, USA) was performed using high density mapping for the estimation of bipolar LA voltage (Figure 1). The bipolar voltage reference interval was set between 0.05 and 0.5 mV. Voltage mapping revealed myocardial sleeves connecting the PVs with the LA and a huge low-voltage area affecting almost entirely the anterior wall (Figure 1). Pulmonary vein isolation (PVI) was then performed with two sets of ostial and antral PFA applications per each PV (targeting ≥ 12 applications/vein as in the registration trial)⁴ with subsequent confirmation of entrance and exit block, without a waiting period (Figure 2). After successful PVI, LA substrate modification was performed, and an AML approach was pursued in order to target the low-voltage area and reduce the potential for peri-mitral re-entrant circuits. The AML targeted the fibrotic area, connecting the circular PVs lesions (starting from the right superior PV) to the mitral-valve annulus. This kind of linear lesion has been previously performed and validated with a radiofrequency approach.⁵ The AML was ablated with 14 additional PFA applications, delivered sequentially along the anterior mitral wall (Figure 2). Successful bidirectional block was confirmed by pacing maneuvers and a prolongation of the interval between the onset P-wave to left atrial appendage (LAA) activation (from 165 ms before the ablation to 240 ms after ablation at the

end of the procedure) (Figure 3). No PFA related side effects (such as vagal reaction or coronary spasm) or procedure related complications were identified during and after the intervention. Following

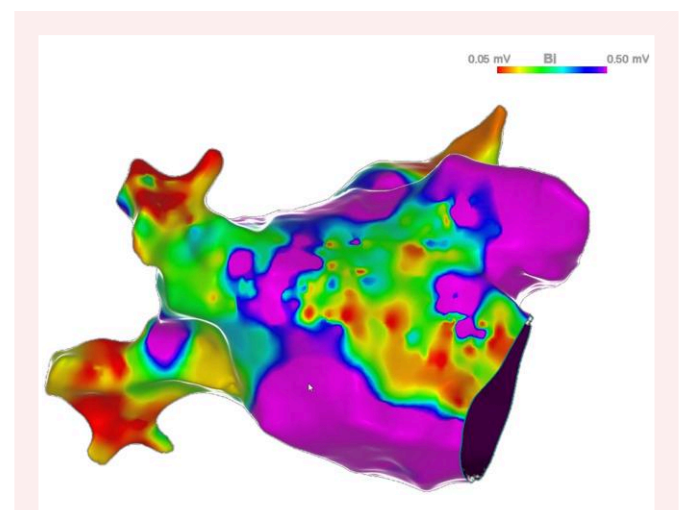


Figure 1 3D bipolar voltage map (carto V8, biosense webster, Irvine, USA) showing severe left atrial (LA) fibrosis affecting the anterior LA wall.

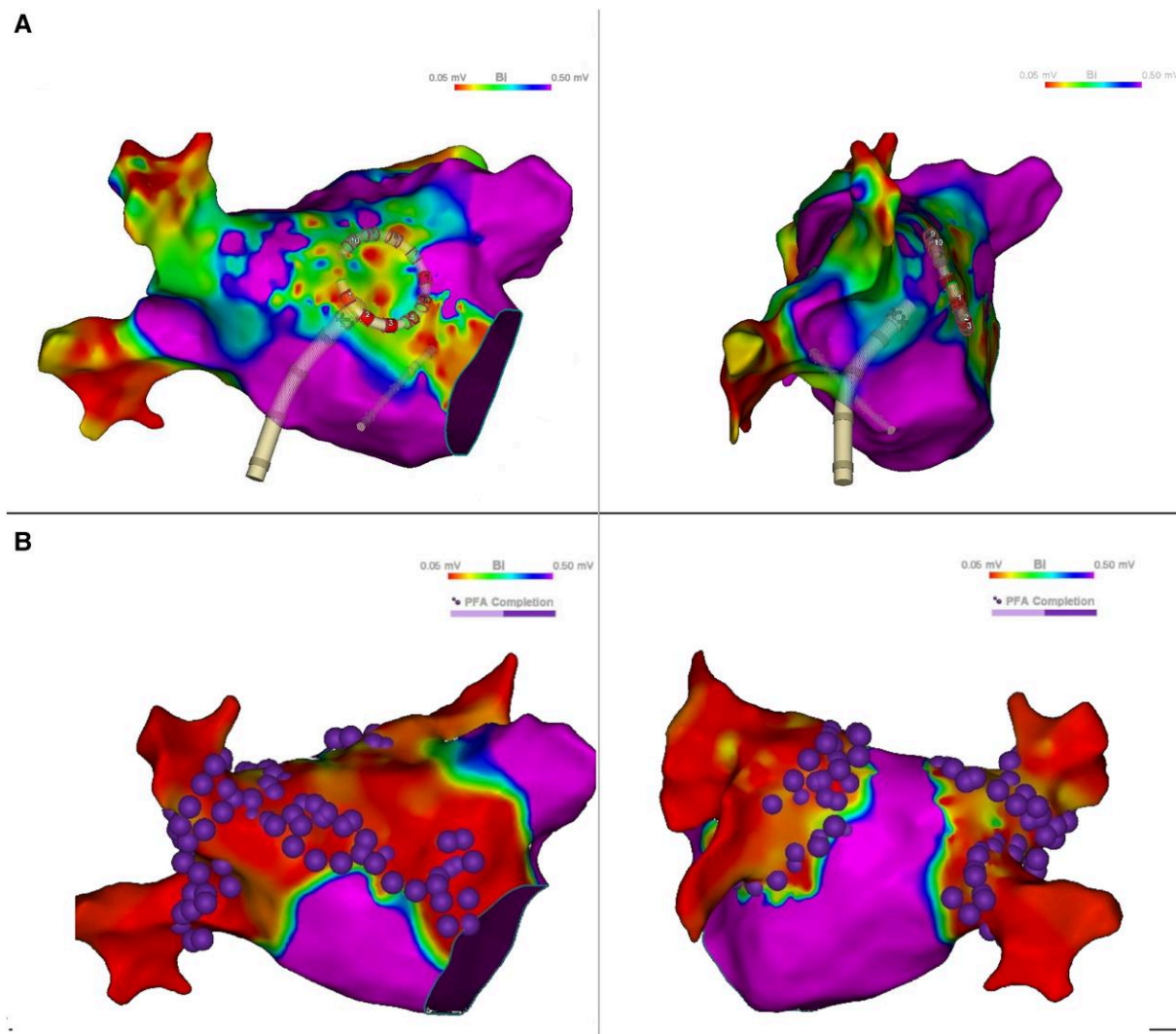


Figure 2 (A) left atrial bipolar voltage map with the varipulse catheter placed at the anterior wall with fibrotic tissue during mapping and ablation in RAO 30° and right-lateral orientation. (B) Repeat post-ablation bipolar voltage mapping showing acute ablation effects in terms of PFA-induced lesion formation around the pulmonary veins and the septal area from the right sided pulmonary veins to the mitral-valve annulus in RAO 30° and posterior–anterior orientation.

ablation, the patient was discharged the next day in a healthy state and with a prescription for therapeutic anticoagulation.

Discussion

The Varipulse catheter, along with other PFA technologies, has been proven to be a safe and effective alternative to existing AF ablation technologies.⁴ Comparative evidence has shown PFA to have similar reliability and safety characteristics to other energy sources employed for PVI but allowing for shorter procedural times and likely less fibrosis in the chronic

stage.^{6,7} In patients with AF and LA fibrosis, PVI and additional substrate modification targeting areas of bipolar low voltage has been associated in some studies with improved freedom from AF recurrence, at the cost of longer procedural durations and fluoroscopy time, despite other studies having inconsistent results.^{8–11} Some reports also point out the possible influence of linear ablations on atrial mechanics, but no definitive evidence is available to date.¹² The feasibility of non-PV ablation lines, such as cavo-tricuspid isthmus (CTI) or mitral isthmus, with other PFA technologies has already been demonstrated elsewhere,^{13–15} but with the use of different catheter designs, such as variable distal shape catheters.

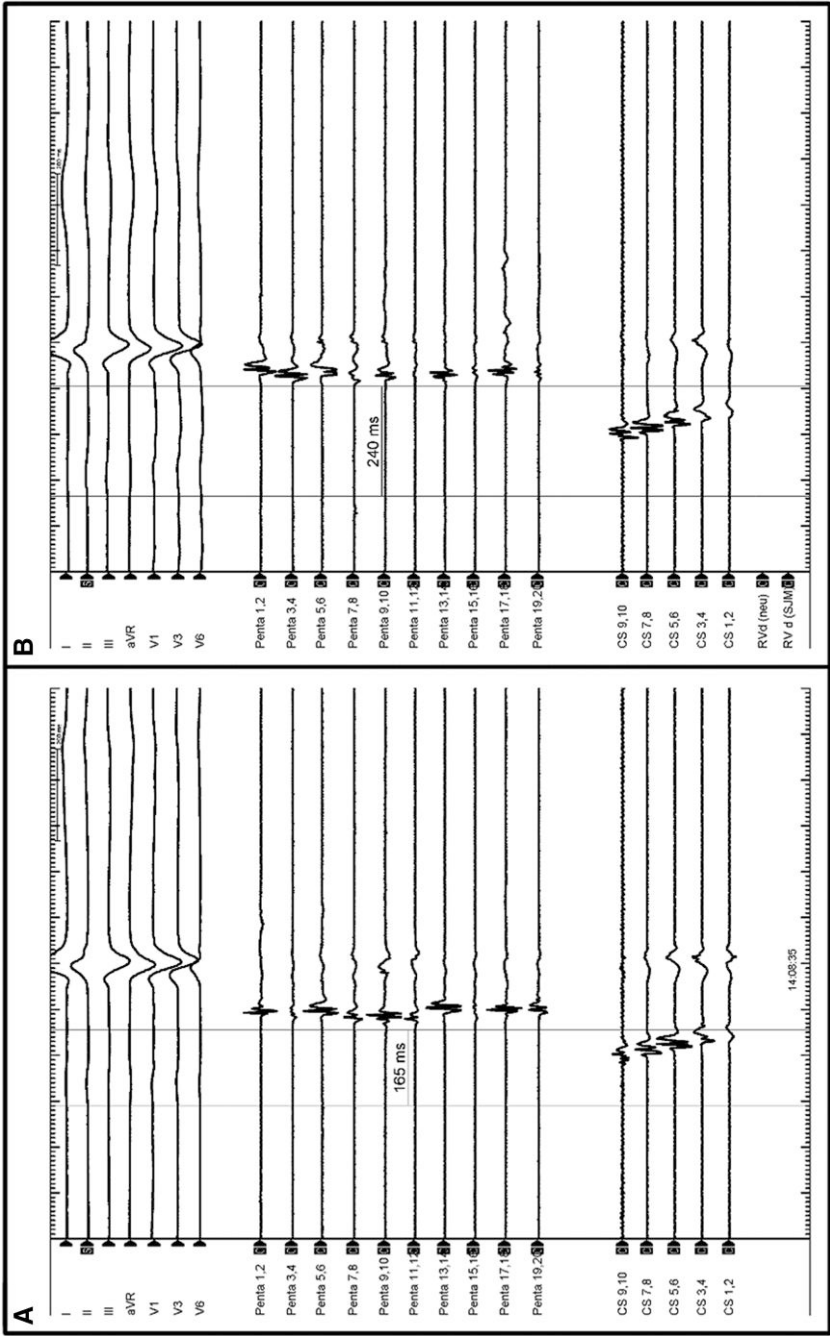


Figure 3 Evidence of anterior mitral line block by prolongation of the interval between the onset P-wave to left atrial appendage (LAA) activation. From 165 ms before the ablation (A) to 240 ms after the block (B).

In this case report, we present a successful PFA-guided ablation including PVI and additional individual substrate modification in terms of bidirectional block of an AML. This shows the flexibility of this novel PFA device, which can also be utilized to create linear lesions if required, thereby eliminating the need for additional catheters and reducing both the cost and duration of the procedure. Further research is needed to investigate the safety and efficacy of linear lesions conducted using PFA technology beyond the pulmonary veins and its potential advantages compared to radiofrequency ablation. However, current evidence suggests that these procedures are both safe and effective.¹⁶

Conclusion

Individual LA substrate modification, including linear lesion sets like AML, can be safely delivered as an add-on to PVI using the novel Varipulse PFA catheter in patients with AF, resulting in effective electrical block.

Lead author biography



Moneeb Khalaph, MD is a specialist in electrophysiology. In 2013, he graduated from the faculty of medicine at Damascus University, Syria. Since April 2019, he is at the Clinic for Electrophysiology at the Herz- und Diabeteszentrum NRW, University Hospital of the Ruhr-Universität Bochum, Bad Oeynhausen, Germany. His clinical research focus in arrhythmia management is arrhythmia ablation.

Consent: The authors confirm that written consent for submission and publication of this case report associated text has been obtained from the patient in line with COPE guidelines.

Conflict of interest. Prof. Sommer and Prof. Sohns are, respectively, Editor in Chief and Assistant Editor of the Journal.

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Data availability

Data will be made available from the authors on reasonable request.

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