



# Pulsed Electric Field versus Cryoballoon to Treat Paroxysmal Atrial Fibrillation (PERFECT-PAF) Randomized Trial: A Periprocedural Clinical and Cost Analysis

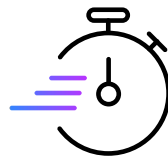
Chierchia, et al. ESC Sept 2, 2024

## OBJECTIVE

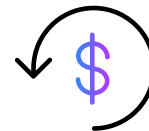
- ▶ The PERFECT-PAF trial was designed to compare the safety, efficacy and procedural costs of FARAPULSE™ Pulsed Field Ablation versus cryoballoon ablation (CBA) for pulmonary vein isolation in paroxysmal atrial fibrillation (PAF) patients.



SAFETY



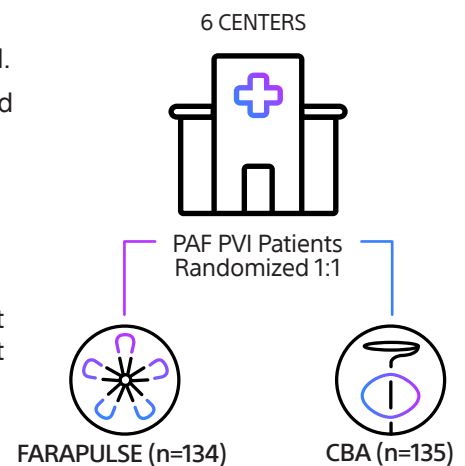
EFFICIENCY



COST

## METHODS

- ▶ The clinical safety and economic value of FARAPULSE versus CBA was assessed in a multicenter, randomized, controlled, non-inferiority trial.
- ▶ Data was collected across 6 European centers between October 2023 and May 2024.
- ▶ The primary safety endpoint included procedure and device related adverse events (AEs) within 7 days post-ablation.
- ▶ Procedural parameters [procedure times, anesthesia, complications] were collected on FARAPULSE (n=134) and CBA (n=135) patients in addition to clinical management and health care utilization data ≤30 post procedure [length of stay, ICU admission, emergency (ED) and outpatient visits, and rehospitalizations].
- ▶ Total costs were calculated based on the cost of the procedure, anesthesia, re-hospitalization, ICU, ED and outpatient visit costs.



## RESULTS

### SAFETY

- ▶ The incidence of adverse events both during the procedure and within a 7-day period was significantly reduced with FARAPULSE, at 0.7%, compared to CBA's 8.1% (p=0.0053), and 0.7% against 5.9% (p=0.036) respectively.



SAFETY

7-day Adverse Event Rate

**0.7%\*** vs **5.9%**  
 FARAPULSE vs CBA  
\*significantly lower p=0.036

	PFA (n=134)	CRYO (n=135)	p-value
Overall periprocedural adverse events, n (%)	1 (0.7%)	11 (8.1%)	0.0053
Major adverse events, n (%)	1 (0.7%)	4 (3.0%)	0.3703
Femoral artery pseudoaneurysm*	1 (0.7%)	1 (0.7%)	1.000
Tamponade requiring drainage	0 (0.0%)	1 (0.7%)	1.000
Persistent phrenic nerve injury	0 (0.0%)	2 (1.5%)	0.4981
7-day adverse event rate, n (%)	1 (0.7%)	8 (5.9%)	0.0360

\*requiring surgery

### PROCEDURAL CHARACTERISTICS

- ▶ FARAPULSE had significantly lower (p<0.001) room time, procedure time, LA dwell time and fluoroscopy times.



EFFICIENCY

	PFA	CBA	Time Savings
Room Time	77 ± 14	97 ± 20	20 min
Procedure Time	53 ± 12	69 ± 18	17 min
LA Dwell Time	28 ± 8	48 ± 15	20 min
Fluoroscopy	12 ± 5	15 ± 6	3 min

Mean ± SD

More predictable\*\*  
 procedures with  
**FARAPULSE**

\*\*Lower standard deviations – F-statistic analysis

### COST PER PATIENT

- ▶ The total costs per patient within 30-days were 13.7% lower with FARAPULSE:
  - ▶ FARAPULSE: 1,997.9€ (95% CI: 1,919.6€-2,076.1€)
  - ▶ CBA: 2,291.1€ (95% CI: 2,163.6€-2,418.6€)
- ▶ The driver of the cost savings with FARAPULSE was the significantly shorter procedure times (p<0.001). Length of hospital stay, ICU, ED usage, outpatient visits, and re-hospitalizations within 30-days of the intervention did not differ between FARAPULSE and CBA.



COST

**13.7%** lower with  
**FARAPULSE**  
 due to  
 lab efficiency

### CONCLUSIONS

- ▶ FARAPULSE had fewer overall peri-procedural and 7-day adverse event rates compared to CBA in PAF patients.
- ▶ FARAPULSE procedure times were shorter and more predictable resulting in an overall lower cost per patient at 30-days due to lab efficiency.
- ▶ Long-term follow-up data will be analyzed to further investigate the potential clinical and economic impact of FARAPULSE vs CBA.

## FARAWAVE™ Pulsed Field Ablation Catheter

**CAUTION:** Federal law (USA) restricts this device to sale by or on the order of a physician. Rx only. Prior to use, please see the complete "Instructions for Use" for more information on Indications, Contraindications, Warnings, Precautions, Adverse Events, and Operator's Instructions.

**INTENDED USE** The FARAPULSE Pulsed Field Ablation (PFA) System is intended for the isolation of the pulmonary veins in the treatment of paroxysmal atrial fibrillation by rendering targeted cardiac tissue electrically non-conductive to prevent cardiac arrhythmia initiation or maintenance.

**INDICATIONS FOR USE** The FARAWAVE Catheter is indicated for the isolation of pulmonary veins in the treatment of drug-refractory, recurrent, symptomatic Paroxysmal Atrial Fibrillation (PAF).

**INTENDED PATIENT POPULATION** The FARAPULSE PFA System is intended for adult patients who are age 18 or older who have drug-refractory, recurrent, symptomatic PAF.

**CONTRAINDICATIONS** The FARAWAVE Catheter is contraindicated for use in: patients with active systemic infection; in patients with a mechanical prosthetic heart valve through which the catheter must pass; in patients with conditions where insertion into or manipulation in the cardiac chambers is unsafe as these conditions (e.g., presence of intracardiac thrombus or myxoma, history of recent cardiac surgery with atriotomy, etc.) may increase the risk of systemic embolism or cardiac perforation; in patients with a bleeding disorder, or who are unable to receive heparin or an acceptable alternative to achieve adequate anticoagulation; in patients who have vena cava embolic protection filter devices and/or known femoral thrombus who require catheter insertion from the femoral approach; in patients with a contraindication to an invasive electrophysiology procedure where insertion or manipulation of a catheter in the cardiac chambers is deemed unsafe, such as but not limited to, a recent previous cardiac surgery (e.g., ventriculotomy or atriotomy, Coronary Artery Bypass Graft [CABG], PTCA/PCI/coronary stent procedure/unstable angina) and/or in patients with congenital heart disease where the underlying abnormality increases the risk of the ablation (e.g. severe rotational anomalies of the heart or great vessels); via transseptal approach in patients with an intra-atrial baffle or a foramen ovale patch.

**WARNINGS** If the visibility of the EP catheter is compromised for any reason, the user should stop and not resume ablation therapy until catheter visibility is established in order to prevent patient injuries such as perforation, heart block and injury to adjacent structures. Cardiac mapping and ablation procedures should be performed only by physicians thoroughly trained in invasive cardiology, in the techniques of mapping and ablation, and in the specific approach to be used, in a fully-equipped electrophysiology lab. Device specific physician in-service training is made available by the manufacturer. Administer appropriate levels of peri-procedural anticoagulation therapy for patients undergoing left-sided and transseptal cardiac procedures. There is an increased risk of thromboemboli if appropriate anticoagulation levels are not maintained while the transseptal sheath and/or catheter is in the left side of the heart. Administer anticoagulation therapy during and post procedure according to the institution's standards to minimize bleeding and thrombotic complications. Carefully read all equipment and ancillary device instructions required for the procedure prior to use. Observe all contraindications, warnings, and precautions noted in these instructions. Failure to do so may result in patient complications. Do not use the device if past the "Use By" date on the device package. Do not use if sterile barrier is damaged or unintentionally opened before use, as use of non-sterile devices may result in patient injury. Before using, inspect the FARAWAVE Catheter for any defects or physical damage, including electrical insulation on the cables and the catheter shaft that, if used, may cause patient and/or user injury. Do not use defective or damaged devices. Replace damaged equipment if necessary. No modification of this equipment is allowed. Electromagnetic Interference (EMI) from any source during normal operation may adversely affect the visualization and tracking of the catheter during the procedure, which can cause patient injuries such as perforation, heart block and injury to adjacent structures. Use of the FARAWAVE Catheter with generators other than a compatible BSC PFA Generator can lead to unexpected energy delivery resulting in either insufficient ablation treatment or over-delivery of energy leading to possible patient hazardous events such as thrombus formation, tissue damage, etc. Patients undergoing ablation are at risk for complete AV block which requires the implantation of a temporary and/or permanent pacemaker. When the catheter is in the patient, neither the patient nor the catheter connector should be allowed to come in contact with grounded metal surfaces to minimize the potential for electrical shock. Ensure that the cable/catheter connection remains dry throughout the procedure in order to prevent electric shock or other patient injuries as well as to prevent loss of device function. Fibrin may accumulate in or on the sheath/catheter assembly during the procedure. Aspirate when removing the catheter. In the presence of anticoagulation, there may be an increased risk of bleeding from all causes. Electrical recording or stimulation equipment must be isolated. Current leakage from any electrical equipment that is connected to the patient must not exceed 10 microamps for intracardiac electrodes. Care must be taken to ensure that any equipment used in connection with the FARAWAVE Catheter be type CF, be defibrillation proof, meet IEC 60601-1 electrical safety requirements, and comply with all local regulatory requirements for specified intended use to reduce the potential risk of inadvertent electrical shock. Do not directly touch the patient when ablation energy is being delivered to prevent the risk of electric shock. Stimulation of cardiac tissues caused by pacing stimulus and/or ablation energy may lead to inadvertent induction of arrhythmias. These arrhythmias may require defibrillation that could also result in skin burns. Warnings for patients with implantable pacemakers (PPMs) and Implantable Cardioverter Defibrillators (ICDs): PPMs, ICDs, and leads can be adversely affected by ablation energy. It is important to refer to the device manufacturer's instruction for use prior to performing ablation procedures. Do not apply ablation energy directly to a lead or to tissue immediately in contact with a lead because it could potentially damage the lead or lead function. Temporarily reprogram the pacemaker or defibrillator per the manufacturer guidelines during ablation. The device could be damaged by the ablation procedure. Interrogate the device fully after the ablation per the manufacturer guidelines and reprogram to preoperative sensing and pacing parameters. Program the ICD Tachy therapy to "Off" to prevent inappropriate shock and/or possible damage to the device from the ablation procedure. Remember to turn Tachy Therapy to "On" once ablation is complete. Have temporary external sources of pacing and defibrillation available. Perform a complete analysis of the implanted device function after ablation. Fluoroscopic or appropriate imaging guidance and care must be taken during catheter advancement, manipulation, and withdrawal to avoid lead dislodgement. Monitor pre- and post- measurements for sensing and pacing thresholds and impedances to determine the integrity of the lead-patient function. Ablation in contact with any other electrodes alters the function of the catheter and can lead to embolism. At no time should a FARAWAVE Catheter be advanced, withdrawn, rotated, deployed or undeployed when resistance is felt, without determining the cause. Valve damage, vascular and/or cardiac perforation is a risk with any intracardiac catheter. Catheter entrapment within the heart or blood vessels is a possible complication of cardiac ablation procedures. The potential for catheter entrapment may be increased when the catheter is over torqued and/or positioned in the chordae tendinae. The occurrence of this complication may necessitate surgical intervention and/or repair of injured tissue and/or valve damage. Do not use the FARAWAVE Catheter in the proximity of Magnetic Resonance Imaging (MRI) equipment because the MRI equipment may adversely impact the function of a PFA Generator and the ablation system may adversely impact the image quality. This can also lead to loss of visibility during ablation which can cause patient injuries such as perforation, heart block and injury to adjacent structures. Catheter ablation procedures present the potential for significant radiation exposure, which can result in acute radiation injury as well as an increased risk for somatic and genetic effects, to both patients and laboratory staff due to the radiation beam intensity and duration of the fluoroscopic imaging. Catheter ablation should only be performed after adequate attention has been given to the potential radiation exposure associated with the procedure, and steps have been taken to minimize this exposure. Due to radiation exposure during catheter ablation, the safety and effectiveness of this device has not yet been established in pregnant and/or nursing women and pediatric patients. There are no data to support the safety and effectiveness of this device in the pediatric population. Prior to the procedure, always identify the patient's risk of volume overload. Monitor the patient's fluid balance throughout the procedure and after the procedure to avoid fluid volume overload. Some patients may have factors that reduce their ability to handle the volume overload, making them susceptible to developing pulmonary edema or heart failure during or after the procedure. Patients with congestive heart failure or renal insufficiency, and the elderly are particularly susceptible. Always maintain a constant heparinized normal saline infusion to prevent coagulation within the lumen of the catheter that may result in embolism. Excessive curves or kinking of the catheter may damage internal wires and components, including the flush lumen. This damage may affect mechanical and electrical performance leading to patient injury. Do not attempt to bend, kink, or shape the patient-contact portions or flush lumen of the FARAWAVE Catheter. Doing so could cause electrical or mechanical catheter failure resulting in patient injury. Kinking of the flush lumen may compromise flow through the device leading to potential thrombus formation and embolism. Use both fluoroscopy, or other visualization techniques such as echocardiography, and electrograms to monitor the advancement of the catheter to the area of the endocardium under investigation to avoid conduction pathway injury, cardiac perforation or tamponade. The FARAWAVE Catheter tip and guidewire move forward during device undeployment. Device deployment and undeployment should be visualized using fluoroscopy. Failure to do so may result in catheter damage and/or patient injury. Do not deliver ablation energy with the catheter outside the target site. Ablation Generators can deliver significant electrical energy and may cause patient injury such as arrhythmia and heart block. Always verify that the tubing set, catheter, sheath and all connections have been properly cleared of air prior to inserting the catheter into the vasculature. Air entrapped in the tubing, catheter or sheath can cause potential injury or cardiac arrest. The operator is responsible for removing all air from the system. Patients undergoing left-sided ablation procedures should be closely monitored during and post procedure for clinical manifestations of infarction, pulmonary vein injury, nerve damage, and/or embolism. Patients undergoing an ablation procedure have the potential for greater anticoagulation and therefore Activated Coagulation Time (ACT) should be monitored closely due to the increased risk for bleeding/ hemorrhage and/or embolism. Patients with hemodynamic instability or cardiogenic shock are at increased risk for life-threatening adverse events and ablation must be done with extreme caution. The FARAWAVE Catheter is not intended to be used for internal cardioversion. Doing so may result in perforation, arrhythmias, embolism, thrombus and/or patient death. Inspect irrigation saline for air bubbles and remove any air bubbles prior to its use in the procedure. Air bubbles in the irrigation saline may cause embolism. If there is uncertainty regarding the patient's anticoagulation status or rhythm prior to the procedure, there should be a low threshold to perform a Transesophageal Echocardiogram (TEE) prior to the procedure to confirm absence of mural thrombus and/or thrombus in the left atrial appendage. Guiding catheters and/or long introducer sheaths present the potential for thromboembolic events. Pre-flush and maintain lumen patency with heparinized intravenous infusion. Do not wipe this catheter with organic solvents such as alcohol or immerse the handle and/or cable connector in fluids. This may result in electrical or mechanical catheter failures. It may also result in an allergic reaction from the patient. Pre-procedural anticoagulation therapy is at the discretion of the physician. However, patients with a history of thromboembolic events may require therapeutic anticoagulation therapy, pre-, during and post-ablation to reduce the incidence of major complications. Peri-procedural anticoagulation therapy is not recommended for patients undergoing left-sided and transseptal cardiac procedures and should be considered for selected patients undergoing right-sided procedures. The safety and/or efficacy of epicardial use of the FARAWAVE Catheter has not been evaluated in a clinical trial. Care should be used during multiple sheath/catheter exchanges through the transseptal puncture to avoid causing a residual atrial septal defect that would require repair. Do not leave the FARAWAVE Catheter in the patient for more than four (4) hours. Failure to remove the device before four hours after first insertion could result in formation of thrombus with attendant stroke risks. Use of the FARAWAVE Catheter with delivery devices other than the FARADRIIVE Sheath can result in poor access to endocardial locations, inefficient ablation delivery and inadequate procedural outcomes. Cardiac ablation has the potential of causing unintended myocardial injury. Clinical indications of myocardial ischemia should be closely monitored during the procedure (e.g., ECG changes). The FARAWAVE Catheter has not been studied clinically in the mitral isthmus or cavotricuspid isthmus areas. Ablations in areas adjacent to coronary arteries may lead to coronary artery spasm and/or injury, and the resulting myocardial injury can be fatal. Ensure that the guidewire is properly inserted into the catheter for adequate support during use. Do not attempt to deploy or un-deploy the FARAWAVE Catheter without a guidewire fully inserted, at or past the FARAWAVE Catheter tip. Failure to do so may result in catheter damage and/or patient injury. When positioning on cardiac structures, the guidewire should be retracted to prevent cardiac perforation or tissue damage. Ensure the tip of the device is not against tissue prior to advancing or retracting the guidewire to prevent cardiac perforation or tissue damage. The risk of igniting flammable gases or other materials is potential outcome of ablation procedures. Precautions must be taken to restrict flammable materials from the electrosurgical suite. Take care when manipulating the guidewire to prevent cardiac or vessel trauma. To avoid cardiac damage, do not use excessive force when manipulating the catheter in vivo. Specifically, use caution when maneuvering while undeployed. Note that mapping and recording data do not require the use of force on the tissue. Minimize catheter exchanges and always advance and withdraw components through the valve slowly to minimize the vacuum created during withdrawal and to reduce the risk of air embolism. Follow advancement or withdrawal of catheters with appropriate aspiration and flushing according to institutional standards or consensus statements. Instruct users with co-implanted devices to refer to ancillary device labeling as well as the manufacturer of the ancillary device for recommended compatibility and settings. Use caution when advancing, retracting or otherwise manipulating system components to avoid damaging tissue or vessels or interfering with previously implanted medical devices. When advancing or undeploying the FARAWAVE catheter, do not retract the guidewire simultaneously. If resistance is felt during retraction of the guidewire, do not continue to retract the guidewire until cause of resistance is determined as this may result in cardiac trauma. If resistance is felt, it may be necessary to advance guidewire under imaging guidance before continuing to retract. Ensure that the guidewire is not contacting ablation electrodes prior to starting ablation to prevent inappropriate energy delivery. Always un-deploy the catheter and withdraw the catheter into the sheath before removing the catheter from the Left Atrium (LA). Deploying the catheter in the septal puncture site or crossing the septum while the catheter is unsheathed or deployed may cause serious atrial septal defects or other cardiac and vessel trauma. Use visualization (such as fluoroscopy) to verify undeployment. Avoid deploying the catheter in constrained parts of the anatomy to prevent cardiac trauma or damage to the device. Prior to starting ablation verify that the catheter has been positioned and deployed correctly to prevent inappropriate application of ablation energy. Do not deploy the catheter while the distal end is inside the sheath as it could lead to catheter damage which may result in patient harm. PV potentials recorded from the electrodes on the FARAWAVE Catheter will likely show a significant reduction in amplitude after the first application of PFA. This should not be used as an indication that no further ablation is necessary. The nominal dose of PFA should be delivered in accordance to the parameters listed in the Operational Instructions section, regardless of absence of PV signal. Potential biohazard after use. Handle and dispose of in accordance with applicable regulations.

**PRECAUTIONS** Do not attempt to use with devices, including guidewires, larger than the delivery lumen diameter specified on the package label. Care must be taken to ensure all luer fittings are secure to prevent leaking. It is essential that a cardiac defibrillator with paddles connected is readily available in the procedure room for use if Ventricular Fibrillation is noted subsequent to ablation. There is limited data to support the safety and effectiveness of this device in patients older than 75 years. Catheter deployment and undeployment should occur under imaging guidance. Catheter may be fully deployed or undeployed even though the slider switch is not fully engaged. Failure to monitor deployment may result in catheter damage and need for catheter exchange. Device deployment friction is increased when attempting to deploy the device when the catheter shaft is bent. FARAWAVE Catheter deployment should always occur with the catheter shaft as straight as possible. Do not apply excessive force to the deployment mechanism when deploying the catheter as doing so may damage the catheter. Avoid allowing the distal end of the catheter to be put into an acute bend, particularly when advancing the catheter beyond the sheath or deploying the catheter. A catheter exchange may be necessary if the catheter deploys improperly.

**ADVERSE EVENTS** Potential adverse events associated with use of the FARAWAVE Catheter includes, but are not limited to: • Pain or discomfort, for example: Angina, Chest pain, Non-cardiovascular pain, • Cardiac arrest, • Death, • Electric shock, • Hypotension, • Infection/inflammation/exposure to biohazardous material, • Edema/heart failure/pleural effusion, • Renal failure/insufficiency, • Respiratory distress/insufficiency/dyspnea • Arrhythmia (new or exacerbated), Conduction pathway injury (heart block, nodal injury, etc.), • Nerve injury, for example: Phrenic nerve injury, Vagal nerve injury, • Gastrointestinal disorders, • Vessel trauma, including: Perforation, Dissection, Coronary artery injury, Vasospasm, Occlusion, Hemothorax, • Cardiac trauma, for example: Cardiac perforation/cardiac tamponade/pericardial effusion, Valvular damage, Stiff left atrial syndrome, • Injury related to tissue damage and/or adjacent structures, for example: Esophageal injury, Pulmonary injury, Catheter entrapment, Physical trauma, • Fistula, for example: Atrio-esophageal fistula, Bronchopericardial fistula, • PV stenosis and its symptoms, for example: Cough, Shortness of breath, fatigue, Hemoptysis, • Surgical and access complications, for example: Hematoma/seroma, AV fistula, Bleeding, Pseudoaneurysm, Pneumothorax, Residual atrial septal defect, • Thrombus/thrombosis, • Muscle spasm, • Injury due to embolism/thromboembolism/air embolism/foreign body embolism, Cerebrovascular Accident (CVA)/stroke, Transient Ischemic Attack (TIA), Myocardial infarction, Neurological impairment and its symptoms, for example: Cognitive changes, visual disturbances, headache, motor impairment, sensory impairment, and speech impairment, Pulmonary embolism, Asymptomatic cerebral embolism, • Hemolysis, • Procedural related side effects, for example: Allergic reaction (including anaphylaxis), Genitourinary complication, Side effects related to medication or anesthesia, Radiation injury/tissue burn, Vasovagal response, Fluid volume overload. The potential adverse events may be related to the ablation catheter(s) and/or the interventional procedure. The severity and/or the frequency of these potential adverse events may vary and may result in prolonged procedure time and/or additional medical and/or surgical intervention, implantation of a permanent device such as a pacemaker, and in rare cases, may result in death. 97173260 (Rev. A)

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