

# Techniques for Left Common Pulmonary Vein Isolation using PVAC: Insights from Two Cases of Left Common Ostia

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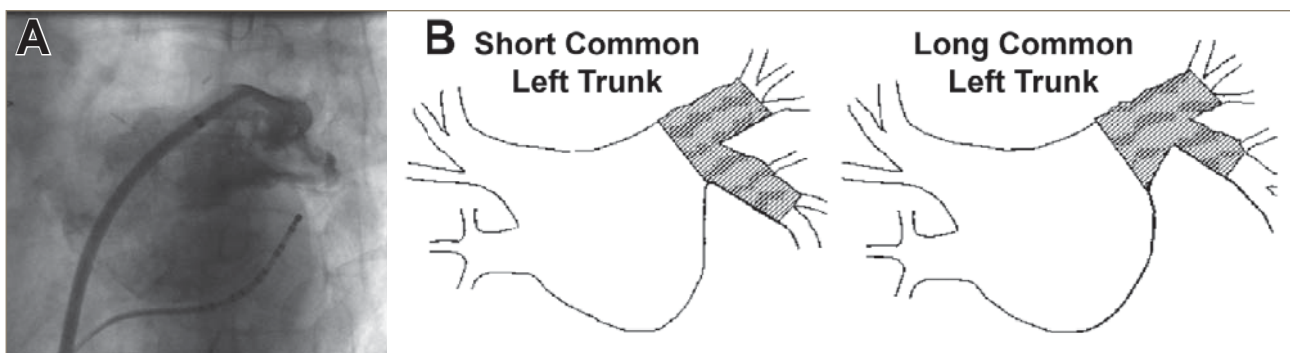
## INTRODUCTION

Atrial fibrillation (AF) is a widespread and clinically serious cardiac arrhythmia, associated with potentially debilitating symptoms and an increased risk of stroke<sup>1,2</sup>. Modern advancements in the understanding of the mechanisms of AF have revealed the role of the pulmonary veins (PV) as a frequent focal origin of arrhythmic activity<sup>3,4</sup>. Techniques for electrically disconnecting the pulmonary veins with ablation lesions have been proposed, but the procedure often proves to be difficult and time-consuming. Recent technological developments in both ablation catheters and alternative energy sources have facilitated the procedural challenges of electrically isolating the PVs and may help more centers perform PV isolation, thereby reducing the symptomatic burden.

A novel radio frequency (RF) ablation system which is designed to simplify and shorten the procedure for PV isolation, has recently been introduced. The system consists of a decapolar, helical, over-the-wire catheter (Pulmonary Vein Ablation Catheter, PVACT™, Ablation Frontiers, Carlsbad, CA, USA) and a multi-channel radio frequency (RF) generator (GENius™, Ablation Frontiers,

Carlsbad, CA, USA)<sup>5,6,7,8,9</sup>. This system allows the operator to deliver pre-defined ratios of bipolar and unipolar RF energy to any or all electrodes on the catheter array simultaneously. *In silico*, *in vitro*, and *in vivo* data have shown that lesion depth is inversely proportional to the proportion of bipolar energy (data presented at Boston Atrial Fibrillation Symposium 2008). The system allows the creation of an 80mm long contiguous lesion with a single 60 second application of RF; depths are controlled by the ratio of bipolar:unipolar energy, varying 3 mm to 7 mm. Because the electrodes are smaller than that of a typical 4mm tip ablation catheter, lesions can be created in a highly efficient manner, with less than 10W of power per electrode.

Atypical left atrial anatomies pose a challenge to ablation therapy, with common ostia of the left PV being reported as a highly frequent variant<sup>10,11</sup>. A common left ostium, or common trunk, has a junction between the lower wall of the left superior PV and upper wall of the left inferior PV that lies outside the rim of the left atrium. This report describes two consecutive patients with common left pulmonary trunks and the techniques utilized with the PVAC to create the desired lesion set for PV isolation.



**Figure 1:** (A) The left common PV trunk as viewed from an LAO 45 projection with vein outlined for clarity (right), (B) common anatomical variations (Kato, et. al. Circ 2003).

## CASE ONE

### PRE-PROCEDURE

A 54-year-old male with a five-year history of paroxysmal AF (PAF) was referred for ablation. Three years prior, he had undergone an epicardial microwave ablation via thoracoscopy to create a “box” lesion set around the PVs. After an initial six months of relief, symptomatic PAF returned, with six months of subsequent monitoring demonstrating an increase in frequency of episodes and symptom severity. The patient elected to undergo another ablation procedure, which was performed using a 4mm, irrigated-tip catheter (Therapy™ Cool Path™, St. Jude Medical, Irvine, CA, USA) used in conjunction with a 3-D Mapping System (NavX™, St. Jude Medical, St. Paul, MN, USA). Six months post-procedure, the patient’s AF returned and he experienced increasingly severe episodes of PAF. He was referred to our clinic for an ablation, which was undertaken with the PVAC and GENius generator.

### METHODS

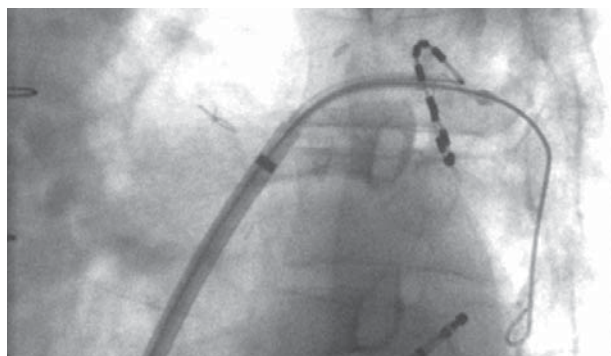
The patient was administered local anaesthesia and a 6F decapolar diagnostic catheter (Dynamic XT™, Bard, Lowell, MA, USA) was situated in the patient’s coronary sinus for pacing purposes by way of a fixed curve sheath inserted in the right femoral vein.

A 9.8F steerable transseptal sheath (Channel™, Bard, Lowell, MA, USA) was also introduced via the right femoral vein and maneuvered across the fossa ovalis into the left atrium via standard transseptal puncture. 5000U of unfractionated heparin was administered via the steerable sheath and a 60-minute timer was started to indicate when an activated clotting time (ACT) measurement would be performed. PV angiography with the steerable sheath revealed four enlarged vessels (diameter greater than 15mm) and a long left common PV trunk (Figure 1).



**Figure 2:** The PVAC catheter situated in the ceiling of the trunk. Positioning the guidewire in an inferior branch allowed for variations in electrode-tissue contact. This facilitated lesion creation around anterior and superior portions of the vein.

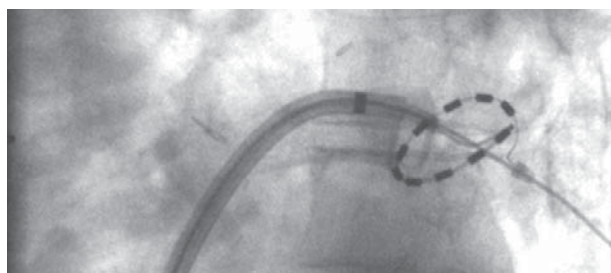
After angiography, a 0.032” guidewire was inserted into the PVAC and the catheter was advanced into the steerable sheath. With the guidewire inserted approximately 3 cm into the left superior PV (LSPV), the distal array of the PVAC was deployed into the left atrium. By using steering mechanisms available on both the PVAC



**Figure 3:** By “unwinding” the catheter slightly, the proximal electrodes were brought into position for RF application along the posterior wall of the vein.

and steerable sheath, the electrode array was nestled against the anterior aspect, or “ceiling”, of the common trunk (Figure 2). Energy was applied only to the anterior electrode pairs in contact with atrial tissue, while the posterior electrodes were inactive in the superior aspect. Energy was delivered in 60 second applications with a 4:1 ratio of bipolar:unipolar energy. This setting represents 80% bipolar and 20% unipolar RF energy, with a lesion depth in the range of 4mm. The catheter was rotated slightly to gain a new position and RF applied until local PV potentials were eliminated. The guidewire was then repositioned into a more inferior branch to allow variations of electrode apposition against the anterior and superior walls.

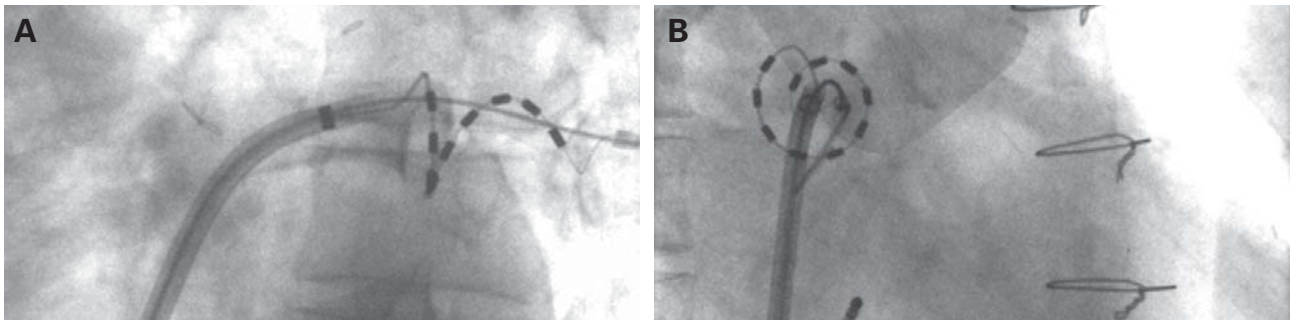
In order to facilitate contact of electrodes to the posterior wall of the superior portion of the trunk, the catheter slide was moved forward slightly to unwind the spiral array. With the spiral extended, the slight change in the



**Figure 4:** PVAC in the floor of the common ostium. The guidewire was placed in a sub-branch to position the distal array inferiorly, the shaft was advanced to engage proximal poles against the antrum; RF was not applied to the distal electrodes.

plane of the distal and proximal electrodes allowed the array to make good contact with the posterior wall. In this configuration, the proximal poles were activated for lesion formation (Figure 3), but the distal two pairs of electrodes were deactivated, as they were considered too deep in the vein for RF application.

After completion of the “roof” portion of the common ostium, lesions were created in the inferior aspect, or



**Figure 5:** (A) By extending the slide slightly and applying clockwise torque the PVAC was “unwound” into the vein. (B) RAO shows the proximal electrodes in contact with the postero-inferior segments of the vein.

“floor”, utilizing two maneuvers. First, the guidewire was repositioned into an inferior sub-branch of the inferior vessel, which deflected the catheter in an anterior direction (Figure 4). The catheter was advanced into the sheath so that the inferior portion of the array butressed against the tissue, and the superior portion prolapsed into the common vestibule. RF was applied to the lower portion of the array only. Small variations in this position were achieved with catheter rotation until local potentials were eliminated.

Next the catheter slide was advanced and clockwise torque was applied, thus extending the spiral approximately 1-2 cm distally into the vein (Figure 5). In this

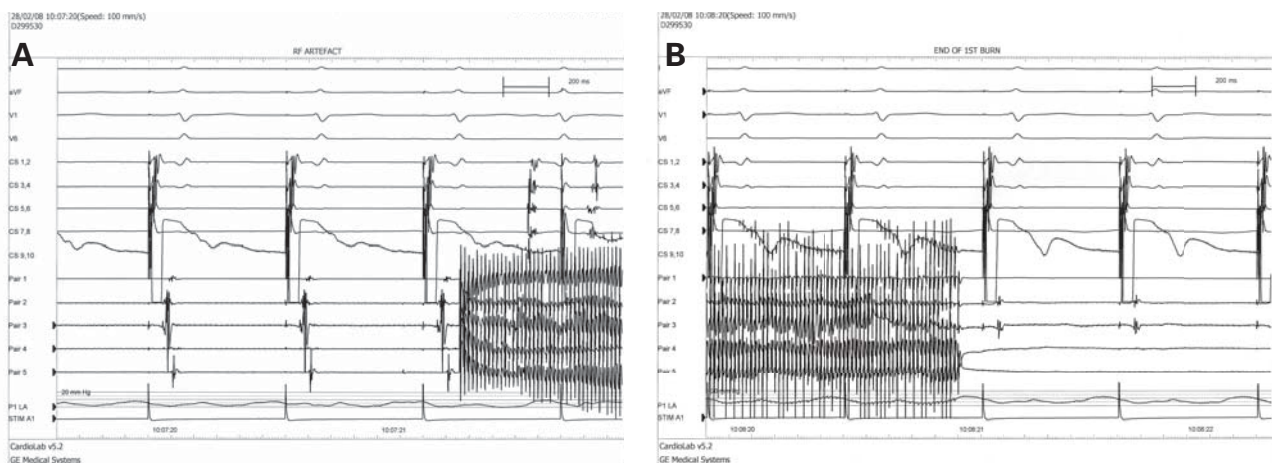
position, the proximal poles remain in the ostium while the distal poles are prolapsed into the vein. RF is delivered selectively using the proximal & inferior poles, in order to avoid delivering RF into the PV.

The electrogram obtained after the first lesion (Figure 6A) shows a sharp late pulmonary vein potential (PVP) on pairs 2, 3, and 5 during pacing from the proximal coronary sinus (CS). At the end of one 60-second burn,

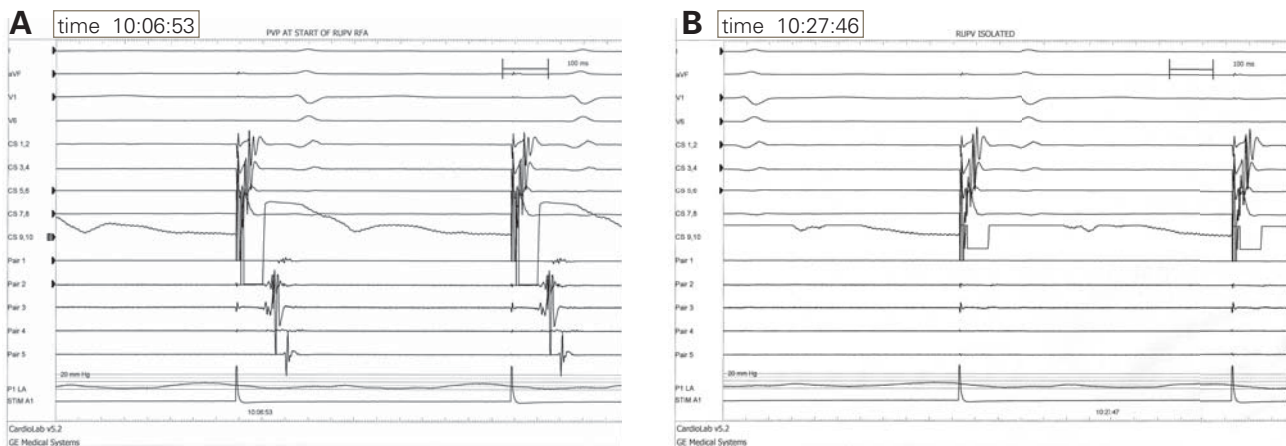
the recording showed a significant reduction in PVP amplitude (Figure 6B).

By changing guidewire position, adjusting the steering knob, and “unwinding” the catheter at various depths into the vein, it was possible to obtain multiple positions with different electrode-tissue contact on the proximal poles. When PV potentials were observed at the proximal array, RF was applied, and the distal electrodes were not activated.

When local signals could no longer be identified at the antral-ostial boundary, the catheter slide was advanced so that the distal poles were positioned farther into the



**Figure 6:** (A) Electrogram at first RF application. Ectopy and AF is induced following application of RF seen on CS. Artifact on the PVAC channels is due to RF duty-cycle. (B) After 60 seconds of RF, PV potentials are significantly diminished.



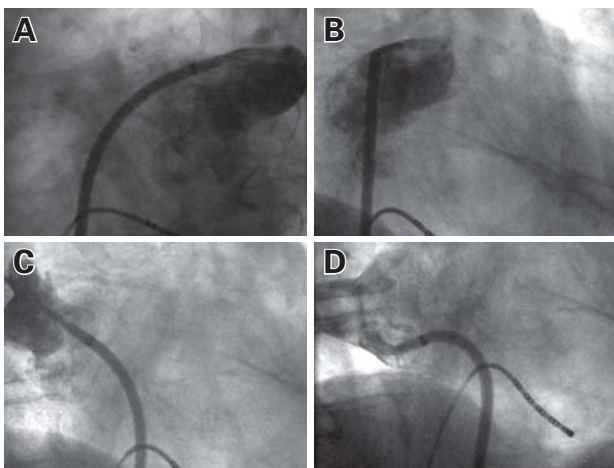
**Figure 7:** (A) Mapping of RSPV prior to ablation, and (B) following RF applications.

vein. Pacing from proximal CS and distal PVAC electrodes can demonstrate confirmation of bi-directional block. This pacing maneuver was repeated for the superior branch of the common vein.

Lesions were applied to the right PVs and isolation confirmed in a similar fashion. Note that the patient had remarkable PVP in all veins despite prior ablation. Recordings taken pre- and post-ablation of the RSPV demonstrate the reduction in PVP using this technique (Figure 7).

## RESULTS

Total RF duration was 24.8 minutes delivered in 27 discrete applications with an average number of  $8.1 \pm 2.3$  electrodes activated. Total procedure time was 55 minutes with a fluoroscopy time of 15 minutes. After the final RF application, fifteen seconds of 200ms stimulation from proximal CS failed to induce an atrial tachyarrhythmia.



**Figure 8:** PV angiography demonstrated a left common ostium (A) & (B). RAO projections also show enlarged right superior (C) and right inferior pulmonary veins (D).

At 3 months follow up, patient had discontinued AAD therapy and was free of AF, demonstrated by 5-day Holter monitor.

## CASE PRESENTATION TWO

### PRE-PROCEDURE

A 74-year-old male with a history of hospitalizations for AF symptoms due to ineffective treatment with  $\beta$ -blocker and  $Ca^{++}$  channel blockade. Class Ic antiarrhythmic agents were contraindicated due to prior myocardial infarction (MI). The referring cardiologist suggested ablation therapy be attempted before prescribing long-term amiodarone. The patient was referred to our center, but 10 days prior to his scheduled procedure he was admitted to emergency care for AF-related symptoms.

### METHODS

We employed the same imaging and ablation strategy described in the previous case. PV angiography confirmed large right-sided veins and a common left trunk, similar to that in the first case (Figure 8). The patient's initial electrophysiology study (EPS) confirmed persistent AF (Figure 9). The left trunk was tackled using the combination of "unwinding" the catheter and sub-selecting different PV branches with the guidewire (Figure 13).

As pulmonary vein isolation progressed, AF appeared to organize, resembling a typical right-sided cavotricuspid isthmus dependent flutter (Figure 11). After the left trunk was isolated, with disconnection confirmed in the same manner as described in the previous case, the right superior pulmonary vein (RSPV) was targeted. The large ostium required the same type of catheter manipulation to achieve isolation (Figure 10).

Coronary sinus activation appeared typical of a right atrial focus. However, with PVAC placed in the right veins an early activation was observed on pairs 2 and 3, suggesting a focal origin (Figure 12A). As the vein was progressively ablated, tachycardia cycle length increased and sinus rhythm was achieved during RF application (Figure 12B).

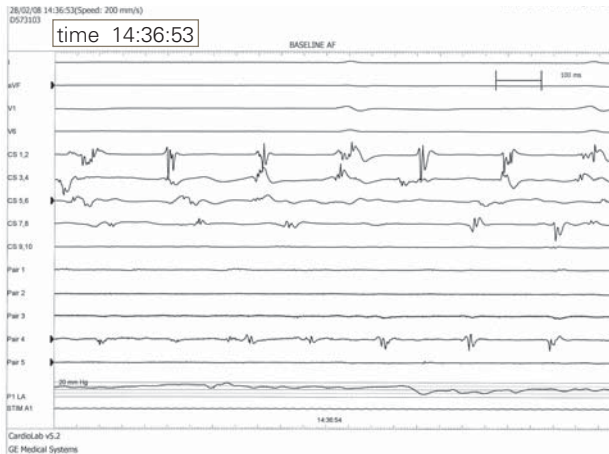


Figure 9: AF evident at procedure start (14:36).

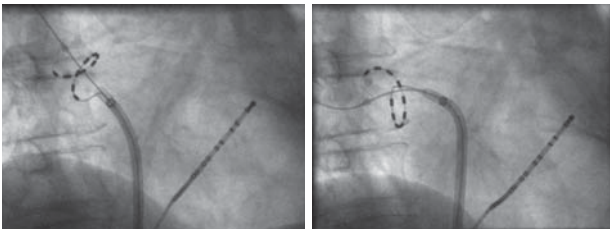


Figure 10: The techniques of “unwinding” and deploying the wire into different branches were also applied to the RSPV.

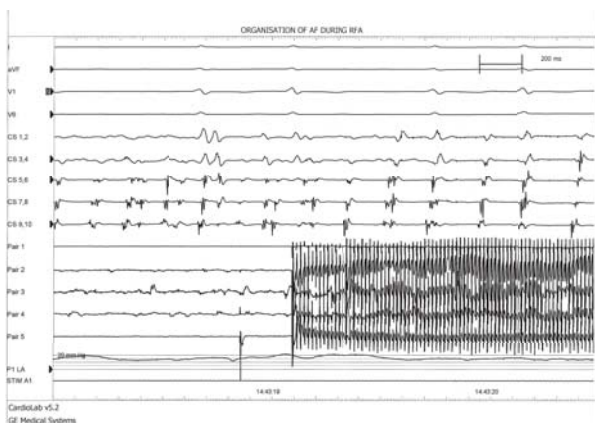


Figure 11: AF activation became more organized as lesions were created (14:43).

## RESULTS

35 RF applications were delivered, totaling 33.7 minutes with an average of  $8.6 \pm 1.9$  electrodes activated per application. Total procedure time was 62 minutes with a fluoroscopy time of 18 minutes. After all RF applications were delivered, bi-directional block was confirmed in all three ostia. 15 seconds of CS stimulation at 200 ms could not induce an atrial tachyarrhythmia.

At 3 months clinical follow-up, the patient was free of AF symptoms and reported significant quality of life improvement.

## DISCUSSION

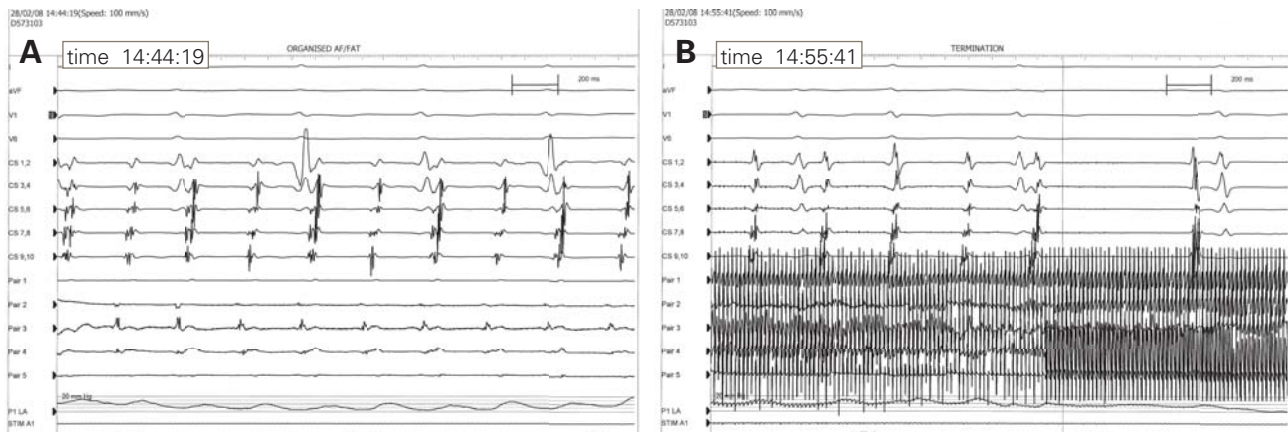
Electrical isolation for AF is a promising procedure but time-efficient, repeatable techniques have proven elusive. Human variations in anatomy and vasculature have contributed to the challenge and these two cases serve as an example of the more common challenges.

For these cases, we defined successful PVI as bi-directional block across the ostia of the veins defined by pacing and sensing alternatively from the PVAC and CS catheter. We also challenged isolation with CS burst pacing to verify non-inducibility.

The use of the PVAC / GENius system allowed for time-efficient PVI. The PVAC's unique handling properties enabled specific maneuvers and the GENius interface allowed activation of only the user-defined electrodes for optimal lesion sets. Also, the catheter was used to pace and sense on either side of block to allow for confirmation of disconnection. This approach may be unfamiliar to operators accustomed to the traditional tip catheter, but these maneuvers are straightforward. Utilizing these techniques, both procedures were each successfully completed within 60 minutes of transseptal puncture, and without the need for 3D imaging or robotic-assisted steering.

## CONCLUSIONS

This innovative new ablation catheter and duty cycled RF generator are effective at pulmonary vein isolation, even in cases of common pulmonary vein trunks.



**Figure 12:** (A) Post-RFA organization suggests a right atrial flutter, but early activation is observed on PVAC 2 & 3 (14:44). (B) Atrial tachyarrhythmia slows and sinus rhythm (SR) is achieved during RF application (14:55).



**Figure 13:** Step-wise fluoroscopic images show the catheter placed in LSPV, then “unwound”, and then the wire inserted into a different branch. Repeating these maneuvers allowed circumferential position around the ostium of the common vestibule.

Furthermore, the successful ablation procedures could be performed in a short period of time (<60 min) and without the use of imaging or mapping technologies. The off-center design and construction of the ablation catheter actually make it particularly well suited for such challenging ablation procedures, although admittedly physicians unfamiliar with this particular device may experience a short learning curve to get used to it.

These are two consecutive case studies submitted from our hospital, a teaching center in the North of England that routinely treats AF patients and regularly performs catheter ablations. We recognize that this paper has two serious limitations, the first of which is scope (we present just two case studies) and the second is a lack of long-term data. Since both procedures were performed only recently, no long-term data is yet available. While acute results appear quite favorable, further study is warranted to determine long-term safety and efficacy of this innovative technology.

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