

Intermittent unidirectional exit conduction from the right superior pulmonary vein to the left atrium after atrial fibrillation ablation: case report

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Statement of consent

The patient provided written informed consent to the ablation procedure, data retrieval, analysis and for publication according to COPE guidelines.

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Introduction

The goal of pulmonary vein isolation (PVI) is to prevent pulmonary vein (PV) triggers from activating the left atrium (LA) by achieving a permanent PV-to-LA exit block. Demonstration of LA-to-PV entrance block is usually deemed sufficient, as unidirectional blocks are scarce. Still, the most accurate endpoint of the PVI is verifying both the entrance and exit blocks.

Case presentation

We report a 48 years old male patient who underwent his initial PVI for symptomatic, lone paroxysmal atrial fibrillation (AF). At the end of that procedure, the bidirectional conduction block was confirmed in all four PVs. After that, the patient presented with ~2% of symptomatic premature atrial contractions (PAC). As there was no AF recurrence, a repeat procedure was not planned for many years. Finally, due to the persistence of the unusually intensive symptoms, the patient was admitted to a repeated electrophysiological study.

We planned to assess the PVs first during the repeat procedure, considering the previous PVI. A decapolar catheter was positioned in the coronary sinus, and after the double transseptal puncture, an Orion diagnostic catheter (INTELLAMAP ORION, Boston Scientific, Marlborough, MA, USA) and StablePoint ablation catheter (INTELLANAV STABLEPOINT, Boston Scientific, Marlborough, MA, USA) were placed in the LA. An electroanatomical map was created using the Rhythmia mapping system (Boston Scientific, Marlborough, MA, USA). Entrance block was confirmed in all four PVs (Fig. 1).

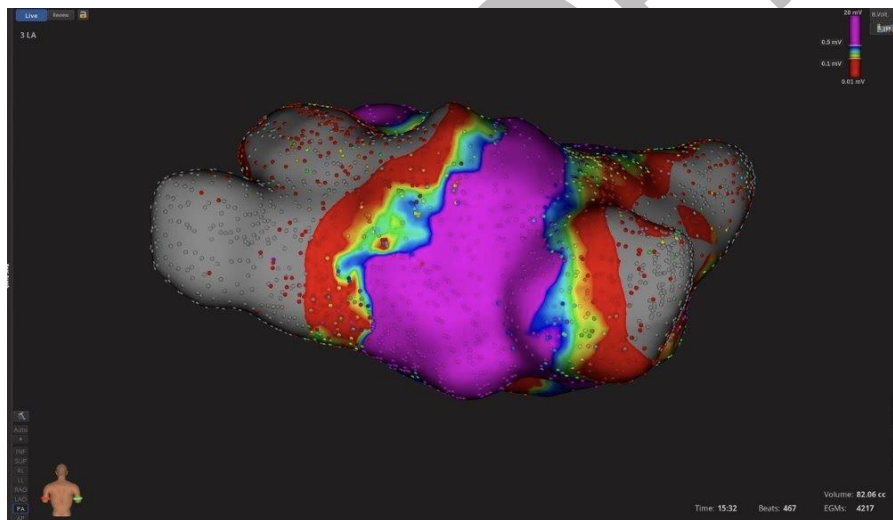


Figure 1: voltage map of the LA, PA view. Abbreviations: LA = left atrium; PA = posteroanterior.

However, a PV automaticity could be observed in the right superior pulmonary vein (RSPV, Fig. 2). The PV ectopy was sometimes conducted to the LA, causing the clinical PACs. The conduction of these ectopies to the LA was random as sometimes ectopies occurring after the atrial refractory period also did not result in PAC (see Fig. 2). Thus, intermittent, unidirectional exit conduction was confirmed from the RSPV.

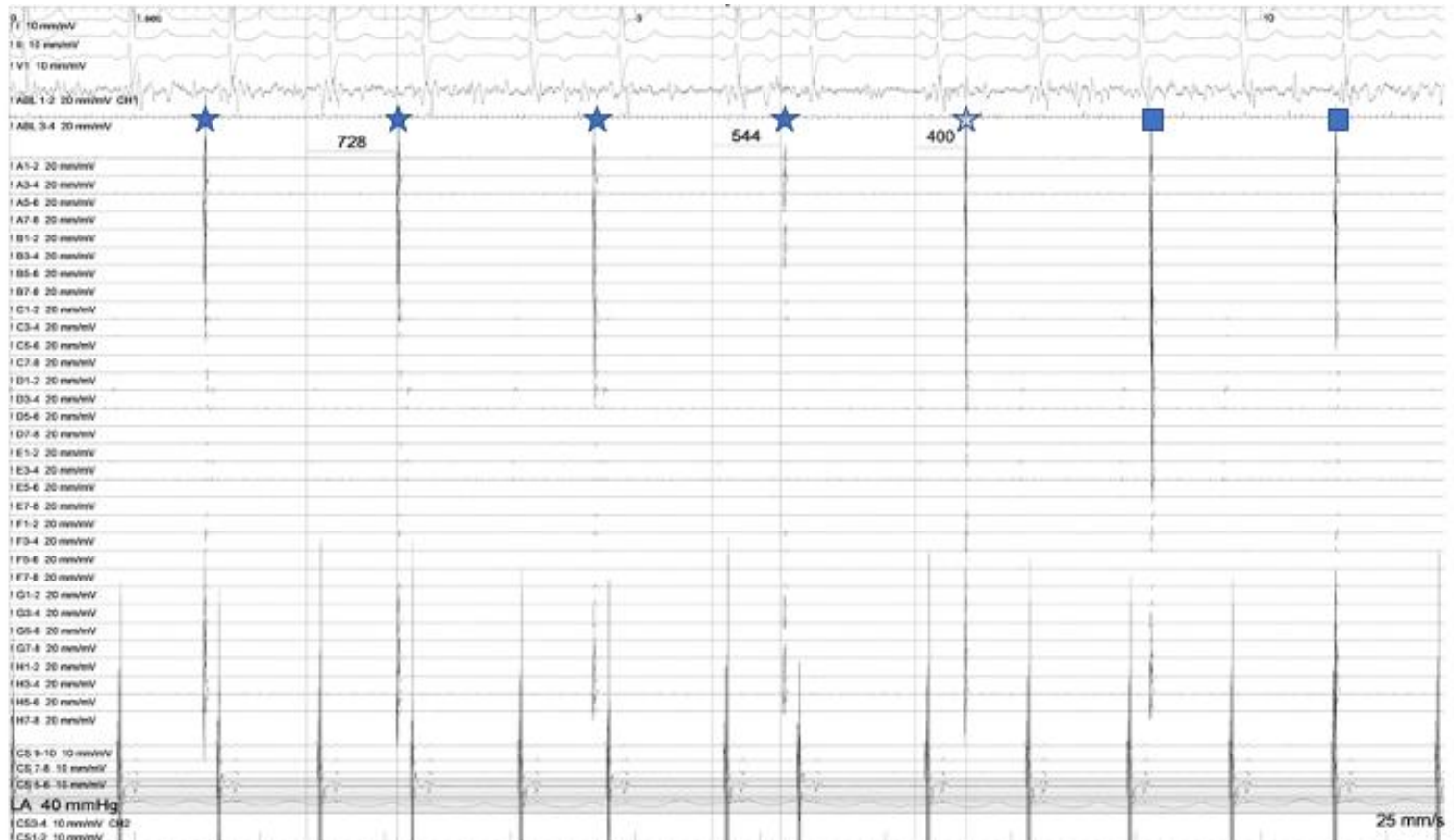


Figure 2: IEGM and surface leads (25 mm/sec registration speed). Spontaneous ectopies occur every 1400 ms in the RSPV, registered by the Orion catheter (IEGMs A1 – H8). The bold stars indicate those PV ectopies that are conducted to the LA, causing the clinical PACs. The P wave morphology is not much different compared to sinus P waves. The empty star indicates a late, non-conducted ectopy, the coupling interval of which is much longer (400 ms) than the atrial ERP of the patient (210 ms). The bold squares indicate those ectopies that are not conducted to the LA as they either occur simultaneously with the sinus beat or fall into the refractory phase of the LA. The abovementioned characteristics are why we concluded that the unidirectional block is intermittent.

Abbreviations: IEGMs = intracardiac electrograms; RSPV = right superior pulmonary vein; PV = pulmonary vein; LA = left atrium; PACs = premature atrial contractions.

We aimed to find the gap location using activation mapping during PACs (Fig. 3). As the PACs originated from the RSPV, the activation sequence on the coronary sinus catheter was similar to sinus beats. To discriminate the PACs, the following settings were applied on the Rhythmia system: coronary sinus distal (CS 1-2) was used as the timing reference defining “time 0” for each beat, a secondary atrial reference was chosen as coronary sinus proximal (CS 9-10) and was used as propagation reference by the system (ΔR). It was established that the coupling between timing and propagation reference was 15ms during a sinus rhythm beat and 9ms once the PAC occurs, enabling the system to validate beat morphology. In this case, ΔR facilitates rejection of sinus beats, ensuring only premature atrial beats of the desired coupling are accepted into the map; hence the acquisition of points occurs only during the clinical PACs.

After ablation at the gap location, the RSPV ectopies became fully dissociated from the LA. Entrance and exit block was confirmed for all four PVs. The patient is free of any symptoms six months after the procedure.

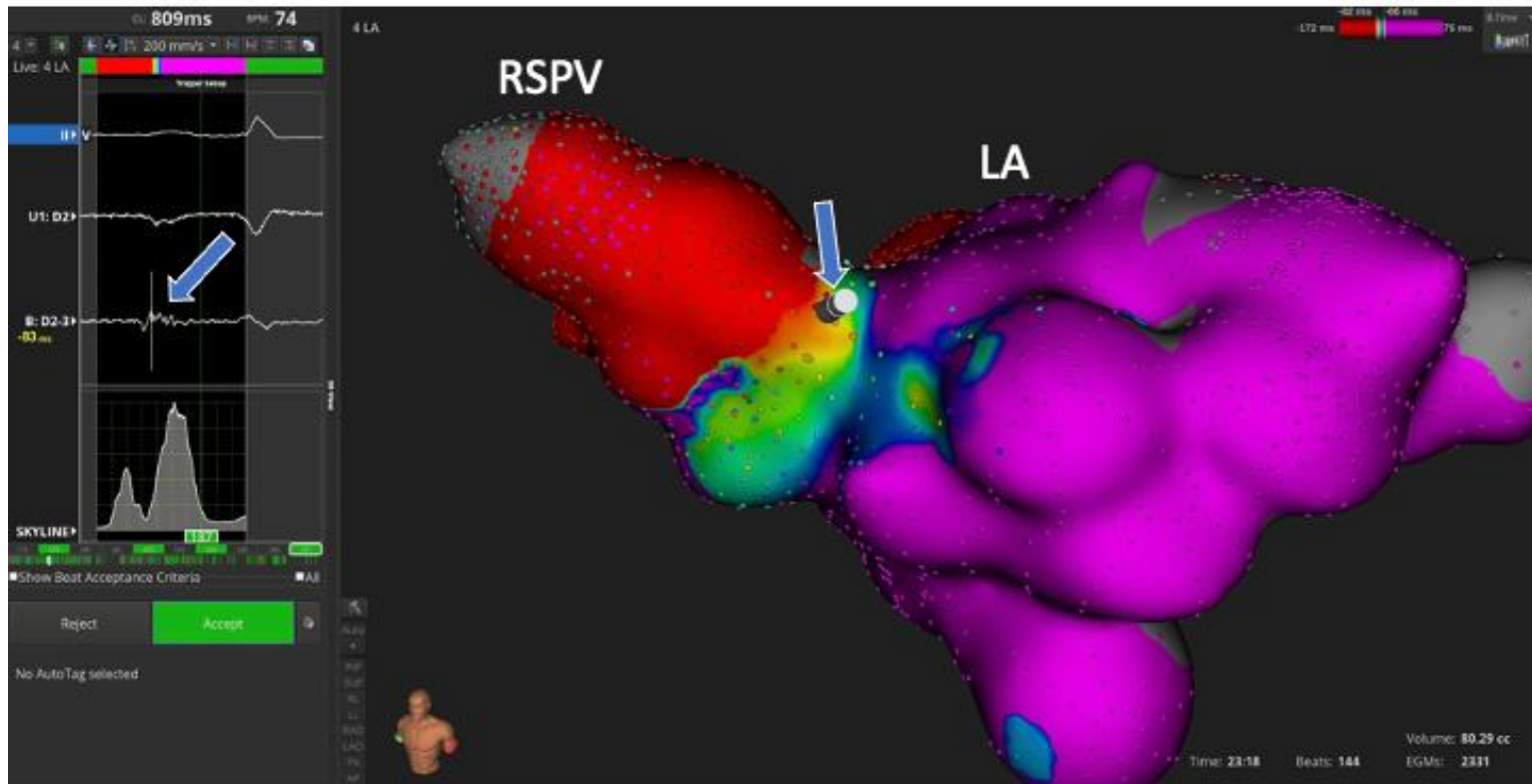


Figure 3: Rhythmia activation map created during PACs. The breakthrough point of the exit conduction is at the superior part of the right PVs (right side). The IEGMs show a fractionated potential, corresponding to the slow conduction from the RSPV (blue arrow). Modified anteroposterior view (see the torso in the left lower corner of the left panel). Abbreviations: PACs = premature atrial contractions; RSPV = right superior pulmonary vein; LA = left atrium.

Discussion

Only a few studies have reported cases of unidirectional exit conduction (1). To our knowledge, this is the first report of a case with intermittent unidirectional exit conduction from a PV to the LA. Entrance block of all PVs was established both by observing the absence of near-field signals and by high-density voltage map. However, exit conduction was present, but only some of the RSPV ectopies were conducted to the LA, even if they occurred after the refractory period of the atrial tissue (see Fig. 2). Therefore, we established the intermittent nature of unidirectional exit conduction. The gap was located using timing and propagation reference with the Rhythmia system, and it was successfully ablated.

In the first study investigating the incidence of unidirectional blocks, Gerstenfeld et al. reported that after confirming the entrance block, 42% of PVs show exit conduction determined using PV pacing (with 10 mA amplitude, 2 ms pulse width) (2). This high rate could be explained by the accidental registration of far-field captures, as pacing maneuvers from the PVs can capture adjacent atrial tissue around the ostium. Compared to other studies, this may overestimate the true prevalence of unidirectional exit conduction. Several studies have used a different method, where PVs showing spontaneous activity were examined (conduction was

not determined using PV pacing), which could eliminate the problem of far-field capture. Chen et al. reported unidirectional exit conduction in 11 of 341 (3.2%) ipsilateral PVs with spontaneous automaticity (3), and Duytchaever et al. found only 1 PV of 172 (0.6%) with the same method (4). However, lower unidirectional block rates using PV pacing were also reported just recently by Nakashima et al., who found only 5 of 247 (2%) PVs with unidirectional exit conduction, which was evaluated by properly executed PV pacing (5). There is an argument about whether exit block confirmation adds to the efficacy of the procedure, given the low rate of unidirectional conduction (5).

While entrance block is easy to demonstrate, the evaluation of exit block is more challenging because PV pacing can run into several problems: 1) loss of capture within the pulmonary vein, 2) uneven distribution and lack of continuity of myocardium bands within the PVs, 3) inability to see the local potentials of PV capture, or 4) far-field capture. For these reasons, many laboratories do not routinely evaluate exit conduction (6). Far-field capture happens when pacing directly captures the adjacent atrial structures, e.g. the left atrial appendage (LAA). Capture of the LAA may occur during pacing from the left superior PV, leading to a misinterpretation of the results in up to 16% of cases (known as pseudo-pulmonary vein exit conduction) (7). However, this phenomenon can be avoided by reducing the pacing output to lose far-field LAA capture while maintaining local pulmonary vein (PV) capture. Additionally, verifying pulmonary vein isolation can be strengthened by pacing the LAA, as it allows for differentiation between local PV potential and far-field signals from the LAA (8).

There are two methods for addressing acute pulmonary vein (PV) reconnection after initial confirmation of bidirectional blocks: further ablation after a waiting period of >20 minutes (Class IIa recommendation) and testing dormant conduction with adenosine stimulation (Class IIb) (9). The necessity of these techniques has been questioned in many studies. Since the widespread availability of contact-force sensing catheters and ablation-index-guided PVI, the studies that reassessed the benefits of a waiting period concluded that it is unnecessary (10, 11). Adenosine has been reported to provoke dormant conduction between the LA and PVs after confirming a bidirectional block. The results of the UNDER-ATP trial suggest that adenosine-guided PVI does not reduce the incidence of recurrent AF (12). This was by far the largest randomized controlled trial investigating the usefulness of adenosine testing; however, one meta-analysis came to the opposite conclusion (13). Thus, this is still an ongoing debate among electrophysiologists. A novel use for adenosine has also been raised in another study showing that in cases where operators were unable to see the local potentials of PV capture, adenosine administration made the local potentials visible during PV pacing (14).

Spontaneous PV activity is a relatively frequent phenomenon, present in 30-35% of veins after PVI (3, 4). In one study it was shown to be an independent predictor for increased risk of PV reconnection, while a demonstrable exit block was not (15). Meanwhile, spontaneous PV activities help to evaluate the result of the PVI, as the dissociation of the PV ectopies from the LA confirms the bidirectional block.

Our current case is a rare phenomenon where demonstrating and mapping the unidirectional, intermittent conduction was clinically necessary and led to a successful procedure and a symptom-free patient.

Conclusion

Accurate electrophysiological evaluation of PVI is a key part of the procedure, which can determine clinical efficacy. In ambiguous cases, PV pacing helps to assess exit block; however, it must be performed thoroughly to avoid pitfalls such as far-field capture of the LA or non-capture of the PV. In cases where spontaneous PV activity can be detected, careful observation of the automaticity and the examination of its relation to the atrial signals are essential for successful PVI.

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