

Temporal elimination of an interatrial epicardial connection by ablation encircling the right-sided pulmonary veins



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Introduction

Radiofrequency (RF)-based circumferential antral pulmonary vein (PV) isolation (CAPVI) is one of the widely accepted invasive treatments for atrial fibrillation.¹ Despite the continued development of mapping and ablation technologies, acute and chronic PV reconnections can still occur.² Previous anatomical and electrophysiological studies reported that the existence of epicardial connections (ECs) via intercaval fibers connecting the right-sided PVs and right atrium (RA) can preclude isolation of these PVs.^{3–7} However, the anterior ablation line for the isolation of right-sided PVs, which intersects a theoretical pathway of ECs, may eliminate ECs by transmural lesion formation from the 3-dimensional point of view.^{4,8} In the present case, a temporal and spatial relation between the electrophysiological findings and ablation results suggested that an EC was inadvertently and temporarily eliminated by CAPVI.

Case report

A 60-year-old man was referred to our institution for catheter ablation of symptomatic paroxysmal atrial fibrillation. The ablation procedure was performed using a 3-dimensional navigation system (CARTO 3; Biosense Webster, Inc, Diamond Bar, CA). Before CAPVI, a breakthrough at the right-sided PV carina was observed on the activation map of the left atrium during sinus rhythm (Figure 1A, Supplemental movie). CAPVI was performed via point-by-point RF applications with a ThermoCool SmartTouch irrigated-tip contact force-sensing ablation catheter (Biosense Webster, Inc). After the left-sided PVs were successfully isolated, CAPVI for the right-sided PVs was performed during sinus rhythm. RF energy at a power setting

KEY TEACHING POINTS

- The presence of an epicardial connection (EC) between the right-sided pulmonary veins (PVs) and right atrium (RA) was previously reported to preclude circumferential antral PV isolation.
- The anterior line for isolation of the right-sided PVs can eliminate ECs by transmural lesion formation, but its effect may be transient.
- Because inadvertent elimination of ECs by endocardial ablation renders a risk of reconnection of the right-sided PVs via the ECs, ablation of the PV or RA insertion may be a better strategy.

of 45 W and an ablation index of ≥ 520 was delivered continuously from the inferior part of the right inferior PV to the superior part in the anterior antrum. During this procedure, a Lasso catheter (Biosense Webster, Inc) was placed between the ostium of the right superior PV and the antrum. During the sixth RF application of the anterior line, the earliest PV potential shifted from the carina region (Lasso electrodes 11–12) to the posterior antrum (Lasso 3–4) 6 seconds after the application started, whereas there had been no change during the first to fifth RF applications (Figure 1B, C). The timing of the PV potential at the other locations, such as Lasso 3–4, with reference to the coronary sinus potentials remained unchanged from before to after the sixth RF application. After the anterior antral ablation, RF energy at a power setting of 40 W and an ablation index ≥ 400 was delivered from the inferior part of the right inferior PV to the superior part in the posterior antrum, resulting in successful first-pass isolation with bidirectional block. Forty minutes after the completion of CAPVI for the right-sided PVs, the Lasso catheter was repositioned into the right superior PV and showed a reconnection of the right-sided PVs. An activation map obtained during pacing from the mid carina of the right-sided PVs with the Lasso catheter revealed that the earliest activation site was the posterior RA, implying

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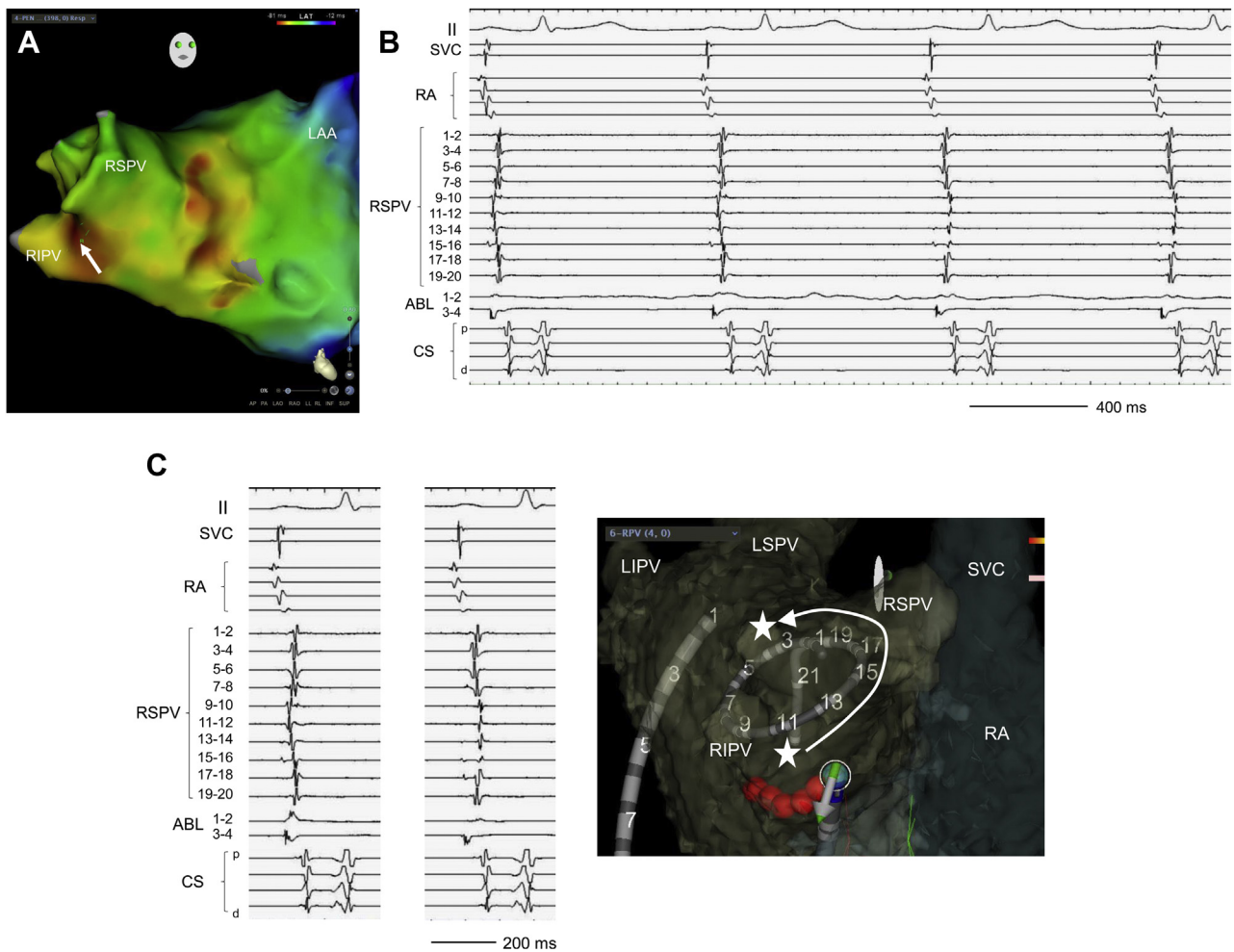


Figure 1 A: Activation map in the left atrium during sinus rhythm before ablation. The white arrow indicates the carina breakthrough. B: Intracardiac electrograms during the sixth radiofrequency (RF) application. C: Intracardiac electrograms before and after the sixth RF application, and the 3-dimensional image showing the location of the ablation and Lasso catheters (Biosense Webster, Inc, Diamond Bar, CA) at the sixth RF application. The earliest site of the pulmonary vein potential (white star) shifted from the carina region (Lasso 11–12) to the posterior antrum (Lasso 3–4). ABL = ablation catheter; CS = coronary sinus; d = distal; LAA = left atrial appendage; LIPV = left inferior pulmonary vein; LSPV = left superior pulmonary vein; p = proximal; RA = right atrium; RIPV = right inferior pulmonary vein; RSPV = right superior pulmonary vein; SVC = superior vena cava.

that the right-sided PVs had reconnected via an EC (Figure 2A). High-frequency potentials were recorded at the earliest site in the posterior RA during both sinus rhythm and pacing from the carina. Focal RF applications at a power setting of 35 W at this site resulted in durable isolation of the right-sided PVs with bidirectional block (Figure 2B, C). No further reconnection was observed even with isoproterenol infusion.

Discussion

Previous anatomical studies have clearly revealed muscular bridges connecting the right-sided PVs and RA.^{6,7} In the usual clinical situation, however, we can speculate the existence and the electrical and anatomical properties of ECs using mapping and pacing techniques only by the endocardial approach.^{3–5} In the present case, the right-sided PVs were successfully isolated by first-pass CAPVI, but then they reconnected during the procedure. The activation map obtained during pacing from the carina showed that

the earliest site was the posterior RA, indicating that the right-sided PVs had reconnected via the EC. Also, the PV breakthrough in the activation map during sinus rhythm suggested the existence of the EC before the CAPVI.³ During the sixth RF application of the anterior line of CAPVI for the right-sided PVs, the earliest PV potential shifted from the carina region to the posterior antrum, implying that the EC was inadvertently eliminated at this time.

The earliest site in the RA during pacing from the right-sided PV carina was a theoretical RA insertion, as was the earliest breakthrough site in the activation map during sinus rhythm. The theoretical pathway of the EC in the present case can be drawn by connecting the theoretical sites of RA insertion, the sixth RF application site, and the theoretical sites of PV insertion (Figure 3). According to previous studies, a certain percentage of patients were considered to have ECs between the right-sided PVs and RA (22% in the study of Yoshida and colleagues³ and 7% in that of Barrio-Lopez and colleagues⁵). In contrast, the first-pass isolation

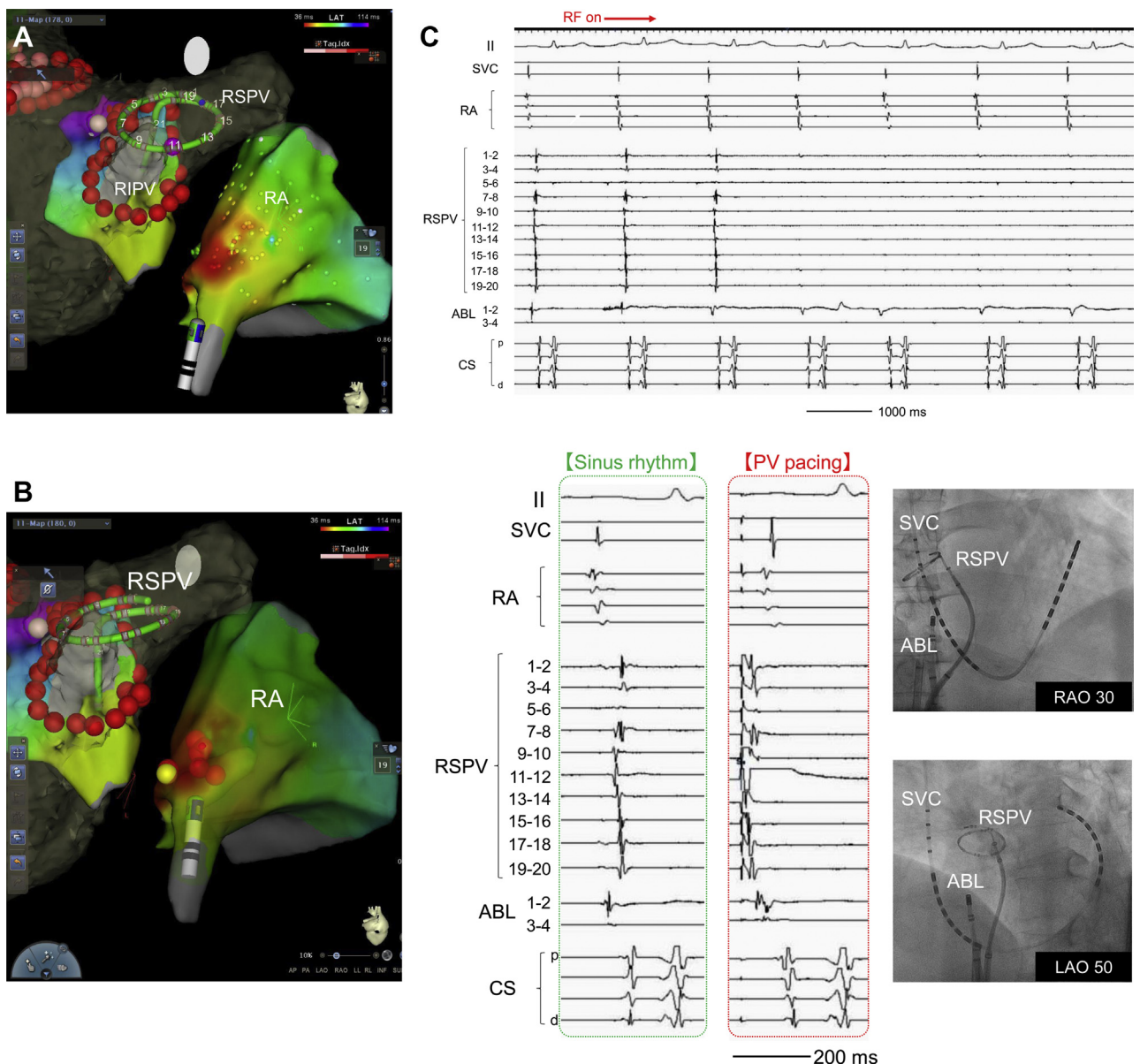


Figure 2 **A**: Activation map of both atria during pacing from the right-sided pulmonary vein (PV) carina. The earliest site was the posterior right atrium. The purple tag indicates the pacing site. **B**: Three-dimensional image, intracardiac electrograms during sinus rhythm and pacing from the right-sided PV carina, and fluoroscopic images at the successful ablation site. High-frequency potentials were recorded by the ablation catheter at the successful site during both sinus rhythm and pacing from the right-sided PV carina. A radiofrequency (RF) application at the yellow tag successfully isolated the right-sided PVs. Red tags indicate RF applications made before the yellow tag, which resulted only in delay of the PV potentials. **C**: Intracardiac electrograms after RF application started at the successful site. PV potentials disappeared immediately after RF application started. ABL = ablation catheter; CS = coronary sinus; d = distal; LAO = left anterior oblique view; p = proximal; RA = right atrium; RAO = right anterior oblique view; RIPV = right inferior pulmonary vein; RSPV = right superior pulmonary vein; SVC = superior vena cava.

rate for the right-sided PVs by CAPVI was 100% in a clinical study using the CLOSE protocol.² This discrepancy might be due to the lesion design of CAPVI—ie, an anterior line that is close to the PV carina can eliminate ECs at the PV insertion. Lin and colleagues⁹ reported that the distance between the ablation line and the PV carina was the major determinant for the need for carina ablation, implying that if the lesion setting of the anterior line was close to or was involved in the carina, it would eliminate the PV insertion of the EC. However, we speculated that the EC in the present case was temporarily eliminated by the CAPVI not at the PV

insertion but in the mid portion based on the 3-dimensional image (Figure 3).

Although the ablation strategy for ECs has not been well established yet, there might be a risk of acute or chronic reconnection if an EC is inadvertently eliminated because RF applications from the endocardium during CAPVI are unlikely to create a sufficient lesion at the EC. A drastic change in the sequence of PV potentials during CAPVI can provide a clue to the inadvertent elimination of an EC. In such cases, operators should be aware of the risk of PV reconnection via an EC.

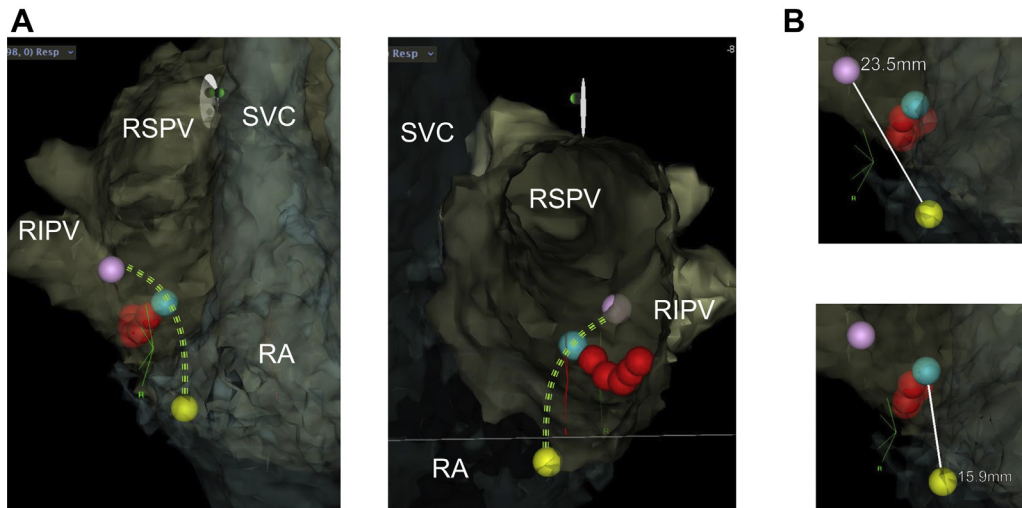


Figure 3 **A:** Outer and inner views of computed tomography merged and 3-dimensional images. The yellow tag indicates the successful ablation site in the right atrium (RA). The blue tag indicates the sixth radiofrequency (RF) application site, and the red tags indicate the first to fifth RF application sites of the anterior line. The light purple tag corresponds to the earliest pulmonary vein (PV) breakthrough site in the activation map during sinus rhythm before ablation. A green broken line was drawn to connect the successful site and earliest PV breakthrough site and pass through the sixth RF application site, indicating the theoretical pathway of the epicardial connection. **B:** Anatomical distances from the successful site in the RA. The direct distance from the successful site to the earliest PV breakthrough site was 23.5 mm, and that to the sixth RF site was 15.9 mm. RIPV = right inferior pulmonary vein; RSPV = right superior pulmonary vein; SVC = superior vena cava.

Conclusions

The EC in the present case was considered to be inadvertently and temporarily eliminated by the CAPVI. Electrophysiologists should realize that the CAPVI procedure can mask the presence of an EC by transmural lesion formation and cause an acute or chronic PV reconnection via an EC. A drastic change in the PV potential sequence during ablation in the anterior line may alert electrophysiologists to be aware of the inadvertent elimination of an EC.

Appendix Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.hrcr.2020.08.006>.

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