Journal of Cardiology Cases 27 (2023) 27–31

Contents lists available at ScienceDirect

Journal of Cardiology Cases

journal homepage: www.elsevier.com/locate/jccase

Case Report

Identification of interatrial epicardial connections between the right-sided pulmonary veins and right atrium using coherent map

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ARTICLE INFO

Article history:
Received 22 July 2022
Received in revised form 5 September 2022
Accepted 14 September 2022

Keywords:
Atrial fibrillation
Catheter ablation
Pulmonary vein isolation

ABSTRACT

A 43-year-old man underwent circumferential pulmonary vein isolation (PVI) for persistent atrial fibrillation. Although first-pass circumferential PV antrum ablation was performed, complete PVI was not obtained. A gap map showed the site of earliest activation was the right-sided PV carina, which was the same site of breakthrough on the left atrium map before ablation. Using a coherent map enabled us easily and clearly to evaluate the breakthrough sites. To identify whether the conduction from the right PV carina connected to adjacent structures, an activation map was obtained during pacing from the right PV carina. This revealed that the site of earliest activation was the posterior right atrium (RA) and implied a direct connection between the right-sided PVs and RA. The first radiofrequency (RF) application in the posterior RA resulted in only temporary isolation of the right-sided PVs with bi-directional block. Therefore, we performed a second set of RF applications to the right PV carina. PVI was obtained immediately after initiating the second set of applications and no further reconnection was observed.

Learning objective: Pulmonary vein isolation (PVI) is widely accepted as an atrial fibrillation ablation procedure. Previous anatomical studies have revealed the presence of epicardial muscular bundles/fibers connecting the right-sided PVs and right atrium. In some patients, the presence of epicardial connections (ECs) precludes successful first-pass PVI. Identification and elimination of these connections is imperative to achieve complete PVI. The coherent map was useful for evaluating ECs.

Introduction

Pulmonary vein isolation (PVI) is a widely accepted cardiac ablation procedure used to treat atrial fibrillation (AF) [1]. Complete electrical isolation of all four PVs is essential; nonetheless, acute or chronic electrical reconnection can occur [2]. Reconnection can be caused by residual conduction gaps along the ablation line or other connections between the PVs and left atrium (LA). Previous studies have reported that the presence of epicardial connections (ECs) via intercaval fibers that connect the right-sided PVs and right atrium (RA) can preclude successful PVI [3–5]. We report a patient with these ECs that were clearly identified using three-dimensional mapping, especially a coherent map, and were successfully ablated.

Case report

A 43-year-old man was referred to our hospital for radiofrequency (RF) catheter ablation of persistent AF that was resistant to medical treatment. Ablation was performed using a three-dimensional system (CARTO 3; Biosense Webster, Inc., Irvine, CA, USA). Prior to ablation, the activation map of the LA during high right atrial pacing showed two sites of breakthrough, one at the right-sided PV carina and the other at the anterior LA, which appeared to be via Bachmann's bundle (Fig. 1A). Circumferential PVI was performed via point-by point RF applications using a contact force–sensing irrigated ablation catheter (ThermoCool SmartTouch; Biosense Webster, Inc.). After the left-sided PVs were successfully isolated, we isolated the right-sided ones during sinus rhythm. RF energy was delivered to the anterior wall at a power setting of 40 W and an ablation index of 400; the settings for the posterior wall were 35 W and 380, respectively. During the ablation of the anterior wall, the activation patterns of the right-sided PV potentials were not changed. Although first-pass circumferential PV antrum ablation was performed, complete PVI was not achieved. After ablation on the right, the activation map of the LA during coronary sinus pacing showed

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https://doi.org/10.1016/j.jccase.2022.09.012

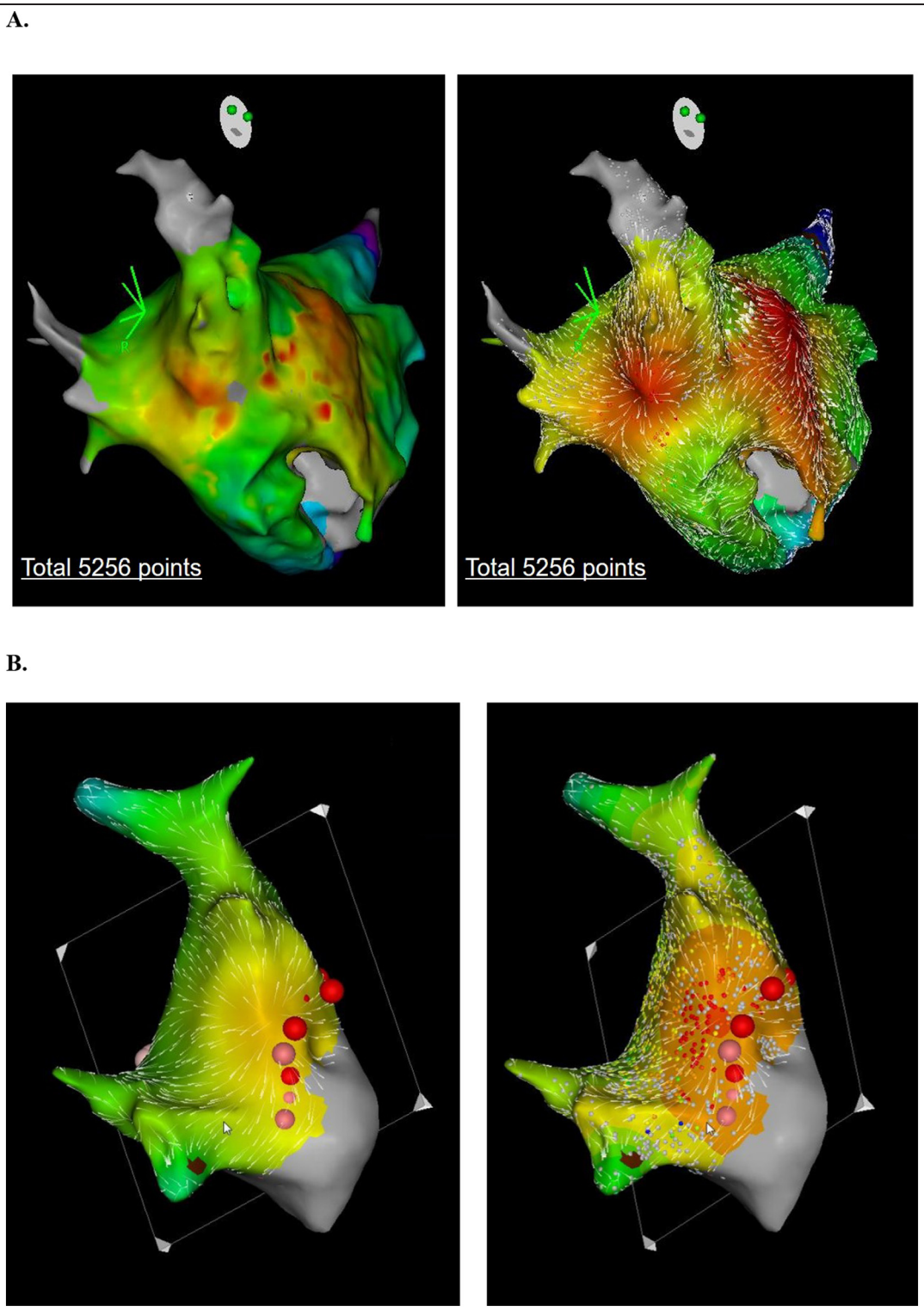


Fig. 1. (A) Activation map of the left atrium during high right atrial pacing before ablation. Left panel: The local activation time map showed breakthrough at the right-sided pulmonary vein carina and the anterior wall of left atrium. Right panel: The coherent map showed the breakthrough sites more clearly. In total, 5256 points were mapped. (B) Activation map of the left atrium after the first-pass ablation. Left panel: The coherent map after the first-pass ablation also showed that the breakthrough site was the same as before ablation. Right panel: The coherent map with isochronal mapping clearly showed the breakthrough sites.

the earliest activation at the right-sided PVs, the same site of breakthrough in the initial map. The ripple map is shown in Video 1, and the coherent map is shown in Fig. 1B. The coherent map clearly revealed the breakthrough sites and showed that the distance from the breakthrough sites spreading at the right-sided PV carina to the anterior ablation line was adequate (9.1 mm). Therefore, we positioned a Lasso catheter (Biosense Webster, Inc.) inside the ablation line and obtained an activation map during pacing from the right PV carina to identify whether the conduction from the right PV carina connected to adjacent structures. An activation map of the LA and RA revealed that the site of

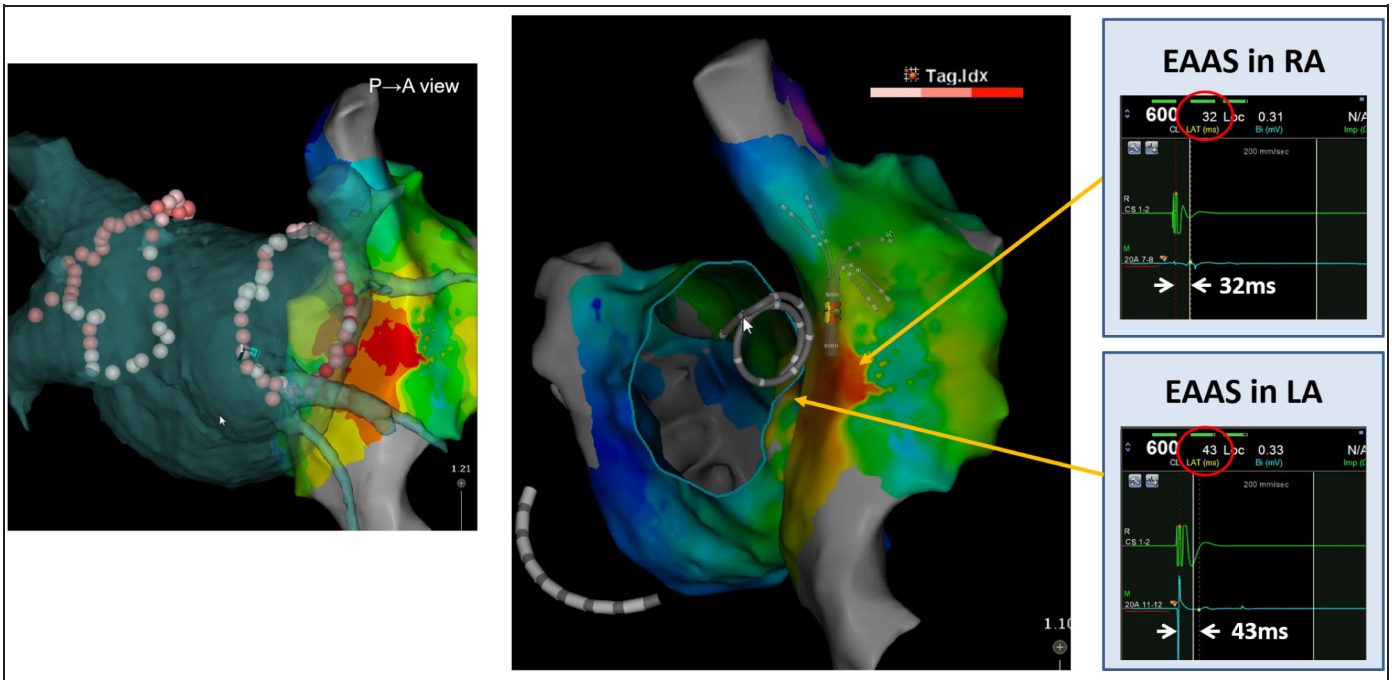


Fig. 2. Activation map of the left and right atrium during pacing from the right-sided pulmonary vein carina. The earliest activation site was the posterior right atrium. The interval from pacing to the local potential was 32 ms. The anterior wall along the right side of the pulmonary vein was also activated early; however, the interval from pacing to the local potential was 43 ms. Red and pink tags indicate the sites of radiofrequency application during first-pass pulmonary vein isolation.
EAAS, earliest atrial activation site; RA, right atrium; LA, left atrium.

earliest activation was the posterior RA, which implied a direct connection between the right-sided PVs and RA (Fig. 2, Video 2). First, focal RF applications were performed in the posterior RA at a power setting of 35 W. This resulted in isolation of the right-sided PVs with bi-directional block (Fig. 3A); however, the time to attain isolation after RF applications were initiated was somewhat long (10 s). Five minutes after the right-sided PVs were isolated, the Lasso catheter showed reconnection. Then, we performed RF applications using the same power settings on the opposite site (right PV carina), which achieved PVI immediately after applications began (Fig. 3B). After confirming bi-directional block, LA roof dependent re-entrant atrial tachycardia (AT) was induced. This terminated during roof line ablation. No further reconnection or arrhythmias were observed, even after isoproterenol infusion.

Discussion

Previous anatomic studies have revealed the presence of epicardial muscular bundles/fibers connecting the right-sided PVs and RA [4]. Yoshida et al. confirmed the presence of ECs between the right PV carina and RA using high-density electrophysiologic mapping [5,6]. In our patient, the PV breakthrough in the activation map before ablation suggested the presence of an EC. The second activation map around the right-sided PVs during pacing from the coronary sinus after unsuccessful first-pass isolation also showed the same site of earliest activation (PV carina). If there were no ECs bridging over the right anterior-sided PV antrum, ablation of the anterior wall should have affected the PV potentials. However, during ablation at this s*ite, the activation patterns of the PV potentials did not change. A recent study defined the non-endocardial gap using the following criteria: (1) the earliest activation site inside the initial PVI line during LA pacing was located 5 mm away from the PVI line, and (2) the PV–antrum connection was eliminated by ablation at the earliest activation site outside the PVI lines during PV pacing [7]. In the present case, the distance from the breakthrough sites to the anterior ablation line was 9.1 mm, which was adequate. These findings implied that there were no gaps in the ablation line and indicated an EC with neighboring structures. In addition, the third activation map during pacing from the carina showed that the site of earliest activation was the posterior RA, which indicated that the right-sided PVs had reconnected via the EC. We were able to obtain PV isolation by ablation of both the posterior RA and right-sided PV carina, which suggests that our speculation was reasonable. The site of earliest activation in the RA during pacing from the right-sided PV carina was a theoretical insertion to RA, as the earliest breakthrough site in the PV carina was the theoretical insertion to LA. In addition, the distance (length of EC) between the two sites was 18.2 mm (Fig. 3C). The first RF applications in the posterior RA required a long time to isolation (10 s) and resulted in only temporary PVI, probably because they did not completely eliminate conduction or the muscular bundles were diffuse and multiple. A previous study also reported difficulty with isolating PV–RA ECs with RF ablation applications in the RA because of the presence of multiple epicardial muscle fibers connecting the PVs and RA [8]. Therefore, additional PV carina ablation may be required in some patients.

Although many procedures for AF ablation have been proposed, evidence for their efficacy is lacking [9]. However, PVI is widely accepted and requires complete and definite isolation. Our patient demonstrates that ECs may be present between the right PV carina and RA. Identification and elimination of these connections is imperative to achieve complete circumferential antral PVI. The coherent map was very useful for evaluating the breakthrough sites. To the best of our knowledge, the present study is the first to demonstrate the clinical significance of using a coherent map to evaluate ECs.

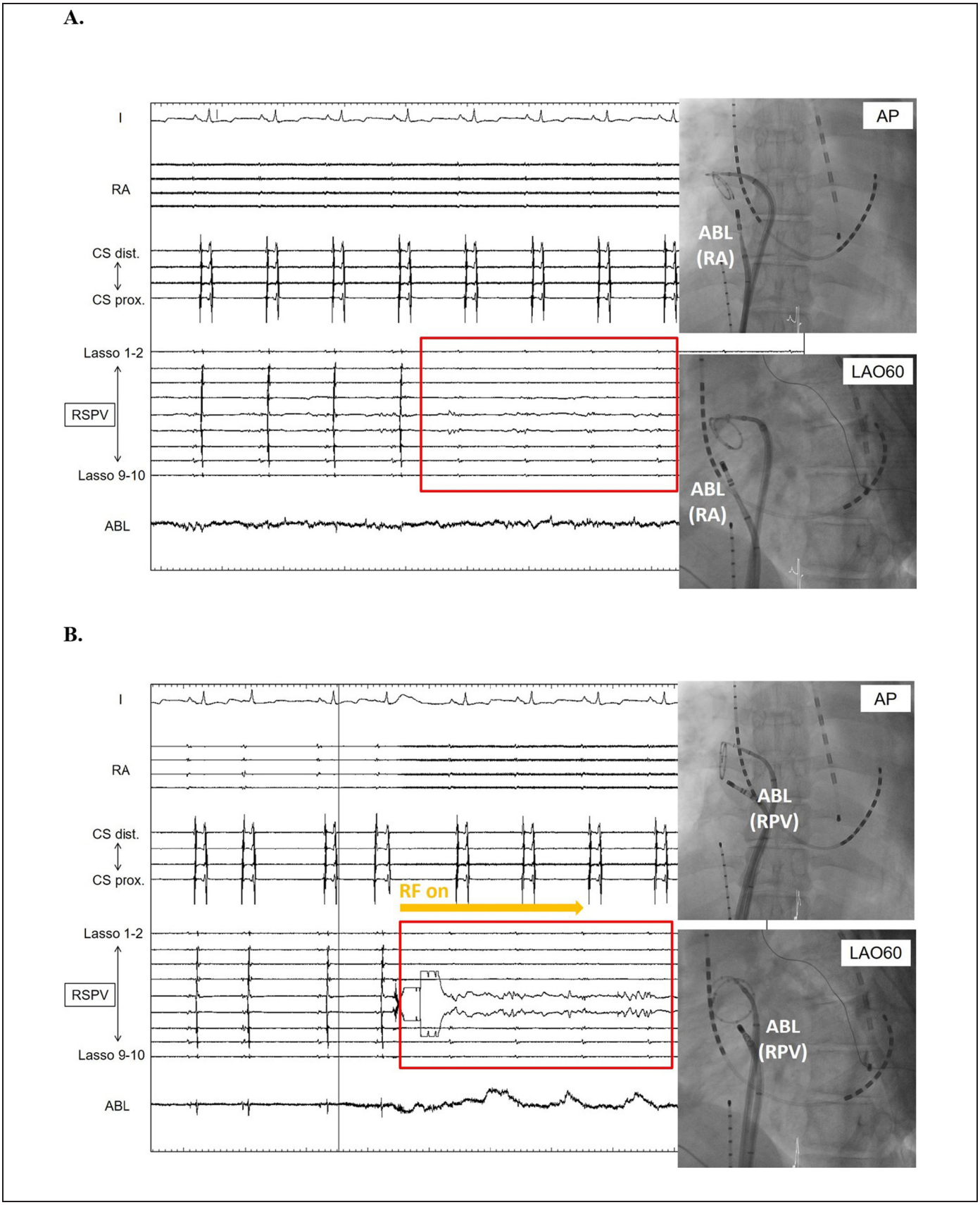
Supplementary data to this article can be found online at https://doi.org/10.1016/j.jccase.2022.09.012.

Declaration of competing interest

The authors have no conflicts of interest to disclose.

Acknowledgment

We thank Edanz (https://jp.edanz.com/ac) for editing a draft of this manuscript.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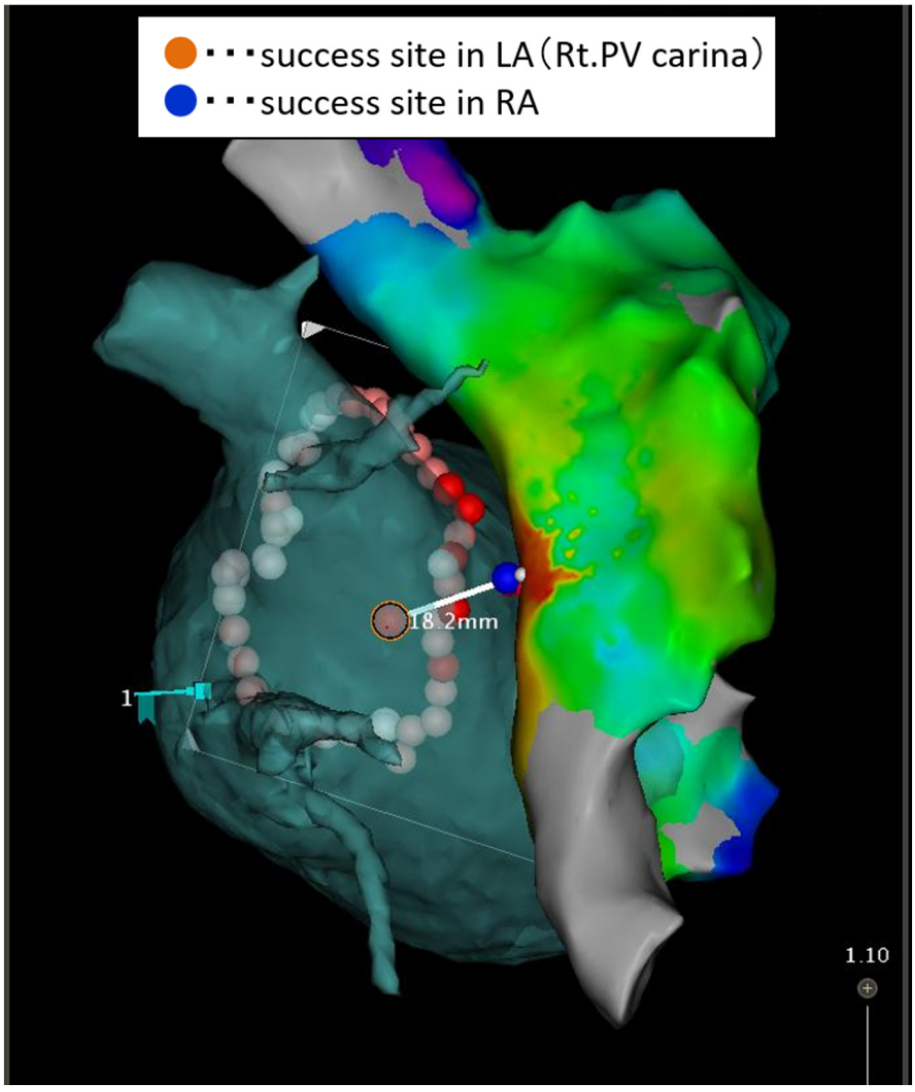

Fig. 3. (A) Intracardiac electrograms and fluoroscopic imaging at the first successful ablation site in the right atrium. The right-sided pulmonary vein potentials disappeared; however, reconnection of these potentials was confirmed 5 min after isolation was achieved. (B) Intracardiac electrograms and fluoroscopic imaging at the second successful ablation site in the left atrium. The right-sided pulmonary vein potentials disappeared immediately after applications were initiated and never reconnected. (C) Three-dimensional imaging showing the sites of successful ablation in both atria. The blue tag indicates the first successful radiofrequency application site in the posterior right atrium. The orange tag indicates the second successful radiofrequency application site in the left atrium. The distance between these two sites was 18.2 mm. The red and pink tags indicate the first-pass radiofrequency application sites.
ABL, ablation catheter; RA, right atrium; CS, coronary sinus; prox., proximal; dist., distal; RSPV, right superior pulmonary vein; RPV, right pulmonary vein; AP, anteroposterior view; LAO, left anterior oblique view.

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