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.

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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

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.
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 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-sides PV antrum, ablation of the anterior wall should have affected the PV potentials. However, during ablation at this site, 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.

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Declaration of competing interest

The authors have no conflicts of interest to disclose.
A.

B.
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