Dual-chamber open-window mapping for an epicardial accessory pathway through the posterior coronary vein

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Introduction

The conventional mapping approach for atrioventricular accessory pathways (APs) typically involves a point-by-point mapping technique. This method aims to identify the specific connection sites of the AP to either the atria or the ventricles. However, this approach relies on the accurate interpretation of local electrograms, which can be challenging and time-consuming. In recent years, there have been reports highlighting the efficacy of an alternative mapping technique called open-window mapping (OWM) for localizing APs.[1] Although this method simplifies the mapping process and aids precise identification of the AP location, it is unclear whether this approach can be applied for localizing epicardial APs.

KEY TEACHING POINTS

- The open-window mapping (OWM) is effective for localizing atrioventricular accessory pathways (APs), but its efficacy in identifying epicardial APs remains unclear.
- This case demonstrates that the OWM can effectively visualize the activation of epicardial APs through the posterior coronary vein.
- The automated annotation process, in which near-field signals are distinguished from far-field signals based on the highest -dV/dt at each acquired point, may have played a role in accurately visualizing the activation of the epicardial AP.

Case report

A 51-year-old woman with Wolff-Parkinson-White syndrome was referred to our institution for catheter ablation. She also had a history of paroxysmal atrial fibrillation, which was associated with the occurrence of pseudo–ventricular tachycardia. The baseline surface electrocardiogram showed preexcitation with a positive delta wave in leads I, II, aVL, and V_2-V_6 and negative delta waves in leads III, aVR, and aVF (Figure 1A). During sinus rhythm, the earliest ventricular activation was observed at the proximal coronary sinus (CS), and AH and HV intervals were 90 ms and -10 ms, respectively. The deflection of delta waves during maximum preexcitation with rapid atrial pacing was the same as that observed during sinus rhythm. During right ventricular pacing, retrograde conduction without decremental conduction properties was observed. The sequence of CS electrograms during the retrograde conduction was suggestive of a left posteroseptal AP. Narrow QRS tachycardia with a tachycardia cycle length of 345 ms was induced by atrial extrastimulation (Figure 1B and 1C). The sequence of atrial potentials during the tachycardia was the same as that observed during the right ventricular pacing. The standard electrophysiological study made the diagnosis of orthodromic atrioventricular reentrant tachycardia (AVRT). The OWM was performed with a high-density mapping system (CARTO 3 mapping system, Biosense-Webster, Inc, Diamond Bar, CA) to determine the AP location. Using the Octaray mapping catheter (Biosense-Webster, Inc), sequential contact mapping of the left atrium and basal left ventricle was performed during the AVRT. The maximum peak of the local electrogram in the CS served as the reference point for the window of interest, which was set to cover both atrial and ventricular activation (from -115 to 96 ms). The local activation time was annotated to a unipolar signal with the highest -dV/dt value. The OWM showed the earliest atrial activation at the left posteroseptum 13 mm remote from the mitral annulus (Figure 2A). The fragmented potential was observed at the earliest atrial activation site. The early-meets-late (EML) algorithm was applied to the map to

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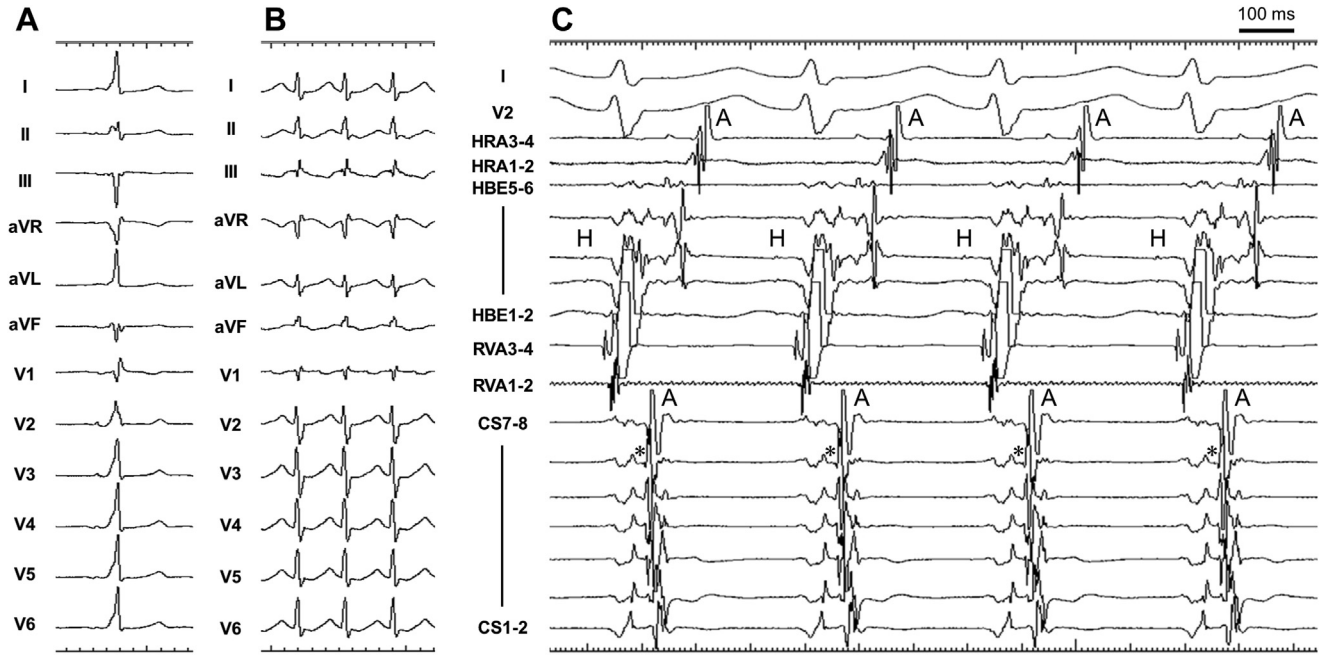

Figure 1 Surface electrocardiograms and intracardiac electrograms. **A:** Surface electrocardiograms during sinus rhythm. **B:** Surface electrocardiograms during atrioventricular reentrant tachycardia (AVRT). **C:** Intracardiac electrograms during AVRT. The asterisks (*) indicate the earliest atrial activation site, which was located at the proximal coronary sinus (CS). HBE = His bundle electrogram; HRA = high right atrium; RVA = right ventricular apex.

visualize the conduction block at the mitral annulus. We set a lower threshold of 25% during mapping and thereafter gradually raised it to 40%; however, the EML gap, which served as a visual estimation of the AP conduction, was not observed beside the earliest atrial activation site. Since the epicardial AP through CS musculature was suspected, we performed CS venography, which did not reveal CS diverticulum or aneurysm. CS was mapped using the Octaray catheter, revealing that the activation propagated from the ventricle to the earliest atrial activation site on the left posteroseptum through the posterior coronary vein (PCV) and CS (Figure 2B and Supplemental Video 1). Furthermore, fragmented potential, which preceded the earliest activation on the left posteroseptum by 20 ms, was observed in the PCV. Therefore, the AP was diagnosed as the epicardial AP through the PCV. Radiofrequency energy (power setting of 25 W) was delivered to the ostium of the PCV (Figure 2C and 2D), resulting in the termination of the AVRT in 3.5 seconds (Figure 2E). After the termination of the AVRT, neither anterograde nor retrograde conductions through the AP were observed. AP conduction did not recur during the procedure. Owing to the history of frequent episodes of paroxysmal atrial fibrillation and at the patient's request, pulmonary vein isolation was subsequently performed. The patient has remained symptom free with no evidence of the reconnection of the AP throughout 6 months of follow-up.

Discussion

The myocardial coat covering the proximal CS extends to the terminal portion of the middle cardiac vein and posterior cardiac veins in 3% and 2% of hearts, respectively.[2] These extensions of CS musculature may serve as the substrate for epicardial APs in the posteroseptal and left posterior regions when they connect to the epicardial surface of the ventricle.[3,4] It has been suggested that such CS APs are associated with CS abnormalities, including diverticulum and aneurysm.[5] However, it was reported that up to 70% of such APs occur without CS anomalies.[3] Therefore, the presence of normal CS anatomy in this case is not uncommon for CS APs.

The most commonly reported surface electrocardiographic pattern for CS APs is a negative delta wave in lead II.[6,7] In contrast, the present case exhibited preexcitation with a positive delta wave in lead II. However, this finding does not rule out the possibility of CS APs, given that the sensitivity of a negative delta wave in lead II for diagnosing CS APs was reported as 77% in a previous study.[7] The deflection of the delta wave is influenced by the location of the ventricular insertion site. Therefore, even though anterograde conduction through the AP was not assessed using electroanatomic mapping in this case, the rightward deviation of the ventricular insertion site may have led to the positive delta wave observed in lead II.

The OWM uses an automated annotation process without considering the specific cardiac chamber. This distinguishes it from conventional mapping, where signals can be erroneously annotated to the wrong cardiac chamber. The OWM effectively visualizes the AP connection, manifesting as a breakout of the activation to the chamber of interest. In the present case, the atrial insertion site of the epicardial AP was correctly identified by the OWM as a centrifugal activation located 13 mm remote from the mitral annulus. On the

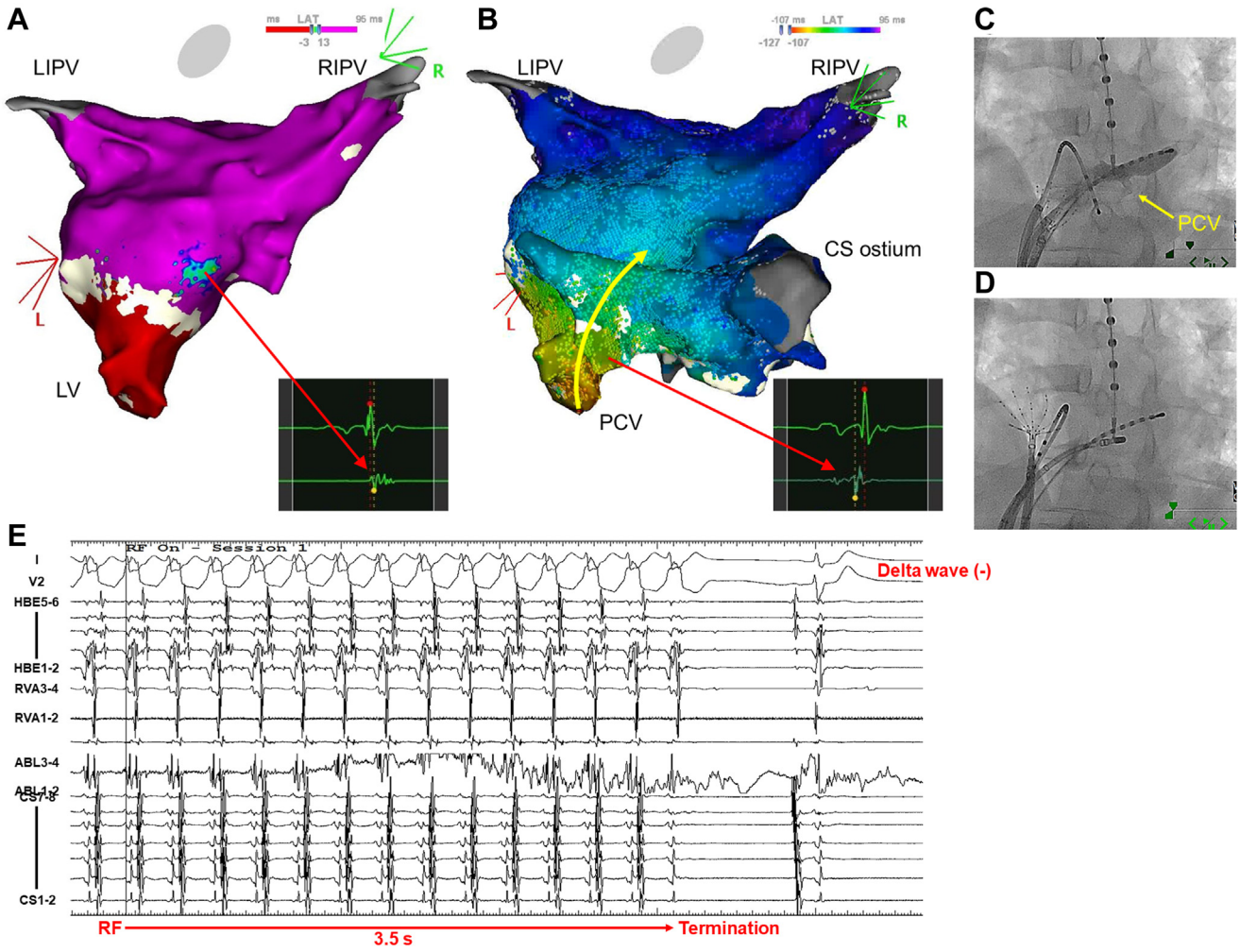

Figure 2 Open-window mapping (OWM) during orthodromic atrioventricular reentrant tachycardia (AVRT) and coronary sinus (CS) venography. **A:** The OWM of the left atrium. The lower threshold of the early-meets-late (EML) algorithm was set at 30%. No EML gap was observed in the conduction block (depicted as a white line) at the mitral annulus. The earliest atrial activation was noted on the left posteroseptum, where the fragmented potential was recorded. **B:** The OWM of the left atrium and CS (also refer to Supplemental Video 1). The activation originated from the posterior coronary vein (PCV) and propagated through the CS toward the earliest atrial activation site on the left posteroseptum (indicated by a yellow arrow). Fragmented potential was recorded in the PCV. **C:** CS venography. The PCV drained into the proximal CS. **D:** Catheter position during ablation. The ablation catheter was placed in the proximal PCV. **E:** Surface electrocardiogram and intracardiac electrograms during ablation. Orthodromic AVRT presented as wide QRS tachycardia because of concomitant right bundle branch block. LIPV = left inferior pulmonary vein; LV = left ventricle; RF = radiofrequency application; RIPV = right inferior pulmonary vein.

other hand, if ventricular potentials in the annular region were mistakenly annotated as atrial potentials in the conventional mapping approach, the resulting activation map would show the activation propagating from the annular region to the true earliest atrial activation site, leading to an incorrect diagnosis of a typical atrioventricular AP. In addition, the OWM effectively visualized the activation of the CS AP, even though the signals of the CS AP are generally smaller than those of the atrial and ventricular myocardium. In the OWM, near-field signals are differentiated from far-field signals by annotating the signals with the highest -dV/dt at each acquired point. This annotation method likely aided in the accurate delineation of CS AP activation.

Moreover, the EML algorithm significantly aided in accurately diagnosing the epicardial AP. To ensure that the insertion of the AP is away from the annulus, it is crucial to identify the position of the annulus correctly. In this case, the EML algorithm facilitated this process by visualizing the conduction block in the annular region. Of note, the insertion of the epicardial AP may present as an EML gap when the insertion site of the AP is close to the annulus. Therefore, cautious interpretation of the map is essential to distinguish between an epicardial AP and a typical atrioventricular AP by the OWM.

To the best of our knowledge, this is the first case report demonstrating the appropriate localization of the atrial connection site of an epicardial AP through the PCV by the OWM. This case highlights the potential utility of the OWM, not only in detecting endocardial APs but also in identifying epicardial APs.

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Appendix

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2023.11.011.

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