IMAGES

Delineating multiple septal accessory pathways using open-window mapping with a novel multi-spline mapping catheter

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Introduction

Open-window mapping (OWM) is a novel mapping method for catheter ablation of accessory pathways (APs). This method expands the window of interest to analyze both atrial and ventricular signals. With the extended early-meets-late (EEML) algorithm, OWM facilitates the visualization of the location and width of APs in patients with Wolff-Parkinson-White (WPW) syndrome.[1–3] Its efficacy has been proven in nonseptal APs but is unestablished in septal APs. Here, we report a case of 2 septal APs correctly identified by the OWM and EEML algorithm using a novel multi-spline mapping catheter.

Case report

A 47-year-old man without a history of heart disease was referred to our hospital due to a complaint of intermittent presyncope. The 12-lead electrocardiogram (ECG) exhibited manifest WPW syndrome (Supplemental Figure 1), and the location of the AP was estimated to be on the right posterior septum. There were no ECG recordings during presyncope, but the symptoms were alleviated by breath-holding and handgrip. Therefore, arrhythmias related to APs, including orthodromic reciprocating tachycardia, were considered plausible causes of his presyncope.

After obtaining the patient's informed consent, we conducted an electrophysiological study. Under local anesthesia, 4 electrode catheters were positioned in the right atrial appendage, His bundle region, coronary sinus (CS), and right ventricular apex. The His bundle electrograms overlapped with the ventricular potentials, which made it difficult to determine the His bundle potential recording area. Neither atrial nor ventricular extrastimulus pacing revealed any decremental conduction. During ventricular pacing, the CS ostium was the earliest atrial activation site. The effective refractory periods of the antegrade and retrograde APs were 600/320 and 600/340 ms, respectively, which were shorter than that of the atrioventricular (AV) node. Para-Hisian pacing indicated retrograde AP conduction without evidence of nodal conduction.

Given that tachycardia was not induced by extrastimuli, dual-chamber OWM was performed during right ventricular pacing using the CARTO 3 system and Octaray catheter (both Biosense Webster, Irvine, CA). After adjusting for the EEML setting (lower threshold of 20%), 2 conduction pathways on the right posterior septum and mid septum were elucidated. The activation map displayed 2 ventriculoatrial (VA) conductions 12.4 mm apart (Figure 1A and Supplemental Movie 1), suggesting the presence of either (1) 2 APs (ie, posterior-septal and midseptal APs) or (2) a single AP branching into 2 atrial sites. The local electrograms exhibited continuous AP potentials between the atrial and ventricular potentials at the 2 conduction sites (sites a and d in Figure 1A), while wide separated potentials were observed between the 2 sites (sites b and d in Figure 1A).

Owing to safety concerns, radiofrequency catheter ablation was initially performed for the posterior VA conduction

KEY TEACHING POINTS

- Open-window mapping (OWM) and the extended early-meets-late algorithm facilitate the visualization of the location and width of accessory pathways (APs) in patients with Wolff-Parkinson-White syndrome.
- The novel multi-spline mapping catheter (Octaray; Biosense Webster, Irvine, CA) improves the accuracy of OWM and helps identify complex septal AP locations.
- Differential diagnosis is necessary to determine whether the septal conduction is through an AP or the atrioventricular node. Efforts should be made to identify the His bundle recording site to avoid injury to the intrinsic conduction system.

KEYWORDS Accessory pathway; Catheter ablation; Electroanatomic mapping; Open-window mapping; Wolff-Parkinson-White syndrome
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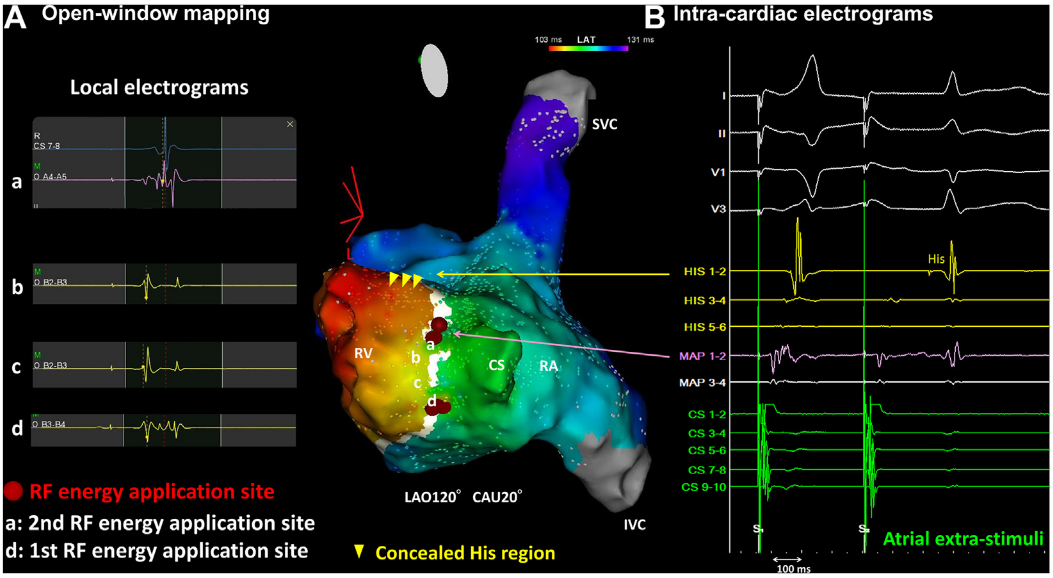

Figure 1 **A:** The dual-chamber open-window activation map created using the CARTO 3 system and Octaray mapping catheter (both Biosense Webster, Irving, CA). During ventricular pacing, the ventriculoatrial conduction was evaluated and 2 conduction breakthrough sites (sites **a** and **d**) were identified in the posterior septum and midseptum. **B:** Intracardiac electrograms during atrial extrastimuli. The delta wave on the surface electrograms diminished, and a high-frequency clear His potential was recorded on the His electrodes. In contrast, His potential was not recorded on the distal tip of the ablation catheter placed at the midseptal breakthrough site (site **a**). See text for details. I, II, V_1, and V_3 represent surface electrocardiogram; HIS 1–2 and 5–6 represent distal-to-proximal His catheter electrograms; MAP 1–2 and 3–4 represent distal-to-proximal ablation catheter electrograms; and CS 1–2 to 9–10 represent distal-to-proximal CS recordings. CS = coronary sinus; HIS = His bundle; IVC = inferior vena cava; LAO = left anterior oblique view; RA = right atrium; RF = radiofrequency; RV = right ventricle; SVC = superior vena cava.

(site d in Figure 1A). Radiofrequency energy applications at 20–30 W using the ThermoCool STSF catheter (Biosense Webster, Irvine, CA) resulted in the separation of the local electrograms (Figure 2). Nevertheless, the delta wave persisted, but the amplitude of the negative delta waves in the inferior leads decreased, indicating a change in the ventricular propagation (Supplemental Figure 1). Therefore, we inferred the presence of 2 APs, with the midseptal AP constituting the residual AP conduction.

Although the midseptal site (site a in Figure 1A) was distant from the His catheter on the fluoroscopic images, undetermined His recordings made us cautious about the potential proximity to the intrinsic conduction system. In addition, the relatively sharp local electrograms made us consider

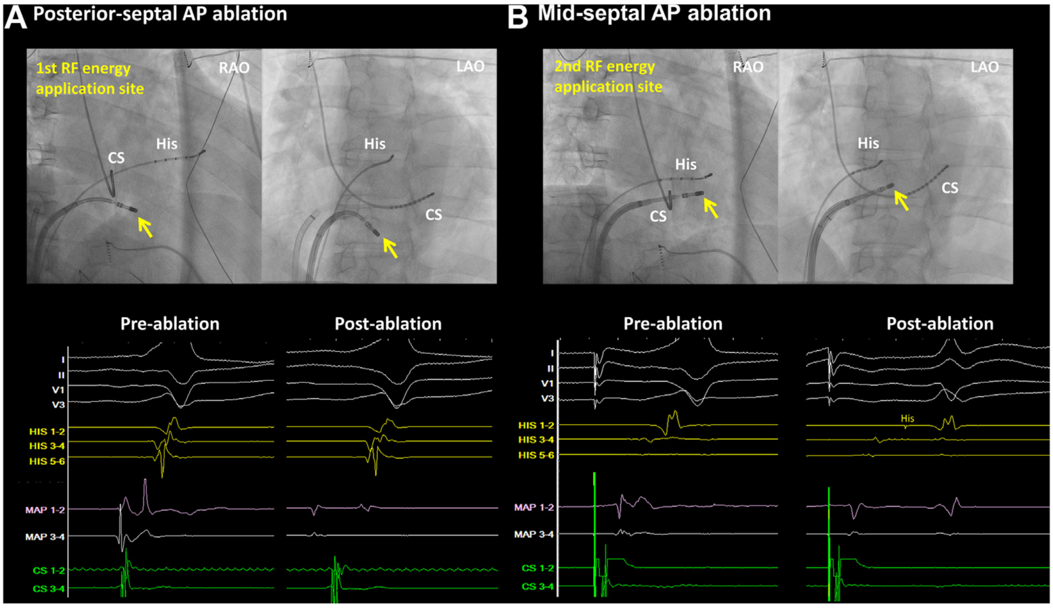

Figure 2 Fluoroscopic images and intracardiac electrograms during catheter ablation of the septal APs. The yellow arrow indicates the RF energy application site for the posterior septal AP (left panel) and midseptal AP (right panel). AP = accessory pathway; RAO = right anterior oblique view. Other abbreviations are as in Figure 1.

the possibility of overlapping with the His bundle potentials. Fortunately, the antegrade conduction via the residual AP became refractory with atrial extrastimulus pacing (600/360 ms), allowing us to observe the His bundle potentials on the distal electrode of the His catheter (Figure 1B). Moreover, the ablation catheter placed at the midseptal conduction (site a in Figure 1A) recorded a separation of the atrial and ventricular potentials and failed to record the His bundle electrograms between them. The disappearance of the middle part of the fragmented potentials indicated that the sharp component interposed between the atrial and ventricular potentials was of AP origin. These findings suggested that the midseptal conduction originated from the AP conduction and was distant from the His bundle recording site. During atrial pacing, radiofrequency energy was applied to the midseptal AP at 10 W, resulting in the disappearance of the delta wave within 1 second. We cautiously increased the radiofrequency power to 30 W while carefully observing the constant atrial-His intervals. Subsequent electrophysiological studies demonstrated decremental AV conduction with no evidence of dual pathways and the absence of VA conduction. The patient was discharged without antiarrhythmic drugs and has remained free from presyncope.

Discussion

Identifying septal APs can be challenging owing to their variations, including oblique running, broadband nature, and multiple conduction pathways.[4] In this case, however, the OWM and EEML algorithm successfully visualized 2 septal conduction pathways 12.4 mm apart, using the Octaray catheter. The Octaray catheter with 48 closely spaced small microelectrodes (0.9 mm^2) allows a higher sampling rate and denser mapping points, thereby enhancing the accurate annotation of the local electrograms.[5] Certainly, the EEML algorithm can be arbitrary according to the threshold settings. However, the local electrograms along the white line clearly showed separate potentials, whereas those at the breakthrough sites exhibited continuous AP potentials between the ventricular and atrial potentials (Figure 1A).

During septal AP ablation, it is crucial to consider the possibility of damaging the intrinsic conduction system, as the His bundle and AV node are located in the anterior septum and midseptum, respectively. The OWM and EEML algorithm, along with the Octaray catheter, can accurately identify the septal APs, thereby potentially reducing injury risk to the conduction system. However, over-reliance on these technologies should be approached with caution, as they may not provide adequate information to assess whether the septal conduction is safe for energy delivery. Since several septal APs exhibit decremental properties,[4] a careful and comprehensive evaluation may be necessary to determine whether the delineated conduction originates from the AP or nodal pathway. Erroneous recognition of nodal conduction as AP conduction can directly cause injury to the intrinsic conduction system. In this study, we used atrial extrastimuli to demonstrate that the midseptal conduction was distinct from the His recording area. Classical maneuvers are still important to identify the His bundle recording area.

Conclusion

OWM and the EEML algorithm are useful for identifying the location, width, and propagation paths of septal APs. The new multi-spline mapping catheter has improved the density and accuracy of OWM, refining the EEML tool and enabling a more detailed visualization of septal conductions in patients with septal APs. However, efforts should not be forgotten to differentiate septal AP conduction from nodal conduction to avoid injury to the intrinsic conduction system.

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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.2023.12.010.

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