Open-window mapping and the extended early-meets-late algorithm for the Wolff–Parkinson–White syndrome

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A 26-year-old otherwise healthy woman with palpitations for as long as she could remember was evaluated for elective catheter ablation. Her 12-lead electrocardiogram (ECG) was consistent with the Wolff–Parkinson–White (WPW) syndrome (Figure 1A). It demonstrated R < S in lead V₁ and delta wave polarities that were positive in the initial 20 ms in leads I, II, III, aVF, and V₁.

Electroanatomic mapping (EAM) was performed using the CARTO 3 System (Version 6, Biosense Webster). Reconstruction of the right atrium and the right ventricle was performed with a 20-electrode, 5-spline PENTARAY Catheter (Biosense Webster). The coronary sinus was reconstructed with an irrigated THERMOCOOL SMARTTOUCH Catheter (Biosense Webster). This was exchanged for a DECANAV Catheter (Biosense Webster). Supraventricular tachycardia (SVT) was induced. Observations supported orthodromic reentrant tachycardia (ORT) using a right free wall atrioventricular (AV) accessory pathway.

Open-window mapping was performed with windows of interest parameters set to analyze both atrial and ventricular signals (Figure 1B). The sinus rhythm window of interest was referenced to the peak of the QRS complex in lead V₆ and set from just prior to the onset of the P wave to the end of the QRS complex, or from −250 ms to 60 ms. The right ventricular pacing window of interest was referenced to the pacing stimulus artifact and set from 20 ms to 200 ms. The ORT window of interest was referenced to the peak of the QRS complex in lead V₆ and set from −100 ms to 200 ms.

Open-window maps with the extended early-meets-late (EEML) algorithm were created in sinus rhythm (1775 points), right ventricular pacing (2041 points), and ORT (4042 points); the ORT map was used for catheter ablation (Figure 2). EEML was adjusted to the propagation map such that the EEML gap served as a visual estimation of the pathway (Figure 3 and Figure 4). In the ORT map, the EEML gap was located at the right superior AV junction segment and suggested the atrial insertion site. It measured 7 mm.

Initial ablation lesions, displayed on final EAM images in Figure 2D, were delivered where AV fusion with accessory pathway potentials was visualized during sinus rhythm (lesion #1, Figure S1) and where VA fusion was seen during ORT (lesion #7). Promising sites within the EEML gap were not seen and, in retrospect, likely due to poor contact. Radiofrequency energy was delivered with a power of 30 W, a temperature limit of 43°C, and for up to 60 s for all lesions. Contact force was less than 5 g for all lesions. Pre-excitation persisted and ORT remained inducible.

A CARTO VIZIGO long sheath (Biosense Webster) was introduced. Higher contact force, approximately 10 g, was achieved within the EEML gap. Lesion #12 was delivered along the septal aspect of the pathway during ORT, led to an increase in local VA time just prior to arrhythmia termination during ablation, but pre-excitation continued (Figure S2). Lesion #13 was delivered along the anterior (free wall) aspect of pathway where a catheter “bump” led to loss of pre-excitation. Less prominent pre-excitation returned and lesions were delivered to fill the EEML gap and eliminate residual anterograde conduction. Two consolidation lesions, each 60 s, were delivered.

There was no evidence of pre-excitation or inducible arrhythmias after ablation, on isoproterenol 1 mcg/min, and after isoproterenol washout. Zero fluoroscopy was used.

High-density mapping with the CARTO 3 System (Version 6) is performed through an automatic annotation method, the CONFIDENSE Mapping Module. The Continuous Mapping Feature performs rapid, ongoing point acquisition for points that satisfy predefined filters. The Tissue Proximity Technology uses impedance measurements to determine the distance to cardiac tissue. If the calculated distance is less than the radius of the electrode of...
the mapping catheter, the electrode is considered to be touching. Wavefront Mapping Annotation analyzes each distal unipolar signal for the greatest negative deflection, or maximum −dV/dt, and marks it as the local activation time. This is displayed on the corresponding bipolar signal. In the reported patient, unipolar signals were referenced to the proximal electrode on the DECANAV Catheter, as opposed to Wilson Central Terminal, for the cleanest signal.

Open-window mapping analyzes the sharpest signal, or the maximum −dV/dt, at each acquired point, irrespective of the cardiac chamber or the conduction pathway of origin. It allows for simultaneous mapping of both atrial and ventricular signals. This contrasts with conventional mapping, where errors can be introduced when signals are not annotated to the correct cardiac chamber.
During ORT, the window of interest is set with the signals corresponding to the estimated expected location of the accessory pathway as the mid-point. The window is opened in forward and backward directions to accommodate atrial and ventricular signals throughout the entire tachycardia CL. In traditional mapping for reentrant arrhythmias, the early-meets-late, or head-meets-tail, is configured to localize the mid-diastolic activated isthmus. Colors (red → orange → yellow → green → cyan → blue → purple) are designated for chronology within each cycle with the mid-diastolic isthmus represented by the interface between red and purple. For open-window mapping of ORT, the CARTO color scheme will likely approximate the accessory pathway at the yellow → green transition. The breakout point is the point corresponding to the earliest maximum dV/dt in the chamber of exit from the pathway.

EEML has adjustable upper and lower threshold values. The lower threshold value displays areas of local conduction block as white lines. These correspond to areas where adjacent points...
have differences in local activation times that are greater than the lower threshold, but less than the upper threshold. This may be used to estimate the valve annulus. A discontinuity in the white line, or EEML gap, may correlate with an accessory pathway and can be adjusted to match propagation mapping to serve as a visual aid.

This is the first report describing open-window mapping with the EEML algorithm to enhance visualization of the location and width of an AV accessory pathway. This may be particularly useful when linear or cluster ablation lesion sets are required for wide pathways.

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CONFLICT OF INTEREST
None.

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ETHICS APPROVAL
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PATIENT CONSENT
Written informed consent was obtained from the patient.

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SUPPORTING INFORMATION
Additional supporting information may be found in the online version of the article at the publisher’s website.

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