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CASE REPORT
Electrophysiology

A novel peak frequency mapping algorithm for the precise localization of accessory pathways in the middle cardiac vein: a case report

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Background Advancements in three-dimensional mapping systems have enhanced the precise accessory pathway (AP) localization and conduction properties. However, accurately identifying the earliest atrial or ventricular activation sites remains challenging, particularly in cases with multiple insertions or epicardial connections.

Case summary A 24-year-old woman with palpitations and a manifest Wolff–Parkinson–White syndrome Type A underwent catheter ablation. Local activation time mapping revealed extensive conduction in the posterior mitral annulus, with a peak frequency (PF) of 291 Hz at the earliest ventricular and earliest atrial activation sites on the endocardium in the omnipolar technology near field (OTNF) mapping. The coronary sinus and middle cardiac vein were additionally mapped using an ablation mapping catheter and a 1.6-Fr electrode catheter. Emphasis mapping identified the Kent bundle location during right ventricular pacing using local activation time and PF mapping. A narrower region of atrial insertion at the entrance of the middle cardiac vein was revealed, with a PF of 645 Hz. The AP connection successfully disappeared 8 s after ablation to the entrance of the middle cardiac vein. At the 3-month follow-up, the patient showed no recurrence of delta waves on the electrocardiogram or related symptoms.

Discussion The novel OTNF concept further enhances this function by differentiating far-field potentials based on annotated PFs. The use of PF values with novel OTNF mapping proved valuable in identifying optimal target sites for the ablation of APs. The combination of OTNF mapping and advanced ablation catheters may enable the precise targeting of specific AP sites.

Keywords Ablation • Accessory pathway • Case report • Epicardium • Omnipolar technology near field • Peak frequency

ESC curriculum 5.5 Supraventricular tachycardia • 5.1 Palpitations

Learning points

- A novel mapping algorithm of omnipolar technology near field (OTNF) and peak frequency mapping facilitated an accurate identification of accessory pathway (AP) within the middle cardiac vein, resulting in successful catheter ablation.
- The OTNF mapping and advanced ablation catheters contributed to precise AP identification, a shortened procedure time, and reduced invasiveness, leading to more effective ablation outcomes.

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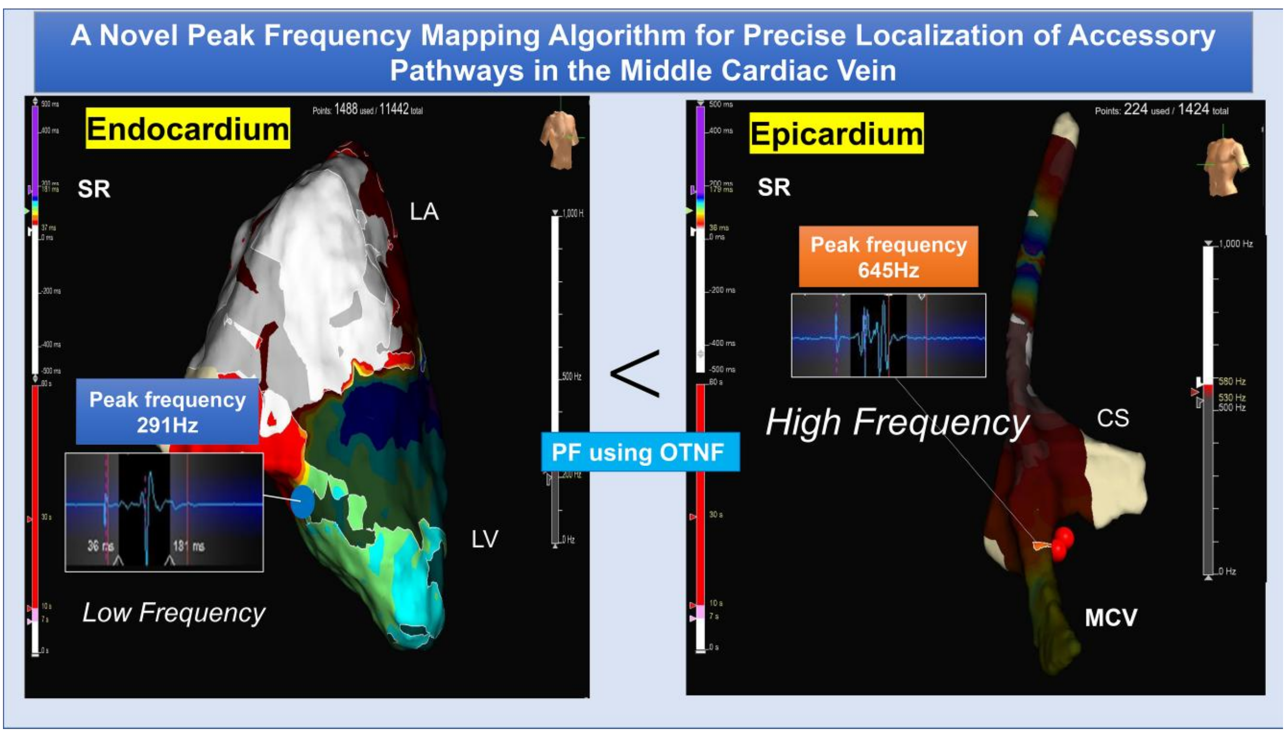
Introduction

Wolff–Parkinson–White (WPW) syndrome is a congenital cardiac anomaly characterized by aberrant electrical conduction through an accessory pathway (AP). Catheter ablation successfully eliminates APs;[1,2] however, accurately identifying the earliest atrial or ventricular activation sites remains challenging, particularly in cases with multiple insertions or epicardial connections. Omnipolar technology near field (OTNF) mapping employs electrogram frequency analysis to distinguish localized signals, differentiating near-field from far-field electrograms.[3] We present a case of manifest WPW syndrome with an AP within the middle cardiac vein (MCV), identified using OTNF and peak frequency (PF) mapping, culminating in successful catheter ablation.

Summary figure



Case presentation

A 24-year-old woman with no significant medical history presented to our institution with palpitations. Examination revealed a blood pressure of 138/76 mmHg and a heart rate of 64 b.p.m.; no abnormalities were observed, supported by laboratory data. A Holter electrocardiogram (ECG) during symptomatic episodes revealed narrow QRS tachycardia at 180 b.p.m. Transthoracic echocardiography demonstrated normal cardiac function. Electrocardiogram revealed pre-excitation sinus rhythm (*Figure 1A*); the delta wave was negative in Leads II, III, and aVF and positive in Leads V1 and V2. Accordingly, manifest WPW syndrome Type A, with possible epicardial AP involvement, was diagnosed.[4] This study complied with the World Medical Association Declaration of Helsinki and was approved by the Ethics Committee.

Catheters were positioned in the right atrial appendage, His-bundle region, coronary sinus (CS), and right ventricular (RV) apex during electrophysiological study, revealing non-decremental ventricular-to-atrial conduction during RV pacing, with the earliest atrial activation site identified at the mitral valve's 6 o'clock position. Accordingly, orthodromic atrioventricular reciprocating tachycardia was defined (*Figure 1B*).[5] High-density mapping of the left atrium (LA) was performed using a mapping catheter (HD Grid, Abbott) in voxel mode with the three-dimensional (3D) mapping system (EnSite X, Abbott) and a nominal 300-Hz low-pass filter. Open-window mapping during sinus rhythm with local activation time revealed extensive atrioventricular conduction in the posterior mitral annulus, with a PF of 291 Hz at the earliest ventricular activation site on the endocardial mitral annulus (*Figure 2A*). Subsequent open-window mapping of the endocardial LA during RV apex pacing at 100 b.p.m. showed atrial insertions dispersed over the posterior mitral annulus, complicating Kent bundle localization (*Figure 2B*). Given this distribution, an endocardial AP was unlikely (see Supplementary material online, *Video S1*). Therefore, an ablation mapping catheter (TactiFlex SE, Abbott) and a 1.6-Fr electrode catheter (Skinny, Kaneka) in NAVX mode mapped the CS and MCV. Coronary sinus contrast revealed no diverticula in the MCV (see Supplementary material online, *Figure S1*). Emphasis mapping (overlaying additional maps based on specific characteristics) identified the Kent bundle location during RV pacing using local activation time and PF mapping. The PF cut-off value, initially set at 250 Hz, was increased in 50-Hz increments.[6] A narrower region of atrial insertion at the entrance of the MCV was found, with a PF of 645 Hz—significantly higher than that in endocardial LA sites on the mitral annulus (*Figure 3*). Local potentials, potentially related to APs, were noted at the emphasized site. The target site at the MCV entrance was subsequently ablated via the right internal jugular vein using an irrigated ablation catheter with a power

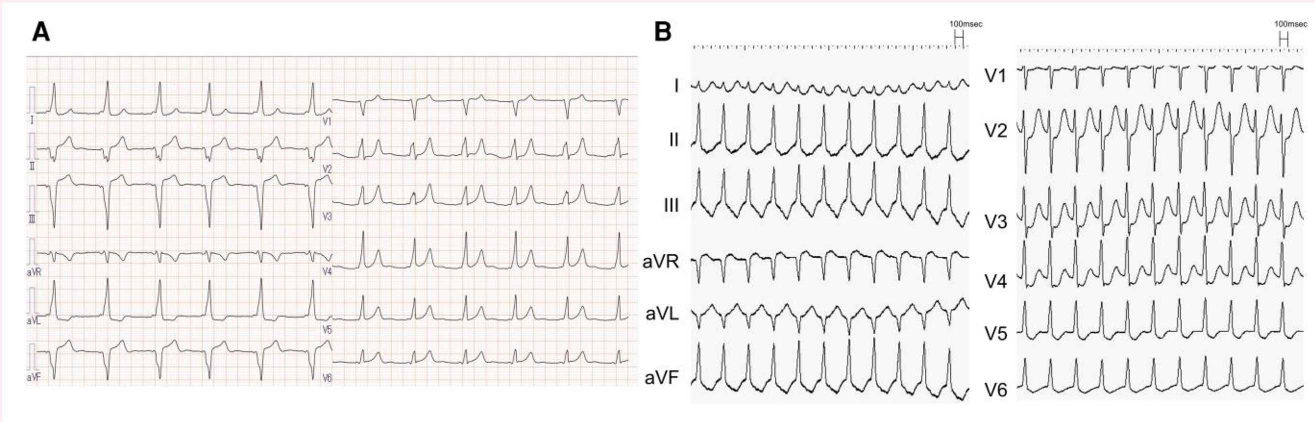


Figure 1 Twelve-lead surface electrocardiogram. (*A*) Electrocardiogram during sinus rhythm. Delta waves were negative in Leads II, III, and aVF and positive in Leads V1 and V2, suggesting an epicardial connection for the accessory pathway. (*B*) Electrocardiogram during atrioventricular reciprocating tachycardia.

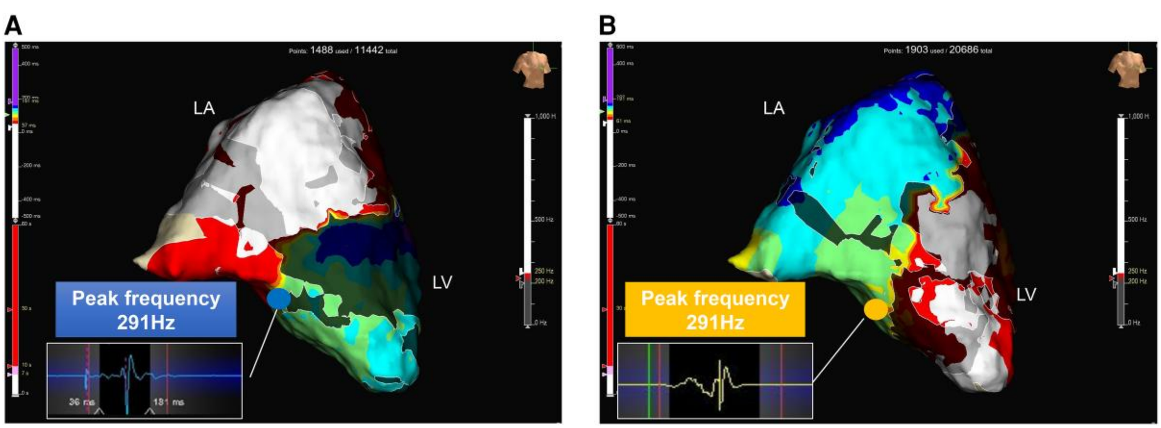


Figure 2 Local activation time map for the left atrium. (*A*) Local activation time map during sinus rhythm. The blue point is the earliest activation ventricular activation site on the mitral annulus in the right anterior oblique view. (*B*) Local activation time map during right ventricular pacing. The orange point highlights the extensive area of atrial insertion in the right anterior oblique view. LA, left atrium; LV, left ventricle.

setting of 30 W. The delta wave on the ECG disappeared 8 s after ablation initiation. Energy was applied for 30 s, with impedance decreasing from 150 to 140 Ω. Retrograde conduction through the Kent bundle was not observed post-ablation with RV pacing. After ablation, isoproterenol was infused (0.1 μg/kg/min) for 20 min and a bolus infusion of 40 mg adenosine triphosphate was administered; no recurrences of the Kent bundle were noted, and no complications occurred. At the 3-month follow-up, the patient showed favourable clinical outcomes, with no recurrence of delta waves on repeat ECG or related symptoms, allowing for a return to normal activities.

Discussion

Herein, the significantly higher PF of local potentials in the MCV compared with those in the endocardial area—where annotations were clearly assigned to near-field components—suggests the AP may attach to the epicardial site of the MCV rather than the LA endocardium. The high PF obtained using the OTNF algorithm may assist in determining AP localization and formulating ablation strategies. Although the optimal PF cut-off to distinguish distal far field from near field has not been defined, we posit that PF values may vary according to local myocardial characteristics, necessitating individualized assessment based on overall PF trends.

The reason for the elevated PF of Kent bundle potentials in this case remains unclear; however, the high frequency may indicate complex AP conduction mechanisms, possibly involving multiple microchannels and increased abnormal conduction velocity.[7–9] Accessory pathway conduction involves propagation through the atrial and ventricular myocardium, and a sudden change in wavefront propagation in the boundary zone might be crucial in changing the propagation direction at the microlevels. We reported a similar case in which the epicardial AP was identified using OTNF, although the successful ablation site was not within the MCV.[3] This and the previous case differ in the AP location (MCV vs. body of the CS) and PF values (645 vs. 245 Hz). Differences in catheter electrode size and spacing may affect PF measurements. However, hypotheses require further verification through simulation-based or experimental studies.

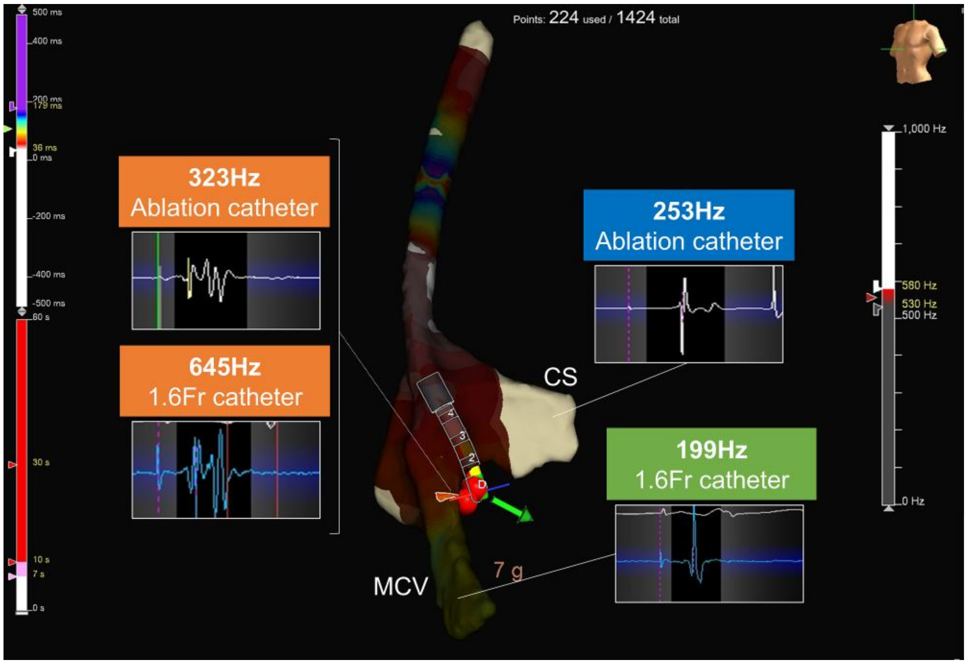


Figure 3 Peak frequency map of the middle cardiac vein during sinus rhythm and the successful ablation site. Left anterior oblique view. The highest peak frequency observed at the middle cardiac vein ostium was 645 Hz recorded on a 1.6-Fr catheter. Red tags indicate successful ablation points. CS, coronary sinus; MCV, middle cardiac vein.

For mapping within the MCV, the internal jugular vein is often preferred due to difficulties in catheter insertion through the femoral route. However, in the present case, mapping in the MCV was performed using a 1.6-Fr catheter rather than a high-density mapping catheter. Nonetheless, OTNF can be applied to electrograms obtained with standard electrode catheters, in addition to grid catheters (despite a high associated cost) and other catheters, including the TactiFlex ablation catheter, demonstrating its versatility and utility.

Previous studies have documented successful catheter ablation of APs within the MCV.[10–12] Typically, AP ablation at the MCV relies on detecting local potentials, such as ventriculoatrial fusion or AP potentials. Moreover, ablation using a monophasic action potential reportedly improves catheter contact with the epicardium, thereby enhancing safety.[11] However, these approaches often prolong the identification process and may result in inadequate ablation, necessitating multiple radiofrequency applications.[10] There remains a risk of complications, such as coronary injury and perforation, particularly with high-power, non-irrigated ablation catheters.[12,13] In contrast, our novel approach incorporating 3D mapping, OTNF, and PF mapping enables objective visualization of the AP location by annotating true AP potentials. In particular, the use of an irrigated-tip ablation catheter facilitates a higher power setting, with adjustable irrigation flow according to catheter contact and orientation. During mapping and ablation in the CS, great care must be taken using fluoroscopy images of cardiac shadows along with monitoring of the ECG and patient vital signs. Fortunately, we observed no adverse events, including ST-segment changes and patient symptoms. Although coronary angiography was not performed in this case, it is important to acknowledge the substantial risks associated with CS ablation. These advancements contribute to precise AP identification, shortened procedure times, and reduced invasiveness, leading to more effective ablation outcomes; nevertheless, this case had a short-term follow-up of 3 months, requiring confirmation of long-term outcomes. Omnipolar technology near field has been reported for atrioventricular nodal re-entrant tachycardia ablation and LA posterior wall isolation.[9,14] Studies using large sample sizes are necessary to validate PF algorithm-guided AP ablation.

Overall, a novel OTNF and PF mapping algorithm facilitated accurate AP identification, resulting in successful catheter ablation.

Lead author biography

Dr Gen Fujiwara is a dedicated cardiologist with subspecialty in arrhythmia, heart failure, and device therapy at Yokkaichi Municipal Hospital in Mie, Japan. He received his medical degree at Mie University in 2019. He was medical staff in cardiology at Yokkaichi Municipal Hospital in 2019–2022 and 2024.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports* online.

Consent: The authors affirm that the patient provided written informed consent for the submission and publication of this case report, including all associated images and text, in compliance with COPE guidelines.

Conflict of interest. None declared.

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Data availability

All data supporting this study are presented within the article.

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