Usefulness of omnipolar technology near field for accessory pathway ablation through the coronary sinus

Yoshiaki Mizutani, MD, PhD,* Satoshi Yanagisawa, MD, PhD,† Yuma Matsumoto, MT,‡ Masaaki Kanashiro, MD, PhD,* Yasuya Inden, MD, PhD,† Toyoaki Murohara, MD, PhD†

*From the *Department of Cardiology, Yokkaichi Municipal Hospital, Yokkaichi, Japan, †Department of Cardiology, Nagoya University Graduate School of Medicine, Nagoya, Japan, and ‡Department of Clinical Laboratory, Yokkaichi Municipal Hospital, Yokkaichi, Japan.*

Introduction

The current 3-dimensional mapping system can annotate both near- and far-field electrograms in a voltage map and a local activation map, sometimes resulting in confusion in the identification of precise conduction pathways and tachycardia circuits. This may be because detection algorithms, such as maximum/minimum dV/dt, may preferentially annotate potentials with large amplitudes. Omnipolar technology near field (OTNF) is a novel mapping algorithm used to isolate true localized signals using a unique frequency analysis on electrograms, with the potential benefit of distinguishing near-field electrograms from far-field ones. Herein, we present a case of successful catheter ablation of the accessory pathway using OTNF through a frequency analysis of local electrograms.

KEY TEACHING POINTS

- A peak frequency map of omnipolar technology near field (OTNF) distinguished exact locations of the accessory pathways passing through an epicardial bypass of the coronary sinus from the far-field potential of the Kent bundle obtained in endocardial left atrial mapping.
- The accessory pathway location could be determined using an emphasis map combined with a local activation map and peak frequency map, resulting in successful ablation.
- A novel mapping algorithm of OTNF can facilitate further understanding of the complex mechanisms underlying the electrical properties of the human heart.

Case report

A 54-year-old man was referred to our hospital with palpitations. Electrocardiogram (ECG) revealed atrial fibrillation (AF) and pseudo–ventricular tachycardia consistent with palpitations (Figure 1A). Electrical alternance between normal QRS complexes and pre-excited complexes was also observed. During the sinus rhythm, a constant delta wave was observed (Figure 1B). Owing to the occasional occurrence of intolerable palpitations of AF and pseudo–ventricular tachycardia, the patient was scheduled for catheter ablation after providing informed consent. The patient had a history of renal transplantation for immunoglobulin A nephropathy and parathyroid transplantation for hyperparathyroidism and hypertension. Preoperative echocardiography revealed a normal left atrium (LA) with a LA volume of 33 mL and volume index of 18 mL/m^2. Plain chest computed tomography revealed a slightly dilated coronary sinus (CS). This study was approved by the institutional review board in Yokkaichi Municipal Hospital.

At the beginning of catheter ablation, a 12-lead surface ECG demonstrated an intermittent wide QRS during sinus rhythm. First, pulmonary vein isolation (PVI) was performed after transseptal puncture using an irrigated ablation catheter (TactiFlex™; Abbott, St. Paul, MN) and 3-dimensional electroanatomical mapping (EnSite™ X EP System; Abbott) owing to the relatively high age of the patient and the results of a recent study showing that accessory pathway ablation alone was associated with a higher incidence of AF recurrence in patients older than 50 years of age.[1] Successful PVI was confirmed by LA mapping using a high-density mapping catheter (Advisor™ HD Grid; Abbott).

A subsequent electrophysiological study demonstrated nondecremental ventricular (V)–atrial (A) conduction during V pacing, and the earliest atrial activation site was identified as the CS ostium. The effective refractory periods of the anterograde and retrograde Kent bundles were 500 ms and 340 ms, respectively. No paroxysmal supraventricular

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Address reprint requests and correspondence: Dr Yoshiaki Mizutani, Department of Cardiology, Yokkaichi Municipal Hospital, 2-2-37, Shibata, Yokkaichi, Mie, 5108567, Japan. E-mail address: yoshiaki522000@yahoo.co.jp.

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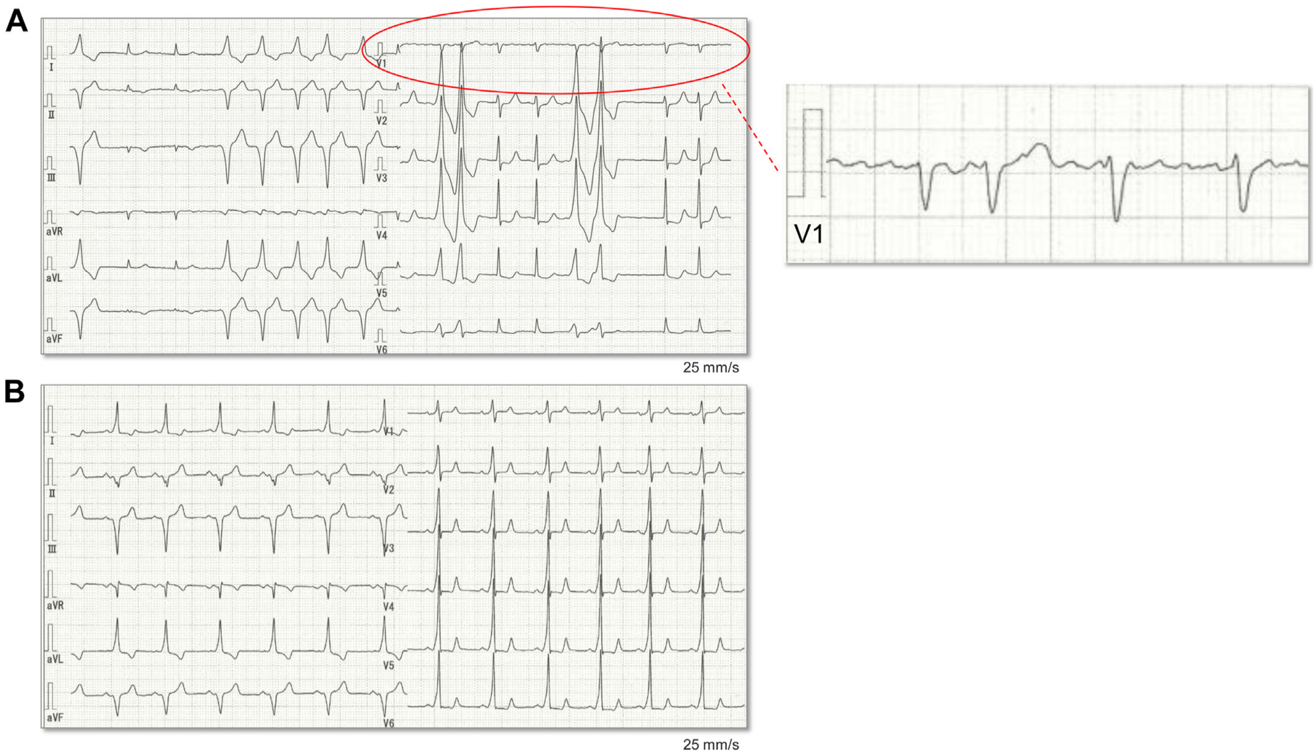

Figure 1 Twelve-lead surface electrocardiograms. **A:** Atrial fibrillation and pseudo–ventricular tachycardia. The lead in V_1 is scaled up (10 mm = 1 mV) and zoomed. Electrical alternance between normal QRS complexes and pre-excited complexes was observed. **B:** Sinus rhythm. Wide QRS and delta waves are suspected to indicate the presence of an anterograde accessory pathway.

tachycardia was induced, despite repeated pacing stimulation with isoproterenol loading. Pacing stimulation from the CS electrode catheter positioned at the mitral lateral wall revealed a distinct potential of the Kent bundle. Therefore, further electroanatomical mapping of the LA and CS was performed to evaluate the conduction of the Kent bundle during the constant atrial pacing from the distal CS electrode catheter at 110 beats/min. The LA was mapped

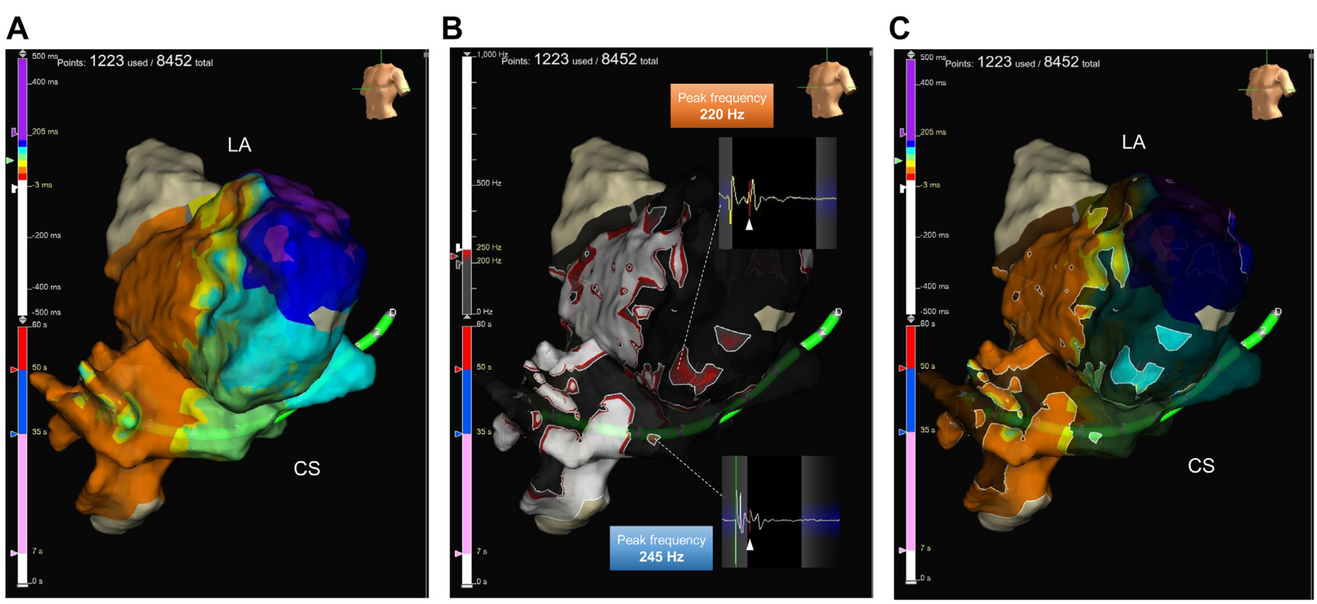

Figure 2 Electroanatomical maps for the left atrium and coronary sinus. **A:** Local activation map during the pacing rhythm from distal coronary sinus (CS) electrodes. The left anterior oblique view. **B:** Peak frequency map. Left anterior oblique view. The frequency cutoff value was set to 200 Hz. The peak frequency was significantly higher on the CS side (245 Hz) than on the left atrium (LA) side (220 Hz), and the highlighted area of the high peak frequency was more focused on the narrow region in the CS. White triangles indicate annotation points. **C:** Emphasis map combined with the local activation and peak frequency maps. Left anterior oblique view.

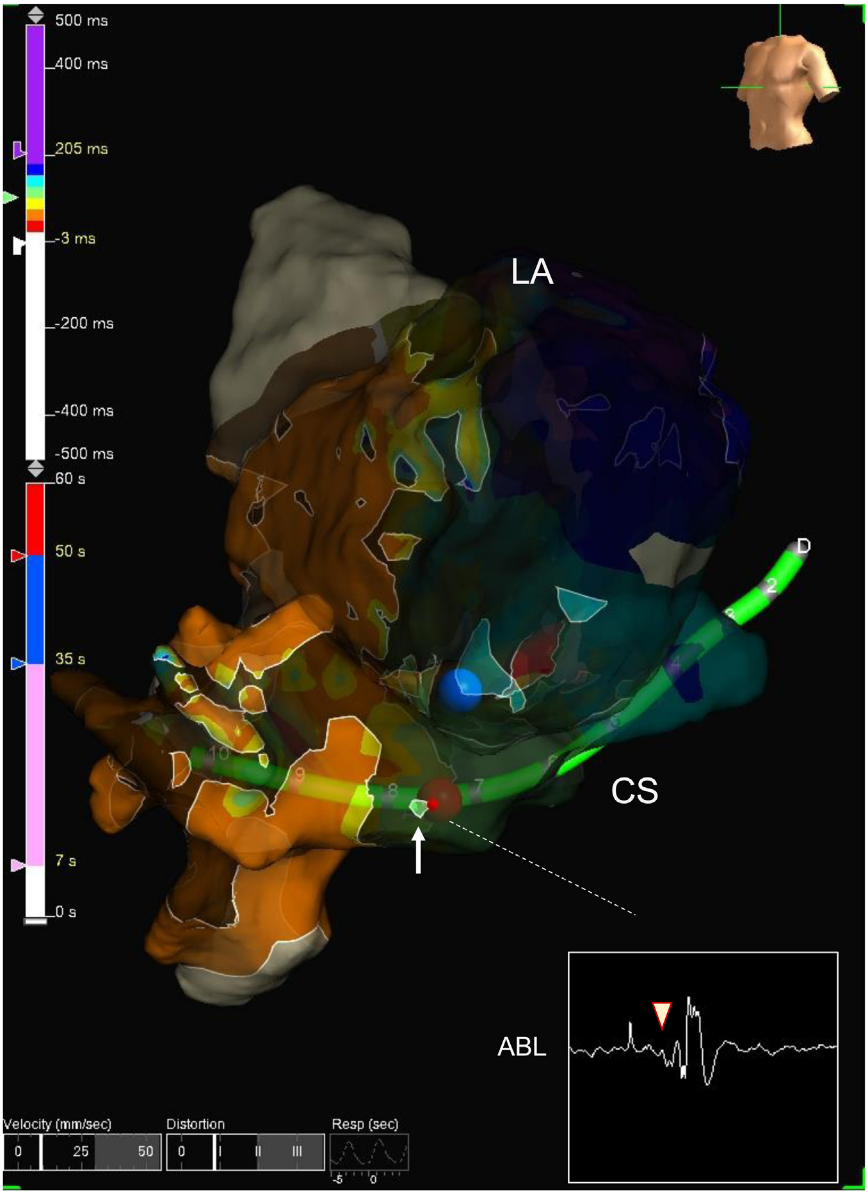

Figure 3 Successful ablation site. The red tag on the highlighted area (*white arrow*) in the coronary sinus (CS) image shows the successful ablation point. The blue tag indicates an unsuccessful ablation point in the left atrium (LA). Light yellow triangle indicates a Kent potential on the intracardiac electrograms recorded in the ablation catheter.

with an HD Grid catheter, whereas the intra-CS was mapped with an ablation catheter. The navigation mode was set to voxel mode to minimize catheter misalignment. Open-window mapping was performed to identify the precise site of the Kent bundle, and the detection algorithm was set to the near field.

The local activation map showed a wide range of atrioventricular conduction at the posterior site of the LA, making it difficult to identify the Kent bundle accurately (Figure 2A). In the peak frequency map, the frequency zone window was adjusted to clarify the Kent bundles. The peak frequency map highlighted the posterior site of the LA at the 6-o'clock position of the mitral valve and CS ostium when the peak frequency detection in the near field was set to 200 Hz. Local potentials with low amplitudes between components A and V were observed at the same site, suggesting the presence of Kent potentials (Figure 2B).

The emphasis map is a specific combined map in which another map is overlaid on the selected map as a base, allowing us to focus on the region of interest based on potential characteristics. The location of the Kent bundle was determined using an emphasis map combined with a local activation map and a peak frequency map (Figure 2C). The frequency of the highlighted area of the LA was 220 Hz. However, the annotation point in the frequency analysis was marked in the V component but not in the Kent bundle (Figure 2B). The highlighted area on the endocardial site was first targeted with an irrigated ablation catheter with a 35 W output, and the delta wave on the ECG disappeared in 3 seconds. However, after 60 seconds of ablation, a delta wave appeared again. Therefore, ablation was attempted using CS. The peak frequency in the highlighted area of the CS contralateral to the first endocardial ablation point was 245 Hz, which is higher than that in the LA endocardium. At this site, the annotation point was clearly assigned to the electrogram of the Kent bundle using frequency analysis (Figure 2B). The delta wave disappeared 3 seconds after the ablation of the highlighted area of the CS (Figure 3). The retrograde Kent bundle was eliminated. No recurrence of the Kent bundles was observed after ablation with isoproterenol or adenosine triphosphate. No complications such as atrioventricular block occurred. At the follow-up of 2 months after ablation, the patient had no symptoms or recurrence of the delta wave or AF on ECG.

Discussion

To the best of our knowledge, this is the first case to use OTNF for identifying the epicardial Kent bundle and for successful catheter ablation. Omnipolar mapping is a useful tool for acquiring optimal local electrogram signals from omnipolar signals at 360°, calculated from cliques, composed of 3 unipoles and 2 orthogonal bipoles, which are useful for assessing the gaps after PVI and various arrhythmias.[2–4] However, detection algorithms such as maximum/minimum dV/dt can involve some dull potentials with large amplitudes, indicating far-field potentials. The novel concept of OTNF enables us to distinguish far-field potentials by annotations of the peak frequency with the setting detection to near-field scaling, regardless of the local amplitude.

In the present case, annotations were automatically assigned to the near field of the V component but not to the local potentials between the A and V components in the endocardial mapping. In addition, the peak frequency at the endocardial site was moderate and spread over a wide area with the same frequency on the map, indicating that the origin of the Kent bundle was located far from the endocardium. In contrast, the higher peak frequency and narrower highlighted area in the CS than in the endocardial area in the LA suggests that the Kent bundle passes through the epicardial side. At this site, the annotation point was clearly assigned to the interpotentials with the possibility of the Kent potential, where the electrograms originated from the near side with a high peak frequency in the frequency map. This hypothesis is also supported by the finding that elimination of the Kent bundle was achieved through the CS approach but not endocardial ablation. Peak frequency analysis of the electrogram and the highlighted area in the frequency mapping were helpful in guiding an appropriate targeting point for ablation and clinical success, as in the present case.

The feasibility of an automated, high-density mapping system for identifying accessory pathway locations with open-window mapping has been reported.[5,6] In the present case, the accurate pathway of the Kent bundle could not be identified in the local activation map with open-window mapping. However, the epicardial Kent bundle could be clearly identified using the novel OTNF mapping tool. The major novelty of this case report is that the Kent potentials, which the standard mapping algorithm including open window mapping cannot annotate automatically, could be firmly annotated within the CS using a novel mapping tool of the peak frequency analysis. It is also important to note that endocardial mapping from the LA annotated the ventricular electrogram alone but not the far-field Kent potentials, which contrasted with the finding from the CS mapping. This case highlights the theory of distinguishing near-field and far-field potential clearly using a new algorithm of the peak frequency analysis, with a potential implication for further improvement of electroanatomical mapping and quality of treatment. The results of our case may allow the critical isthmus for ablation to be better defined and targeted, thereby avoiding an excessive, unnecessary ablation. This new technology can facilitate further understanding of the complex mechanisms underlying the electrical properties of the human heart from an electrophysiological perspective.

Conclusion

This novel mapping algorithm for peak frequency analysis of an electrogram using OTNF may be useful for identifying the precise location of the Kent bundle.

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