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ELECTROPHYSIOLOGY

CASE REPORT: CLINICAL CASE

Coexistence of a Classical Nodoventricular Accessory Pathway With a Left-Sided Mahaim Accessory Pathway

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ABSTRACT

The coexistence of 2 Mahaim pathways represents a diagnostic challenge. We present a case in which the SH/HA intervals were useful for identifying concealed nodoventricular or His-ventricular pathways. (J Am Coll Cardiol Case Rep 2024;29:102220) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 78-year-old man was referred to our institution (Nagoya Ekisaikai Hospital) for catheter ablation of symptomatic and Class Ic drug-resistant pre-excited atrial fibrillation (AF) with a right bundle branch configuration and superior axis (**Figure 1A**). The shortest RR interval was 260 ms. A 12-lead electrocardiogram recorded during sinus rhythm showed minimal pre-excitation (**Figure 1B**). The patient's vital signs and physical examination were unremarkable.

LEARNING OBJECTIVES

- To be able to diagnose the NV/HV pathway by observing SH/HA intervals during RV extrastimulus.
- To understand the mechanism underlying the termination of narrow QRS interval tachycardia without atrial capture by a PVC during His bundle refractoriness that exhibited a fused QRS configuration.

PAST MEDICAL HISTORY

He had a medical history of hypertension, diabetes mellitus, and a previous cerebral infarction.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of accessory pathways (APs) includes the following: atrioventricular (AV) Aps; classical Mahaim pathways such as nodoventricular (NV), nodofascicular (NF), and His-ventricular (HV) pathways; and so-called Mahaim pathways such as atriofascicular and AV pathways with decremental properties.

INVESTIGATIONS

During the electrophysiological study, the atrio-His (AH) and HV intervals were 71 and 37 ms, respectively. Multielectrode catheters were placed in the high right atrium (HRA), His bundle region, coronary sinus (CS), and right ventricular (RV) apex. RV overdrive pacing exhibited concentric decremental

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ABBREVIATIONS AND ACRONYMS

AF = atrial fibrillation
AH = atrio-His
AP = accessory pathway
AV = atrioventricular
AVN = atrioventricular node
CS = coronary sinus
HA = His-atrial
HRA = high right atrium
HV = His-ventricular
MA = mitral annulus
NF = nodofascicular
NV = nodoventricular
ORT = orthodromic reciprocating tachycardia
PVC = premature ventricular contraction
RV = right ventricular
SH = stimulus-His

retrograde conduction with the earliest activation in the His region. Reducing the RV extrastimuli coupling interval resulted in a gradual increase in the stimulus-His (SH) interval. This increase was accompanied by a corresponding gradual increase in the His-Atrial (HA) interval; however, some fluctuation was observed (Figure 2). These observations suggested the presence of an NV/NF and HV pathway excluding the AV pathway. Throughout the RV extrastimuli, the His sequence remained identical to that of sinus rhythm, and the atrial activation sequence remained consistent (Figures 3A and 3B). These observations suggested that the proximal insertion of the AP was located at the distal AVN node (AVN) or the proximal part of the His bundle (Figure 4).

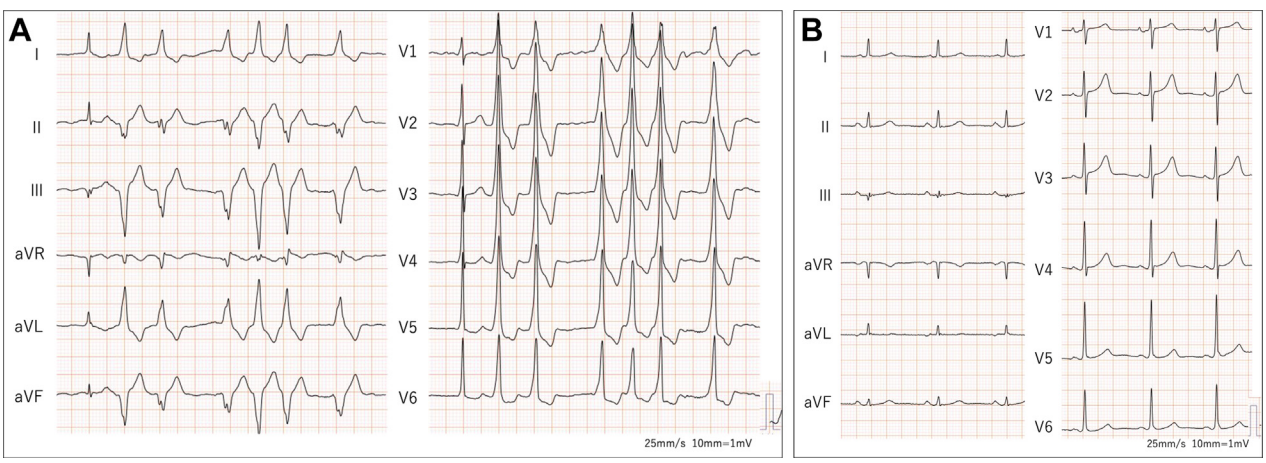
A narrow QRS interval and long RP tachycardia with an atrial sequence similar to that during RV pacing were easily induced by atrial extrastimuli without an AH jump. The tachycardia cycle length and ventriculoatrial interval were 340 and 155 ms, respectively. The presence of an AP and ventricular insertion was indicated by tachycardia termination without atrial capture after a fused premature ventricular contraction (PVC) during His bundle refractoriness (Figure 5A) and during the transition zone under RV overdrive pacing (Figure 5B). An activation map on a 3-dimensional mapping system during retrograde conduction also exhibited the earliest atrial activation in the His bundle. On the basis of those observations, orthodromic reciprocating tachycardia (ORT) through an NV pathway connected to the fast pathway or an HV pathway was diagnosed. We did not target this nonclinical tachycardia induced by extensive atrial extrastimuli because of the high risk of AV block.

Atrial extrastimuli induced a gradual prolongation of the AH and stimulus-QRS intervals and a gradual shortening of the HV interval, findings suggesting a manifest AP with decremental properties. The manifest AP's effective refractory period was <200 ms. The atrial insertion of the manifest AP was more likely in the atrium rather than the AVN because differential atrial pacing with atrial extrastimuli from the HRA and proximal and distal CS exhibited various QRS configurations suggesting the atrial insertion of the AP (Figure 6). Activation mapping during right atrial pacing with a fully pre-excited right bundle branch block configuration revealed that the ventricular insertion of the manifest AP was on the posteroseptal mitral annulus (MA) where no discrete M-potential was observed (Figure 7), thus suggesting an AV pathway with decremental properties rather than an atriofascicular pathway.

MANAGEMENT

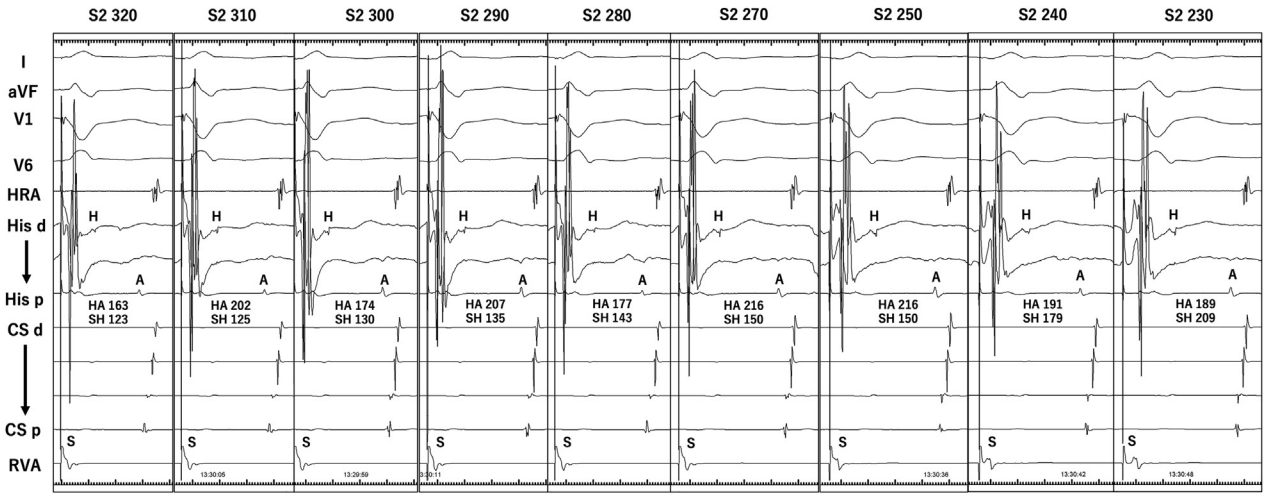
Following pulmonary vein isolation, a radiofrequency application to the earliest ventricular activation site eliminated the manifest AP.

FIGURE 1 12-Lead Electrocardiograms



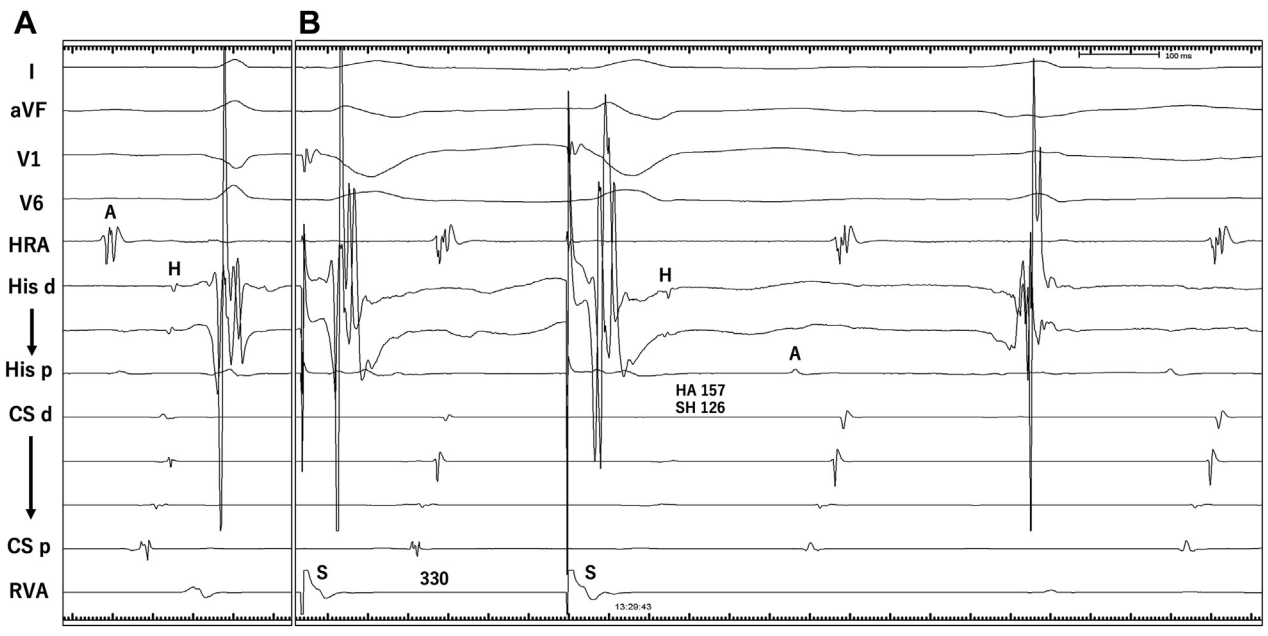
During (A) atrial fibrillation and (B) sinus rhythm.

FIGURE 2 **Intracardiac Electrograms**



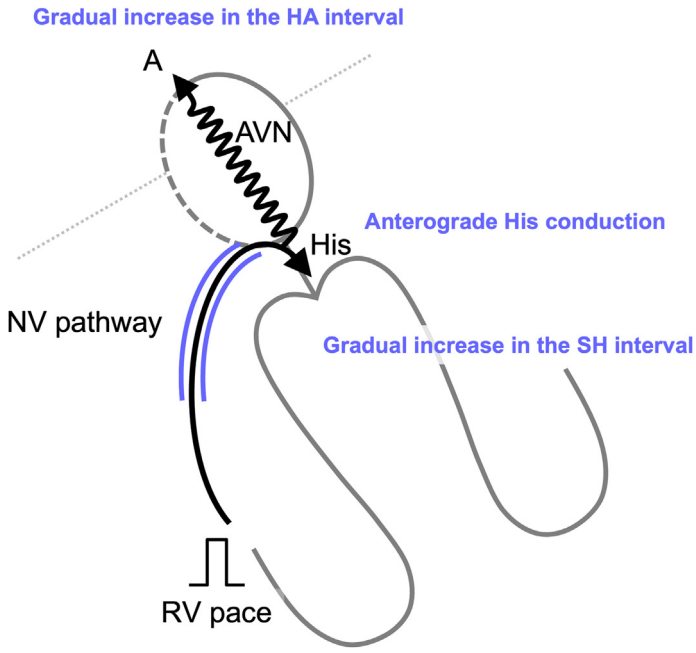
Imaging obtained during right ventricular extrastimuli with a basic cycle length of 600 ms and a coupling interval of 320 to 230 ms. A = atrial; CS = coronary sinus; d = distal; H = His bundle; HRA = high right atrium; RVA = right ventricular apex.

FIGURE 3 **Intracardiac Electrograms**



During (A) sinus rhythm and (B) right ventricular extrastimuli with a coupling interval of 330 ms. The His sequences in A and B are identical. Abbreviations as in Figure 2.

FIGURE 4 Schema of the Plausible Mechanism of the Gradual Increase in the SH and HA Intervals During RV Extrastimuli



A = atrium; AVN = atrioventricular node; HA interval = His-atrial interval; NV pathway = nodoventricular pathway; RV = right ventricular; SH interval = stimulus-His interval.

DISCUSSION

In 1941, Mahaim and Winston[1] reported APs with decremental conduction referred to as NV fibers. Later, Tchou et al[2] demonstrated that most manifest APs are AV or atriofascicular pathways with decremental anterograde conduction properties. Therefore, the NV/NF pathways are classified as classical Mahaim pathways, and decremental atriofascicular/AV pathways are classified as so-called Mahaim pathways.

With retrograde conduction, the key observations are as follows: 1) a gradual increase in the SH and HA intervals was seen during RV extrastimuli, a finding that suggested the presence of a decremental AP other than an AV AP; 2) the anterograde His bundle conduction was inferred even during RV extrastimuli, thus suggesting that the proximal insertion of the AP was located at the distal AVN or the proximal part of the His bundle; and 3) tachycardia termination without atrial capture by a His-refractory PVC exhibited a fused QRS configuration. Hence, those observations, particularly during RV extrastimuli, may be important steps toward identifying concealed NV/HV pathways. Para-Hisian pacing exhibited an AVN/AVN pattern (**Figure 8**), which was consistent with the previous reports.[3,4]

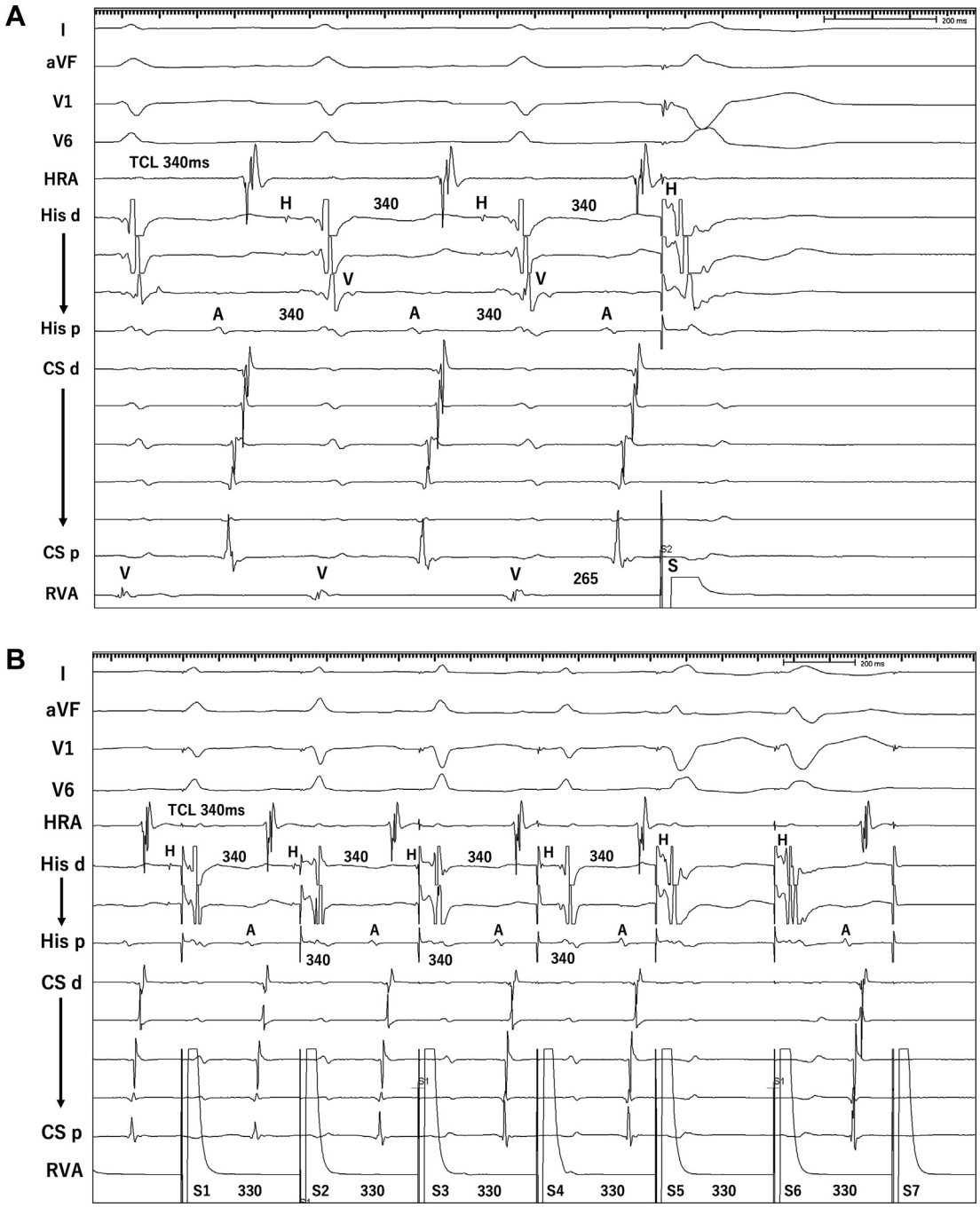
Being considered nonclinical and given the risk of AV block, the concealed AP was not targeted for ablation. However, because documented AF could have resulted from degeneration of the ORT, cryoablation should have been considered as a safe treatment option.

During mapping of the so-called Mahaim pathway, the earliest ventricular potentials were seen on the posteroseptal MA where no discrete M-potential was observed, a finding that indicated a short Mahaim pathway. It is reported that the M-potential is detected only in long Mahaim pathways or AF pathways. In contrast, the M-potential is not seen because all reported left-sided Mahaim pathways are short and AV pathways.[5]

FOLLOW-UP

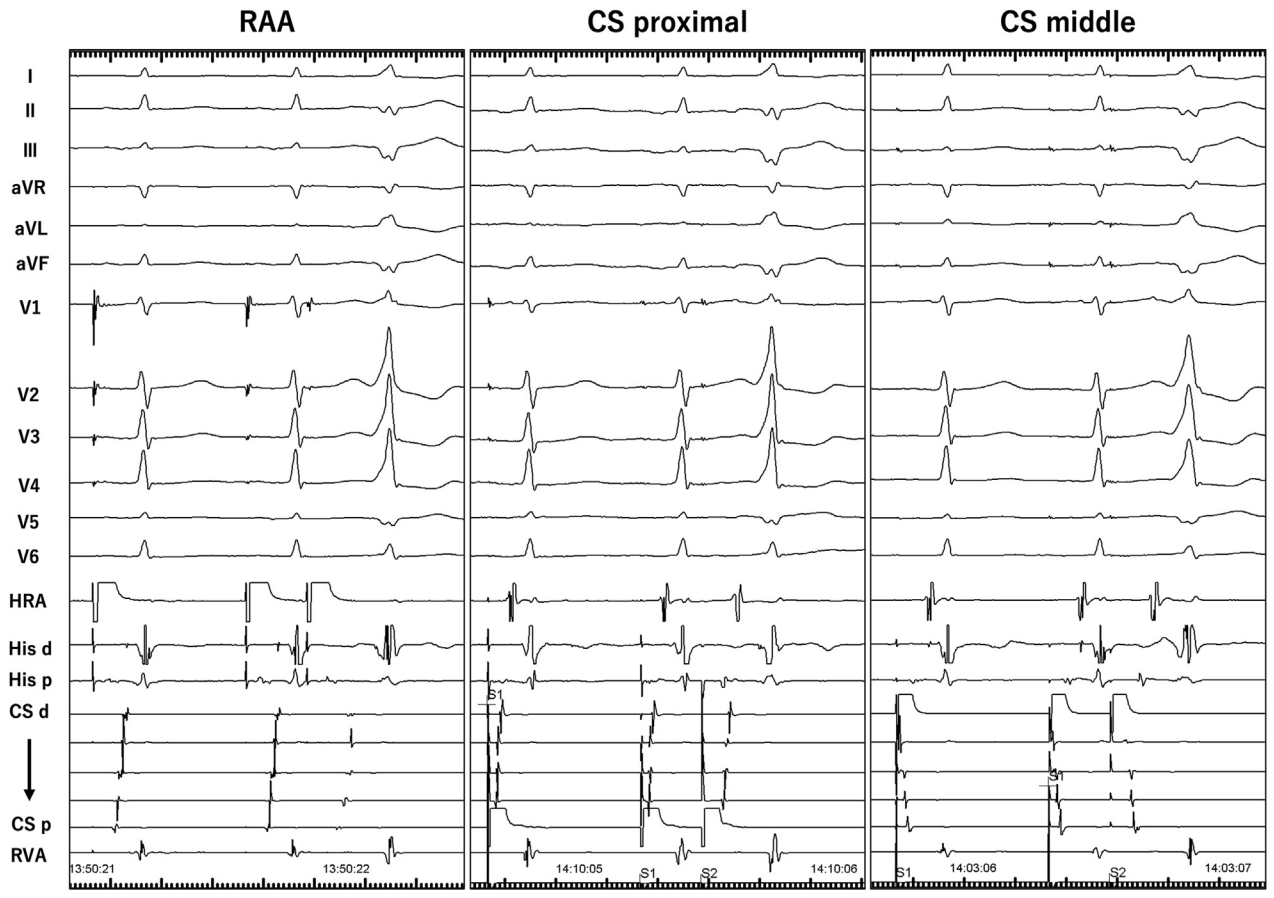
No tachycardia has recurred during the 8 months of follow-up.

FIGURE 5 **Intracardiac Electrograms of Narrow QRS Interval Tachycardia Termination**



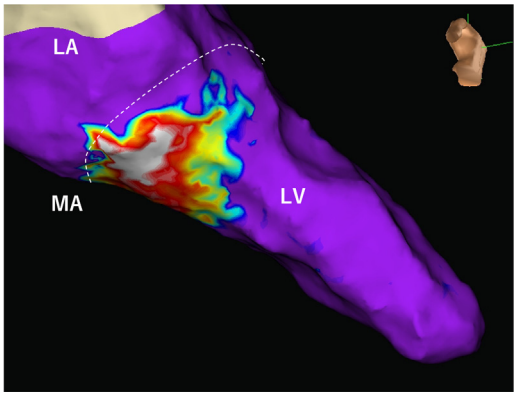
(A) After premature ventricular contraction during His bundle refractoriness. (B) During the transition zone of right ventricular overdrive pacing. TCL = tachycardia cycle length; other abbreviations as in Figure 2.

FIGURE 6 Differential Atrial Pacing



Pacing with atrial extrastimulation (S1, 600 ms; S2, 240 ms) from the (left) high right atrium (HRA; right atrial appendage [RAA]), (middle) proximal coronary sinus (CS p), and (right) distal coronary sinus (CS d) exhibited various QRS configurations.

FIGURE 7 Open Window Mapping During Right Atrial Pacing



The earliest ventricular activation is highlighted in white line in the posteroseptal region of the mitral annulus (MA) which is demonstrated as the dotted line. LA = left atrium; LV = left ventricle.

CONCLUSIONS

We described how to determine the atrial/ventricular insertion of Mahaim pathways. The recording of the SH/HA intervals may be crucial for an accurate delineation of an NV/HV pathway.

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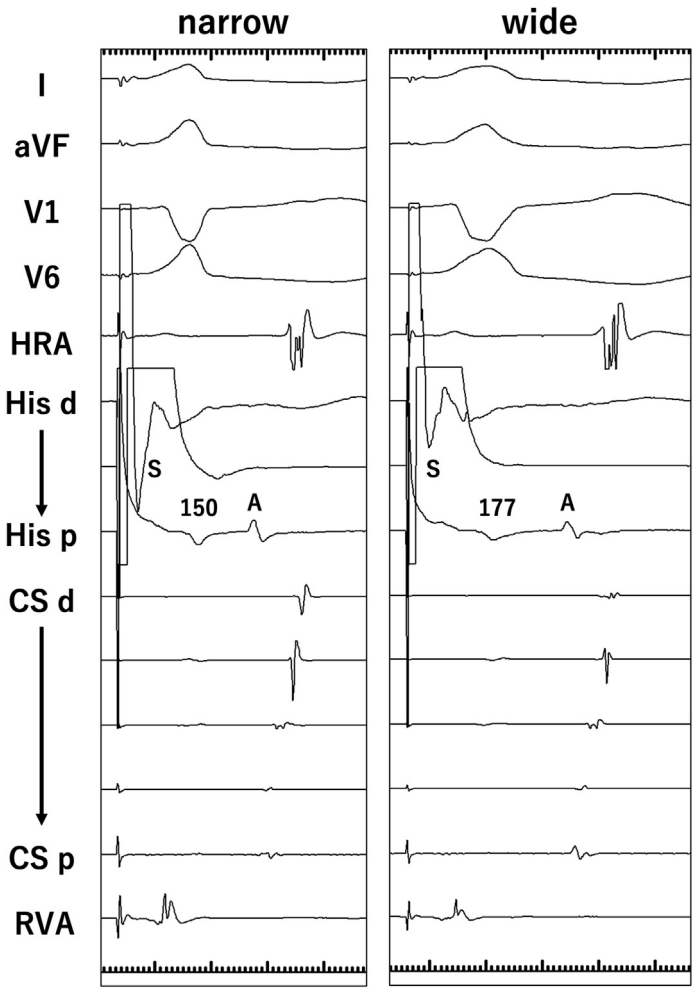
FIGURE 8 Para-Hisian Pacing With His and Ventricular Capture (Narrow) and Only Ventricular Capture (Wide)



Abbreviations as in **Figure 2**.

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KEY WORDS atrioventricular pathway, Mahaim pathway, nodoventricular pathway, orthodromic reciprocating tachycardia, preexcitation