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Case Report

Alternating between exit sites of retrograde slow pathway during fast-slow atrioventricular nodal reentrant tachycardia: case report

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Abstract: We report a case of a 57-year-old male with narrow QRS tachycardia exhibiting the alternance of the cycle length. Differential diagnoses include orthodromic atrioventricular reciprocating tachycardia with alternating antegrade atrioventricular (AV) nodal pathways, atrioventricular nodal re-entrant tachycardia (AVNRT) with alternating AV nodal pathways, and atrial tachycardia with alternating antegrade AV nodal pathways or with Wenckebach periodicity. In electrophysiological study the tachycardia showed alternance in the retrograde atrial conduction sequence and the cycle length. The alternation was caused by that of the HA intervals, between the shorter HA interval with the earliest atrial activation recorded in coronary sinus (CS), and the longer HA interval with that in His bundle region. The tachycardia was diagnosed with fast-slow form of AVNRT exhibiting the alternance of the earliest atrial activation sites. Electroanatomical 3D mapping further revealed that the exit site of retrograde slow pathway (SP) alternated between the left inferior extension (LIE) inside the CS, and the right inferior extension (RIE) in the posterior tricuspid annulus although among conventional electrode catheters the earliest site was the His bundle region. After ablation of the exit site of LIE, the alternation disappeared and fast-slow AVNRT showing a uniform retrograde atrial activation for which the earliest atrial activation site was the exit of RIE sustained. A single application of ablation at this point was insufficient, thereafter conventional SP ablation was added. Then, the ventriculoatrial conduction disappeared and no tachycardia was inducible even with isoproterenol administration. This case is followed by a review of the literature.

Keywords: Atrioventricular node, left inferior extension, right inferior extension, electroanatomical 3D mapping, coronary sinus, tricuspid annulus

Introduction

Paroxysmal supraventricular tachycardias (PSVT) usually present with a regular narrow QRS complex. Most of them are atrioventricular nodal re-entrant tachycardia (AVNRT) or orthodromic atrioventricular reciprocating tachycardia (AVRT). The reentry circuit of AVNRT consists of pathways connecting the atrium to the atrioventricular (AV) node, which are the fast pathway (FP) and the slow pathway (SP). SPs are believed to correspond to the right and left inferior extensions (RIE and LIE) of the compact AV node [1]. The vast majority of AVNRT is of the typical form, slow-fast form of AVNRT, while ~6% of cases are atypical AVNRT (fast-slow, slow-slow, or indeterminate/unclassified form of AVNRT) [2]. Based on electroanatomical 3D mapping, the sites of the earliest retrograde atrial activation during atypical AVNRT were either inside the coronary sinus (CS), corresponding to the location of the exit of the LIE, or in the posterior tricuspid annulus (TA), corresponding to the location of the exit of the RIE [3]. For atypical AVNRT, the ablation target is the standard anatomic region of the SP or the site of the earliest retrograde atrial activation [2].

We hereby report a case of a patient with fast-slow form of AVNRT exhibiting the alternance of the cycle length (CL), caused by alternans in the exit site of retrograde SPs between LIE and RIE.

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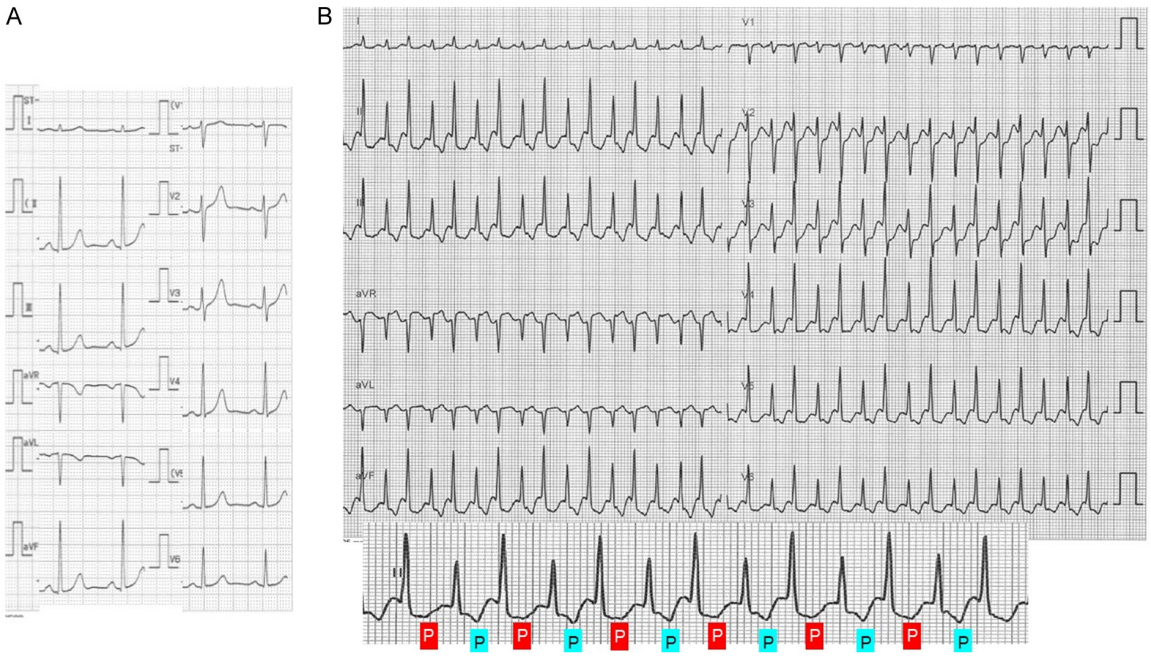

Figure 1. 12-lead electrocardiogram during sinus rhythm (A) and tachycardia (B). (B) The lower figure shows the enlarged view of lead II, exhibiting the alternating retrograde P waves.

Case presentation

A 57-year-old man presented with palpitations over the past 19 years. A 12-lead electrocardiogram (ECG) was within normal limits. He had a narrow QRS tachycardia, at a rate of 227 bpm (**Figure 1**). The tachycardia showed alternance in CL and retrograde P wave.

In the electrophysiological study, catheters are positioned at the CS, high right atrium (HRA), right ventricular apex (RVA), and His bundle electrogram region (HBE). The CS catheter was withdrawn such that the proximal pair was at the ostium of the CS (**Figure 2**). Constant ventricular stimulation indicated dual retrograde pathways (**Figure 3**). Para-Hisian pacing results were consistent with an AV nodal pattern, excluding the presence of an AV accessory pathway (**Figure 4**).

During programmed atrial extrastimulation with isoproterenol administration, the tachycardia with a CL of 256 msec was induced without AH jump up (**Figure 5**), in which atrial activation sequence was identical to that of **Figure 3B**. Thereafter, the tachycardia showed alternance in the retrograde atrial conduction sequence and CL between 232 msec and 336 msec (**Figure 6**). The reason for the alternating CL was the alternation of the HA intervals, which were 130 msec in the shorter CL with the earliest atrial activation recorded in CS 5-6, and 176 msec in the longer CL with that in HBE 1-2. Atrial or ventricular constant pacing during tachycardia could not be done due to termination of the tachycardia. Premature ventricular complexes during His refractoriness did not affect the tachycardia, thus not using a concealed nodoventricular/nodofascicular accessory pathway (**Figure 7**). VA (ventriculoatrial) conduction blocked during the tachycardia, excluding the possibility of AT. As a result, this narrow QRS tachycardia was diagnosed as atypical AVNRT, fast/slow type with two different retrograde AV nodal SPs.

Firstly, we targeted the tachycardia with shorter CL and performed the 3D mapping of the atrial activation during the tachycardia using Ensite system (Abbott Laboratories, Chicago, Illinois, USA). The earliest site was in the CS, 7 mm distal from the CS ostium (**Figure 8**), indicating the exit site of LIE. The tachycardia with shorter CL was diagnosed as fast/slow (LIE) AVNRT. After ablation of this site, the alternation disappeared and fast/slow AVNRT showing a uniform retrograde atrial activation for which the earliest site was the HBE among conventional electrode catheters sustained. However, Ensite

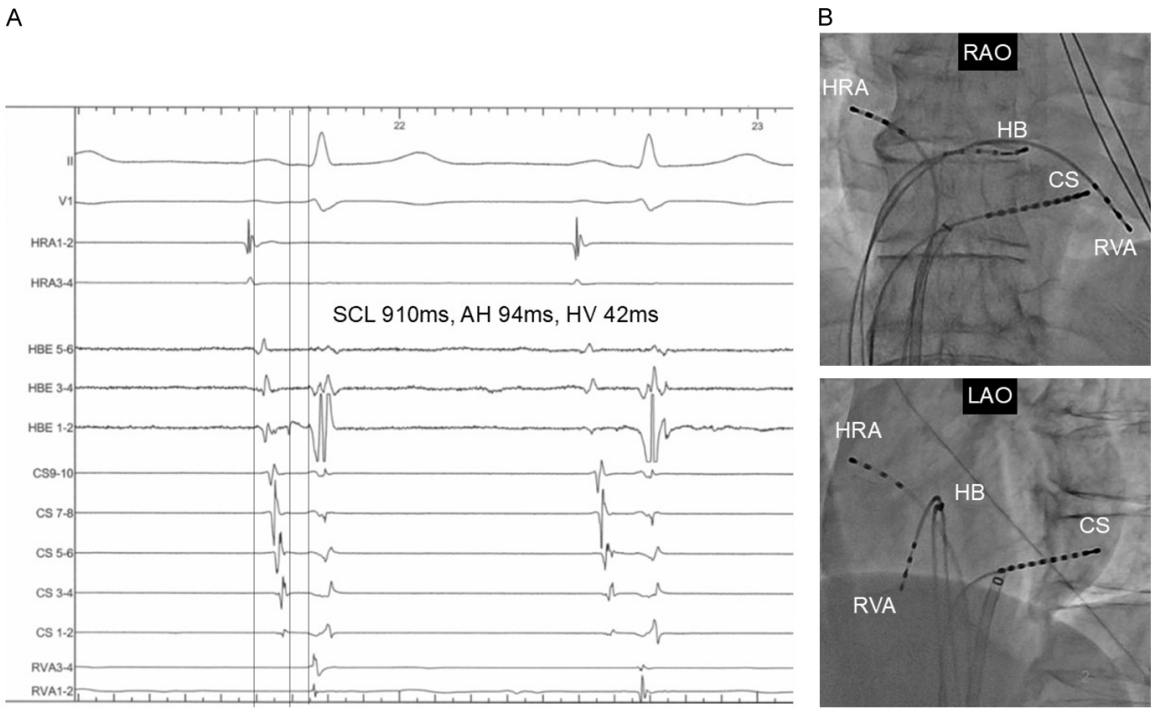

Figure 2. Intracardiac electrograms during sinus rhythm (A) and electrode catheter positions (B). (B) Fluoroscopic images in the right anterior oblique (RAO) and left anterior oblique (LAO) projections. AH: atrio-His, CS: coronary sinus, HB: His bundle electrogram region, HBE: His bundle electrogram, HRA: high right atrium, HV: His-ventricular, RVA: right ventricular apex, and SCL: sinus cycle length.

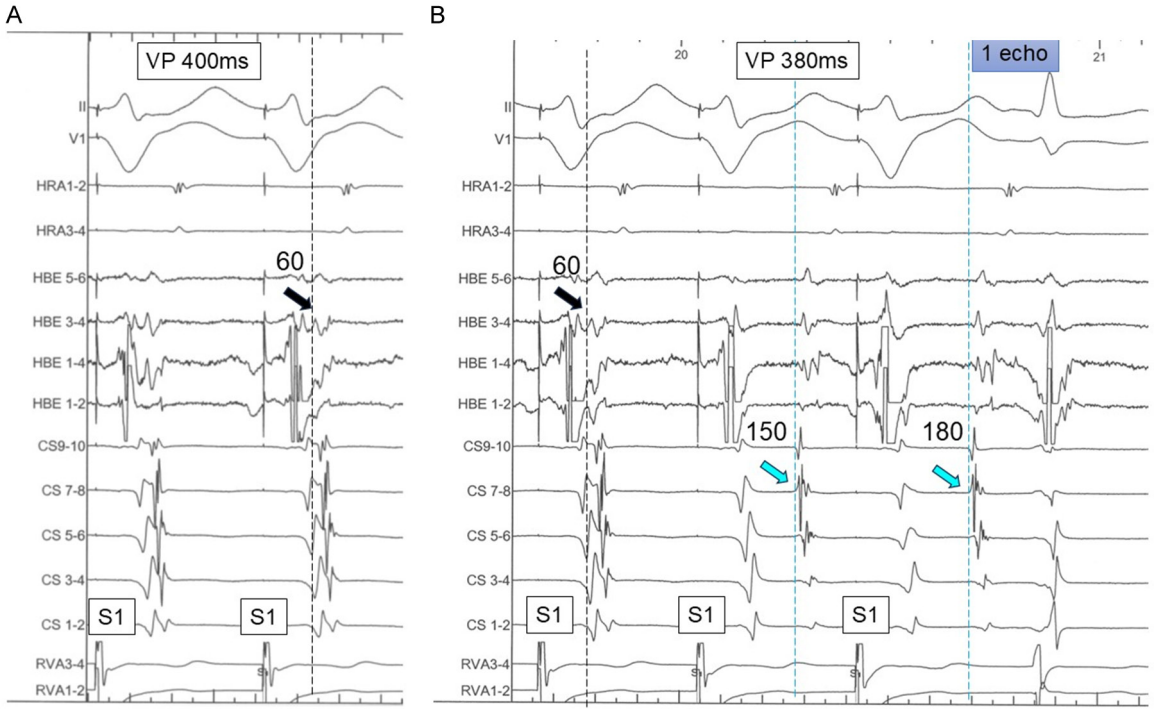

Figure 3. Intracardiac electrograms during constant ventricular stimulation. (A) During constant ventricular stimulation of 400 msec, the earliest retrograde atrial site is HBE 3-4 (black arrow), with the VA interval of 60 msec. (B) During stimulation of 380 msec, in the 2nd beat the VA interval suddenly prolongs to 150 msec and the earliest atrial activation site changes to CS 7-8 (blue arrow). During the third beat the VA conduction prolongs further to 180 msec, showing decrementation, and produces a single echo (B). VP, ventricular pacing.

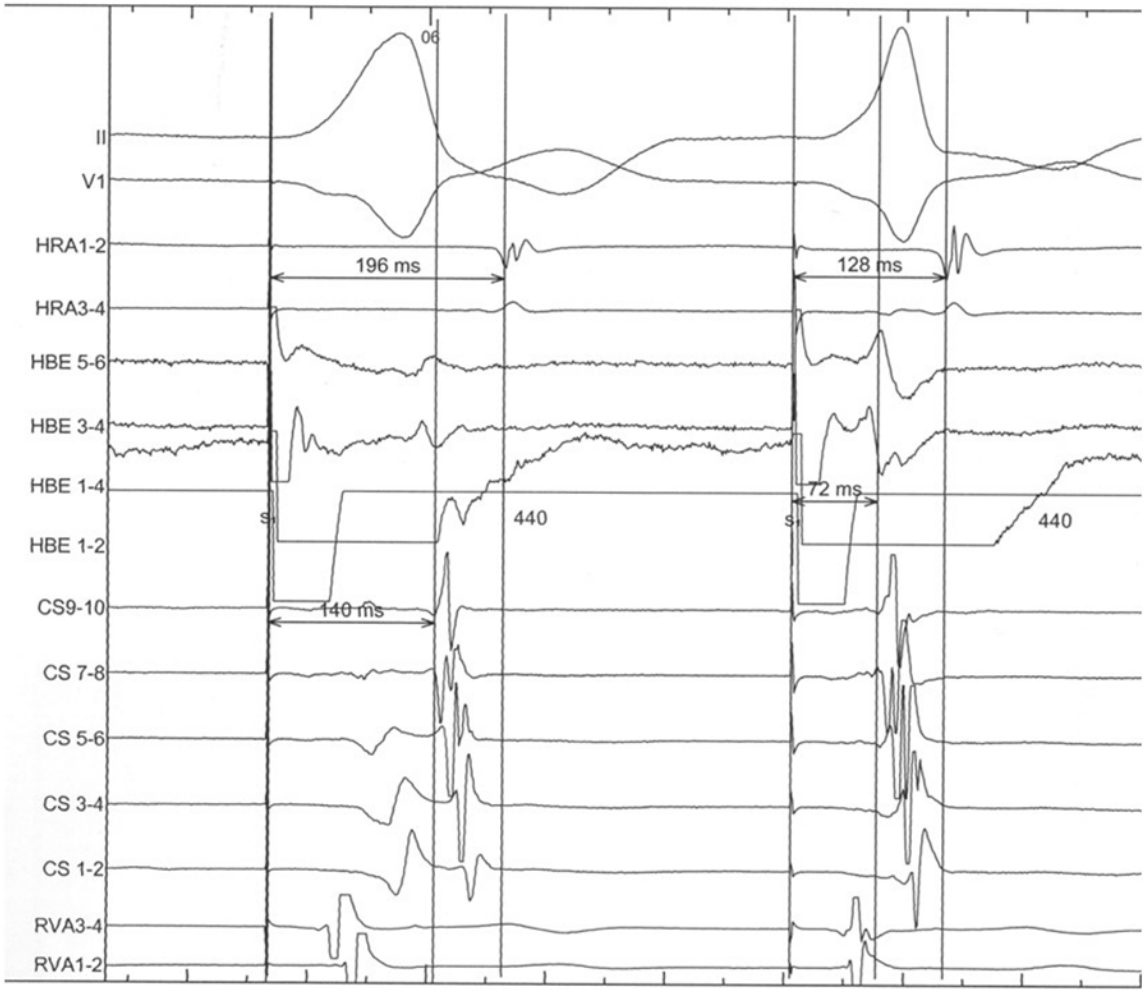

Figure 4. Para-Hisian pacing. The left beat with wide QRS is only RV pacing and the right beat with narrow QRS is His and right ventricular pacing. The retrograde atrial activation sequence is similar between these two. In the left paced beat, the S-A interval prolonged and the local V-A interval at the earliest atrial activation site, that is, the HBE, is also prolonged. All these findings are consistent with an AV nodal pattern.

mapping during tachycardia demonstrated that the earliest atrial activation site was located at the inferior TA (**Figure 9**). This site was supposed to be the atrial exit site of RIE, meaning that for the longer CL this tachycardia was fast/slow (RIE) AVNRT (**Figure 10**). A single application of ablation at this point was insufficient, thereafter conventional SP ablation was added. Then, the VA conduction disappeared. No tachycardia was inducible even with isoproterenol administration.

The patient was doing well without palpitations during his 3-year follow-up visit.

Discussion

PSVTs rarely present unusual manifestations such as CL alternation. In such cases, differential diagnoses include orthodromic AVRT with alternating antegrade AV nodal pathways, AVNRT with alternating AV nodal pathways, and atrial tachycardia (AT) with alternating antegrade AV nodal pathways or with Wenckebach periodicity [4]. The alternation of tachycardia CL in the present case accompanied alternating atrial activation sequence, indicating that there would be AVNRT with two different retrograde AV nodal pathways, orthodromic AVRTs with two different accessory pathways, two ATs, or the alternating among AT, AVNRT, and AVRT. In our case the antegrade pathway of the tachycardia was AV nodal FP. Para-Hisian pacing and premature ventricular complexes during His refractoriness indicated that the AV node was the only retrograde conduction pathway [2, 5]. Retrograde conduction through SP (LIE) was

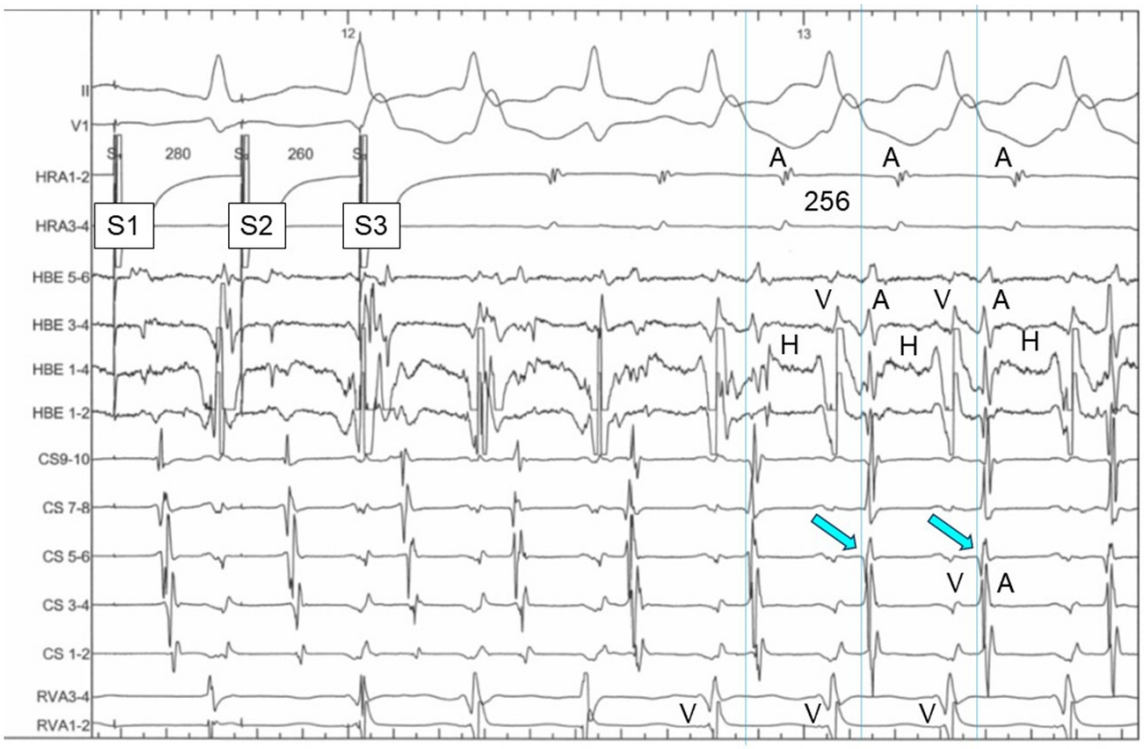

Figure 5. Induction of fast/slow type AVNRT. During programmed atrial extrastimulation (S1S1 = 400 ms, S1S2 = 280 ms, S2S3 = 260 ms), a tachycardia started without AH jump up. The earliest atrial site is CS 5-6 (blue arrow). Local electrocardiograms indicate that the CS catheter position appears to be slightly retracted compared to **Figure 3**.

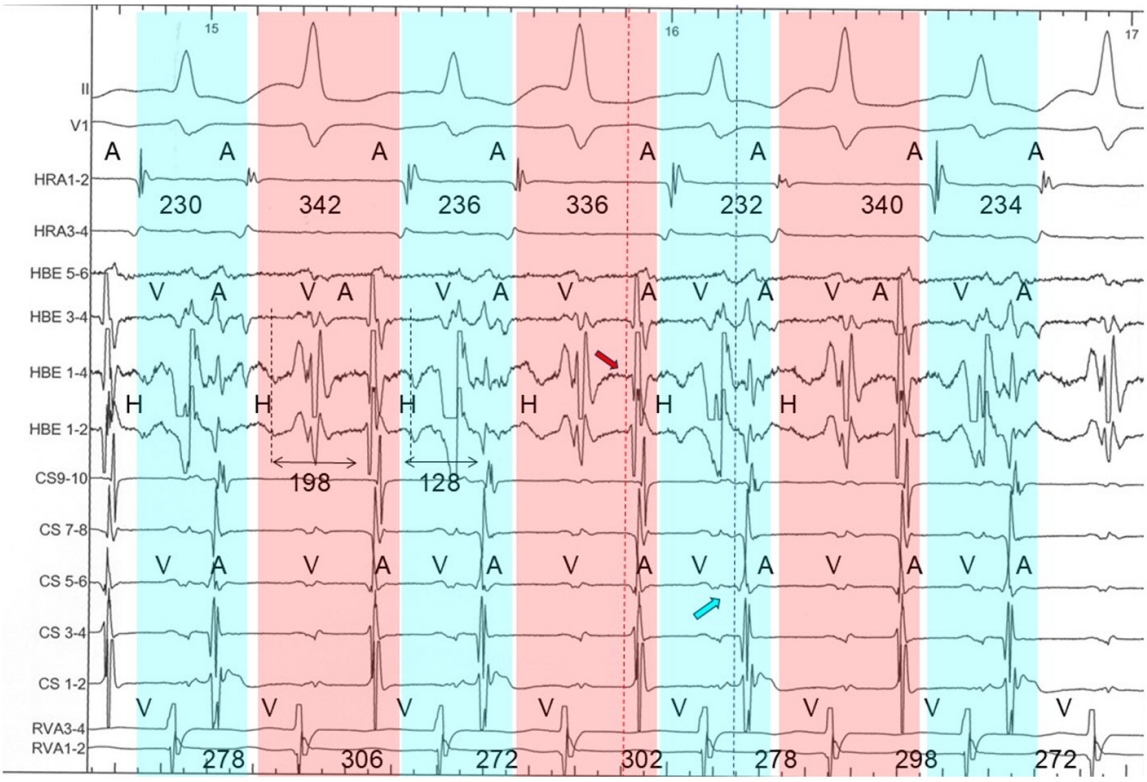

Figure 6. Alternance of the retrograde atrial activation sequence and CL during the tachycardia. The earliest atrial site is CS 5-6 (blue arrow) when the VA interval is shorter, and HBE 1-2 (red arrow) when that is longer. During alternance, beats with the shorter VA interval are filled in blue and those with the longer VA interval are in red.

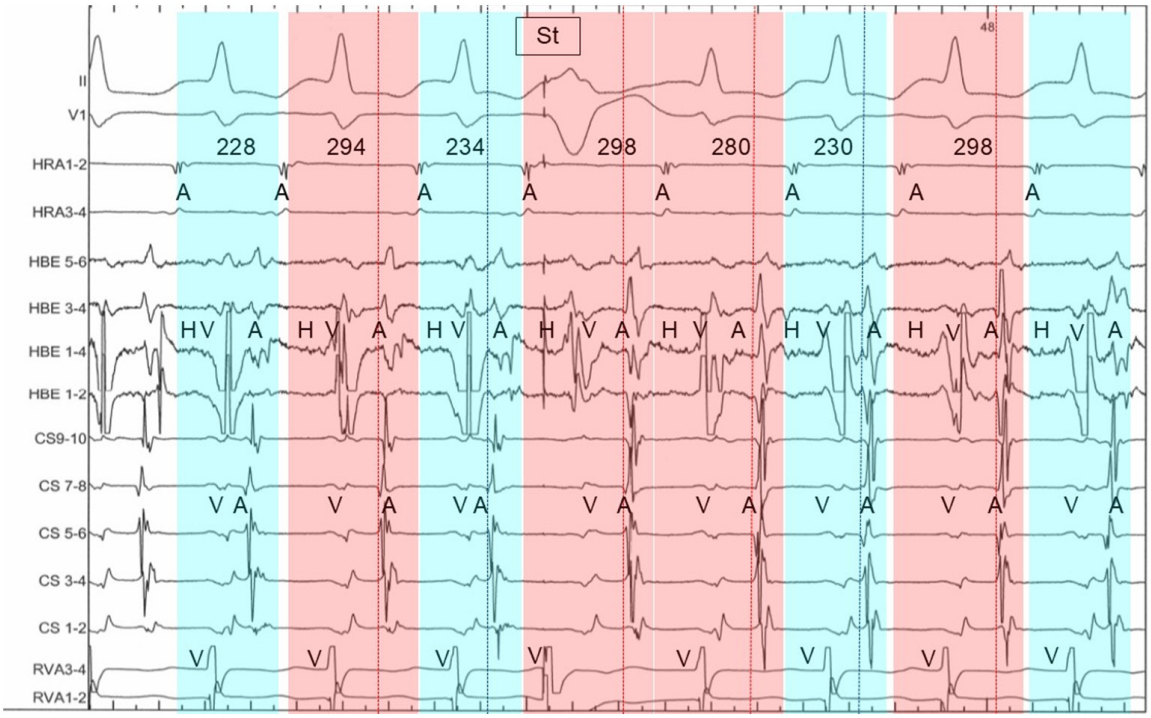

Figure 7. Premature ventricular complexes during His refractoriness. The next atrial conduction after ventricular premature is not affected. Beats with the shorter VA interval are filled in blue and those with the longer VA interval are in red. St, stimulus.

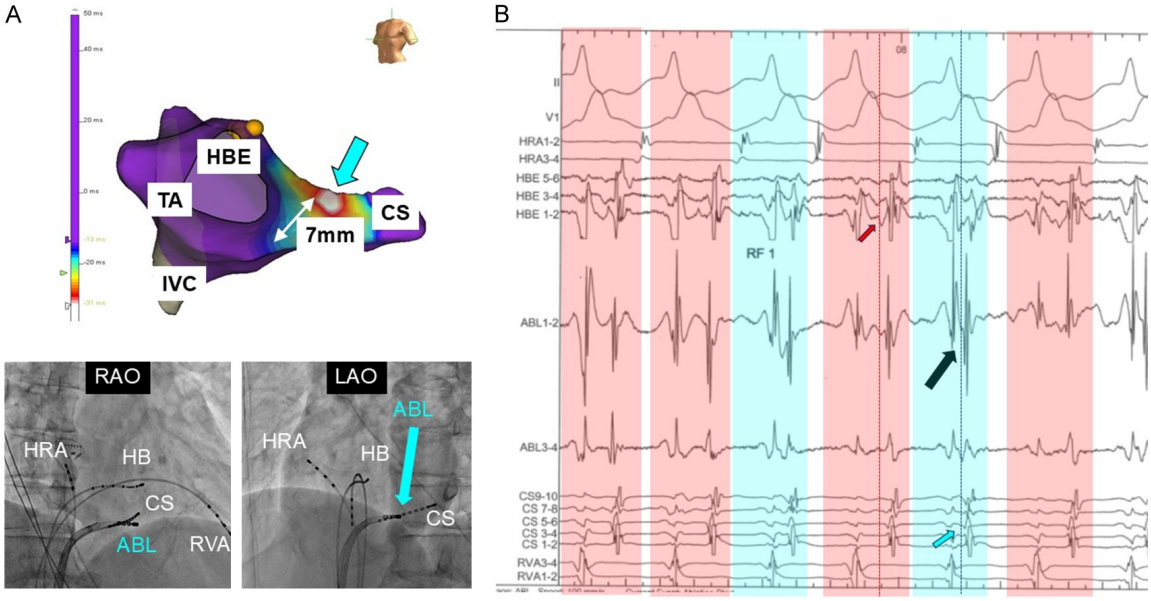

Figure 8. Catheter ablation of the earliest atrial activation site during shorter CL. A: Atrial activation mapping during the tachycardia with shorter CL using Ensite 3D system and fluoroscopic images. B: The local electrogram of the ablation catheter is earliest (black arrow). Beats with the shorter VA interval are filled in blue and those with the longer VA interval are in red. ABL: ablation catheter, IVC: inferior vena cava, and TA: tricuspid annulus. Other abbreviations are as in the previous figures.

Figure 9. Intracardiac electrograms during tachycardia after disappearance of alternance. The atrium activates earlier in HBE 1-2 (red arrow) compared to CS; however, the earliest atrial site is ABL1-2 (black arrow) which is placed at the TA.

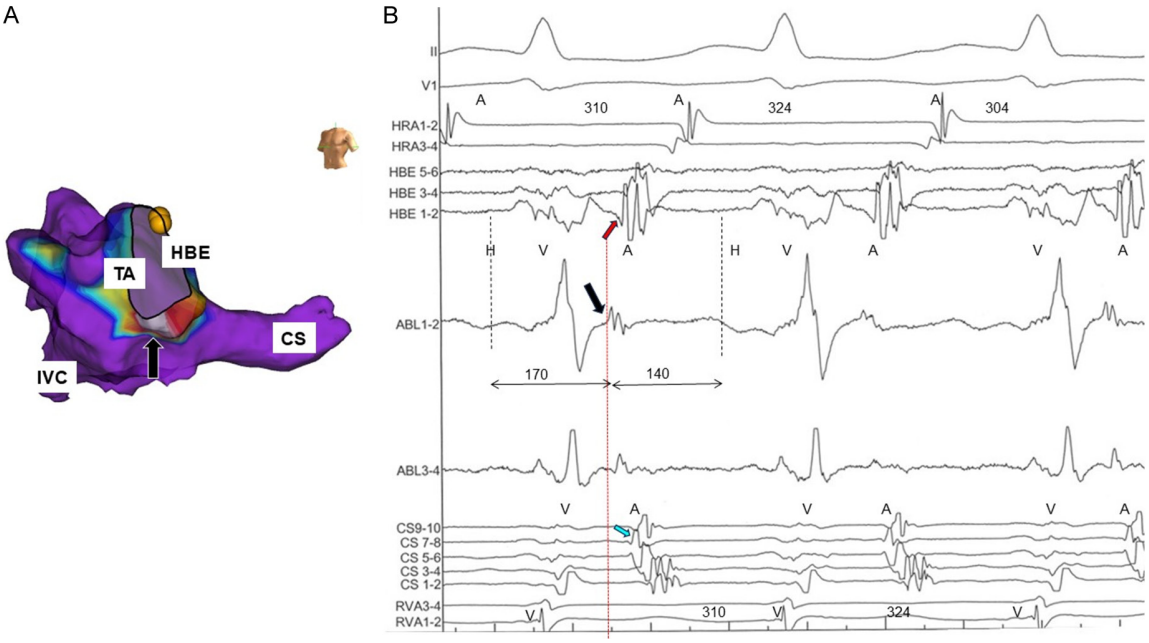

Figure 10. Atrial activation mapping during tachycardia. A: Ensite 3D mapping shows that the earliest site is on the TA at 6:00 o'clock projection in the LAO view (black arrow). B: Intracardiac electrograms demonstrate that ABL catheter at the point is earliest (black arrow).

not demonstrated during ventricular pacing, however, there was VA dissociation during tachycardia, which excludes ATs. Moreover, HA intervals were constant between 135 msec and 180 msec, suggesting the VA linking in the present case. Therefore, the more likely explanation is fast-slow type AVNRT with two distinct, beat-to-beat alternating SPs during tachycardia. 3D mapping revealed that the atrial exit sites of two SPs were in the CS and on the TA, meaning that they were LIE and RIE. Based on these, this tachycardia is diagnosed as an alternance between fast/slow (LIE) and fast/slow (RIE) AVNRT. To our knowledge, CL alternans due to the retrograde limb alternating over two SPs has not been previously described in the literature.

The human compact AV node contains RIE and LIE histologically, which are SPs, forming part of the tachycardia circuit in AVNRTs [1]. We previously reported that among fourteen patients with atypical AVNRT, 7 patients had solely LIE, 3 solely RIE, and 4 had both LIE and RIE by using 3D electroanatomical mapping of the exit site during tachycardia. In four patients having both LIE and RIE, all except for the present case had two different fast/slow AVNRTs, each using RIE and LIE. It was only the present case demonstrating alternance between fast/slow (LIE) and fast/slow (RIE) AVNRT [3].

It is crucial to identify all alternate pathways for the treatment of the tachycardia, otherwise it is possible that unrecognized second tachycardia may be diagnosed as a recurrence despite successful ablation of first tachycardia. Careful analysis is required for efficient and effective ablation therapy. SP ablation is effective in both typical and atypical AVNRT. Moreover, the procedure can be accomplished in atypical AVNRT, by targeting the inferior nodal extensions [2]. Being aware of LIE and RIE exits when ablating atypical AVNRT would allow appropriate diagnosis even in cases with multiple SP exits or in cases the actual retrograde SP tract during tachycardia switches sides after ablation of one of LIE or RIE.

Another unique point of the present case was the location of the exit of RIE. We previously showed that the RIE exit was in the TA posterior to the CS ostium. In the present case it was on the TA at 6:00 o'clock projection in the LAO view, which was most posterior in our cases [3]. For the identification of the exits of RIE which is not clinically well recognized, mapping of a wide area in the posterior and posteroseptal TA might be required.

Conclusion

We described a case in which fast/slow AVNRT displayed alternance in the CL, caused by alternance in the exit site of retrograde SPs between LIE and RIE.

Disclosure of conflict of interest

None.

Abbreviations

AV, atrioventricular; AVNRT, atrioventricular nodal re-entrant tachycardia; AVRT, atrioventricular reciprocating tachycardia; CS, coronary sinus; FP, fast pathway; HBE, His bundle region; LIE, left inferior extension; PSVT, paroxysmal supraventricular tachycardia; RIE, right inferior extension; SP, slow pathway; TA, tricuspid annulus; VA, ventriculoatrial.

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