Pitfalls and Nuances of Parahisian pacing: A revisit through an interesting case

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A 40-year-old gentleman underwent electrophysiology study for WPW syndrome with recurrent orthodromic atrioventricular re-entrant tachycardia. A right anterior accessory pathway (AP) was ablated close to the septum anterior to His catheter (Appendix 1AB). During the study, parahisian pacing (PHP) was performed before and after ablation to determine the route of VA conduction (VAC). It is important to mention that the CS decapolar catheter could not be placed fully deep inside, hence CS-12 was located near middle CS whereas the CS-34 was 2–3 cm inside proximal CS. Another decapolar catheter was placed on the atrial aspect of tricuspid annulus, with RA-5 bipole near high right atrium (HRA) (Appendix 1AB). PHP was performed at 600 ms cycle length (PCL) starting at 20 mA current @ 2 ms pulse width. Keeping the PCL and catheter position fixed, the current output was gradually reduced in a stepwise manner when various responses were noted.

What are the responses observed in Fig. 2 and Fig. 3?

2. Commentary

In the subsequent discussion- His plus myocardium, only myocardial capture, pure His capture and simultaneous atrial capture are annotated as \( H + V \), \( V \), \( H \), and \( A + V \) respectively [1]. The ideal way to differentiate \( H + V \) vs. \( V \) capture is by analyzing whether His-signal is obscured inside or released from the ventricular signal on the second His catheter [2,3]. However, in our case they were concluded on the basis of QRS morphology and width as His release was not well appreciated.

In Fig. 1A, the first beat represented a \( V \) only capture (QRS width 138 ms) and second beat was a \( H + V \) (i.e. Para-His capture, QRS width 114 ms) capture. The atrial activation sequence remained identical suggesting only one route for VAC. The Stimulus-A electrogram (SA) measurements were also identical. This would be called an extra-nodal response. This proves the presence of an AP, although participation of the AP in supraventricular tachycardia cannot be ascertained from PHP maneuver.

In Fig. 1B shows (at a different time during the same pacing protocol as Fig. 1A) \( V \) capture in both beats (QRS — 138 ms) and second beat was a \( H + V \) (i.e. Para-His capture, QRS width 114 ms) capture. The atrial activation sequence remained identical suggesting only one route for VAC. The Stimulus-A electrogram (SA) measurements were also identical. This would be called an extra-nodal response. This proves the presence of an AP, although participation of the AP in supraventricular tachycardia cannot be ascertained from PHP maneuver.
Another way to validate SAC is by looking for atrial electrograms immediately adjacent to the pacing spike at the catheter near the pacing bipole (MAP and HisP here), although sometimes it is difficult to discriminate from V-EGM recorded nearly at the same time [4]. However, if anytime pure his capture (H) without any local myocardial capture can be achieved with (H + A) and without SAC (H) (also encountered in this case, described below), the difference of EGM attached to pacing spike could be compared to delineate presence or absence of atrial electrogram, respectively [4]. An easier and practical way to validate SAC, is to look for SA prolongation when the QRS morphology remains unchanged, as happened in the second beat (V) (Fig. 1B). Among the common responses during PHP, nodal response can also have prolongation of VA, but only during concomitant QRS widening and/or His-EGM release (if visible). In our case, nodal response was ruled out as the SA interval widened in spite of identical QRS width in the second beat. Hence, everything was suggestive of A + V in the first beat. Moreover, a short SA of <60 or 70 ms on the proximal CS or high right atrial electrodes respectively, is highly suggestive of SAC by itself as shown in an earlier study [5]. 'Intermittent' direct AP

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**Fig. 1.** Electrodes shown from top to bottom are four surface ECGs (1, aVF, V4, V1), CS12 (Middle CS) to CS34 (proximal), His distal and proximal, roving mapping catheter (MAP) right atrium RA 5 (proximal, near high RA) to RA 1 (distal, lower RA). A: First beat is A + H + V capture. Second beat is A + H capture. Adjacent atrial electrogram (marked as 'A') was noticeable along with the delayed separate ventricular EGM in the second beat (best seen in MAPP, marked as V). B: First beat is H + V with shorter SA. Second beat is H with a longer SA. However, the VA remains the same (red line). Longer SA (i.e HA here) during H with fixed VA suggest extra-nodal response via an accessory pathway. In addition, the atrial electrogram adjacent to pacing spike (A) is distinctly absent in Fig. 2B, as compared to the second beat of Figs. 1B and Fig. 2A. Underlying RBBB also got unmasked.

**Fig. 2.** Electrodes shown from top to bottom are four surface ECGs (1, aVF, V4, V1), CS12 (Middle CS) to CS34 (proximal), His distal and proximal, roving mapping catheter (MAP) right atrium RA 5 (proximal, near high RA) to RA 1 (distal, lower RA). A: First beat is A + H + V capture. Second beat is A + H capture. Adjacent atrial electrogram (marked as 'A') was noticeable along with the delayed separate ventricular EGM in the second beat (best seen in MAPP, marked as V). B: First beat is H + V with shorter SA. Second beat is H with a longer SA. However, the VA remains the same (red line). Longer SA (i.e HA here) during H with fixed VA suggest extra-nodal response via an accessory pathway. In addition, the atrial electrogram adjacent to pacing spike (A) is distinctly absent in Fig. 2B, as compared to the second beat of Figs. 1B and Fig. 2A. Underlying RBBB also got unmasked.
capture, an extremely rare finding, however cannot be ruled out from above observations.

Subsequently, Fig. 2A shows 2 similar but non-identical QRS. The QRS width is slightly narrower in the second beat. Both QRS are having an isoelectric interval. However, a close look at V4 shows slurring suggesting a probable H + V capture. The isoelectric interval is longer in the second beat, likely pointing towards H capture. The convincing proof was evident from intracardiac electrograms having late V-EGM recorded separately from the pacing artefact in the second beat (best appreciated in MAPd). Additional finding noted was SAC in both the beats (A + H + V and A + H). Unless this is promptly recognized there could be a mistaken consideration of the wider beat as V and narrower beat as H + V. In certain situations such errors can lead to a misdiagnosis [3]. Moreover, as the ventricular EGM of the second beat is delayed and recorded separately from the pacing spike, it rendered an opportunity to properly analyze the adjacent atrial electrogram (marked with ‘A’) in MAPp further confirming A + H.

The next intriguing observation noted in Fig. 2B during the PHP was prolongation of SA during H (second beat) as compared to H + V (first beat). This resulted in 38–45 ms increment in SA (i.e. HA here). In contrast, the VA interval was fixed (76 ms) during both the beats with similar atrial activation pattern. Fixed VA and variable HA again suggested an accessory pathway just from these 2 beats. An additional interesting observation was made when the underlying RBBB got unmasked during H (Fig. 2B). We believe, the prolongation of SA by 38–45 ms in second beat was exaggerated due to the underlying RBBB as during H the impulse has to travel down via left bundle (LB) followed by trans-septal conduction and then VAC via right sided AP. Interestingly, even during this pure H capture (second beat of Fig. 3B) the VAC did not show nodal response, but rather took a longer but still relatively faster route via the AP (Route A in Appendix 2). VAC over AV node (Route B in Appendix 2) might have taken place concomitantly, but was too slow to get reflected in the electrograms. This speculation is supported by post-ablation long VA time during nodal response (Fig. 3A).

To summarize, this single case illustrates several pitfalls and challenges encountered during PHP manoeuvre. We speculate, many of these happened because the pacing bipole (His-D) was more proximate to the atrial side of the proximal His region (Fig. 3B). We believe, unwarranted findings like SAC might be avoided by placing the pacing catheter at a more preferable distal His region [2,3]. Pure H capture, a rare finding, can confound the interpretations if not recognized by subtle differences from H + V capture. Having a dedicated RV apex and RV base catheter can help identify H with the EGMs in the former preceding the latter. When identified correctly, H capture can offer important electrophysiological insights in deciphering the route of VAC.

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Data availability statement

All raw data and recording during the case are available for review.

Declaration of competing interest

None.

Consent has been taken from the patient.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ipej.2021.08.001.

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