Delivering premature his complexe maneuver in differentiating between paroxysmal supraventricular tachycardias

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ABSTRACT

Background: It is difficult to differentiate between paroxysmal supraventricular tachycardias in some circumstances. Delivering premature His complexes (PHC), a new maneuver, has been recently introduced. The study aimed to describe and evaluate initially the value of this maneuver.

Methods: From 12/2021 to 05/2022, 30 patients who underwent electrophysiological studies were diagnosed with AVRT or AVNRT, and successful RF ablations. The PHC maneuver was performed when making differential diagnoses.

Results: 12 AVRT cases and 18 AVNRT cases underwent the premature His complex maneuver. Delivering PHCs disturbed all AVRTs in both early PHCs ($\Delta A1A2 = 21,33$ ms) and late PHCs ($\Delta A1A2 = 44,43$ms). Late PHCs ($\Delta PHC < 20$ms) did not disturb the AVNRT circuit ($\Delta A1A2 = 0$ms). Early PHCs ($\Delta PHC \geq 20$ms) with mean $\Delta PHC = 38,9$ms would advance the next atrial potential of $\Delta A1A2 = 15,85$ms, but it was significantly shorter than the atrial advancement of $\Delta A1A2 = 44,43$ms in AVRT ($p<0,05$). In comparison with the prematurity of PHC, the advancement of the next atrial potential $\Delta A1A2$ in AVRT was greater than or equal to it ($\Delta A1A2-\Delta PHC \geq 0$ms, however in AVNRT was always shorter ($\Delta A1A2-\Delta PHC \leq -5$ms). This maneuver had accurate results in all cases with a sensitivity and specificity of 100%.

Conclusions: This initial evaluation suggested that this maneuver had highly accurate in differentiating AVNRT and AVRT. Premature His complexes will absolutely disturb the AVRT circuit. Delivering late PHCs could not disturb the AVNRT circuit, and early PHCs would advance the next atrial potential with an amount shorter than the prematurity of PHC. Further studies are necessary to determine the value of the maneuver in clinical practice.

Keywords: Premature His complex, AVNRT, AVRT, PHC.

1. INTRODUCTION

Paroxysmal supraventricular tachycardia (PSVT) is represented by typical features such as rapid rate, narrow QRS, abrupt onset and termination, and two main types were atrioventricular nodal reentry tachycardia (AVNRT) and atrioventricular reentry tachycardia (AVRT) [1].

The thorough management of paroxysmal supraventricular tachycardia should be concerned, in which medical treatment does not completely

prevent the recurrence even being associated with side effects. Radiofrequency catheter ablation is an effective approach with more advantages. However, in order to get successful ablation, it is necessary to determine the exact mechanism causing the tachycardia. Although many maneuvers have been performed to make differential diagnosis, in some difficult circumstances, a combination of different maneuvers were needed to differentiate [2].

In 2020, the study was conducted to differentiate AVNRT and AVRT by a new maneuver, delivering premature His complexes (PHC) during tachycardias based on the following principles:

- PHC would disturb AVRT circuits due to the His bundle being an inherent part of this reentry circuit.

- When the pacing captured His, the AVRT circuit would be disturbed by an amount equal to the prematurity of PHC (except to decremental accessory pathways). When the septal accessory pathways are located closely to the pacing site, the myocardial activation conducted by PHCs would cause an advancement of the next atrial potential with a greater amount than the prematurity of PHC.

- AVNRT circuits were not disturbed by a PHC < 20ms due to essential retrograde conduction to impact this reentry circuit caused by His bundle not being belonged it.

- PHCs $\geq$ 20ms could disturb AVNRT with a shorter advancement than the prematurity of PHC, because of the necessity of retrograde conduction for PHC to penetrate to AVNRT circuit.

## 2. METHODS

a. The study design: a cross sectional study.

b. Subjects: From 10/2021 to 05/2022, 30 patients who underwent electrophysiological studies and were diagnosed with sustained AVRT or AVNRT, and successful RF ablations in Vietnam National Heart Institute, Bach Mai Hospital, and Cardiovascular Center, E Hospital.

c. The electrophysiological studies and RF ablations: all patients underwent electrophysiological studies to make a diagnosis and successful RF ablations following the standard protocol.

d. The premature His complex maneuver

- A pacing catheter was inserted into the distal His bundle, then a pacing was delivered with 06 sensed stimuli (S1) and 01 paced stimulus (S2, output 20mA, and 2ms). S2 would be decreased 10ms follow to each previous S2 with a beginning cycle length of 10ms less than the tachycardia cycle length to induce PHCs.

- Confirming captured His patterns, after that the maneuver needed to be performed again when not captured His and captured atrial morphology.

- After delivering PHCs, measurement of the H1H1, H1S1, A1A1, A1A2 intervals as shown in the figure, and then calculating the values of $\Delta PHC = H1H1 - H1S2$, $\Delta A1A2 = A1A1 - A1A2$, $\Delta A1A2 - \Delta PHC$.

$\triangle$ PHC = 20 ms
$\triangle$ A1-A2 = 0 ms

$\triangle$ PHC = 60 ms
$\triangle$ A1-A2 = 22 ms
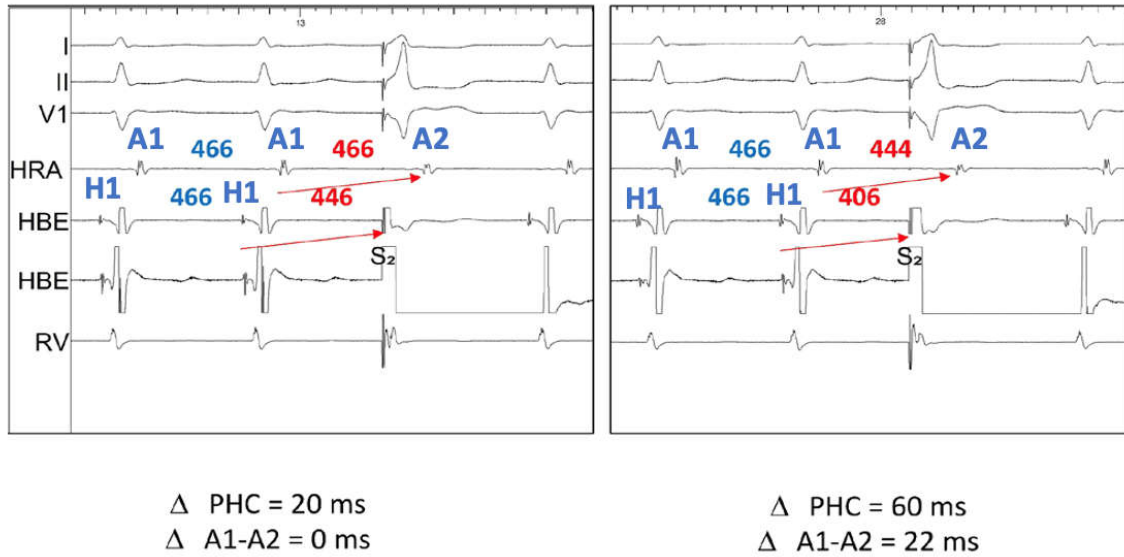
Figure 1. The description of the parameters when performing the maneuver [3].

　　　e. Statistics: Using SPSS 26.0 software and the difference was significant with $p < 0.05$.

　　　f. Ethics: The study was conducted in accordance with the adopted decision of Hanoi Medical University.

3. RESULTS

Table 1. Electrophysiological characteristics of paroxysmal supraventricular tachycardias

Parameters (ms)	AVRT (Mean ± sd)	AVNRT (Mean ± sd)	p
TCL	341,83 ± 35,86	368,22 ± 40,78	0,073
AH	167,42 ± 50,47	248,61 ± 50,52	**< 0,0001**
HA	162,67 ± 32,73	119,44 ± 49,17	**0,007**
VA	119,91 ± 30,91	58,75 ± 19,06	**< 0,0001**
HV	48,33 ± 12,13	52,94 ± 14,04	0,347
QRS	80,50 ± 11,44	77,72 ± 13,52	0,55

The tachycardia cycle length of AVNRT is longer than that of AVRT but the difference was not statistically significant ($p>0.05$). The HA, and VA intervals in AVRT were significantly longer than in AVNRT ($p<0.05$). Longer AH intervals were statistically significant in AVNRT ($p<0.05$). Meanwhile, the QRS complexes and HV intervals of the two tachycardias had no difference with $p > 0.05$

Table 2. Electrophysiological characteristics of late PHCs (ΔPHC <20ms)

Parameters (ms)	AVRT (Mean ± sd)	AVNRT (Mean ± sd)	p
ΔPHC	12,22 ± 2,91	11,43 ± 3,96	0,586
ΔA1A2	21,33 ± 15,36	0	**0,003**
ΔA1A2-ΔPHC	9,11 ± 13,90	-11,43 ± 3,96	**0,002**

When delivering a late PHC (ΔPHC < 20ms) in both AVRT and AVNRT (no difference $p > 0.05$) did not disturb the atrial sequence in AVNRT (ΔA1A2 = 0ms) but advanced the atrial sequence in AVRT with the mean ΔA1A2 of 21.33ms, this difference was statistically significant with $p<0.05$. The advancement of the next potential during AVNRT and AVRT in comparison with the prematurity (ΔA1A2-ΔPHC) was completely different with $p < 0.05$.

**Table 3.** Electrophysiological characteristics of early PHCs (ΔPHC ≥ 20ms)

Parameters (ms)	AVRT (Mean ± sd)	AVNRT (Mean ± sd)	p
ΔPHC	29,57 ± 8,54	38,92 ± 11,54	0,056
ΔA1A2	44,43 ± 14,92	15,85 ± 14,47	**0,001**
ΔA1A2-ΔPHC	14,86 ± 16,63	-22,46 ± 11,49	**<0,0001**

When delivering an early PHCs (ΔPHC 20ms) in both AVRT and AVNRT (no difference with $p > 0.05$), it disturbed the next atrial sequence in both circuits, but the atrial advancement in AVRT was greater than that of AVNRT, with statistical significance with $p<0.05$. The advancement of the next atrial potential during AVNRT and AVRT in a comparison with the prematurity of PHCs (ΔA1A2-ΔPHC) was completely different with $p < 0.05$.

Table 4. Initial diagnostic value of the maneuver

Maneuvers	Characteristics	Before RF		After RF	
		AVRT	AVNRT	AVRT	AVNRT
ΔPHC < 20ms (n=23)	ΔA1A2 > 0 (n=9)	9	0	9 (100%)	0
	ΔA1A2 = 0 (n= 14)	0	14	0	14 (100%)
ΔPHC ≥ 20ms (n = 20)	ΔA1A2-ΔPHC ≥ 0 (n=7)	7	0	7 (100%)	0
	ΔA1A2-ΔPHC ≤ -5 (n = 13)	0	13	0	13 (100%)
PHC Maneuver		12	0	12 (100%)	0
		0	18	0	18 (100%)

Late PHCs (ΔPHC < 20ms) were performed in 23 cases could make the differential diagnosis 100% accurate. Early PHCs (ΔPHC ≥20ms) were performed in 20 cases and could also be accurately diagnosed with 100% sensitivity and specificity. Thus, delivering PHCs has diagnostic value in differentiating AVRT and AVNRT with 100% sensitivity and specificity
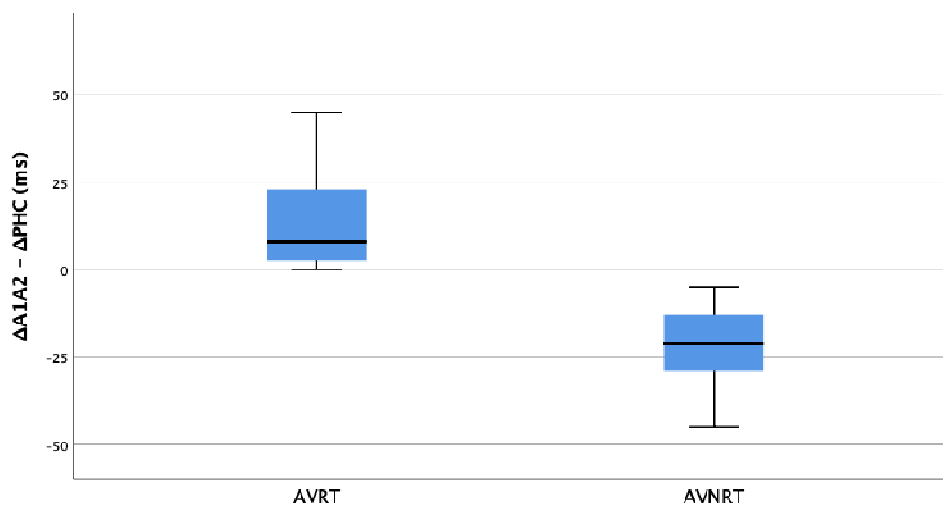
Figure 2. The difference between the advancement of the next atrial potential (ΔA1A2) and the prematurity of PHCs when delivering early PHCs (Δ PHC ≥ 20ms).

After delivering early PHCs (ΔPHC ≥20ms) would advance the next atrial sequence in both AVRT and AVNRT, in which the advancement of the next atrial potential A1A2 was greater than or equal to the prematurity of early PHCs in AVRT (ΔA1A2-ΔPHC ≥ 0), in contrast to in AVNRT, it was always shorter than the prematurity of early PHCs (A1A2-ΔPHC ≤ -5ms).

4. Discussion

Features of paroxysmal supraventricular tachycardias

Atrioventricular reentry tachycardia (AVRT) and atrioventricular nodal reentry tachycardia (AVNRT) are two main types of paroxysmal supraventricular tachycardias, characterized by abrupt onset and termination, and a regular rapid rhythm, narrow QRS with mean QRS in this study was 80.5ms and 77.2ms, respectively, there was no difference between the two tachycardias with $p > 0.05$. The cycle length of AVNRT tachycardia was longer than that of AVRT tachycardia (368.22ms versus 341.83ms),

but this difference was not statistically significant with $p > 0.05$. Similarly, in Mills' study of 100 patients with supraventricular tachycardias, the cycle length of AVRT was significantly shorter than that of AVNRT [4]. However, a recent study in a pediatric population showed that there was no difference in tachycardia cycle length between AVRT and AVNRT after adjusted for age, in which the mechanism of tachycardia was not a predictive factor but the tachycardia cycle length increases with age [5].

The AVNRT reentry circuit is based on the fast and slow pathways of the atrioventricular node with different conduction characteristics and

refractory periods as demonstrated by the AH jump phenomenon. Therefore, the AH interval of AVNRT is usually much longer than that of AVRT, and in this study, it was 248.61ms versus 167.43ms, respectively, with p < 0.05. Meanwhile, the VA interval can be used to differentiate between AVNRT and AVRT with relatively high sensitivity and specificity. In this study, the VA of AVRT was significantly longer than that of AVNRT (119.91ms vs 75ms) and >90ms, this difference is statistically significant with p<0.05. However, in some difficult cases such as atypical AVNRT and septal AVRT, additional maneuvers may be required for the differential diagnosis [2].

Features of PHCs and initial diagnostic values

After late PHCs (ΔPHC < 20ms), the mean prematurity of PHCs were performed in AVNRT and AVRT were 11.43ms and 12.22ms, respectively, with no statistically significant difference, p > 0.05. These PHCs did not disturb the next atrial sequence of AVNRT (ΔA1A2 = 0ms), but advanced in all AVRTs with a mean ΔA1A2 of 21,33ms. The value of sensitivity and specificity of these late PHCs in the differential diagnosis of AVRT and AVNRT was 100% (Table 4). This result was similar to Padanilam's outcomes with the sensitivity and specificity of 100% for differentiation when delivering late PHCs [3].

In a study on the reentry characteristics of the AVNRT circuit, it was found that there is a lower common pathway or the conduction time from His to the reentry circuit, with conduction characteristics ≥ 15ms [6]. In addition, to perform an entrainment maneuver on a reentry circuit or impact it, the stimuli needed a cycle length

shorter than the tachycardia cycle length is about 16-30 ms [7]. In 2020, Padanilam hypothesized that an early PHC (≥ 20ms) would potentially disturb the atrioventricular nodal reentry tachycardia because of the need for conduction time from His to this reentry circuit [3].

In our study, the mean prematurity of early PHCs was 38.92ms (the minimum was 21ms) would disturb the next atrial sequence of the AVNRT, with the mean atrial advancement ΔA1A2 of 15.85ms. These early PHCs were shorter than in Padanilam's study with a mean of 48ms (28-70ms), but early PHCs still required ≥ 20ms to penetrate to AVNRT circuits Meanwhile, the mean prematuric of early PHCs when delivering PHCs during the AVRT tachycardias was 29.57ms (not statistically significant difference compared with AVNRT, p>0.05), both of which advanced the next atrial potential with a mean ΔA1A2 of 44.43ms, this advancement was much greater than in the AVNRT (15.85ms), with statistical significance p<005. In comparison with the prematurity of PHCs, the advancement of the next atrial sequence A1A2 of AVRT ≥ 0ms (at least equal to PHC), while that of AVNRT is always smaller (≤ -5ms) (Figure 2). This result was similar to that in Padanilam's study, early PHCs disturbed the atrial sequence of AVNRT by a shorter amount than the prematurity of early PHCs. Table 4 showed that the differential diagnosis value of early PHCs was 100%, while in Padanilam's study, it had a sensitivity of 90% and a specificity of 100%. The possible reason was the initial study with a sample size being small, and we have not been performed this maneuver on a sufficiently large number of cases.

Therefore, it is necessary to conduct further follow-up studies in larger sample sizes to be able to more specifically and accurately evaluate the results of the maneuver in clinical practice.

5. Conclusion

The PHC maneuver was relatively simple, effective, and had a highly accurate initial diagnostic value. All PHCs definitely changed AVRT circuits, and PHCs <20ms did not disturb AVNRT. PHCs ≥ 20ms advanced AVNRT by a smaller amount than the prematurity of PHCs. Further studies are necessary to determine the value of the maneuver in clinical practice.

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