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Использование парагисиальной электростимуляции как электрофизиологического метода классификации наджелудочковой тахикардии при нормальной ЭКГ покоя

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Резюме

Введение. Пароксизмальная наджелудочковая тахикардия (НЖТ) представляет собой периодическую НЖТ в отличие от трепетания предсердий (ТП), фибрилляции предсердий (ФП) и мультифокальной предсердной тахикардии (ПТ), включая атриовентрикулярную узловую реципрокную тахикардию (АВУРТ), атриовентрикулярную реципрокную тахикардию (АВРТ) и ПТ. Некоторые методы электрофизиологических (ЭФ) исследований показали свою эффективность при оценке и дифференциации этих состояний. С помощью парагисиальной кардиостимуляции можно установить, происходит ли ретроградная активация предсердий через атриовентрикулярные узлы (АВУ) («узловой ответ») или через вспомогательный путь (ВП) («экстранодальный»), а также выявить скрытые септальные вспомогательные пути.
Цель. Дифференцировать типы наджелудочковой тахикардии (НЖТ), используя парагисиальную электростимуляцию, у пациентов с нормальной ЭКГ покоя на основании реакции на парагисиальную электрокадиостимуляцию (ПГ ЭКГ).
Материалы и методы. В данное перекрестное исследование были включены пациенты с НЖТ с нормальными показателями ЭКГ в состоянии покоя, которым с ноября 2021 по август 2022 г. были проведены электрофизиологические исследования и радиочастотная абляция. Для определения того, происходит ли проводимость по средней линии через АВУ или через септальный путь, в синусовом ритме выполняли парагисиальную кардиостимуляцию с захватом и без захвата правой ножки пучка Гиса.
Результаты. Исследование показало, что у 73,5% пациентов была зарегистрирована АВУРТ, у 23% – АВРТ и только в 4 случаях ПТ. В 80 из 83 случаев АВУРТ реакция на ПГ ЭКГ была узловой, в то время как из 26 случаев АВРТ узловой ответ был получен лишь в четырех случаях. Чувствительность ПГ ЭКГ при выявлении АВРТ составила 84,6%.
Заключение. ПГ ЭКГ является эффективным инвазивным электрофизиологическим методом дифференциации НЖТ, демонстрирующим высокую чувствительность в

отношении определения АВРТ как возможного типа аритмии. Вместе с тем необходимо тщательно подходить к выполнению этой процедуры и интерпретации полученных данных, чтобы исключить «подводные камни», присущие данному методу.
Ключевые слова: парагисиальная электростимуляция, электрофизиологический метод, наджелудочковая тахикардия, ЭКГ покоя, экстранодальный ответ

■ INTRODUCTION

Supraventricular tachycardia denotes the including of one or more cardiac parts above His bundle bifurcation, like the atrioventricular node (AVN), atrial myocardium, coronary sinus (CS), proximal His bundle (HB), venae cavae, pulmonary veins, or abnormal atrioventricular (AV) linkages other than the HB (bypass tract (BTs)) [1].

Narrow QRS-complex (Q wave, R wave and S wave of ECG) SVT is a tachyarrhythmia with a rate >100 beats/min and QRS duration <120 ms [2, 3].

NC-SVT include inappropriate sinus tachycardia, sinus tachycardia, focal atrial tachycardia (AT), sinoatrial nodal reentrant tachycardia, atrial fibrillation (AF), multifocal AT, atrial flutter (AFL), atrioventricular nodal reentrant tachycardia (AVNRT), junctional tachycardia, and atrio-ventricular reentrant tachycardia (AVRT) [1, 2].

Paroxysmal SVT is applied to intermittent SVT other than the AFL, AF, and multifocal AT. It describes a clinical syndrome characterized by regular and rapid tachycardia (abrupt onset and termination). The major causes are AVNRT (50–60%), AVRT (30%), and focal AT (10%) [1].

Individuals are referred for ablation because of symptomatic paroxysmal SVT. The AVNRT was the common mechanism (56%), followed by AVRT (27%) and AT (17%). The mechanism of SVT depends on age and gender [4]. The majority of patients with AVRT were men, whereas the majority with AVNRT and AT were women. As the number of cases increased, there was a significant and reasonable decline in the number of cases [4].

AVNRT is the predominant mechanism in cases undergoing ablation, and after the age of 20 years, it accounts for the largest number in each age group. It is unusual in pediatric patients and typically manifests in early life [5]. Female sex and elderly patients favor AVNRT detection over AVRT. AVRT is present earlier in life than AVNRT (common in the first two decades), with an average of >10 years separating the time of clinical presentation of AVRT from AVNRT [6]. This finding is consistent with the congenital nature of the substrate. However, a minority of cases have a relatively late onset of symptoms associated with AVRT and thus continue to account for a small proportion of ablations in older patients. Men account for a higher proportion of AVRT at all ages [7].

During normal electrical activity, reentry of the cardiac cycle begins in the sinoatrial nodes and continues to propagate until the entire heart is activated, and the impulse dies if all fibers depolarize and are completely refractory. The link to re-excite areas that were previously depolarized has recovered from the first depolarization [6]. Reentry, circus movement, reentrant excitation, reciprocal or echo beat, or reciprocating tachycardia (RT) refers to the repetitive propagation of activation waves that return to their origin sites to reactivate [6].

Several electrophysiology study maneuvers have been found to be helpful in the invasive electrophysiological assessment of SVT. The para-Hisian sites are anatomically

close to and electrically distant from the HB. Para-Hisian pacing at high output captures the proximal HB or RB (His bundle or proximal right bundle branch) as well as the adjacent ventricular myocardium. At a lower output, direct HB-RB captures are lost and retrograde activation of the HB is delayed because the RB and HB are insulated from the adjacent myocardium and peripheral inputs to the Purkinje system, which are situated far from the para-Hisian pacing sites [7–9].

By maintaining local ventricular captures while intermittently losing His bundle and proximal right bundle branch (HB-RB) captures, retrograde VA conduction can be classified as dependent on the local ventricular activation timing, HB activation, or both (fusion) [9].

Para-Hisian pacing techniques are used to determine the routes of retrograde electrical conduction from the ventricles to the atria. Reliable tools are available to establish the presence of a para-septal accessory pathway [10, 11]. Proper interpretation of para-Hisian pacing requires systematic approaches and an understanding of potential pitfalls [11].

The goal of para-Hisian pacing is to achieve retrograde atrial activation by the atrioventricular nodes or by extranodal responses. Other methods identify various forms of fusion, such as multiple APs, combinations of retrograde AVN conduction and APs [12].

Para-Hisian pacing via capture of ventricles (wide-paced QRS), atriums (atrial activation in the HB regions post-pacing artifacts), HB (narrow-paced QRS), or any combination [11, 12].

■ PURPOSE OF THE STUDY

To differentiate the types of SVTs using para-Hisian pacing in patients with normal resting ECG according to the para-Hisian pacing response.

■ MATERIALS AND METHODS

This cross-sectional study enrolled patients with SVT with normal resting ECG who were scheduled for electrophysiological study and radiofrequency ablation from November 2021 to August 2022.

The patient stopped any anti-arrhythmic drug one week prior to the EP study and six weeks for amiodarone users.

History, laboratory investigations and ECG were done one day prior to EPS.

The electrophysiological study procedure was started using four intravenous lines through the right and left femoral veins. The EP device WorkMate Claris system (ST. Jude Medical), a steerable decapolar catheter deployed in the coronary sinus, then two quadripolar catheters for the right atrium, right ventricular apex, and one hexapolar catheter in the His region.

Para-Hisian Pacing

This maneuver, performed in sinus rhythm, helps determine whether midline conduction occurs through the AV node or septal pathway.

Pacing was started at a high output (10–20 mv) to capture the deeply seated and insulated His directly and the surrounding myocardial tissue. The pacing output gradually decreased until his capture was lost. When His is captured directly, the resulting QRS will be narrow; when His capture is lost, the QRS will widen into a BBB pattern. The time from the stimulation artifact to the subsequent atrial signal (SA interval) was measured during His capture and loss of His capture.

The His bundle electrogram was recorded with a 6 F hexa-polar catheter with 2 mm interelectrode spacing to localize the His bundle and proximal right bundle branch.

For para-Hisian pacing, the catheter was positioned 1–2 cm anterior and apical to the His bundle at the anterobasal right ventricular septum.

Bipolar ventricular pacing was performed through the distal pair of electrodes (2 mm spacing) at a long pacing cycle length (>500 ms) and high output (10 mA). A narrow QRS indicates direct HB-RB capture. The pacing output then decreased until the paced QRS complex widened, indicating loss of HB-RB capture.

The response to para-Hisian pacing was determined by the change in the following variables between HB-RB capture and HB-RB noncapture [7]:

1. Atrial activation sequences.
2. Stimulus -Atrial Interval.
3. H-A interval measured in His bundle electrogram.

In the absence of AP, loss of His capture resulted in a widening of the QRS complex and a simultaneous increase in stimulation-atrial time (denoted as the Noda para-Hisian response)

In contrast, the presence of a septal AP results in an identical stimulation-atrial time both with and without His capture (extranodal response, via accessory pathway).

Statistical Analysis

The data were analyzed using Statistical Package for Social Science (SPSS) version 22. The results are presented as a simple self-explanatory tabulation. The sensitivity and specificity were measured.

■ RESULTS

This is a cross-sectional study included 113 patients with supraventricular tachycardia: 78 females (69%) and 35 males (31%), with a mean age of 36±11 years and range of 15–65 years.

The Ventriculoatrial (VA) conduction of the study cases revealed that 89 cases (78.8%) had decremental VA conduction, while 24 (21.2%) had non-decremental conduction (Table 1).

Also, 88 cases (77.9%) received Nodal para-Hisian pacing response, while 25 cases (22.1%) received extranodal response (Table 2).

Table 1
VA conduction of study cases

VA Conduction	No.	%
Decremental	89	78.8
Non-Decremental	24	21.2

Table 2
Para-Hisian response of study case

Para-Hisian	No.	%
Nodal	88	77.9
Extra-Nodal	25	22.1

Table 3
SVT category

SVT	No.	%
AVNRT	83	73.5
AVRT	26	23
AT	4	3.5

Table 4
Correlation between para-Hisian pacing response with VA conduction and types of SVT

VA conduction	Para-Hisian pacing	
	Nodal	Extra-Nodal
Decremental	84 (95.5)	5 (20)
Non-decremental	4 (4.5)	20 (80)
Total	88	25
SVT	**Para-Hisian Pacing**	
	Nodal	**Extra-Nodal**
AVNRT	80 (91)	3 (12)
AVRT	4 (4.5)	22 (88)
AT	4 (4.5)	–
Total	88	25

Table 5
Correlation of VA conduction with types of SVT

SVT	VA conduction	
	Decremental	Non-Decremental
AVNRT	81 (91)	2 (8.4)
AVRT	4 (4.5)	22 (91.6)
AT	4 (4.5)	–
Total	89	24

The study revealed that 73.5% of the patients received AVNRT, 23% AVRT, while only four case got AT (Table 3). The study revealed 74.7% of AVNRT cases were female and 53.8% of AVRT were male, whereas All AT cases were female.

The para-Hisian pacing response was nodal in 84 patients with VA, while four patients with VA showed non-decremental conduction (Table 4). The para-Hisian pacing response was nodal in 80 cases of AVNRT, while four with AVRT received nodal response (Table 4).

The para-Hisian pacing response was nodal in 81 cases of AVNRT, while 4 cases with AVRT showed decremental conduction (Table 5). The types of AVRT in the study cases were orthodromic in 16 cases, antidromic in 7 cases, and PJRT in 3 cases. Sites of the accessory pathway of AVRT were as follows: 6 left lateral, 2 left inferolateral, 3 anteroseptal, 8 posteroseptal, 4 midseptal, and 3 right-sided.

■ DISCUSSION

The study results revealed that 73.5% of the study patients received AVNRT and 23% AVRT, while only 4% suffered from AT, and the gender distribution of various forms of SVT, which is consistent the epidemiological data regarding the frequency of SVT from ACC/AHA/HRS [1].

The use of para-Hisian pacing is a valuable method to categorize SVT according to whether it is nodal (via AVN, whether fast or slow pathway) or extranodal (via a concealed accessory pathway).

The sensitivity in our study about 84.6 % for para-Hisian pacing to detect AVRT as a possible mechanism of arrhythmia. Nevertheless, there are multiple pitfalls [13, 14]: using a hexa-polar catheter can abolish the ability to record retrograde His bundle electrogram potential and HA intervals when pacing. Therefore, two quadri-polar catheters were used, one for pacing and the other for recording (octa-polar catheter).

Assurance of the lack of atrial capture via the pacing stimulus is important for correct interpretation of Parahisian pacing. When very short stimulation to the proximal coronary sinus artery <60 ms present and stimulation to the high right atria <70 ms are suggestive of direct capture of atria from pacing catheters. A stimulation atrial EGM time of >90 ms (proximal coronary sinus) and >100 ms (high right atrium) strongly argues against direct atrial capture.

Para-Hisian pacing during sinus rhythm is useful to prove the presence of an AV septal BT; however, it does not show whether BT participates during arrhythmia.

The classic PHP only allows the determination of whether the present mapped retrograde atrial activation, at a certain time and PCL, is dependent on HB activation.

Moreover, although a nodal pattern does not exclude the presence of an AP, the latter does not confirm the underlying mechanism of tachycardia [14].

This technique requires extra care and case education to overcome the pitfall of catheter movement during respiration, which may result in inadvertent atrial capture or failure to pace the para-Hisian region.

The location of the AP and the retrograde conduction time over this bypass tract must be considered when interpreting the results of para-Hisian pacing [15].

Stimulus to the ventricular bypass tract interval (SVBT) is increased as APs are located progressively farther from the para-Hisian pacing site.

Therefore, for left free-wall BTs, which are located far from the pacing site, the SVBT interval can be sufficiently long to have the atria retrogradely activated via the AVN during the HB-RB non capture state and incorrectly exclude the left-sided accessory pathway [7].

■ CONCLUSION

Para-Hisian pacing is a good invasive electrophysiological method to categorize supraventricular tachycardia with good sensitivity in predicting AVRT as a possible type of arrhythmia; nevertheless, it needs careful interpretation and implementation to overcome the pitfalls inherent in such a method.

We recommend the routine use of para-Hisian in cases with SVT subjected to EP study and radiofrequency ablation to detect concealed accessory pathways not detected in another test.

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