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Original article

Characterization of the Nodal Slow Pathway in Patients With Nodal Reentrant Tachycardia: Clinical Implications for Guiding Ablation

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ABSTRACT

Introduction and objectives: Nodal slow pathway ablation is the treatment of choice for nodal reentrant tachycardia. No demographic, anatomic, or electrophysiologic variables have been reported to predict an exact location of the slow pathway in the atrioventricular node or its proximity to the fast pathway. The purpose of this study was to analyze these variables.
Methods: The study prospectively included 54 patients (17 men; mean age, 55 [16] years) who had undergone successful slow pathway ablation. The refractory periods of both pathways and their differential conduction time were measured, and calculations were performed to obtain the distance from the His-bundle region (location of the fast pathway) to the coronary sinus ostium (to estimate the anteroposterior length of the triangle of Koch) and to the slow pathway area.
Results: The differential conduction time (139 [98] ms) did not correlate with the His-coronary sinus distance (19 [6] mm; $P = .6$) or the His-slow pathway distance (14 [4] mm; $P = .4$). When the His-coronary sinus distance was larger, the His-slow pathway distance was also larger ($r = 0.652$; $P < .01$) and the anatomic correlation between the triangle dimensions and the separation between the two pathways was confirmed. In patients older than 70 years, smaller triangle sizes and a shorter distance between both pathways were observed ($P < .001$).
Conclusions: A greater anteroposterior dimension of the triangle of Koch is associated with a slow-pathway location farther from the fast pathway. In elderly patients the two pathways are closer together (higher risk of atrioventricular block).

Caracterización de la vía lenta nodular en pacientes con taquicardia por reentrada nodular: implicaciones clínicas para guiar la ablación

Palabras clave:
Taquicardia por reentrada nodular
Vía lenta
Triángulo de Koch
Ablación con catéter

RESUMEN

Introducción y objetivos: La ablación de vía lenta nodular es el tratamiento de elección de la taquicardia por reentrada nodular. No hay descritas variables demográficas, anatómicas ni electrofisiológicas que predigan una localización exacta de la vía lenta dentro del nódulo auriculoventricular ni su proximidad a la vía rápida. El objetivo es estudiar estas variables.
Métodos: Se incluyó prospectivamente a 54 pacientes (17 varones; media de edad, 55 ± 16 años) sometidos a ablación efectiva de vía lenta. Se midieron los periodos refractarios de ambas vías y su tiempo de conducción diferencial. Se calculó las distancias desde la región hisiana (correspondiente a la localización de la vía rápida) hasta el *ostium* del seno coronario (con lo que se obtuvo una estimación de la longitud anteroposterior del triángulo de Koch) y también hasta la zona de la vía lenta.
Resultados: El tiempo de conducción diferencial (139 ± 98 ms) no se correlacionó con las distancias His-seno coronario (19 ± 6 mm; p = 0,6) ni His-vía lenta (14 ± 4 mm; p = 0,4). A mayor distancia His-seno coronario, se estableció mayor distancia His-vía lenta (r = 0,652; p < 0,01) y se confirmó la correlación anatómica entre las dimensiones del triángulo y la separación entre ambas vías. En los pacientes mayores de 70 años, se observaron menor tamaño del triángulo y menor distancia entre ambas vías (p < 0,001).
Conclusiones: Una mayor dimensión anteroposterior del triángulo de Koch se asocia a una localización de vía lenta más alejada de la rápida, encontrándose ambas más próximas entre sí (mayor riesgo de bloqueo auriculoventricular) en los pacientes de edad avanzada.

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Abbreviations

AH: atrial-His
CSO: coronary sinus ostium
FP: fast pathway
NRT: nodal reentrant tachycardia
SP: slow pathway

INTRODUCTION

Nodal reentrant tachycardia (NRT) is the most common form of presentation of paroxysmal supraventricular tachycardia.[1] The electrophysiologic mechanism behind NRT initiation and maintenance is reentry between 2 pathways with different conduction characteristics, both of which are part of the atrioventricular nodal (AVN) structure.[1,2] The slow pathway (SP) is identified as an inferior and posterior AVN extension near the coronary sinus ostium (CSO), which is anatomically the inferior apex of the triangle of Koch.[2–4] Nevertheless, a clear histologic differentiation between the 2 pathways (slow and fast) in the AVN is still controversial.[2,5–8] The unpredictable anatomic separation between the SP and the fast pathway (FP) plays a critical role in the outcome of SP ablation (the treatment of choice in these patients), due to the possible risk of atrioventricular (AV) block caused by FP involvement.[9,10]

Previous studies have suggested that the anatomic location of the SP may correlate with its electrophysiologic properties.[11,12] These properties include the duration of the A(H)-A(Md) interval, which would express the "electrical" distance between the 2 pathways and would indicate the risk of AV block during SP ablation.[13] However, no linear correlation has been identified between conduction times and FP and SP refractory periods or their relative anatomic situation. There are also no data on how patient age at NRT onset influences the anatomic site of SP, its proximity to the FP or, therefore, the risk of AV block during ablation.

Lastly, no studies have investigated the influence of more than 2 conduction patterns in the AVN (demonstrated by the presence of a second jump of the atrial-His [AH] interval, seen in up to 40% of NRT cases) on SP ablation outcome.[14]

Our purpose was to identify whether there is a correlation between SP and FP electrophysiologic characteristics, triangle of Koch size, and SP location in patients with NRT. We also analyzed the influence of sex and age on SP location.

METHODS

Study Population

We prospectively included 56 patients who had undergone electrophysiologic analysis and successful NRT ablation. All patients gave written consent in accordance with our institutional guidelines. To determine the exact anatomic location of SP in all patients, we excluded any patients with other mechanisms of supraventricular tachycardia or with unsuccessful ablation.

Electrophysiologic Study

The electrophysiologic study was performed through the right femoral vein, advancing 2 electrode catheters (tetrapolar, 6 Fr, with electrodes spaced 5 mm apart, Bard Inc.; Murray Hill, New Jersey, United States) to positions in the upper right atrium and His/right ventricle.

Intracardiac bipolar electrograms (filter at 30-500 Hz) were recorded and saved throughout the procedure using the Lab Pro system (Bard Inc.) and were subsequently analyzed. Electronic calibrators with a 2-ms resolution were used at a screen speed of 100 mm/s for all measurements. The NRT diagnosis was confirmed using previously described electrophysiologic criteria, including criteria for para-Hisian entrainment without His-bundle capture.[1,15]

Electrophysiologic Measurements

The electrophysiologic measurements included the refractory periods of both nodal pathways, sinus cycle length, tachycardia cycle, AH- and His-ventricle intervals, and antegrade Wenckebach point, before and after ablation. Dual nodal pathway physiology (presence of nodal SP) was established if an increase > 50 ms in the AH interval (A2H2) was observed along with a decrease of 10 ms in the coupling interval during elective atrial pacing (AH jump). The conduction time difference between SP and FP was measured as the difference between the A2H2 interval in the first beat after the AH jump (initial SP conduction) and the maximum A2H2 interval before reaching the FP effective refractory period (as an approximation of the longest FP conduction time before the AH jump). Unlike previous reports, we speculated that this conduction time difference would better express the differential conduction characteristics of the 2 pathways, unlike the individual AH-interval measurements during FP or SP conduction.[11,12] A second AH jump is expressed as A3H3.

Anatomic Measurements of the Triangle of Koch

The anatomic measurements were performed using fluoroscopic calibrators with the 5-mm reference in the electrode distance of 1 of the tetrapolar leads (His-bundle lead in right anterior oblique view; right atrial lead in left anterior oblique view). To prevent errors in the measurements related to more vertical or horizontal heart orientation, both views were adjusted to obtain an exact lead-to-lead measurement of 5 mm in the reference catheter.[16–19]

Before the ablation procedure was started, the mapping/ablation catheter was advanced to the coronary sinus until the proximal leads were at the level of the CSO. The distance (in millimeters) between the CSO and the proximal His-bundle region was then measured in the left anterior oblique view (view with best catheter deployment in the coronary sinus, with the CSO indicating the lower limit of the triangle of Koch). Therefore, the His-CSO distance was estimated as an approximation of the vertical length of the triangle of Koch. By dividing this length into 3 thirds, the SP location was qualitatively classified into a high, middle, or low position. Following ablation, the FP-to-SP distance was determined by using the right anterior oblique views and measuring the distance between the distal lead of the mapping/ablation catheter (region of effective SP ablation) and the proximal recording region of the His bundle.

Slow Pathway Ablation

The radiofrequency energy was 50 W (55 °C) in the SP area, when a solid-tip 4-mm ablation catheter was used (electrode distance, 5 mm; Bard Inc.). Radiofrequency emission was discontinued when AV dissociation was observed during AV