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Original research article

A simplified approach for evaluating sustained slow pathway conduction for diagnosis and treatment of atrioventricular nodal reentry tachycardia in children and adults

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ABSTRACT

Purpose: During incremental atrial pacing in patients with atrioventricular nodal reentrant tachycardia, the PR interval often exceeds the RR interval (PR > RR) during stable 1:1 AV conduction. However, the PR/RR ratio has never been evaluated in a large group of patients with pacing from the proximal coronary sinus and after isoproterenol challenge. Our study validates new site of pacing and easier method of identification of PR > RR.
Material and methods: A prospective protocol of incremental atrial pacing from the proximal coronary sinus was carried out in 398 patients (AVNRT-228 and control-170). The maximum stimulus to the Q wave interval (S-Q = PR), SS interval (S-S), and Q-Q (RR) interval were measured at baseline and 10 min after successful slow pathway ablation and after isoproterenol challenge (obligatory).
Results: The mean maximum PR/RR ratios at baseline were 1.17 ± 0.24 and 0.82 ± 0.13 ($p < 0.00001$) in the AVNRT and controls respectively. There were no PR/RR ratios ≥1 at baseline and after isoproterenol challenge in 12.3% of the AVNRT group and in 95.9% of the control group ($p < 0.0001$). PR/RR ratios ≥1 were absent in 98% of AVNRT cases after slow pathway ablation/modification in children and 99% of such cases in adults (P = NS). The diagnostic performance of PR/RR ratio evaluation before and after isoproterenol challenge had the highest diagnostic performance for AVNRT with PR/RR > = 1 (sensitivity: 88%, specificity: 96%, PPV-97%, NPV-85%).
Conclusions: The PR/RR ratio is a simple tool for slow pathway substrate and AVNRT evaluation. Eliminating PR/RR ratios ≥1 may serve as a surrogate endpoint for slow pathway ablation in children and adults with AVNRT.

1. Introduction

Atrioventricular (AV) nodal reentrant tachycardia (AVNRT) is the most common form of paroxysmal regular supraventricular tachycardia in pediatric and adult patients referred for invasive electrophysiological study and catheter ablation (CA) [1–4]. The presence of dual AV nodal physiology (DAVN) is typically reported as a substrate for AVNRT. The classical definition of DAVN is an atrio-His (AH) jump greater than

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Table 1
Comparison of previous and simplified approaches for PR/RR ratio measurement.

Authors	Baker et al. [6]	Kannankeri et al. [9]	Blurton et al. [8]	Martinez-Sanchez et al. [7]	Sledz et al. (present study)
AVNRT (n)	30	61	92	85	228
Control (n)	27	0	46	56	170
Pacing site	HRA	HRA	HRA	HRA	PCS
Children < 18 (%)	0	90	100	0	26
DAVN by only A2H2 evaluation (S2, Jump value)	Yes (ND)	YES (≥50 ms)	YES (≥40 ms)	YES (≥50 ms)	NO (S2, S3 or S4 ≥ 50 ms)
PR/RR ratio ≥ 1 accepted only in 1 beat	no, continuous stable for 15 s	no, continuous	no, continuous	no, continuous	yes
Isoproterenol challenge when neccessary for induction	no	yes	yes	yes	yes
Isoproterenol challenge and PR > RR measurement in all cases after ablation	no	no	no	no	yes
Catheters (number)	4	4	3	3	2
General anesthesia (% of patients)	0	0	> 50	0	0
PR > RR in AVNRT(%)	93	93	60	78	88
PR > RR in controls (%)	11	ND	13	12	4
% of standard „jump" in AVNRT	57	52	42	61	49
% of standard „jump" in controls	11	ND	30	18	9

Abbreviations: AVNRT – atrioventricular nodal reentrant tachycardia; HRA – high right atrium; PCS –k proximal coronary sinus; DAVN – dual AV nodal (physiology); A2H2 – atrial potential after premature extrastimulus; S2 – the first premature extrastimulus after train (S1); ND – not declared; S3 – the second premature extrastimulus after S2 and train; S4 – the third premature extrastimulus after S2, S3 and train; PR/RR ratio – PR interval to RR interval ratio: from the atrial stimulus to earliest R wave on ECG during incremental atrial pacing; PR > RR – the PR interval often exceeds the RR interval.

50 ms with a 10-ms decrement in A1A2. However, this condition is only met in approximately half of pediatric patients with AVNRT [4]. Moreover, criteria for DAVN have been reported in up to 44% of patients without AVNRT, especially in the pediatric population [4–9]. In patients with AVNRT, however, DAVN is documented less often than sustained slow pathway conduction (SSPC) during incremental atrial pacing (IAP). In patients with AVNRT and a fast rate of IAP, the PR interval often exceeds the RR interval (PR/RR > 1) during stable 1:1 AV conduction. This phenomenon could be a substrate for the inducibility of AVNRT, and its absence could be a marker of slow pathway ablation or modification [6–9].

SSPC has never been evaluated in such a way in a large, unselected group of patients (more than 100) with AVNRT. Moreover, there has been no prospective study on a simplified approach for evaluating SSPC with pacing from the proximal coronary sinus (PCS) at baseline and when needed after isoproterenol infusion. Previous studies involved only the high right atrium pacing site and IAP with several PR intervals exceeding the RR interval with stable 1:1 AV conduction (Table 1) [4–9].

The aim of our study is to characterize the baseline and post-ablation AV nodal conduction features during IAP from the PCS in unselected pediatric and adult patients with AVNRT. We also compared our findings to a control population of patients without AVNRT. The results show that the simplified approach for SSPC evaluation could be a simple, fast, and accurate technique for AVNRT diagnosis and endpoint of SP ablation or modification.

SP ablation was defined as lack of dual atrioventricular physiology and non-inducibility of AVNRT. SP modification was defined as non-inducibility of AVNRT with residual jump and/or single echo beat.

2. Material and methods

Data were collected from a prospective multicenter registry that covers procedures from six centers. Patients were recruited between 2010 and 2013. The intracardiac signals and measurements shown in Figs. 1 and 2 were obtained from procedures performed in the year 2016. All of the patients investigated had been referred for electrophysiological study and radiofrequency catheter ablation. A prospective protocol of IAP was carried out in 398 patients who were referred for ablation due to documented AVNRT (n = 228, study group) and other non-SP-dependent arrhythmias (control, n = 170).

All patients in the AVNRT group had documented narrow QRS tachycardia prior to EPS. In the control group, 70 patients with accessory pathway had orthodromic tachycardia, 24 patients had atrial flutter (narrow QRS), and 10 patients had atrial tachycardia. Therefore, narrow QRS tachycardia was documented in 104 patients in the control group. The study protocol complies with the Declaration of Helsinki and was approved by 2 local Institutional Review Boards: 1) Bioethics Committee of the Regional Specialist Hospital, Centre for Research and Development in Wroclaw, Poland (approval number KB/2/2010, 2 June 2010); 2) Bioethics Committee of the Swietokrzyska Chamber of Physicians and Dentists in Kielce, Poland (approval number 6/A/2009, 9 February 2009). All patients gave informed consent prior to the procedure. Antiarrhythmic drugs were discontinued for a minimum of 5 half-lives prior to the study.

2.1. Electrophysiological study and ablation

Minimally invasive non-fluoroscopic imaging and catheter ablation were performed with minimum fluoroscopy exposure (4–8 frames/s) or non-fluoroscopic navigation and imaging. A detailed description of the approach is reported in previous studies [10,11]. Shortly, the left anterior oblique view (or biplane left and right anterior oblique view for the MINI CA approach) was used to assess the catheter position and electroanatomical mapping. An EP-tracer (EP Recording System, CardioTek, Maastricht, the Netherlands) was used for all procedures to record the input from all 12 electrocardiography (ECG) leads and intracardiac signals simultaneously. Under fluoroscopic or non-fluoroscopic guidance, a decapolar catheter was placed in the coronary sinus, and one mapping/ablation catheter was positioned using a "dynamic approach" in the His bundle region, PCS, right atrium, and right ventricle. The catheter was either a 4 or 8-mm gold tip catheter (Biotronik), a 4-mm platinum-iridium catheter (St. Jude Medical, St. Paul, Minn., USA), or an 8-mm gold tip catheter (Osypka AG, Germany).

A three-dimensional electroanatomical system (3D-EAM, Ensite Velocity, St. Jude Medical) was used according to the discretion of the treating physician or the availability in the center. Bipolar intracardiac electrograms were filtered between 40 and 500 kHz and recorded at 100 mm/s. All pacing maneuvers from the ventricle or atrium were performed at a minimum of twice the diastolic threshold using a programmable stimulator built into the recording system.

Electrophysiological measurements were obtained in the baseline