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Unraveling the complexities of AVNRT ablation and its impact on electrophysiological features: A comprehensive review in children?

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Abstract

BACKGROUND: Paroxysmal Supraventricular Tachycardia (PSVT) is a broad term referring to any rapid heart rhythm originating above the heart's ventricles. Atrioventricular Nodal Reentrant Tachycardia (AVNRT) is a specific type of PSVT characterized by abnormal circuits or pathways within the atrioventricular (AV) node, a crucial component of the heart's electrical conduction system. AVNRT can cause rapid heartbeats due to abnormal electrical impulses circulating within the AV node. This study aimed to explore the association between the QT, PR, and QRS intervals before and after RF ablation.

METHODS: In this cross-sectional study, 115 children with recurrent cardiac arrhythmias were screened and included between 2010 and 2023. The management of arrhythmias followed established guidelines and consensus statements.

RESULTS: The mean age of the 115 children was 9.91 ± 3.30 years, and 52.2% were female. Statistical analysis revealed a significant difference in cycle length (p=0.001), ventricular drive cycle length (p=0.001), atrioventricular Wenckebach (p=0.002), and antegrade effective refractory period of the AV node (p=0.013) before and after ablation.

CONCLUSION: Supraventricular arrhythmias in children present complex cases that require individualized treatment approaches. Assessing the QT, PR, and QRS intervals before and after RF ablation provides a valuable tool for evaluating the success of these procedures, particularly in cases involving AVNRT.

Keywords: PSVT; AVNRT; QT Interval; PR Interval; QRS Duration

Introduction

PSVT is a broad term referring to any rapid heart rhythm originating above the heart's ventricles. It encompasses various types of supraventricular tachycardia, including AVNRT [1]. AVNRT specifically refers to a type of PSVT characterized by an abnormal circuit or pathways within the AV node, a crucial component of the heart's electrical conduction system. AVNRT can cause rapid and irregular heartbeats due to abnormal electrical impulses circulating within the AV node[2].

Cardiac conduction velocity characteristics, ventricular depolarization, and repolarization may be affected by abnormal cardiac electrophysiologic conditions resulting from factors that lead to PSVT.

One of the well-known causes of these changes is the presence of an accessory pathway leading to atrioventricular tachycardia (AVRT), which significantly alters ventricular myocardial depolarization and repolarization. Dual AV node physiology may also affect cardiac electrophysiological conditions; however, fewer studies have focused on this issue.

One of the best methods to evaluate these changes in AVNRT is to compare cardiac electrophysiological characteristics before and after cardiac catheter ablation[3].

Furthermore, the coexistence of hereditary cardiac diseases, such as channelopathies, with this group of tachyarrhythmias may lead to distinct electrophysiological manifestations compared to each condition alone. There are limited studies addressing this issue, particularly in the pediatric population; therefore, we decided to assess surface ECGs and EP characteristics during the EPS/ablation procedure.

AVNRT ablation is considered an effective treatment for recurrent AVNRT episodes that do not respond well to medication. By modifying the heart's electrical pathways, AVNRT ablation can significantly improve a patient's quality of life and reduce the frequency of tachycardia episodes.

This article explores a comparative assessment of the QT, PR, and QRS intervals before and after supraventricular arrhythmia ablation in children.

The QT interval, defined as the duration extending from the onset of the QRS complex to the end of the T wave in an ECG, reflects the duration of ventricular depolarization and repolarization. Prolongation of this interval can predispose individuals, including children, to serious complications such as ventricular arrhythmias and sudden cardiac death[4-7].

Methods

This prospective study received medico-legal approval and was conducted from 2017 to 2023, encompassing all children with recurrent cardiac arrhythmias. The management of arrhythmias followed established guidelines and consensus statements.

For each participant, a comprehensive medical history was obtained, and standard diagnostic procedures were performed. These included a 12-lead standard electrocardiogram (ECG), simple chest radiography, and transthoracic echocardiography.

Statistical Analysis

Data are presented as mean ± standard deviation (SD) or frequency (%), as appropriate. Continuous variables were compared before and after ablation using a paired t-test. All statistical analyses were performed using SPSS version 24.0 software (SPSS, Inc., Chicago, IL, USA). A p-value of less than 0.05 was considered statistically significant.

Patient permission/consent statement

The patient provided informed consent for the publication of this report, and the procedure was performed in accordance with the center's ethical policy.

Results

One hundred fifteen children, aged between 4 and 15 years, with arrhythmias were included in the study. The demographic, echocardiographic, and ECG findings of the study population are summarized in Tables 1 and 2.

Basic electrocardiogram (ECG) results were normal in all patients. Echocardiography revealed structural heart disease in three patients (2.6%), with simple defects such as small septal defects and patent ductus arteriosus.

Regarding the indications for ablation, 68 patients experienced frequent heart palpitations, 46 had documented paroxysmal supraventricular tachycardia (PSVT), and one patient had heart failure (Table 3). The average heart rate during arrhythmia episodes was 270 ± 50 beats per minute.

The success rate of ablation was 100%, with only one patient experiencing a complication in the form of an increased PR interval.

In statistical analysis comparing ECG and electrophysiological findings before and

Table 1. Demographic Findings of the Study Population

Variables*	Total number	Mean	Minimum	Maximum
Age (year)	115	9.91±.0	4	15
Weight (kg)	115	36.37±6.24	15	87
Height (cm)	115	141.50±20.21	100	187

*Continuous variables are presented as mean ± standard deviation.

Table 2. Sex Distribution Findings of the Study Population

Sex	Frequency	Percentage
Male	55	47.8
Female	60	52.2
Total	115	100

Categorical data are presented as frequency (percentage).

Table 3. Indication of Ablation for These Patients

Indication	Frequency	Percent	Percentage
Palpitation	68	59.1	59.1
Documented PSVT	46	40.0	40.0
Heart Failure	1	0.9	0.9
Total number	115	100	100

Categorical data are presented as frequency (percentage).

Table 4. Compare ECG finding before and after AVNRT ablation

Variables *	Before ablation	After ablation	p value
Cycle length (ms)	622.14±113.80	555.11±81.13	<0.001
PR Interval (ms)	121.34±18.32	120.54±25.59	0.746
QRS duration (ms)	89.96±11.39	88.25±13.69	0.608
Corrected QT (ms)	438.96±30.30	435.99±30.03	0.471

*Continuous variables are presented as mean ± standard deviation and analyzed using paired t-test.

Table 5. Compare electrophysiological finding before and after AVNRT ablation

Variables *	Before ablation	After ablation	p value
Ventriculoarterial Wenckebach (ms)	261.63±86.22	267.74±70.31	0.611
Retrograde AVN effective refractory period (ms)	240.89±66.63	232.12±44.77	0.381
Ventricular effective refractory period (ms)	206.03±9.98	210.29±21.38	0.268
Ventricular Drive cycle length (ms)	464.46±27.64	482.53±33.52	<0.001
Atrioventricular Wenckebach (ms)	268.28±41.82	282.70±39.64	0.002
Antegrade effective refractory period of AVN (ms)	245.65±56.58	225.94±40.08	0.013
Atrial effective refractory period (ms)	200±20.54	199±11.97	0.823
Atrial Drive cycle length (ms)	476.70±31.20	479.55±35.26	0.469
AH interval (ms)	72.27±13.52	67.08±16.81	0.070
HV interval (ms)	40.13±11.02	38.77±7.05	0.330

*Continuous variables are presented as mean ± standard deviation and analyzed using paired t-test.

after AVNRT ablation, there was a significant difference in cycle length ($p < 0.001$), ventricular drive cycle length ($p < 0.001$), atrioventricular Wenckebach ($p = 0.002$), and the antegrade effective refractory period of the AV node ($p = 0.013$) before and after ablation (Tables 4 and 5).

Discussion

AVNRT is one of the most common forms of PSVT among pediatric tachyarrhythmia patients, who present with normal ECG patterns between episodes of tachycardia. Catheter ablation is one of the primary treatment options for this patient group.

Changes in PR intervals may be observed on surface ECGs due to conduction via slow or fast pathways. However, there are limited studies investigating the effects of slow pathway ablation on ventricular depolarization and repolarization, as well as other conduction velocity characteristics.

The impact of atrioventricular nodal reentrant tachycardia (AVNRT) ablation on QTc, PR, and QRS intervals can vary among individuals. Generally, AVNRT ablation aims to correct abnormal electrical pathways in the heart, which may influence the duration of various intervals on an electrocardiogram (ECG)[8].

To date, no specific study has investigated the effect of dual AV node ablation on ventricular depolarization and repolarization states. In our study, the corrected QTc changed significantly after catheter ablation. This may be due to alterations in the depolarization phase, resulting in a shorter QT interval and shorter QRS duration. The autonomic system has long been recognized as a key factor influencing the QT interval.

No significant change was observed in the PR interval, consistent with previous studies. The peri-AV node region contains a rich autonomic network, and one strong hypothesis suggests that local parasympathetic denervation in Koch's triangle, along with increased sympathetic activity following slow pathway ablation, may influence cardiac conduction properties. These autonomic changes after catheter ablation could play a role in cardiac electrophysiology, particularly in pediatric patients[9].

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In our study, the antegrade refractory period of the fast pathway decreased after slow pathway ablation, but this change was not statistically significant. Pi-Chang Lee et al. reported similar findings in children undergoing AVNRT ablation[10].

Consistent with other studies, antegrade slow pathway ablation did not alter the PR interval post-ablation[8]. However, this should be assessed in cases without PR prolongation resulting from ablation-related complications.

It is important to note that these effects can vary from patient to patient. Careful monitoring and analysis of ECG data are essential for evaluating specific changes in QTc, PR, and QRS intervals following AVNRT ablation. Additionally, individual patient characteristics, underlying heart conditions, and procedural variations may contribute to the observed outcomes[11].

Moreover, the impact of AVNRT ablation extends beyond the immediate changes in QTc, PR, and QRS intervals. The success of the procedure is often evaluated based on its ability to restore normal heart rhythm and alleviate symptoms associated with AVNRT.

We strongly recommend further evaluation of the autonomic system's role in dual-node physiology before and after ablation in children. Although slow pathway ablation in patients with AVNRT does not affect surface ECG characteristics in sinus rhythm, it is associated with other cardiac conduction disorders and may alter ECG parameters. In addition to intrinsic AV node conduction properties, considering the autonomic system's influence on dual AV node physiology before and after ablation is essential.

Conclusion

Supraventricular arrhythmias in children present complex cases that require individualized treatment approaches. Assessing the QT, PR, and QRS intervals before and after RF ablation serves as a valuable tool for evaluating the success of these procedures, particularly when the supraventricular arrhythmia involves AVNRT.

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Conflict of interests

The authors declare no conflict of interest.

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Author's Contributions

Study Conception or Design: MRK, FR
Data Acquisition: MRK, FR, DRN
Data Analysis or Interpretation: FR
Manuscript Drafting: FR, DRN
Critical Manuscript Revision: MRK, FR
All authors have approved the final manuscript and are responsible for all aspects of the work.

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