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# Evaluation of AVNRT & AVRT by Different Criteria: Old & New

**Abdul Hamid[1], Tahmina Alam Sonali[2], Rizwan Rehan[1], Pijous Biswas[3], Subas Caandro Datta[4], Asif Zaman[5]**

[1]Department of Cardiology, Chattagram Medical College Hospital, Chattagram, Bangladesh
[2]Chattagram Medical College Hospital, Chattagram, Bangladesh
[3]Department of Cardiology, National Institute of Cardiovascular Disease, Dhaka, Bangladesh
[4]Department of Cardiology, Bangamata Sheikh Fozilatunnesa Mujib General Hospital, Sirajganj, Bangladesh
[5]Department of Cardiology, Evercare Hospital, Dhaka, Bangladesh
Email: sagarcmc45@gmail.com

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## Abstract

The two most frequent causes of paroxysmal SVT are atrioventricular tachycardia (AVRT) and atrioventricular nodal re-entrant tachycardia (AVNRT). The purpose of this study was to assess the diagnostic efficacy of traditional and newly proposed ECG criteria in the identification of Avnrt and Avrt. **Aim of the Study:** The aim of this study was to evaluate Atrioventricular Nodal Reentrant Tachycardia (AVNRT) and Atrioventricular Re-entrant Tachycardia (AVRT) using both traditional and novel criteria. **Methods:** This prospective observational study was conducted at the Electrophysiology Unit, Department of Cardiology, National Institute of Cardiovascular Diseases (NICVD) in Dhaka, from February 2019 to January 2020. A total of 62 patients with Supraventricular Tachycardia (SVT) undergoing electrophysiology study (EPS) were included. Standard ECG criteria were applied for the differential diagnosis, and electrophysiological diagnoses were made using established criteria. Statistical analysis, including descriptive statistics and appropriate tests, was performed using SPSS 23.0. **Result:** In our study of 62 patients with Supraventricular Tachycardia (SVT), we found that 66.1% had AVNRT and 33.9% had AVRT. The mean age in AVNRT was higher than AVRT (41.3 ± 9.7 vs. 38.5 ± 14.3, $p = 0.36$) with statistically no significant difference, with similar gender distribution between AVNRT and AVRT groups. Classical AVNRT criteria were present in 30.6% of patients, and 45.2% showed a Pseudo R' wave in aVR. Additionally, 30.6% had an RP interval ≥100ms, more prevalent in AVRT patients (66.7%). **Conclusion:** Integrating traditional and novel criteria, including lead aVR analysis, enhances the electrocardiographic diagnosis of AVNRT

and AVRT, offering a pathway to refined patient care.

**Keywords**

SVT (Supraventricular Tachycardia), AVNRT (Atrioventricular Nodal Re-Entrant Tachycardia), AVRT (Atrioventricular Re-Entrant Tachycardia), ECG Criteria, Electrophysiology

## 1. Introduction

Supraventricular tachycardia (SVT) encompasses a spectrum of arrhythmias that involve atrial or atrioventricular (AV) nodal tissue in sustaining the arrhythmia. With an annual incidence of around 35 instances per 100,000 people and a prevalence of 2.25 cases per 1000 people [1], SVT represents a significant clinical concern, particularly for women, who are twice as likely as men to develop paroxysmal SVT (PSVT). The two most frequent causes of paroxysmal SVT are atrioventricular tachycardia (AVRT) and atrioventricular nodal re-entrant tachycardia (AVNRT), the latter affecting 50% - 60% of patients with SVT. [2]

Historically, diagnosing these arrhythmias relied heavily on electrophysiological (EP) studies, [3] with AVNRT identified through dual atrioventricular nodal routes and AVRT through pre-excitation patterns on an ECG indicative of accessory pathways. [4] Over time, the approach to diagnosing SVT has evolved, incorporating advanced non-invasive ECG criteria alongside traditional methods. This shift reflects advancements in ECG technology, which have facilitated the development of new diagnostic markers, enhancing our ability to evaluate and manage SVT more comprehensively.

Electrophysiological testing remains the gold standard for determining the inducibility and cause of SVT and guiding catheter ablation using radiofrequency—a recommended treatment for symptomatic cases. [5] [6] Accurate SVT prediction using surface ECG can significantly aid in ablation planning, reducing surgery, radiation time, and associated risks.

The 2015 American College of Cardiology/American Heart Association/Heart Rhythm Society (ACC/AHA/HRS) guidelines recognize standard ECG definitions for AVNRT, such as the presence of a pseudo R' wave in the V1 lead and pseudo s waves in inferior leads (DII, DIII, and aVF). [7] Recent research has highlighted the utility of the aVL lead, [6] often underrepresented in literature, which has proved to be as sensitive and specific as traditional criteria for differentiating AVNRT from AVRT. Additionally, the lead aVR, providing insight into the upper right side of the heart, has shown promise in distinguishing wide complex SVT from ventricular tachycardia through its morphology.

For AVNRT, the emphasis has switched to subtle ECG changes and responses to certain pharmacological treatments. [8] Similarly, with AVRT, the direction of conduction whether orthodromic or antidromic has become a significant factor in diagnosis, with consequences for treatment options. [4] Although it is not used routinely, lead aVR, which was previously overlooked, is becoming increasingly important. Several studies have investigated the potential of lead aVR to differentiate SVT patients. [5] [9]-[11]

Vereckei *et al*. (2008) reported a sensitivity of 98% in distinguishing wide complex supraventricular tachycardia from ventricular tachycardia solely through the analysis of aVR morphology. [12]

In typical AVNRT, retrograde VA conduction occurs via the fast nodal pathway, evidenced by the earliest atrial activation in the low septal right atrium. The presence of a pseudo-R' wave in lead aVR with a narrow QRS complex can suggest AVNRT. This study aims to assess the diagnostic efficacy of both traditional and newly proposed ECG criteria in identifying AVNRT, thereby enhancing clinical decision-making and patient outcomes.

## 2. Objectives

- The aim of this study was to evaluate Atrioventricular Nodal Reentrant Tachycardia (AVNRT) and Atrioventricular Re-entrant Tachycardia (AVRT) using both traditional and novel criteria.

## 3. Methodology & Materials

This prospective observational study was conducted at the Electrophysiology Unit, Department of Cardiology, National Institute of Cardiovascular Diseases (NICVD) in Dhaka, spanning from February 2019 to January 2020. A total of 62 patients undergoing electrophysiology study (EPS) due to Supraventricular Tachycardia (SVT) were included using purposive sampling.

**Inclusion Criteria:**

1) Patients undergoing electrophysiology procedure for regular narrow complex tachycardia.

2) Patients giving consent to participate in the study.

**Exclusion Criteria:**

1) Patients unwilling to enroll in the study.

2) Patients diagnosed with paroxysmal supraventricular tachycardia who are suspected to have atrial tachycardia, atrial fibrillation, or atrial flutter, structural heart disease, or bundle branch block during sinus rhythm.

3) Patients who have manifested pre-excitation on 12-lead ECG during sinus rhythm.

4) Patients with acute heart failure, congestive cardiac failure, or cardiogenic shock.

5) Patients with significant ST-T changes on 12-lead ECG during sinus rhythm.

Data, including demographics, medical history, and ECG findings, were collected through detailed clinical examinations and interviews using a structured proforma. Standard ECG criteria were applied for the differential diagnosis, and electrophysiological diagnoses were made using established criteria.

Statistical analysis, including descriptive statistics and appropriate tests, was performed using SPSS 23.0. Ethical approval was obtained from NICVD's Ethical Review Committee, and informed consent was obtained from all participants, ensuring confidentiality and the right to withdraw from the study at any time.

## 4. Result

The study included patients diagnosed with AVNRT and AVRT conditions. (Table 1) The average age of the study population was 40.4 years. The age distribution revealed that the most common age group among patients with AVNRT was 40 - 49 years, whereas patients with AVRT were equally distributed across the age groups of 20 - 29, 30 - 39, and 50 - 59 years. The mean age for AVNRT patients was 41.3 years, slightly higher than that for AVRT patients (38.5 years), although this difference was not statistically significant ($p > 0.05$).

Gender distribution among the study participants showed that 36 (58.1%) were female and 26 (41.9%) were male. There was no significant variation in gender distribution between the AVNRT and AVRT groups.

**Table 1.** Demographic characteristics (age and gender distribution) of study subjects diagnosed with AVNRT and AVRT (n = 62).

| Variables | | AVNRT (n = 41) | | AVRT (n = 21) | | p value |
|---|---|---|---|---|---|---|
| | | Number | % | Number | % | |
| Age in years | 10 - 19 | 1 | 2.4 | 2 | 9.5 | |
| | 20 - 29 | 4 | 9.8 | 5 | 23.8 | |
| | 30 - 39 | 10 | 24.4 | 5 | 23.8 | |
| | 40 - 49 | 15 | 36.6 | 2 | 9.5 | |
| | 50 - 59 | 10 | 24.4 | 5 | 23.8 | |
| | ≥60 | 1 | 2.4 | 2 | 9.5 | |
| Mean ± SD | | 41.3 ± 9.7 | | 38.5 ± 14.3 | | 0.36 |
| (Range) | | (13 - 60) | | (18 - 65) | | |
| Gender | Male | 15 | 36.6 | 11 | 52.4 | 0.23 |
| | Female | 26 | 63.4 | 10 | 47.5 | |

Figure 1 illustrates the distribution of confirmed SVT types based on evaluation using various criteria, subsequently confirmed by electrophysiology study. Among the study population, 41 patients (66.1%) were diagnosed with AVNRT, while 21 patients (33.9%) were diagnosed with AVRT upon final evaluation.

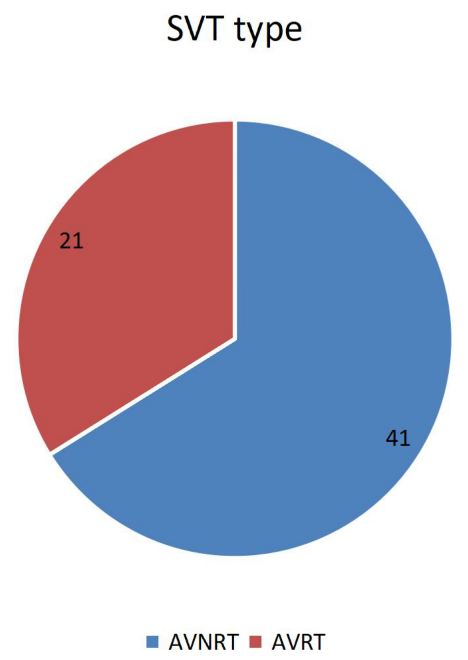


**Figure 1.** Distribution of AVNRT and AVRT cases in study patients (n = 62).

**Table 2.** Presence of pseudo-R' wave on V1 lead of ECG in patients with AVNRT and AVRT (N = 62).

| Pseudo-R' wave | AVNRT (n = 41) | | AVRT (n = 21) | | Total | | p value |
|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | |
| Present | 22 | 53.7 | 4 | 19.0 | 26 | 41.9 | 0.01[s] |
| Absent | 19 | 46.3 | 17 | 81.0 | 36 | 58.1 | |

A total of 41.9% of patients showed a pseudo-R' wave on the V1 lead of the ECG. Among those diagnosed with AVNRT, 53.7% showed this feature, whereas among those with AVRT, the occurrence was 19%. This disparity was statistically significant ($p < 0.05$). (**Table 2**)

**Table 3.** Distribution of study population based on the presence of pseudo-S waves in inferior leads of ECG (N = 62).

| Pseudo-S wave | AVNRT (n = 41) | | AVRT (n = 21) | | Total | | p value |
|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | |
| Present | 25 | 61.0 | 5 | 23.8 | 30 | 48.4 | 0.006[s] |
| Absent | 16 | 39.0 | 16 | 76.2 | 32 | 51.6 | |

A total of 48.4% of patients showed a pseudo-S wave on the inferior leads of the ECG. Among those diagnosed with AVNRT, 61% demonstrated this characteristic, whereas among those with AVRT, 23.8% showed a pseudo-S wave on the inferior leads of the ECG. This difference was statistically significant ($p = 0.006$). (**Table 3**)

**Table 4.** Distribution of study population based on the presence of classical AVNRT criteria in ECG leads (n = 62).

| Classical AVNRT criteria | AVNRT (n = 41) | | AVRT (n = 21) | | Total | | p value |
|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | |
| Present | 17 | 41.5 | 2 | 9.5 | 19 | 30.6 | 0.01[s] |
| Absent | 24 | 58.5 | 19 | 90.5 | 43 | 69.4 | |

In total, 30.6% of patients showed classical AVNRT criteria in at least one lead on the ECG. Among patients diagnosed with AVNRT, 41.5% met these criteria, while among those with AVRT, 9.5% demonstrated classical AVNRT criteria in at least one lead of the ECG. This observed difference was statistically significant ($p = 0.01$). (**Table 4**)

**Table 5.** Distribution of study population based on the presence of aVL notch on ECG (n = 62).

| aVL notch | AVNRT (n = 41) | | AVRT (n = 21) | | Total | | p value |
|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | |
| Present | 19 | 46.3 | 2 | 9.5 | 21 | 33.9 | 0.004[s] |
| Absent | 22 | 53.7 | 19 | 90.5 | 41 | 66.1 | |

Overall, 33.9% of patients showed an aVL notch on the ECG. Among patients diagnosed with AVNRT, 46.3% showed an aVL notch, whereas among those with AVRT, 9.5% showed an aVL notch on ECG. This disparity was statistically significant ($p = 0.004$). (**Table 5**)

**Table 6.** Distribution of study population based on the presence of pseudo R' wave in aVR across 12-lead ECG (N = 62).

| Pseudo R' wave in aVR | AVNRT (n = 41) | | AVRT (n = 21) | | Total | | p value |
|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | |
| Present | 25 | 61.0 | 3 | 14.3 | 28 | 45.2 | <0.001[s] |
| Absent | 16 | 39.0 | 18 | 85.7 | 34 | 54.8 | |

In total, 45.2% of patients showed a Pseudo R' wave in aVR on at least one lead of the ECG. Specifically, among patients diagnosed with AVNRT, 61% showed this feature, whereas among those with AVRT, 14.3% showed a Pseudo R' wave in aVR. This difference was statistically significant ($p < 0.001$). (**Table 6**)

**Table 7.** Distribution of study population based on the presence of visible P-wave in any of the 12 leads of ECG (N = 62).

| Visible P wave | AVNRT (n = 41) | | AVRT (n = 21) | | Total | | p value |
|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | |
| Present | 6 | 14.6 | 17 | 81.0 | 23 | 37.1 | <0.001[s] |
| Absent | 35 | 85.4 | 4 | 19.0 | 39 | 62.9 | |

In total, 37.1% of patients showed a visible P wave in at least one lead on the ECG. Specifically, among patients diagnosed with AVNRT, 14.6% had a visible P wave, while among those with AVRT, 81% showed this characteristic on at least one lead of the ECG. This difference was statistically significant ($p < 0.001$). (**Table 7**)

**Table 8.** Distribution of study population based on the presence of RP interval ≥ 100 ms in at least one of the 12 leads of ECG (N = 62).

| RP interval ≥ 100 ms | AVNRT (n = 41) | | AVRT (n = 21) | | Total | | p value |
|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | |
| Present | 5 | 12.2 | 14 | 66.7 | 19 | 30.6 | <0.001[s] |
| Absent | 36 | 87.8 | 7 | 33.3 | 43 | 69.4 | |

In total, 30.6% of patients showed an RP interval ≥100ms in at least one lead on the ECG. Among patients diagnosed with AVNRT, 12.2% had an RP interval ≥100ms, whereas among those with AVRT, 66.7% showed this characteristic in at least one lead of the ECG. This difference was statistically highly significant ($p < 0.001$). (**Table 8**)

**Table 9.** Sensitivity, specificity, predictive value of different ECG criteria for distinguishing AVNRT and AVRT.

| | Pseudo-R' wave in V1 (AVNRT) | Pseudo-S wave in II-III-Avf (AVNRT) | Classical AVNRT criteria (AVNRT) | aVL notch (AVNRT) | Pseudo-R' wave in Avr (AVNRT) | Visible P wave (AVRT) | RP ≥ 100 ms interval (AVRT) |
|---|---|---|---|---|---|---|---|
| Specificity (%) | 53.7 | 61 | 41.5 | 46.3 | 61 | 81 | 66.7 |
| Sensitivity (%) | 81 | 76.2 | 90.5 | 90.5 | 85.7 | 85.4 | 87.8 |
| Positive predictive value (%) | 84.6 | 83.3 | 89.5 | 90.5 | 89.3 | 73.9 | 73.7 |
| Negative predictive value (%) | 47.2 | 50 | 44.2 | 46.3 | 52.9 | 89.7 | 83.7 |
| Accuracy (%) | 66.1 | 62.9 | 58.1 | 61.3 | 69.4 | 83.9 | 80.6 |

**Table 9** presents the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of various ECG criteria for differentiating AVNRT and AVRT. Sensitivity and specificity in the differentiation of AVNRT were as follows: Pseudo R' wave in aVR 61% and 85.7%; Pseudo R' wave in V1 53.7% and 81%; Pseudo S-wave 61% and 76.2%; classical AVNRT criteria 41.5% and 90.5%; and aVL notch 46.3% and 90.5%. The sensitivity and specificity of visible P wave in differentiating AVRT from AVNRT were 81% and 85.4%, respectively. The RP interval ≥100ms demonstrated a sensitivity of 66.7% and specificity of 87.8% in distinguishing AVRT from AVNRT.

## 5. Discussion

AVNRT, representing around 60% of paroxysmal regular supraventricular tachycardias, is the most common form of paroxysmal tachycardia. [13] In our study, 41 patients (66.1%) had AVNRT and 21 patients (33.9%) had AVRT, which is similar to the study by Haghjoo and colleagues, who found 62% AVNRT and 38% AVRT cases in their study. [9]

The average age of the patients included in our study was 40.4 ± 11.4 years, with ages ranging from 13 to 65 years. Our findings revealed that the average age of patients with AVNRT was higher compared to those with AVRT (41.3 ± 9.7 vs. 38.5 ± 14.3, p = 0.36), aligning with the study by Shabbir M *et al.* [14], which reported older patients with AVNRT (49.4 ± 16.4 vs. 36.0 ± 18.7 years). These age-related differences are important for tailoring specific diagnostic and therapeutic strategies for different age groups.

In our study, there were 36 (58.1%) female patients and 26 (41.9%) male patients, which closely aligns with the findings of Di Toro *et al.* [6] Among patients diagnosed with AVNRT, there was a higher proportion of women compared to those with AVRT (71% versus 53%, p = 0.035). Another study similarly observed a female predominance with a male-to-female ratio of 2:3. [15] The observed female predominance in AVNRT cases underscores the need for heightened clinical vigilance in female patients presenting with PSVT symptoms.

In our study, 41.9% of patients displayed a pseudo-R' wave on lead V1 of ECG. This was significantly more common in patients with AVNRT, where 53.7% exhibited this feature, compared to 19% of those with AVRT. This finding is consistent with a study that reported a pseudo-R' wave in aVR in 67% of AVNRT cases and 10% in AVRT cases. [9] The higher prevalence of this ECG feature in AVNRT patients highlights its potential as a valuable diagnostic marker.

Similarly, 48.4% of patients demonstrated a pseudo-S wave on the inferior leads of ECG, with a higher incidence noted in patients with AVNRT (61%) compared to those with AVRT (23.8%), a statistically significant difference (p = 0.006). This supports previous findings that reported a pseudo-S wave in the inferior leads at a frequency of 45% in AVNRT cases and 8.6% in AVRT cases. [6] These differences in ECG presentations between AVNRT and AVRT further emphasize the importance of detailed ECG analysis in differentiating these arrhythmias.

In our study, 30.6% of patients met the classical AVNRT criteria on at least one ECG lead, with 41.5% of patients with AVNRT and 9.5% with AVRT satisfying these criteria, a statistically significant difference (p = 0.01). Additionally, 33.9% of patients exhibited a notch in lead aVL on ECG, with 46.3% of those with AVNRT and 9.5% with AVRT demonstrating this feature (p = 0.004). These findings are consistent with a study that found the aVL notch present in 51.3% of AVNRT patients compared to 7.4% of AVRT patients. [6] The significant presence of these criteria in AVNRT patients supports their utility in clinical practice.

In our study, a total of 45.2% of patients exhibited a pseudo-R' wave in aVR on ECG, with 61% of AVNRT patients and 14.3% of AVRT patients showing this feature ($p < 0.001$). This contrast aligns with another study that observed pseudo-R' in aVR in 67% of AVNRT cases and 10% in AVRT cases. [9] Conversely, another study reported a pseudo-R' wave in aVR at a rate of 24.9% in AVNRT and 5.5% in AVRT cases. [14] This highlights the potential of lead aVR in enhancing the diagnostic accuracy for AVNRT, reinforcing its inclusion in routine ECG analysis.

Our study also found that 37.1% of patients had a visible P wave in at least one lead on ECG. Among AVNRT patients, 14.6% had a visible P wave, compared to 81% of AVRT patients ($p < 0.001$). This is comparable with the findings of Tai *et al*. [17], who first proposed the criteria and found an accuracy of 97.8% for visible retrograde P waves in discriminating AVNRT from AVRT.

The sensitivity and specificity of various ECG criteria in differentiating AVNRT from AVRT were also evaluated. The sensitivity and specificity for the pseudo-R' wave in lead aVR were 61% and 85.7%, respectively, which is comparable to another study that showed sensitivity and specificity values of 67% and 90%, respectively. [9] Other criteria, such as the pseudo-R' wave in V1 (sensitivity 53.7%, specificity 81%), pseudo-S wave in inferior leads (sensitivity 61%, specificity 76.2%), classical AVNRT criteria (sensitivity 41.5%, specificity 90.5%), and aVL notch (sensitivity 46.3%, specificity 90.5%) also showed similar diagnostic accuracies as reported by Haghjoo *et al*. [9] Another also found similar result in their findings with sensitivity, specificity PPV and NPV for Pseudo r wave in lead V1 27%, 94%,92%,32% for Pseudo S wave in inferior leads has 52%, 84%, 90%, 39% for classical criteria 16%, 97%, 94%,30% and for Notch in lead aVL 27%, 94%, 92%, 32%. [16] These findings suggest that combining these criteria provides a robust approach for non-invasive differentiation of SVT subtypes.

The RP interval ≥100ms had a sensitivity and specificity of 66.7% and 87.8%, respectively, for differentiating AVRT from AVNRT, which is consistent with another study that reported a sensitivity and specificity of 79% and 87%, respectively. [9] Di Toro *et al*. [6] also found that identifiable P-waves had a sensitivity of 88% and specificity of 82%, and an RP interval of ≥100 ms had a sensitivity of 79% and specificity of 87%. These findings further reinforce the utility of these criteria in clinical practice.

This study has several limitations. The sensitivity and specificity of ECG markers can vary based on patient characteristics and the presence of concurrent cardiac conditions, which may not be fully accounted for in our sample. The relatively small sample size limits the generalizability of our findings to broader populations. Additionally, while non-invasive ECG criteria provide valuable diagnostic insights, EP studies remain the gold standard for definitive diagnosis and treatment planning. Future studies should aim to validate these criteria in larger, multi-center cohorts to enhance their clinical utility.

Considering the results of different studies, including our own, there is no single criterion with 100% accuracy in differentiating AVNRT from AVRT. However, the aVR criteria exhibit acceptable sensitivity and specificity, which is superior to classical criteria. This approach can be used either independently or in conjunction with other established ECG criteria to distinguish between AVNRT and AVRT before undergoing the gold standard EP study.

## 6. Limitations of the Study

While our study supported the hypothesis, there are several limitations that may have influenced the results:

- The study was conducted at a single center.
- The study population was relatively small.
- Only patients referred for electrophysiologic testing were included, which may not be representative of all narrow QRS complex cases.
- Some patients had lost their earlier surface ECGs during tachycardia, which were collected by tachycardia induction during electrophysiology.
- The study period was short, potentially affecting the outcomes if it could have been extended.

## 7. Conclusion

The comprehensive evaluation of AVNRT and AVRT in this study underscores the significance of both established and emerging diagnostic criteria. While the traditional markers continue to provide a reliable foundation for diagnosis, the incorporation of new criteria, the detailed assessment of conduction pathways for AVRT, has demonstrated enhanced diagnostic capabilities. The combined use of these criteria not only enriches our understanding of these arrhythmias but also paves the way for more accurate and individualized patient care. The observed sensitivity and specificity across all criteria affirm their collective importance in the electrocardiographic diagnosis of SVT, supporting their integration into clinical practice as complementary tools.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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