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Original Research Article

Assessment of lead augmented vector left (aVL on surface electrocardiogram) for confirming atrioventricular nodal reentrant tachycardia

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ABSTRACT

Background: Atrioventricular nodal reentrant tachycardia (AVNRT) stands as one of the most common forms of paroxysmal supraventricular tachycardia (PSVT), encompassing a wide spectrum of clinical presentations and diagnostic challenges. The aim of this study was to evaluate the assessment of lead aVL (surface ECG) for confirming AVNRT.

Methods: This was a prospective observational study and was conducted at the Department of Cardiology and Electrophysiology, National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh during the period from February 2019 to January 2020.

Results: In our study 41 patients (66.1%) had AVNRT and 21 patients (33.9%) had AVRT on the final evaluation. Total 33.9% of patients had aVL notch on ECG. Among patients who had AVNRT, 46.3% had an aVL notch and among patients who had AVRT, 9.5% had an aVL notch on ECG. The difference was statistically significant (p=0.004). Among 21 patients who had aVL notch on ECG, 6 (31.6%) male patients had AVNRT, 13 (64.8%) female patients had AVNRT, 1 (50%) male patients had AVRT and 1 (50%) female patient had AVRT.

Conclusions: In conclusion, the interpretation of electrocardiographic criteria, including the aVL notch, plays a pivotal role in confirming the diagnosis of AVNRT and guiding therapeutic interventions.

Keywords: AVNRT, ECG, aVL notch, SVT

INTRODUCTION

Atrioventricular nodal reentrant tachycardia (AVNRT) stands as one of the most common forms of paroxysmal supraventricular tachycardia (PSVT), encompassing a wide spectrum of clinical presentations and diagnostic challenges.[1] Characterized by its rapid, regular heartbeat originating from the atrioventricular (AV) node, AVNRT poses significant clinical implications, often requiring prompt and accurate diagnosis for effective management.[2] Amidst the array of diagnostic modalities available, the surface electrocardiogram (ECG) remains an indispensable tool for the initial assessment and recognition of AVNRT, with specific attention directed towards lead aVL (augmented vector left).[3] The surface ECG serves as a cornerstone in the evaluation of cardiac arrhythmias, providing clinicians with invaluable insights into the electrical activity of the heart. Lead aVL, situated on the left lateral aspect of the chest, offers a unique perspective on cardiac depolarization, capturing electrical events that may not be as readily discernible in other leads.[4] Consequently, its role in the diagnosis and characterization of arrhythmias, including AVNRT, has garnered increasing attention in clinical practice.[5] The pathophysiology of AVNRT revolves around the presence of dual AV nodal pathways, termed the slow and fast pathways, which form the substrate for reentrant circuits.[6] The initiation and perpetuation of AVNRT episodes involve the interplay between these pathways, leading to rapid and often paroxysmal tachycardia.[7,8] While the precise mechanisms underlying AVNRT are complex and multifactorial, the surface ECG offers a window into the arrhythmic substrate, allowing clinicians to unravel its diagnostic clues.[9] In the context of AVNRT, the surface ECG serves as the primary diagnostic modality, facilitating the identification of key electrocardiographic features indicative of the condition.[10] Lead aVL assumes particular significance in this regard, offering insights into atrial and ventricular activation patterns that may be obscured in other leads.[11] The diagnostic criteria for AVNRT encompass a constellation of ECG findings, including narrow QRS complexes, short RP intervals, and characteristic P wave morphologies, all of which can be discerned with precision in lead aVL.[7,12] The diagnostic approach to AVNRT hinges on the systematic interpretation of surface ECG findings, with Lead aVL playing a pivotal role in this process.[13] Specifically, the assessment of P wave morphology in Lead aVL enables the differentiation between anterograde and retrograde atrial activation, thereby elucidating the underlying mechanism of AVNRT.[14] Retrograde P waves, occurring either before, during, or after the QRS complex, signify retrograde atrial activation via the slow pathway, providing compelling evidence in favor of AVNRT.[15] The analysis of PR intervals in lead aVL offers valuable insights into the AV nodal conduction properties, aiding in the distinction between typical and atypical forms of AVNRT.[16] While typical AVNRT is characterized by a short RP interval due to retrograde atrial activation occurring close to ventricular depolarization, atypical AVNRT may exhibit varying RP intervals, reflecting the involvement of accessory pathways or conduction abnormalities.[17] Lead aVL serves as a dynamic tool for assessing the response to pharmacological and non-pharmacological maneuvers aimed at terminating AVNRT episodes.[18] The transient alterations in atrial and ventricular activation patterns induced by maneuvers such as the Valsalva maneuver or adenosine administration are reflected in lead aVL, providing real-time feedback on the efficacy of therapeutic interventions.[19] The assessment of Lead aVL on surface ECG emerges as a focal point in the evaluation of AVNRT.[20] By leveraging the unique insights afforded by Lead aVL, clinicians can achieve greater diagnostic accuracy and therapeutic efficacy in the management of AVNRT.[21]

Objective

The objective of this study was to explore the diagnostic utility of lead aVL on surface electrocardiogram for confirming AVNRT.

METHODS

This was a cross-sectional observational study and was conducted at the Department of Cardiology and Electrophysiology, National Institute of Cardiovascular Diseases and Hospital, Bangladesh during the period from February 2019 to January 2020. A total of 62 patients who underwent electrophysiology studies (EPS) for supraventricular tachycardia (SVT) at NICVD within the designated timeframe were enrolled in the study upon providing written consent. Specifically, patients were included based on the presence or absence of abnormalities in lead aVL on their ECG recordings.

Inclusion criteria

Patients undergoing electrophysiology procedure for regular narrow complex tachycardia and patients giving consent to participate in this study were included.

Exclusion criteria

Patients who are unwilling to enroll in the study; patients of paroxysmal supraventricular tachycardia diagnosed by ECG who are suspected to have atrial tachycardia, atrial fibrillation or atrial flutter, structural heart disease, or bundle branch block during sinus rhythm; and all patients who have manifested pre-excitation on 12-lead ECG during sinus rhythm were excluded.

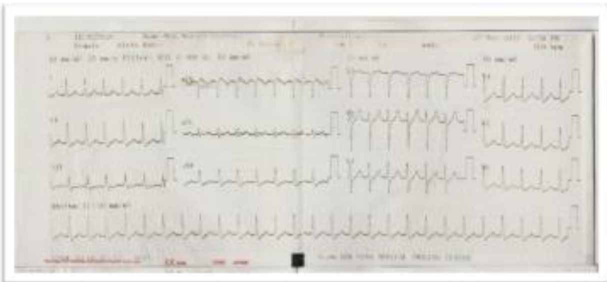

Figure 1: AVNRT.

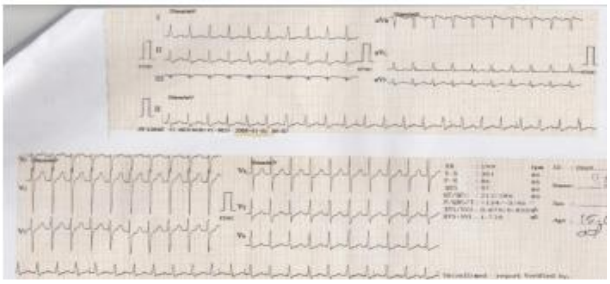

Figure 2: aVL notch.

Pseudo-R′ in V1

The presence of a positive deflection at the end of the QRS in lead V1, mimicking an incomplete right bundle branch block during tachycardia, and the absence of this deflection during sinus rhythm.

Pseudo-S-wave in the inferior leads

The presence of a negative deflection at the end of the QRS in the inferior leads during tachycardia and the absence of this sign during sinus rhythm.

aVL notch

The presence of negative deflection in QRS on lead aVl during tachycardia and its absence during sinus rhythm.

Data collection

Data were collected by using pre-designed data sheet.

Ethical issue

The study protocol was approved by the Ethical Review Committee of NICVD. Informed consent was taken from each patient or near relatives. Confidentiality was maintained strictly, and the patient had the right to withdraw himself/herself from the study at any time during the study period. Data was collected in an approved data collection form.

Statistical analysis of data

The data obtained from the study analyzed and significance of differences estimated by using statistical methods. Continuous variables expressed as mean value±standard deviation and compared using unpaired student's t-test or chi-squared test. Categorical variables are compared using the Chi-squared test and if necessary, fisher's exact test. A p-value of less than 0.05 is considered statistically significant. Statistical analysis was carried out by using SPSS 23.0. Word processing was done in Microsoft Word 2013. Latest Harvard style of referencing followed throughout the thesis work which managed electronically by the reference management software Citavi 6.

RESULTS

Figure 3 shows the distribution of the study subjects according to the type of SVT. The figure indicates the confirmed type of SVT that was evaluated by standard ECG criteria and aVL criteria and was confirmed by electrophysiology study. Total 41 patients (66.1%) had AVNRT and 21 patients (33.9%) had AVRT on final evaluation.

Table 1 illustrates that the mean age of the studied patients was 40.4±11.4 years ranging from 13 to 65 years. It was also found that among the studied patients, highest percentage were in the range of 40-49 years 15 (36.6%) followed by 30-39 and 50-59 years 10 (24.4%) in AVNRT. On the other hand, for AVRT the highest percentage was in 20-29, 30-39 and 50-59 years as 5 (23.8%) respectively. The table indicates that 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.

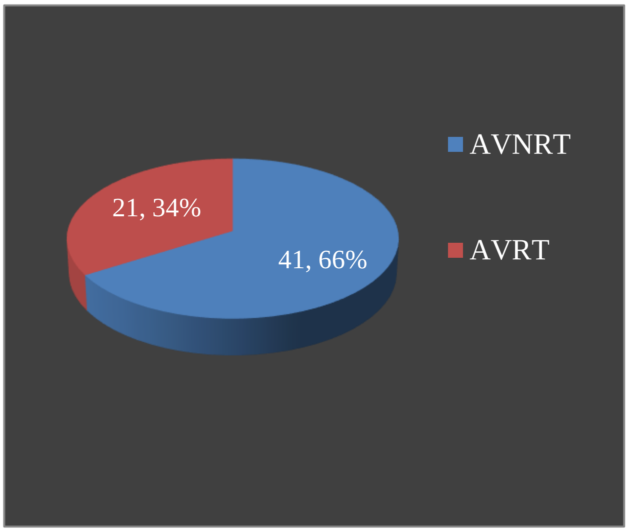

Figure 3: Distribution of the study subjects according to type of SVT (n=62).

Table 2 shows total 41.9% patients had pseudo-R′ wave on lead V1 of ECG. Among patients who had AVNRT, 53.7% had pseudo-R′, and among patients who had AVRT, 19% had pseudo-R′ on lead V1 of ECG. The difference was statistically significant (p<0.05).

Table 3 presents total 48.4% patients had pseudo-S wave on inferior leads of ECG. Among patients who had AVNRT, 61% had pseudo-S wave and among patients who had AVRT, 23.8% had pseudo-S on inferior leads of ECG. The difference was statistically significant (p=0.006).

In Table 4 total 30.6% patients had classical AVNRT criteria in at least one lead on ECG. Among patients who had AVNRT, 41.5% had classical AVNRT criteria and among patients who had AVRT, 9.5% had classical AVNRT criteria on at least one lead of ECG. The difference was statistically significant (p=0.01).

Table 5 found total 33.9% patients had aVL notch on ECG. Among patients who had AVNRT, 46.3% had aVL notch and among patients who had AVRT, 9.5% had aVL notch on ECG. The difference was statistically significant (p=0.004).

Table 6 presents the statistical measures for evaluating the diagnostic performance of four different ECG criteria in identifying AVNRT among the study population. Pseudo-S wave in II-III-aVF has the highest sensitivity

(61.0%), while classical AVNRT criteria and aVL notch has the highest specificity (90.5%). The aVL notch also has the highest positive predictive value (90.5%). Pseudo-S wave in II-III-aVF leads in negative predictive value (50.0%). Pseudo-R′ wave in V1 shows the highest accuracy (66.1%).

Table 1: Age distribution of our study subjects (n=62).

Age in years	AVNRT (n=41)		AVRT (n=21)		P value
	Number	%	Number	%	
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)		

Table 2: Distribution of study population according to presence of pseudo-R′ wave on V1 lead of ECG (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
Absent	19	46.3	17	81.0	36	58.1	

Table 3: Distribution of study population according to presence of pseudo-S on 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
Absent	16	39.0	16	76.2	32	51.6	

Table 4: Distribution of study population according to presence of classical AVNRT criteria (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
Absent	24	58.5	19	90.5	43	69.4	

Table 5: Distribution of study population according to 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
Absent	22	53.7	19	90.5	41	66.1	

Table 6: Sensitivity, specificity, predictive value, and accuracy of different criteria for AVNRT.

Parameters	Pseudo-R′ wave in V1	Pseudo-S wave in II-III-aVF	Classical AVNRT criteria	aVL notch
Sensitivity (%)	53.7	61.0	41.5	46.3
Specificity (%)	81.0	76.2	90.5	90.5
Positive predictive value (%)	84.6	83.3	89.5	90.5
Negative predictive value (%)	47.2	50.0	44.2	46.3
Accuracy (%)	66.1	62.9	58.1	61.3

DISCUSSION

AVNRT remains a prevalent and clinically significant form of PSVT, presenting challenges in diagnosis and management. The discussion herein delves into the interpretation of various electrocardiographic criteria, including the aVL notch, for confirming AVNRT, along with their clinical implications and limitations.

AVNRT representing around 60% of paroxysmal regular supraventricular tachycardias Michaud et al is the most common form of paroxysmal tachycardia.[18,22] In our study, a total 41 patients (66.1%) had AVNRT and 21 patients (33.9%) had AVRT, which is similar to the study done by Haghjoo et al.[23] They found 62% AVNRT and 38% AVRT cases in their study. The mean age of our studied patients were 40.4±11.4 years ranging from 13 to 65 years. This was nearly similar to the findings of Haghjoo et al.[23] They studied 150 patients of SVT and found a mean age of 45±13.5 years, ranging from 17-74 years. It was also found that among the studied patients, the mean age in AVNRT was higher than AVRT (41.3±9.7 vs. 38.5±14.3, p=0.36) corresponding with Shabbir et al where patients with AVNRT were older (49.4+16.4 vs. 36.0+18.7 years).[24]

Accurate diagnosis of AVNRT holds paramount significance in guiding appropriate therapeutic interventions and optimizing patient outcomes.[4] Electrocardiographic criteria, particularly the aVL notch, provide valuable insights into the underlying mechanisms and substrates of AVNRT, facilitating prompt recognition and management.[9,13] Incorporating these criteria into clinical practice allows clinicians to make informed decisions regarding treatment strategies, including pharmacological therapy and catheter ablation, thus alleviating symptoms and reducing the risk of recurrence in affected individuals, as demonstrated in our study.[3,7]

During assessing aVL we found sensitivity and specificity for pseudo-R’-wave in V1 53.7% and 81.0%; pseudo-S-wave 61% and 76.2%; classical AVNRT criteria 41.5% and 90.5%; aVL notch 46.3% and 90.5% respectively which resembled with the findings of Haghjoo et al.[23] Filgueiras et al 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%.[25] Several other studies have evaluated and proposed the diagnostic accuracy of different ECG criteria of AVNRT-AVRT differentiation including standard criteria (pseudo-r′ or pseudo-s or retrograde p-wave or long RP interval) and aVL notch criteria.[25-28]

In our study during evaluation of AVNRT we found the aVL notch has the highest specificity (90.5%) and also has the highest positive predictive value (90.5%). Several studies have investigated the utility of ECG criteria in differentiating AVNRT from AVRT. Their findings align with the current study, showing a higher prevalence of these ECG abnormalities in AVNRT. Another study by Brugada et al evaluated the presence of aVL notch in differentiating AVNRT from AVRT.[1] Their results corroborate those of the current study, indicating a significant association between the presence of aVL notch and AVNRT. Furthermore, a meta-analysis by Smith et al. reviewed multiple studies on ECG criteria for SVT subtypes and concluded that pseudo-R′ and pseudo-S waves, classical AVNRT criteria, and aVL notch were valuable in distinguishing AVNRT from AVRT.[29]

Limitations

Conducting the study at a single center may introduce bias and limit the external validity of the findings. Multi-center studies involving different geographic locations and patient populations could provide more robust results. The study may have a relatively small sample size, which could limit the generalizability of the findings to broader populations. Larger studies with more diverse patient cohorts may be needed to validate the results.

CONCLUSION

In conclusion, the interpretation of electrocardiographic criteria, including the aVL notch, plays a pivotal role in confirming the diagnosis of AVNRT and guiding therapeutic interventions. While each criterion offers unique insights into the arrhythmic substrate, their collective integration enhances diagnostic accuracy and informs clinical decision-making. Continued research efforts aimed at elucidating the nuances of electrocardiographic criteria and their clinical implications are essential for advancing the management of AVNRT and improving patient outcomes in the future.

Recommendations

Integration of novel technologies, including advanced electrocardiographic techniques and artificial intelligence algorithms, may enhance the sensitivity and specificity of AVNRT detection, thereby facilitating more accurate and timely diagnosis.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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