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Diagnostic Accuracy of Lead aVR (in surface ECG) for Confirming Atrio Ventricular Nodal Reentry Tachycardia

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Abstract

Introduction: Slow-fast atrioventricular node re-entrant (AVNRT) the common forms of supraventricular tachycardia (SVT). Electrocardiogram (ECG) during tachycardia helps distinguish between them, often using pseudo R´ wave in lead V1 and pseudo-S wave in inferior leads, but the value of an isolated aVR lead remains unexplored.

Aim of the study: The aim of this study was to find out the diagnostic accuracy of the aVR lead of the surface ECG for AVNRT.

Methods: This cross-sectional observational study was conducted at the department of Cardiology and Electrophysiology, National Institute of Cardiovascular Diseases & Hospital, for 1-year period. After obtaining consent and ensuring ethical compliance, patients underwent electrophysiological study and radiofrequency ablation, to estimate sensitivity, specificity, and positive predictive values for AVNRT.

Result: Among the 62-study population, 41 had AVNRT and 21 had AVRT. The mean age of AVNRT patients was 41.3±9.7 years ranging from 13 to 65 years. About 63.4% were female and 36.6% were male. Among patients who had AVNRT, 61% had pseudo r′ wave in aVR. The overall sensitivity and specificity of lead aVR in the AVNRT was 61% and 85.7%; respectively which is 53.7% and 81% for pseudo-R'-wave in V1, 61% and 76.2%; for pseudo-S-wave, 41.5% and 90.5%; for classical AVNRT criteria.

Conclusion: The detection of a pseudo–R in aVR lead could be as useful criteria for the diagnosis.

Keywords: Lead aVR; ECG; SVT; AVNRT.

Introduction

Supraventricular tachycardia (SVT) is a kind of arrhythmia that causes palpitations and is sustained by atrial or atrioventricular nodal tissue [1]. It occurs in around 35 instances per 100,000 people per year, with a frequency of 2.25 cases per 1,000. The actual frequency in Bangladesh is unclear, however in the United Kingdom, there are roughly 89,000 new cases per year, with 570,000 afflicted individuals. PSVT prevalence increases with age, particularly among women, who are twice as likely as males to have the condition [2-4]. For most patient of supraventricular arrhythmias medical treatment with anti arrythmic drugs is not completely effective. Meanwhile such drugs can be associated with a number of bothersome and even fatal side effects (although rarely), pro arrhythmia, cost, and inconvenience. It is for these reasons that non-pharmacologic interventions, initially using a surgical approach and

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more recently utilizing catheter ablation, have played an increasingly important role in the management of cardiac arrhythmias. The most common causes of paroxysmal SVT are atrioventricular nodal re-entrant tachycardia (AVNRT). AVNRT, which occurs in 50-60% of instances, involves two routes in the AV node with distinct conduction characteristics [5]. Electrophysiological (EP) testing is gold standard and has been used to assess the inducibility and mechanism of SVT and to guide catheter ablation using radiofrequency, which has become the preferred treatment for symptomatic SVT. Accurate prediction of SVT by surface ECG may be helpful in planning the ablation, potentially decreasing the duration of the procedure, time of radiation and likelihood of complications [6,7]. The classic ECG criterion for AVNRT, accepted by the 2015 American College of Cardiology/ American Heart Association/Heart Rhythm Society (ACC/ AHA/HRS) adult SVT treatment guidelines, is the pseudo r′wave in V1 lead and pseudo s wave in inferior leads (DII, DIII, and aVF) [8]. Although it is not used in routine practice, lead aVR which was neglected earlier is getting importance day by day. A few studies have investigated the differentiating ability of the lead aVR in patients with SVT [9-12]. AVR, one of the augmented limbs leads, focuses on the right upper side of the heart, offering specific insights into the right ventricular outflow tract and basal septum due to its unique positioning. Notably, in lead aVR, all waves (P, QRS, T) are negative as depolarization proceeds away from it. When analyzing complex ECGs, considering aVR's waveforms alongside other leads is crucial, as it can provide critical information regarding right ventricular function and pathology [13,14]. The study aimed to find out the diagnostic accuracy of the aVR lead of the surface ECG for AVNRT.

Objectives

The objective of the study was to evaluate the efficacy of lead aVR on surface ECG in diagnosing of AVNRT.

Methodology & Materials

This was a cross-sectional observational study and was conducted at the department of Cardiology and Electrophysiology, National Institute of Cardiovascular Diseases & Hospital, Bangladesh during the period from February 2019 to January 2020. A total of 62 patients, 41 patients had AVNRT and 21 patients had AVRT underwent an electrophysiology study (EPS) due to SVT in NICVD during the specified period of time.

a. Inclusion criteria:

- Patients undergoing electrophysiology procedure for regular narrow complex tachycardia.
- Patient giving consent to participate in this study.

b. Exclusion criteria:

- Patient unwilling to enroll in the study.
- Patients of paroxysmal supraventricular tachycardia diagnosed by ECG who were suspected to have atrial tachycardia, atrial fibrillation or atrial flutter, structural heart disease, or bundle branch block during sinus rhythm.
- Patient with acute heart failure, congestive cardiac failure, cardiogenic shock.

All patients scheduled for electrophysiology due to narrow complex tachycardia were evaluated for inclusion and exclusion criteria before being considered for the study. A thorough history was obtained, and a detailed clinical examination was conducted, with findings documented in a predefined structured proforma. Subsequently, all ECGs underwent review by electrophysiologists who were blinded to patient information and the underlying tachycardia mechanism. The diagnosis of AVNRT and the presence or absence of pseudo r in aVR in AVNRT was meticulously assessed and recorded.

- Pseudo-R′ in V1: 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: 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.
- aVR criteria: Any positive deflection at the end of the QRS in aVR during tachycardia and its absence during sinus rhythm. (Figure:1)
- psedo R in aVr: (A) during atrioventricular node re-entrant (B) sinus rhythm- ref: NICVD. (Figure:2)

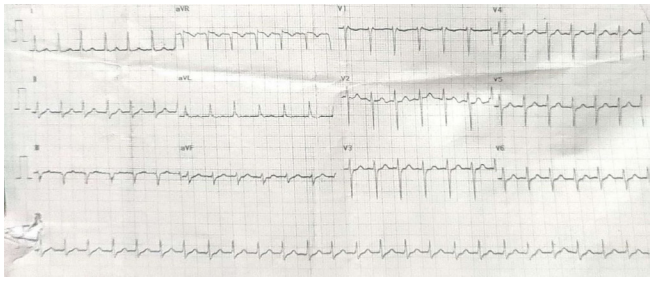

Figure 1: ECG of Atrioventricular Nodal Reentrant Tachycardia shows Pseudo R´ in lead V1.

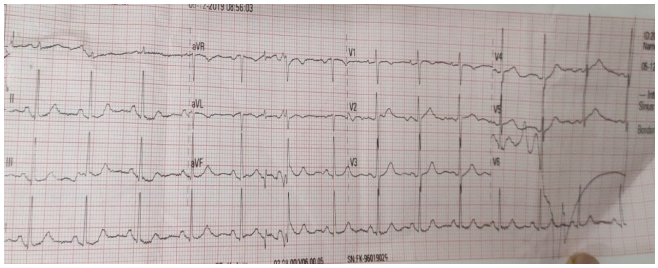

Figure 2: Typical AVNRT shows Pseudo-S in inferior lead.

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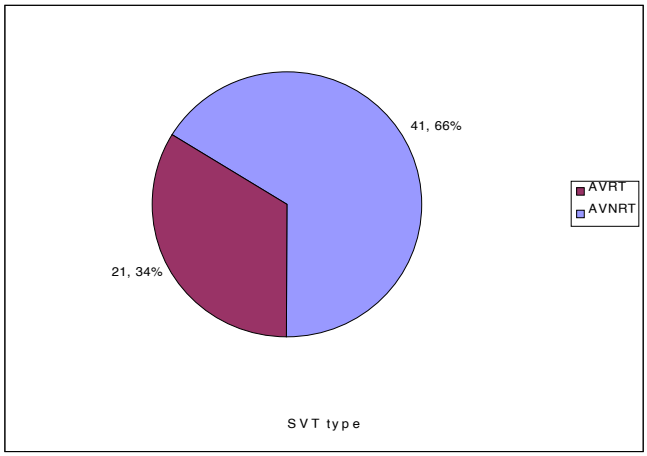

Figure 3: Distribution of the study subjects according to type of SVT (n=62)

Following this initial evaluation, all selected patients underwent an electrophysiology study and radiofrequency ablation, with the definitive diagnosis of tachycardia mechanism, such as AVNRT, confirmed during the electrophysiology procedure.

Statistical Analysis: All data were recorded systematically in preformed data collection form and quantitative data was expressed as mean and standard deviation and qualitative data was expressed as frequency distribution and percentage. Statistical analysis was carried out by using Statistical analysis was done by using SPSS (Statistical Package for Social Science) Version 23 for windows 10. P value <0.05 was considered as statistically significant. Ethical clearance was obtained from National Institute of Cardiovascular Diseases (NICVD) to undertake the current study.

Results

The above figure indicates the confirmed type of SVT that was evaluated by standard ECG criteria and aVR 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: Age distribution of 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	0.36^{ns}
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		

ns= Not significant (p>0.05)
p value was reached from unpaired t test for quantitative variable.

The above table illustrates that the age of the studied patients was 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 & 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.

Table 2 shows that the gender distribution of the respondents. Total 36 (58.1%) patients were female and 26 (41.9%) patients were male in this study. Among patients who had AVNRT, 63.4% were female and 36.6% were male. Among patients who had AVRT, 47.6% were female and 52.4% were male. The difference was not statistically significant (p>0.05).

Table 3 shows the distribution of study population according to detecting a pseudo-R' wave in lead V1 leads of ECG. The sensitivity and specificity for identifying AVNRT among study patients were 53.7% and 81% respectively. The table also indicates a positive predictive value (PPV) of 84.6% and a negative predictive value (NPV) of 47.2%.

Table 4 shows the distribution of study population according to detecting a pseudo-s on inferior leads of ECG. The diagnosis of AVNRT among the study patients with sensitivity and specificity were 61% and 76.2% respectively. The table also indicates PPV and NPV 83.3% and 50% respectively.

Table 2: Gender distribution of study subjects (N=62)

Gender	AVNRT (n=41)		AVRT (n=21)		p value
	Number	%	Number	%	
Male	15	36.6	11	52.4	0.23^{ns}
Female	26	63.4	10	47.6	

Table 3: Distribution of study population according to presence of Pseudo-r wave on V1 lead of ECG (N=62).

Pseudo r wave in V1		AVNRT (n=41)	AVRT (n=21)	Total
Present	Count	22	4	26
	Row %	84.60%	15.40%	100.00%
	Column %	53.70%	19.00%	41.90%
Absent	Count	19	17	36
	Row %	52.80%	47.20%	100.00%
	Column %	46.30%	81.00%	58.10%
Total	Count	41	21	62
	Row %	66.10%	33.90%	100.00%
	Column %	100.00%	100.00%	100.00%

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Table 4: 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
Present	Count	25	5	30
	Row %	83.30%	16.70%	100.00%
	Column %	61.00%	23.80%	48.40%
Absent	Count	16	16	32
	Row %	50.00%	50.00%	100.00%
	Column %	39.00%	76.20%	51.60%
Total	Count	41	21	62
	Row %	66.10%	33.90%	100.00%
	Column %	100.00%	100.00%	100.00%

Table 5 shows the distribution of the study population according to detecting classical AVNRT criteria leads of ECG demonstrated sensitivity and specificity of 41.5% and 90.5%, along with a PPV of 89.5% and NPV of 44.2%.

Table 6 shows the distribution of the study population according to detecting a pseudo r' wave in lead aVR, sensitivity and specificity were 61% and 85.7%, with a PPV of 89.3% and NPV of 52.9%.

Table 7 shows that the sensitivity, specificity, positive predictive value, and negative predictive value of various ECG criteria for AVNRT. Sensitivity and specificity in the differentiation of AVNRT was 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%.

Table 8 shows the bivariate logistic regression analysis of odds ratio (OR) for characteristic of the subject likely for the diagnosis of AVNRT. Bivariate analysis revealed that Pseudo-r wave in aVR was found to be the independent significant predictor for the diagnosis of AVNRT with OR being 9.4.

Table 5: Distribution of study population according to presence of classical AVNRT criteria (N=62).

Classical AVNRT criteria		AVNRT (n=41)	AVRT (n=21)	Total
Present	Count	17	2	19
	Row %	89.50%	10.50%	100.00%
	Column %	41.50%	9.50%	30.60%
Absent	Count	24	19	43
	Row %	55.80%	44.20%	100.00%
	Column %	58.50%	90.50%	69.40%
Total	Count	41	21	62
	Row %	66.10%	33.90%	100.00%
	Column %	100.00%	100.00%	100.00%

Table 6: Distribution of study population according to presence of pseudo r wave in aVR (N=62).

Pseudo r wave in aVR		AVNRT (n=41)	AVRT (n=21)	Total
Present	Count	25	3	28
	Row %	89.30%	10.70%	100.00%
	Column %	61.00%	14.30%	45.20%
Absent	Count	16	18	34
	Row %	47.10%	52.90%	100.00%
	Column %	39.00%	85.70%	54.80%
Total	Count	41	21	62
	Row %	66.10%	33.90%	100.00%
	Column %	100.00%	100.00%	100.00%

Table 7: Sensitivity, specificity, predictive value, and accuracy of different criteria for AVNRT

Variable	AVNRT			
	Pseudo-R' wave in aVR	Pseudo-R' wave in V1	Pseudo-S wave in II-III-aVF	Classical AVNRT criteria
Sensitivity (%)	61	53.7	61	41.5
Specificity (%)	85.7	81	76.2	90.5
Positive predictive value (%)	89.3	84.6	83.3	89.5
Negative predictive value (%)	52.9	47.2	50	44.2
Accuracy (%)	69.4	66.1	62.9	58.1

Table 8: Result of bivariate logistic regression analysis for diagnosis AVNRT by the presence of Pseudo-r wave in aVR.

Variable of interest	Bivariate	
Pseudo-r wave in aVR	OR (95% CI)	P value
	9.4 (2.373– 37.039)	0.001[s]

s = Significant (p<0.05), OR= Odds Ratio

Discussion

AVNRT representing around 60% of paroxysmal regular supraventricular tachycardias is the most common forms of paroxysmal tachycardia. In our study, total 41 patients (66.1%) had AVNRT, which is similar to the study done by Haghjoo and colleagues. They found 62% AVNRT cases in their study [9,15]. The mean age of our studied patients was 34.5±15.64 years ranging from 13 to 65 years. Other study showed that, the 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, mean age in AVNRT (41.3±9.7) correspond with Shabbir M et al,2015 where patients with AVNRT were older (49.4+16.4 years)

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[16]. Total 36 (58.1%) patients were female and 26 (41.9%) patients were male in this study which is close to Di Toro et al2009. There were 96 (64%) women and 54 (36%) men. Among patients who had AVNRT, 63.4% were female and 36.6% were male. Zaman, et al., 2015 also found female predominance and male to female ratio of 2:3 in their study [17]. Though noninvasive differentiation of the most common forms of regular PSVT (AVNRT and AVRT using a concealed accessory pathway) before EPS procedure is of great value, it is sometimes difficult using the surface ECG alone. The correct estimation of the tachycardia mechanism is an important for patient counseling, physician procedural planning, and logistics. In typical AVNRT, atrial stimulation is retrogradely conducted by the fast pathway first to this region, then to the septal RA, proximal and distal CS, the upper part of the septum, and then finally to HRA [18,19]. In AVNRT, this caudo-cranial activation leads to shortly coupled retrograde P-wave which can present itself with notching or pseudo-r′ or pseudo-s deflections in the terminal portion of the QRS complex. In our study, total 41 patients had Pseudo r′ wave in aVR on ECG. Among patients who had AVNRT, 61% had pseudo r′ wave in aVR on at least one lead of ECG. Haghjoo et al showed Pseudo-r′ in aVR (%) 67 in AVNRT.9 On the other hand, Shabbir et al, 2015 showed (24.9% with AVNRT) of 480 patients had pseudo r in avr.16 In differentiating AVNRT, Pseudo R′ wave in lead aVr has the sensitivity, specificity of 61% ,85.7% respectively which is not lower than other standard criteria. Its positive predictive value and negative predictive value are 89.3%,52.9% respectively with an accuracy of 69.4%. It corresponds with the study of Haghjoo et al,2012, where they showed the sensitivity, specificity PPV and NPV of Pseudo-r′ in aVR (%) 67,90,91 and 62 respectively in AVNRT.9 On the other-hand Abdullah et al showed (24.9% with AVNRT) of 480 patients had pseudo r in avr with a sensitivity and specificity of 24.9 and 94.5 respectively in the differentiation of AVNRT [20]. The other ECG criteria of AVNRT were also evaluated with a sensitivity and specificity for pseudo-R'-wave in V1 53.7% and 81%; pseudo-S-wave 61% and 76.2%; espectively which resembles with the findings of Haghjoo et al, 2012 [9]. For typical AVNRT diagnosis, new criterion of pseudo-r′ in aVR had a higher sensitivity 61%; (absolute increase, 11–27%; P¼ 0.05), specificity 85.7% (absolute increase, 6–11%; P¼0.02),, pseudo-r′ in V1 (sensitivity 53.7%; specificity 81%), and pseudo-s in inferior leads (sensitivity 61%; specificity 76.2%). We also found that the pseudo-r′ in aVR had a positive predictive value of 89.3% and a negative predictive value of 52.9%. Filgueiras et al, 2016 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% [21]. But, aVR criteria has an acceptable sensitivity and specificity which is superior to classical criteria. So, it can be used either alone or along-side other standard ECG criteria in AVNRT prior to gold standard EPS study.

Limitations of the study

Our study was conducted at a single center and had a small sample size. Due to the short duration of the study, the findings may not be representative of the wider population. Only patients referred for electrophysiologic testing were included, which may limit its generalizability to all narrow QRS complex cases. Additionally, some patients had lost their earlier surface ECG during tachycardia, which was collected during tachycardia induction during electrophysiology.

Conclusion and Recommendations

The present study demonstrated that accuracy of lead aVR in the electrocardiographic diagnosis of atrioventricular node re-entrant tachycardia has significant role. Overall sensitivity and specificity suggested that it may be used as a complementary tool for diagnosing AVNRT.

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