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Utility of the aVL Lead in the Electrocardiographic Diagnosis of Atrioventricular Nodal Re-Entrant Tachycardia

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Abstract **Original Research Article**

Background: Reciprocating atrioventricular tachycardia can be categorized into common slow–fast atrioventricular node re-entrant (AVNRT) and orthodromic atrioventricular reciprocating tachycardia (AVRT). The electrocardiogram (ECG) during tachycardia is useful in distinguishing these two mechanisms. The presence of a pseudo- R0-wave in lead V1 or pseudo-S-wave in the inferior leads has been widely used, although the value of an isolated aVL lead has not been evaluated yet. To determine whether an isolated aVL lead of the surface 12-lead ECG is useful for the differential diagnosis between AVNRT and AVRT. ***Methods:*** This cross sectional observational study was conducted at the department of Cardiology, National Institute of Cardiovascular Diseases & Hospital, for 1-year period. Patient admitted in NICVD due to supraventricular tachycardia and was screened as a case of AVNRT & AVRT were approached for inclusion of the study. After initial management all patients were subjected to perform electrophysiological study and radiofrequency ablation. The specific pattern of changes in aVL lead were recorded in each cases and were analyze to determine the sensitivity, specificity and positive predictive values to estimate AVRT & AVNRT. Informed written consent was taken from the subject and ethical issues were ensured. Total 60 patients were included for final analysis. Data analysis was done by statistical program Statistical Package for Social Science (SPSS) version 20.0. ***Results:*** Among the 60 study population, mean age was 41.28±11.21 SD (years) [age range: 18-65 years]. Total 44 patients (73%) had AVNRT and 16 patients (27%) had found AVRT in Electrophysiological evaluation. About 61.7% patients were female and 38.3% patients were male in this study with no significant gender difference in between AVNRT and AVRT group ($p>0.05$). Total 43.3% patients had aVL notch on ECG. Among patients who had AVNRT, 54.5% had aVL notch and among patients who had AVRT, 12.5% had aVL notch on ECG. The difference was statistically significant ($p<0.05$). The overall sensitivity and specificity of aVL notch in the differentiation of AVNRT and AVRT was 54.55% and 87.50%, respectively. ***Conclusion:*** The detection of a notch in aVL lead could be as useful criteria for the diagnosis of AVNRT.

Keywords: AVNRT, AVRT, Reciprocating atrioventricular tachycardia.

INTRODUCTION

Supraventricular tachycardia is a type of tachyarrythmia which is responsible for recurrent, occasionally persistent, and a frequent cause of visits to physicians, emergency rooms and coronary care unit [1]. Every year approximately 35 new cases of supraventricular tachycardia (SVT) are detected per 100,000 persons with a prevalence of 2.29 in the general population [1–3]. The exact prevalence of PSVT in Bangladesh is not known. There are approximately 89,000 new cases per year and 570,000 persons with PSVT in UK. Women have twice the risk of men of developing PSVT. Individuals >65 years of age have more than 5 times the risk of younger persons of developing PSVT [2].

Most types of SVT have a re-entry mechanism, and they are classified according to the location of the re-entry circuit. Approximately 60 percent of cases are due to an atrioventricular nodal re-entry circuit which is

known as atrioventricular nodal re-entry tachycardia (AVNRT), and about 30 percent are due to an atrioventricular re-entry circuit which is known as atrioventricular re-entry tachycardia or atrioventricular reciprocating tachycardia (AVRT) [1, 4].

In AVNRT at least two functionally distinct conduction pathways are demonstrable within the atrioventricular node. These are known as slow and fast pathways. In both of the pathways, conduction started in the atria passes to ventricle through one pathway in anterograde fashion and in retrograde fashion back to atria through another pathway. Depending on the pathway through which the anterograde conduction occurs first, two types of AVNRT occur: common and uncommon [5].

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AVRT is another example of an AV nodal-dependent supraventricular tachycardia. The most common tachycardia associated with an accessory pathway is orthodromic AVRT, with a circuit that uses the AV node and His Purkinje system in the anterograde direction, followed by conduction through the ventricle, retrograde conduction over the accessory pathway, and completion of the circuit by conduction through the atrium back into the AV node. Orthodromic AVRT accounts for approximately 90% to 95% of AVRT episodes in patients with a manifest accessory pathway. Pre-excited AVRT, including antidromic AVRT, accounts for 5% of the AVRT episodes in patients with a manifest pathway and involves conduction from the atrium to the ventricle via the accessory pathway, causing a preexcited QRS complex.

This is called antidromic AVRT achycardia when the return reentrant conduction occurs retrogradely via the AV node. In rare cases of pre-excited AVRT, the return conduction occurs via a second accessory AV pathway. Antedromic tachycardia is characterized by wide QRS complex on electrocardiogram (Atié, *et al.*, 1990) because of early activation of a part of the ventricles over the accessory pathway. This results in the combination of a short PR interval and a delta wave [6, 7].

OBJECTIVES

General Objective:

- To determine the usefulness of aVL lead in the electrocardiographic diagnosis of atrioventricular nodal re-entrant tachycardia.

Specific objectives:

- To find out the standard ECG criteria (pseudo-R′ in V1 and pseudo-S-wave in the inferior leads) for the diagnosis of atrioventricular node reentrant tachycardia.
- To compare the the standard criteria with the presence of a notch in aVL lead to distinguish between AVNRT and AVRT.
- To assess the sensitivity, specificity, positive predictive value and negative predictive value of isolated aVL lead criteria for electrocardiographic diagnosis of AVNRT.

METHODS

Study Design

Cross section observational study.

Place of Study

Department of Cardiology National Institute of Cardiovascular Diseases, Dhaka.

Study Period

October 2017 to September, 2018.

Study Population

Patients with Supraventricular tachycardia particularly AVNRT and AVRT fulfilling the inclusion and exclusion criteria within the study period.

Sampling Technique

Purposive Sampling.

Sample Size

Total 60 cases were included in the study.

Enrolment of Subjects

Inclusion Criteria

- Age ≥18 years.
- Patients with supraventricular tachycardia diagnosed by electrocardiography who are suspected to have common atrioventricular nodal reentry tachycardia and atrioventricular re-entrant tachycardia admitted in the EP Unit.
- Patient who are willing to go electrophysiology study.

Exclusion Criteria

- All patients of paroxysmal supraventricular tachycardia diagnosed by electrocardiography who are suspected to have atrial tachycardia.

- All patients who have manifested pre-excitation on 12-lead ECG during sinus rhythm.
- All patients who have bundle branch block, left or right ventricular hypertrophy.
- Patient with organic valvular disease, congenital heart disease, electrolyte abnormalities,
- All patients who remain undiagnosed after the electrophysiology study.

Study Procedure

- Before commencing the study, the study protocol was accepted by ethical review committee of NICVD.
- Patients with paroxysmal supraventricular tachycardia admitted in the Electrophysiology Unit, NICVD for EP study fulfilling the inclusion and exclusion criteria were considered for the study.
- Informed written consent was taken from each patient before enrolment.
- Particulars of the patients and history were recorded in the structured predesigned data collection sheet.
- 12-lead surface electrocardiogram during paroxysmal attack as well as sinus rhythm were collected and evaluated.
- Standard ECG criteria for the differential diagnosis of AVNRT and AVRT and presence or absence of aVL notch in AVNRT or AVRT were assessed and recorded
- All selected Patients were underwent electrophysiology study and radiofrequency ablation
- Electrophysiologic diagnosis of tachycardia mechanism (AVNRT/AVRT) was also recorded.
- Comparison of standard criteria with aVL notch criteria for the differential diagnosis between AVNRT and AVRT were done subsequently.

Statistical Methods

Categorical data were expressed as frequency and percentage. Continuous data were expressed as mean±SD. Differences between the groups were analyzed using the $\chi 2$ test for categorical variables and the Student t-test for continuous variables. Sensitivity, specificity and predictive values were calculated by using standard formula. All statistical analyses were performed using the SPSS 20.0 (IBM Inc., Armonk, NY, USA). Word-processing was done by the word module of Microsoft Office 2016 (Microsoft Corporation, USA).

RESULT

This cross-sectional observational study was conducted in the Department of Cardiology, National Institute of Cardiovascular Diseases, Dhaka during the period From October 2017 to September, 2018. Total 60 SVT patients were included in the study. The findings documented below:

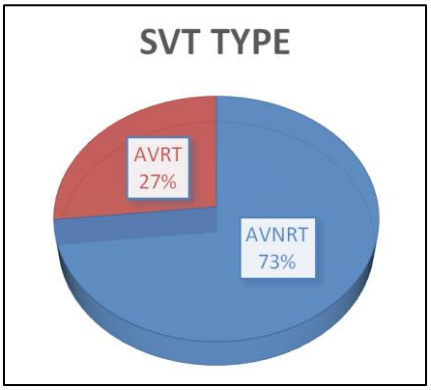

Figure 1: Distribution of study subjects according type of SVT (n=60)

Mean age of the patients were 41.28±11.21 years ranging from 18 to 65 years. Type of SVT was evaluated by standard ECG criteria and aVL criteria and was confirmed by electrophysiology study in all patients. Total 44 patients (73%) had AVNRT and 16 patients (27%) had AVRT on final evaluation. Patients with AVNRT were older than patients with AVRT (42.04±0.04 vs. 39.18±10.17 years, P >0.05).

Table I: Sex distribution of study population (n=60)

Sex	AVNRT (n=44) n(%)	AVRT (n=16) n(%)	Total (n=60) n(%)	*p* value
Male	16 (36.4)	7 (43.8)	23 (38.3)	0.603*
Female	28 (63.6)	9 (56.2)	37 (61.7)	
p determined by Chi-Square test				

*not significant

Total 61.7% patients were female and 38.3% patients were male in this study. Among patients who had AVNRT, 36.4% were male and 63.6% were female. Among patients who had AVRT, 43.8% were male and 56.2% were female. The difference was not statistically significant (p>0.05).

Table II: Distribution of study population according to presence of Pseudo-R′ wave on V_1 lead of ECG (n=60)

Pseudo- R′ wave	AVNRT (n=44) n(%)	AVRT (n=16) n(%)	Total (n=60) n(%)	*p* value
Present	24 (54.5)	2 (12.5)	26 (43.3)	0.004*
Absent	20 (45.5)	14 (87.5)	34 (56.7)	
p determined by Chi-Square test				

*Significant

Total 43.3% patients had pseudo- R′ wave on lead V_1 of ECG. Among patients who had AVNRT, 54.5% had pseudo- R′, and among patients who had AVRT, 12.5% had pseudo- R′ on lead V_1 of ECG. The difference was statistically significant (p<0.05).

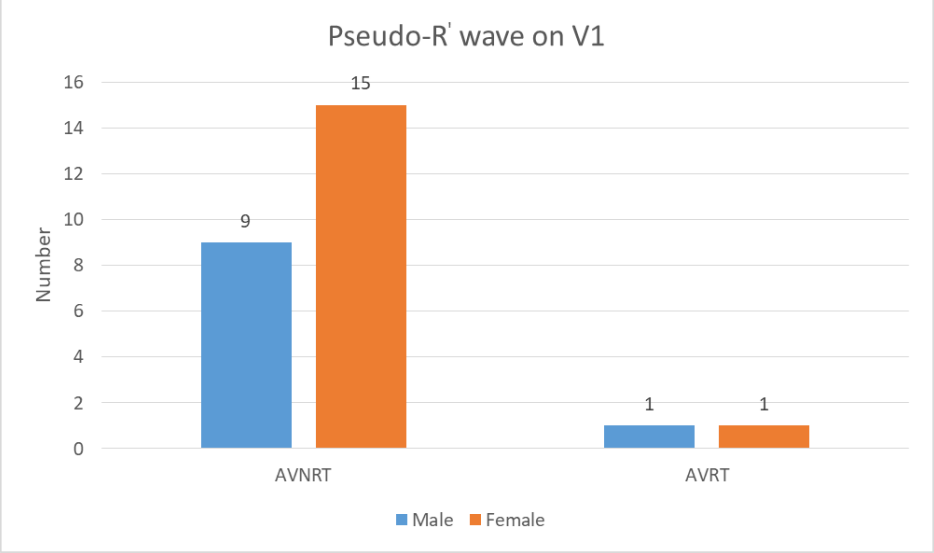

Figure 2: Distribution of pseudo-R' wave in relation to sex (n=26)

Among 26 patients who had pseudo-R' wave on lead V1, 9 male patients had AVNRT, 15 female patients had AVNRT, 1 male patients had AVRT and 1 female patient had AVRT.

Table III: Distribution of study population according to presence of Pseudo-S on inferior leads of ECG (n=60)

Pseudo-S wave	AVNRT (n=44) n(%)	AVRT (n=16) n(%)	Total (n=60) n(%)	*p* value
Present	29 (65.9)	2 (12.5)	31 (51.7)	<0.001*
Absent	15 (34.1)	14 (87.5)	29 (48.3)	
p determined by Chi-Square test				

*Significant

Total 51.7% patients had pseudo-S wave on inferior leads of ECG. Among patients who had AVNRT, 65.9% had pseudo-S wave and among patients who had AVRT, 12.5% had pseudo-S on inferior leads of ECG. The difference was statistically significant (p<0.001).

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

	aVL notch	Pseudo-R′ wave	Pseudo-S wave
Sensitivity (%)	54.55	54.55	65.91
Specificity (%)	87.50	87.50	87.50
Positive predictive value (%)	92.31	92.31	93.54
Negative predictive value (%)	41.18	41.18	48.28
Accuracy (%)	63.33	63.33	71.67

The aVL notch sensitivity and specificity to determine the final diagnosis (AVNRT) was similar to the pseudo- R'-wave of standard criteria but lower than the pseudo-S-wave of standard criteria. Sensitivity and

specificity in the differentiation of AVNRT was as follows: aVL notch 54.55% and 87.50%; pseudo-R'-wave in V_1 54.55% and 87.50%, and pseudo-S-wave 65.91% and 87.50%; respectively.

Table V: Sensitivity, specificity, predictive value, and accuracy of different criteria for AVRT

	Retrograde P wave	RP interval ≥100ms
Sensitivity (%)	100	81.25
Specificity (%)	84.09	88.64
Positive predictive value (%)	69.57	72.22
Negative predictive value (%)	100	92.86
Accuracy (%)	83.33	86.78

The retrograde p wave sensitivity and specificity in differentiating AVRT from AVNRT was 100% and 84.09% respectively. The RP interval ≥100ms sensitivity and specificity in differentiating AVRT from AVNRT was 81.25% and 88.64% respectively.

DISCUSSION

AVNRT and AVRT using a concealed accessory pathway are the most common forms of paroxysmal tachycardia. AVNRT represent around 60% of paroxysmal regular supraventricular tachycardias (Michaud, Gregory and Stevenson, 2018) and AVRT represent approximately 30% of the SVTs (Colucci, Silver and Shubrook, 2010) [8, 9]. In the present study 73% patients had AVNRT and 27% patients had AVRT. This concordant with the findings of Di Toro *et al.,* [10]. They studied 101 SVT patients in the final analysis and found 73.3% having AVNRT and 26.7% having AVRT. Haghjoo and colleagues found 62% AVNRT and 38% AVRT cases in their study (Haghjoo, *et al.,* 2012), which different that the findings of this study [11].

In this study majority patients were female (61.7%) and 38.3% patients were male. Both, AVNRT and AVRT were more common in female patients than male patients. But, AVNRT was relatively more common than AVRT in females. Although the distribution was not statistically significantly different (p>0.05). Di Toro *et al.,* Click or tap here to enter text., Haghjoo *et al.,* (Haghjoo, *et al.,* 2012)Click or tap here to enter text., Zaman *et al.,* (Zaman, *et al.,* 2015) reported similar findings in their study [10, 11, 14]. Di Toro (Di Toro, *et al.,* 2009) noted that there were no gender differences in relation to type of SVT in their study [10]. They found 27 males (36.4%) in the AVNRT group vs. 11 (40.7%) in the AVRT group (P=NS). Haghjoo (Haghjoo, *et al.,* 2012) found that there was a predominance of women in patients with AVNRT compared with AVRT cases (71 vs. 53%) with the difference been significant (p=0.0035) [11]. Zaman (Zaman, *et al.,* 2015) found a female predominance and a male to female ratio of 2:3 in their study [14].

Differentiation of the most common forms of regular PSVT (AVNRT and AVRT using a concealed accessory pathway) is some- times difficult using the surface ECG alone. During sinus rhythm they can be discriminated only when there is obvious pre-excitation, or evidences of dual AV node physiology such as two different PR intervals with a similar rates. Also the initiation of arrhythmia is of paramount importance. If the PSVT starts with abrupt prolongation of PR interval it indicated the anterograde block of fast pathway and conduction over slow pathway before initiation of arrhythmia which is more in favour of AVNRT.

Several studies have evaluated and proposed the diagnostic accuracy of different ECG criteria including standard criteria (pseudo-r′ or pseudo-s or retrograde p-wave or long RP interval) and aVL notch criteria [10, 11, 15].

In this study the sensitivity and specificity of aVL notch criteria proposed by Di Toro *et al.,* (Di Toro, *et al.,* 2009) was tested along with standard criteria in the differentiation of AVNRT from AVRT [10]. The sensitivity and specificity of aVL notch in differentiating AVNRT from AVRT was respectively 54.55% and 86.55%. Sensitivity and specificity of standard pseudo-R'-wave criteria was found to be same as that of aVL notch criteria. Sensitivity and specificity of standard pseudo-S-wave criteria was found to be higher than that of aVL notch criteria (65.91% and 87.50% for pseudo-S-wave; respectively). These findings are comparable to the findings of Di Toro *et al.,* (Di Toro, *et al.,* 2009), Haghjoo *et al.,* (Haghjoo, *et al.,* 2012), and Kalbfleisch *et al.,* (Kalbfleisch, *et al.,* 1993) [10, 11, 16].

Di Toro *et al.,* (Di Toro, *et al.,* 2009) found that the aVL notch criteria had similar sensitivity and specificity to the standard criteria for AVNRT– AVRT differentiation [10]. But, they also found that pseudo-S-wave in the inferior leads showed a sensitivity and specificity of 14 and 100%, respectively, which is far lower than the findings of this study. Therefore when both pseudo-R' and pseudo S criteria are combined contrary to the finding of Di Toro and colleagues (Di Toro, *et al.,* 2009) aVL notch criteria showed lower sensitivity and specificity in our study [10].

Kalbfleisch *et al.,* (Kalbfleisch, *et al.,* 1993) had reported the sensitivity of 58% and specificity of 91% for the pseudo-r′ in V_1 [16]. Haghjoo *et al.,* (Haghjoo, *et al.,* 2012) reported sensitivity and specificity of 56% and 84% respectively for the same criteria [11]. These findings are comparable with our study. But, Haghjoo *et al.,* (Haghjoo, *et al.,* 2012) reported sensitivity and specificity of 40% and 79% respectively for the pseudo-s-wave criteria, which is lower than the findings of this study [11].

The RP interval ≥100ms had a sensitivity and specificity of 81.25% and 88.64% respectively in differentiating AVRT from AVNRT. In comparison Haghjoo *et al.,* (Haghjoo, *et al.,* 2012) found a sensitivity and specificity of 79% and 87% respectively for this criteria in the diagnosis of AVRT [11].

The findings of this study in relation to the findings of other studies shows that no single criteria is has an accuracy of 100% in the differentiation of AVRT from AVNRT leaving EPS study as the gold standard in the diagnosis of the these two types of SVT. But, aVL notch criteria has an acceptable sensitivity and specificity and can be used along-side other standard ECG criteria in the differentiation of AVNRT from AVRT prior to EPS study.

CONCLUSION

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

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