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Utility of the aVL lead in the electrocardiographic diagnosis of atrioventricular node re-entrant tachycardia

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Aims 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-R′-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 and results Consecutive patients referred for paroxysmal regular supraventricular tachycardia radiofrequency ablation were prospectively evaluated. Patients with atrial tachycardia, bundle branch block, manifested pre-excitation, and those undiagnosed after electrophysiology study were excluded. We compared the *standard criteria* with the value of an isolated aVL lead to distinguish between AVNRT and AVRT. One hundred and one patients were included; 73.3% were AVNRT and 26.7% AVRT. Patients with AVNRT were older (49.4 $\pm$ 16.4 vs. 36.0 $\pm$ 18.7 years, $P = 0.001$). The aVL notch and the *standard criteria* were found more frequently in AVNRT than in AVRT (aVL notch: 51.3 vs. 7.4%, $P \leq 0.001$; pseudo-S-wave 45 vs. 8.6% $P = 0.001$; and pseudo-R′-wave in V1 39.7 vs. 11.5%, $P = 0.008$, respectively). The aVL notch sensitivity and specificity to determine the final diagnosis were higher than the *standard criteria* (aVL notch 48.6 and 92.6%; pseudo-S-wave 45 and 91.3%; and pseudo-R′-wave in V1 39.7 and 88.5%, respectively).

Conclusion The presence of a notch in aVL lead appeared to be as sensitive and specific as the standard electrocardiographic criteria for the differential diagnosis of AVNRT.

Keywords aVL notch • AV node re-entrant tachycardia • AV re-entry tachycardia

Introduction

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.

Several studies examined the diagnosis utility of the ECG, and various algorithms were previously reported.[1,2]

The presence of a pseudo-R′-wave in lead V1 or pseudo-S-wave in the inferior leads has been widely used, although the value of an isolated aVL lead to distinguish both mechanisms has not been evaluated yet.

Catheter ablation using radiofrequency energy has become the preferred treatment for symptomatic supraventricular tachycardia. Predicting the mechanism involved in a supraventricular tachycardia before the beginning of the ablation procedure may help in planning the ablation in advance.

The purpose of this study is to determine whether an isolated aVL lead of the surface 12-lead ECG is useful for the differential diagnosis between AVNRT and AVRT.

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Methods

Consecutive patients referred for radiofrequency ablation due to paroxysmal regular supraventricular tachycardia were prospectively evaluated. Patients with atrial tachycardia, bundle branch block, manifested pre-excitation on 12-lead ECG during sinus rhythm, and those who remained undiagnosed after the electrophysiology study were excluded. We compared the *standard criteria* (pseudo-R′ in V1 and pseudo-S-wave in the inferior leads) with the value of an isolated aVL lead to distinguish between AVNRT and AVRT.

The 12-lead ECGs were recorded at a speed of 25 mm/s, gain setting of 10 mm/mV, and filter setting of 0.5 and 1000 Hz.

We defined the *standard criteria* for differential diagnosis between AVNRT and AVRT as follows:

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.

Visible P-wave: deflection in the ST-segment interpreted as a retrograde P-wave in at least one of the 12 leads.

aVL notch: any positive deflection at the end of the QRS during tachycardia and its absence during sinus rhythm (*Figure 1*).

The 12-lead ECGs during tachycardia prior to the ablation were blindly reviewed by two electrophysiologists (D.D.T. and C.L.). The electrophysiologists assessed the presence or absence of the aVL lead notch and the *standard criteria* for differential diagnosis of AVNRT vs. AVRT (*Figure 2*). Disagreement was solved by consensus.

Final differential diagnosis between AVNRT and AVRT was made using the usual criteria in the laboratory: localization and timing of the earliest atrial depolarization during tachycardia, the presence of dual AV node physiology, characteristics of retrograde conduction during ventricular pacing, documentation of transient second-degree AV block during the tachycardia, and pre-excitation of the atrial electrogram after premature ventricular stimulus delivered during refractory His.[3–5] Confirmation of the tachycardia mechanism was, furthermore, supported by the success of the radiofrequency ablation procedure (*Figure 3*).

Typical AVNRT and orthodromic reciprocating tachycardia were considered for the analysis.

Statistical analysis

Continuous data are expressed as mean ± 2SD. Proportions are expressed as percentages with 95% confidence intervals (CIs). Differences between the groups were examined with either the χ^2 or Fisher's exact test. A *t*-test or non-parametric analysis was used for continuous variables. Sensitivity, specificity, and predictive values were calculated as usual.

The area under the ROC curve (AUC) was calculated, and 95% CIs were used to test the hypothesis that the theoretical AUC is 0.5. An AUC with a CI that did not include the 0.5 value was considered as evidence of the electrocardiographic sign's ability to distinguish between the two groups.[6,7]

The inter-observer agreement in analysing the aVL notch was calculated by the κ-statistic.[8] A *P*-value of <0.05 was considered significant. Statistical analysis was performed using Statistic 7.0.

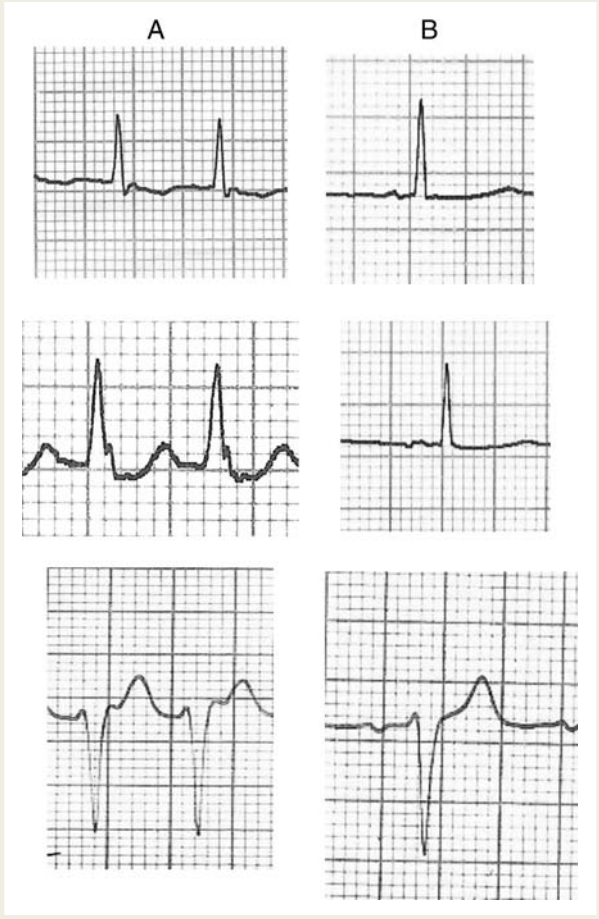

Figure 1 Three types of aVL notch (*A*) during atrioventricular node re-entrant (*B*) sinus rhythm.

Results

One hundred and one patients were included in the analysis; 74 (73.3%) were AVNRT and 27 (26.7%) AVRT. Patients with AVNRT were older (49.4 ± 16.4 vs. 36.0 ± 18.7 years, $P = 0.001$). There were no gender differences, 27 males (36.4%) in the AVNRT group vs. 11 (40.7%) in the AVRT group (P = NS). The demographic and electrocardiographic characteristics of both groups are shown in *Table 1*.

The aVL notch and the *standard criteria* were found more frequently in AVNRT than in AVRT. The aVL notch was found during AVNRT in 51.3 vs. 7.4% in AVRT, $P \leq 0.001$.

The *standard criteria* were found also more frequently in AVNRT than in AVRT: (pseudo-S-wave 45 vs. 8.6%, $P = 0.001$; pseudo-R′-wave in V1 39.7 vs. 11.5%, $P = 0.008$, respectively). The ST-segment depression did not show a significant difference. The tachycardia cycle length was shorter in patients with AVRT

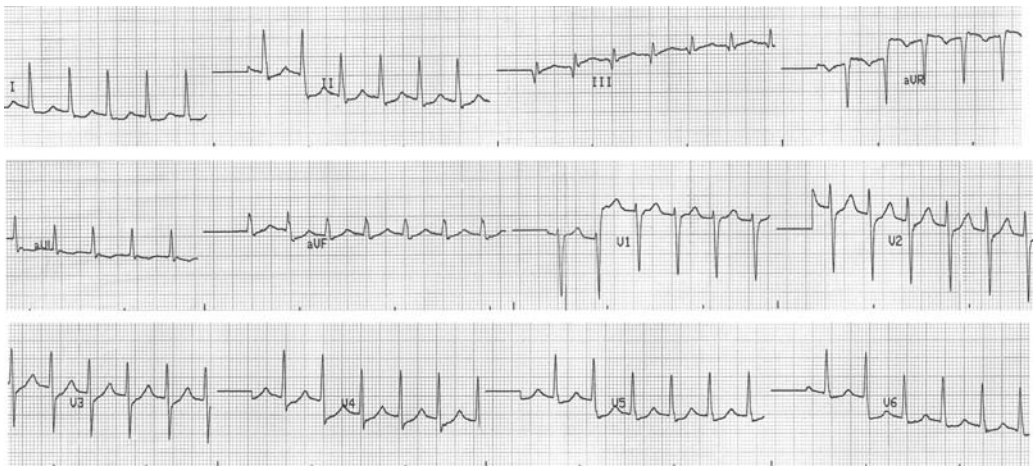

Figure 2 A patient with atrioventricular node re-entrant with notch in aVL lead without pseudo-R in V1 during atrioventricular node re-entrant.

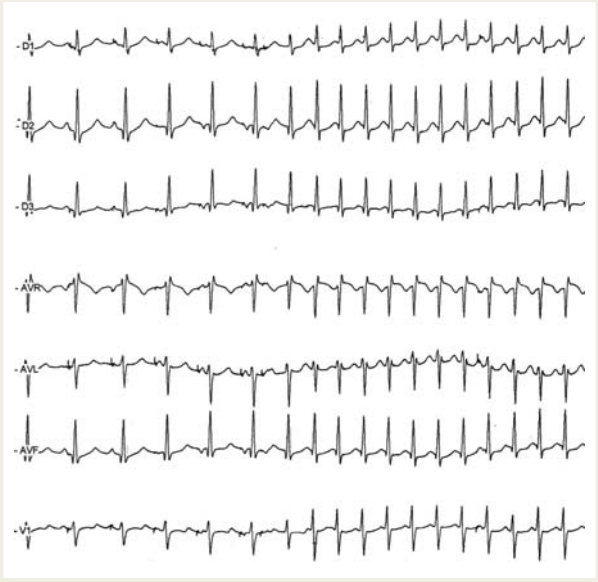

Figure 3 During pacing, the end of the QRS in aVL lead was clear, and the notch at the end of QRS in aVL lead appears after the atrioventricular node re-entrant induction.

than in AVNRT (338 ± 69 vs. 3708 ± 56 mseg, $P = 0.03$). The locations of the accessory pathways were: left free wall 46%, right free wall 20%, and septal 33%.

The aVL notch sensitivity and specificity to determine the final diagnosis was higher than the *standard criteria* (aVL notch 48.6 and 92.6%; pseudo-S-wave 45 and 91.3%; and pseudo-R′-wave in V1 39.7 and 88.5%, respectively), but it did not reach statistical significance (*Table 2*).

The AUC was 0.72 for aVL notch, 0.69 for pseudo-S-wave and 0.64 for pseudo-R′ in lead V1 (P = NS).

Table 1 Demographic and electrocardiographic characteristics in patients with atrioventricular node re-entrant and atrioventricular reciprocating tachycardia

	AVNRT	AVRT	*P*-value
Patients (%)	73.3	26.7	
Female sex (%)	63.6	56.0	NS
Age (years)	49.4 ± 16.4	36.0 ± 18.7	0.001
Tachycardia cycle length (ms)	370	338.6	0.03
aVL notch (%)	51.3	7.4	<0.001
Pseudo-S-wave inf. (%)	45	8.6	0.001
Pseudo-R-wave V1 (%)	39.7	11.5	0.008
QRS alternans (%)	7.4	28.5	0.01
ST-segment depression (%)	51.8	54.0	NS

Table 2 Sensitivity, specificity, predictive value, and likelihood ratio of different criteria for AVRNT

	aVL notch	Pseudo-S-wave in inferior leads	Pseudo-R′-wave in lead V1
Sensitivity (%)	48.6	45.0	39.7
Specificity (%)	92.6	91.3	88.5
Positive predictive value (%)	95	93	91
Negative predictive value (%)	40	39	34
Likelihood ratio (+)	6.56	5.17	3.44
Likelihood ratio (−)	0.55	0.60	0.68

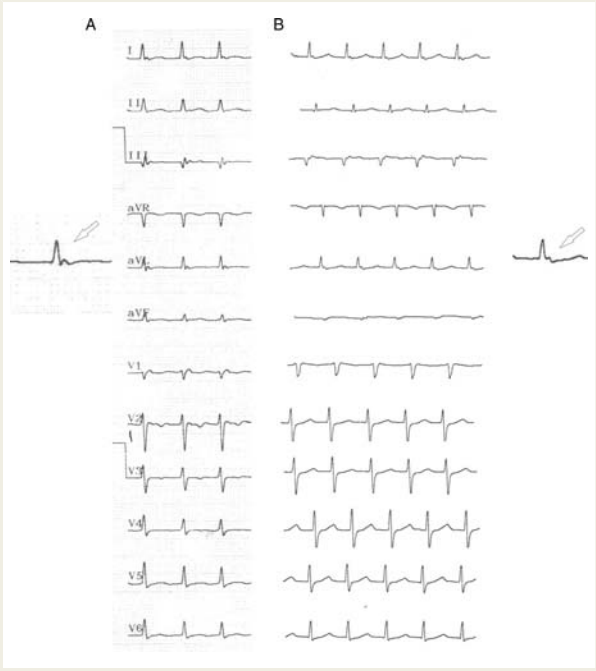

Figure 4 (*A*) A patient with a notch in aVL lead without pseudo-S-wave in the inferior leads during atrioventricular node re-entrant. (*B*) A patients with a notch in aVL lead without pseudo-R in V1 and pseudo-S-wave in the inferior leads during atrioventricular node re-entrant.

The κ-value representative of the inter-observer agreement in analysing the aVL notch was 0.90. *Figure 4* shows patients with a notch in the aVL lead without *standard criteria*.

Discussion

AVNRT and AVRT using a concealed accessory pathway are the most common forms of paroxysmal tachycardia and together represent ~90% of paroxysmal regular supraventricular tachycardias.[9]

The *standard electrocardiographic criteria* for the diagnosis of AVNRT have been assessed in previous studies,[1–10] and some new electrocardiographic algorithms have been proposed.[1,2] To the best of our knowledge, there is no prior study using an isolated aVL lead of the surface 12-lead ECG for the differential diagnosis between AVNRT and AVRT.

In the present study, the aVL notch showed an acceptable sensitivity and specificity, with a reasonable AUC.

The accuracy was very similar to the *standard electrocardiographic criteria*. These criteria were evaluated by Kalbfleisch *et al.*[11] In this study, the pseudo-S-wave in the inferior leads showed a sensitivity and specificity of 14 and 100%, respectively. The pseudo-R′ in lead V1 showed a sensitivity and specificity of 58 and 91%, respectively. Compared with our observations, the Kalbfleisch's study included atrial tachycardia and patients with Wolf–Parkinson–White syndrome, and the prevalence of AVNRT was only 38%. These differences may explain the discrepancy in the results between the two studies.

Anselme *et al.* have shown that during AVNRT, the earliest atrial electrogram is recorded at the distal coronary sinus level in 47% of the patients. This suggests a rapid and favoured exit of the impulse from the atrioventricular node using a left-side atrionodal connection. This wavefront reaches the coronary sinus before the activation wavefront coming from the right-side structures.[12] The activation propagates through the coronary sinus musculature and towards the ostium and the right atrium, reaching the slow pathway and finally depolarizing the His region. At the same time, the activation front depolarizes the coronary sinus musculature and the left atrium. This might explain, in part, the left axis deviation of the retrograde P-wave in the ECG and the positive notch close to the QRS complex in aVL lead, observed in our study.

The percentage of visible P-waves in our study was 36. 5% in AVNRT and 66. 7% in AVRT, instead of that observed by Gonzalez-Torrecilla *et al.* (25 and 72%, respectively).

Finally, the aVL notch was easily to recognize by the observers and the inter-observer agreement was acceptable.

Limitations

Some limitations need to be addressed. Only patients referred for electrophysiologic testing were included and, therefore, this series may not be representative of all narrow QRS complex tachycardias. Only few cases of atrial tachycardia and atypical forms of AV nodal re-entrant were done in our institution and we decided not to include them in the analysis (<3%).

The aVL notch, rather than identifying an unambiguous pattern, has a spectrum of variants; however, the polarity and shape of the notch are very similar in all the cases, but neither the QRS complex in aVL lead nor the time of the retrograde P wave is the same and these are the reasons why the patterns are not identical.

May be the identification of the notch dependent on ECG observer; however, we have an acceptable inter-observer agreement (κ 0.9).

The clinical usefulness of differentiating AV nodal and AV re-entry tachycardia is in doubt, since both arrhythmias have similar expected success rate and equivalent techniques when catheter ablation is performed, but the ECG is the most simple and cheap tool; we have to analyse the different variants of supraventricular tachycardia, and all the information we can get from it follows the interest for the non-invasive diagnosis of these arrhythmias.

Conclusions

The presence of a notch in aVL lead appeared to be as sensitive and specific as the standard electrocardiographic criteria for the differential diagnosis of AVNRT, and maybe, simpler to recognize.

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Conflict of interest: none declared.

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