



# Clinical and Electrophysiological Predictors of Ventriculoatrial Conduction in Patients under Evaluation for Ventricular Tachyarrhythmia

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## Abstract

**Background:** Ventriculoatrial (VA) conduction has an important role in the initiation and maintenance of some arrhythmias. The aim of this study was to evaluate whether clinical and electrophysiological parameters of atrioventricular (AV) conduction can predict VA conduction.

**Methods:** Detailed demographic, electrocardiographic, and echocardiographic data were recorded in 54 consecutive patients undergoing electrophysiological study for the evaluation of ventricular tachyarrhythmia. The basic parameters including atrial-His (AH) and His-ventricular (HV) intervals, atrioventricular Wenckebach point (AVWP), ventriculoatrial Wenckebach point (VAWP), anterograde effective refractory period of atrioventricular node (AERP-AVN), retrograde effective refractory period of atrioventricular node (RERP-AVN) and effective refractory period of ventricle (VERP) were measured based on standard protocol.

**Results:** Mean age of the patients was 59.4 ( $\pm$  13.9) years. Forty-three (79.6%) patients were male and 39 (72.2%) had a history of ischemic heart disease. Ventriculoatrial (VA) conduction was recorded in 21 (38.9%) patients; it was slightly more prevalent in the men (44.2% vs. 18.2%;  $p$  value = 0.114). In the patients without VA conduction, the means of AVWP, AERP-AVN, and PR intervals were significantly more prolonged ( $p$  value = 0.007, 0.030, and 0.045, respectively), and a trend toward more prolonged AH, HV, and QRS interval was seen in them ( $p$  value = 0.078, 0.124, and 0.159, respectively). AVWP was the best predictor for the absence of Ventriculoatrial (VA) conduction. Fifty (92.5%) patients had a better AV than VA conduction. Age, presence of ischemic heart disease, left ventricular ejection fraction, and diastolic function could not predict VA conduction. A significant direct relationship was found between left ventricular ejection fraction and VAWP ( $p$  value = 0.036,  $r$  = 0.4; the Pearson correlation test).

**Conclusion:** Prediction of VA conduction based on clinical and echocardiographic characteristics is not possible. Impairment of AV conduction was the best predictor for the impairment of VA conduction, and most patients had a better AV than VA conduction. In this study, the men had a slightly higher prevalence of VA conduction.

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**Keywords:** Atrioventricular node • Heart conduction system • Cardiac electrophysiology • Ventricular function, left

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## Introduction

It is not possible to determine the presence of ventriculoatrial (VA) conduction from the surface electrocardiogram during sinus rhythm. This entity is of particular significance in some clinical situations such as initiating and maintaining tachyarrhythmia in patients with pre-excitation syndrome and dual atrioventricular (AV) node physiology, pacemaker-mediated tachycardia and pacemaker syndrome, Intracardiac Cardioverter Defibrillator (ICD) recipients for tachyarrhythmia discrimination, and programming and preventing inappropriate shock delivery.<sup>1-4</sup>

The prevalence of VA conduction varies from nearly 20% to 90% and depends on the population studied.<sup>4-9</sup> The prevalence of VA conduction in patients with normal AV conduction is higher, but some investigators have reported the presence of VA conduction in patients with complete AV block if block is located in the His Purkinje system.<sup>10-13</sup>

Several studies have demonstrated that AV conduction is better than VA conduction in most patients at the same paced rates.<sup>13-15</sup>

The current study was designed to assess the prevalence of VA conduction in patients referred for an evaluation of ventricular tachyarrhythmia. It also aimed to evaluate the predictors of VA conduction based on clinical, echocardiographic, and electrophysiological parameters.

## Methods

Between October 2007 and October 2009, 54 patients scheduled for electrophysiological study (EPS) either to assess arrhythmia (according to the American college of cardiology (ACC)/American heart association (AHA) guidelines for the evaluation of clinical syndromes)<sup>16,17</sup> or to verify suspicions of arrhythmia based on Holter monitoring and echocardiographic data were consecutively entered into our study.

The inclusion criteria were as follows: Group I: Patients with structural heart disease and syncope that remained unexplained after appropriate evaluation; Group II: Patients surviving cardiac arrest without evidence of an acute Q wave myocardial infarction in the previous 48 hours; and Group III: Patients with unexplained palpitation or non-sustained ventricular tachycardia (NSVT) in Holter monitoring with left ventricular (LV) dysfunction.

The exclusion criteria were atrial fibrillation (AF) rhythm, history of acute myocardial infarction (MI) in the last month, or any evidence of sinoatrial node dysfunction or grade II-III AV block on surface electrocardiogram (ECG).

All the patients were in sinus rhythm at the time of study and had no evidence of acute ischemia or electrolyte

abnormalities. The patients underwent history taking and physical examination. A history of ischemic heart disease (IHD) was defined as a history of previous MI or documented coronary artery stenosis > 50% of the diameter in the coronary angiogram.

Patients with a history of syncope were excluded from the study if any explained causes for syncope (such as orthostatic hypotension, reflex-mediated syncope, and aortic stenosis [AS]) were identified, and the tilt table test was done if more evaluation was needed.

The study was approved by the Institutional Bioethics Committee, and informed written consent was obtained from all the patients. Electrocardiograms at rest were taken for all the patients, and basic intervals were measured as a mean of three consecutive beats.

A complete M-mode, two-dimensional color Doppler echocardiography and tissue Doppler imaging (TDI) were performed. The LV end systolic and end diastolic dimensions and volumes were recorded, and LV ejection fraction (LVEF) was obtained using the Simpson method. Mitral inflow velocities mitral annular velocities were measured with pulse Doppler and TDI, respectively. According to these measures, the status of diastolic function was determined (normal, mild: grade 1, moderate: grade 2, and severe: grade 3 diastolic dysfunction).<sup>18</sup>

The electrophysiological study was performed (with CardioTek, EP-Tracer software version 1.060) without general anesthesia or sedation. All the patients had discontinued antiarrhythmic drugs (beta blocker, digoxin, calcium channel blocker, and other antiarrhythmic drugs) for at least 5 half lives.

Under local anesthesia and through femoral vein approach, 3 quadri-polar electrode catheters (Finder Diagnostic Catheter, Osypka/Germany) were inserted in the high right atrium, His bundle area, and right ventricular apex under fluoroscopic guide. Intra cardiac conduction intervals were recorded at a paper speed of 100 mm/s simultaneously with electrocardiographic data from 6 surface leads. Basic intervals, namely atrial-His (AH) and His-ventricular (HV), were measured. The presence of VA conduction during ventricular pacing at a cycle length of 600 ms was evaluated.<sup>18</sup>

Incremental atrial and ventricular pacing was commenced at rates just above the sinus rate and continued until AV or VA block [atrioventricular Wenckebach point (AVWP) or ventriculoatrial Wenckebach point (VAWP), respectively] had been achieved or the cycle length had reached 200 ms. Thereafter, the extra stimulus technique was used to measure the antegrade effective refractory period of the AV node (AERP-AVN), retrograde effective refractory period of the AV node (RERP-AVN), and ventricular effective refractory period (VERP).<sup>19</sup>



## Statistical Analysis

The data were reported as distribution frequencies (for qualitative data) and mean ( $\pm$  SD) values (for quantitative ones). The statistical comparisons between the groups (presence or absence of VA conduction) were made using the chi-square and the Fisher exact test for the qualitative variables and the independent T-test for the quantitative ones. The Mann-Whitney and Pearson correlation tests were utilized to rank the variables and to assess the relationship between two quantitative variables, respectively.

Assuming co-linearity between the variables, the variables with suspected impact on VA conduction were included in a binary logistic regression model to determine the importance and independence of each factor for its effect. The area under the ROC curve was measured to evaluate the discrimination of them. Statistical analysis was performed with SPSS 15 software. The results were assumed statistically significant if p value was  $\leq 0.05$ .

## Results

Data were collected from 54 patients at a mean age of 59.4 ( $\pm 13.9$ ) years (ranging from 16 to 78 years). Forty-three (79.6%) patients were male, and 39 (72.2%) patients had a history of ischemic heart disease (IHD). The mean LVEF was 32.8%  $\pm$  10.4% (ranging from 10% to 60%). Normal diastolic function was present in 3 (5.6%) patients. Diastolic dysfunction grades 1, 2, and 3 were seen in 28 (51.9%), 10 (18.5%), and 13 (24.1%) patients, respectively. VA conduction was recorded in 21 (38.9%) patients. VA conduction was slightly more prevalent in the men (44.2%

in men vs. 18.2% in women, p value = 0.114; the Fisher exact test). There was no statistically significant difference between the VA conductive and VA dissociative patients in terms of mean age, presence or absence of ischemic heart disease (IHD), groups of inclusion criteria, mean LVEF, and diastolic function (Table 1).

In the patients without VA conduction, the means of AVWP, AERP-AVN, and PR intervals were significantly more prolonged than those of the patients of the VA-conductive Group (p value = 0.003, 0.030, and 0.045, respectively). A trend toward more prolonged AH, HV, and QRS intervals was also seen in these patients (p value = 0.078, 0.124, and 0.159, respectively). The basic intervals measured in ECG and EPS and the mean of these parameters in the patients with and without VA conduction as well as their statistical significance are summarized in Table 2.

Regarding the correlation between the variables AVWP and AERP-AVN ( $r = 0.68$ ), AH and PR ( $r = 0.68$ ), and HV and QRS ( $r = 0.3$ ) as well as their respective p value; AVWP, PR, and HV intervals were entered in the logistic regression model to find the best predictor for the absence of VA conduction. In the multiple logistic model, AVWP was the best predictor and could predict the absence of VA conduction independently (p value = 0.030) (the Hosmer and Lemeshow test, p value = 0.078; log likelihood = 60.619, Table 3). The values of the area under the ROC curve for AVWP, PR, and HV were 0.757 (95% CI: 0.616 - 0.898), 0.671 (95% CI: 0.513 - 0.829), and 0.590 (95% CI: 0.434 - 0.746), respectively.

Among the patients with VA conduction (21 patients), 17 patients had VAWP longer than AVWP, 3 patients had AVWP longer than VAWP, and one patient showed similar AVWP and VAWP. According to these measurements, 50 patients (33

Table 1. Clinical and paraclinical data in patients under evaluation for ventricular tachyarrhythmia based on VA conduction\*

	VA conduction n=21	VA dissociation n=33	p value
Age (y)	59.5 $\pm$ 12.8	59.3 $\pm$ 14.8	0.949
Male/Female	19/2	24/9	0.114
History of IHD	16 (76.2)	23 (69.7)	0.604
Inclusion criteria group			0.822
Group I	7 (33.3)	12 (36.4)	
Group II	4 (19.1)	8 (24.2)	
Group III	10 (47.6)	13 (39.4)	
LVEF (%)	33.2 $\pm$ 11.8	32.6 $\pm$ 9.5	0.830
Diastolic function			0.474
Normal	2 (9.5)	1 (3)	
Grade I dysfunction	8 (38.1)	20 (60.6)	
Grade II dysfunction	5 (23.8)	5 (15.2)	
Grade III dysfunction	6 (28.6)	7 (21.2)	

\*Data are presented as mean $\pm$ SD or n (%)

VA, Ventriculoatrial; IHD, Ischemic heart disease; LVEF, Left ventricular ejection fraction

Table 2. Descriptive statistics of basic intervals in ECG and EPS in all patients under evaluation for ventricular tachyarrhythmia based on VA conduction

	Total n=54			VA conduction n=21	VA dissociation n=33	p value
	Min	Max	Mean±SD	Mean±SD	Mean±SD	
PR (ms)	120	294	177.8±31	161.9±45.1	183.1±30.6	0.045
QRS (ms)	70	180	113.9±28.1	107.1±24.7	118.2±29.5	0.159
QTc (ms)	352	517	442.2±38.7	438.0±35.9	444.9±40.8	0.531
AH (ms)	50	240	103.9±36.7	92.8±27.6	110.9±40.3	0.078
HV (ms)	30	95	55.6±12.50	52.3±11.2	57.7±13.1	0.124
AERP-AVN (ms)	200	570	297.6±75.1	270.0±62.9	315.1±77.7	0.030
AVWP (ms)	250	600	365.9±78.4	330.5±72.0	388.5±74.8	0.007
RERP-AVN (ms)*	240	350	276.7±32.3	276.7±32.3	-	-
VAWP (ms)*	240	580	396.7±97.5	396.7±97.5	-	-
VERP (ms)	200	310	243.1±23.0	239.0±20.0	245.7±24.6	0.300

\*Only in patients with VA conduction, n = 21

ECG, Electrocardiogram; EPS, Electrophysiological study; VA, Ventriculoatrial; AH, Atrial-His interval; HV, His-ventricular interval; AERP-AVN, Antegrade effective refractory period of atrioventricular node; AVWP, Atrioventricular Wenckebach point; RERP-AVN, Retrograde effective refractory period of atrioventricular node; VAWP, Ventriculoatrial Wenckebach point; VERP, Ventricular effective refractory period

VA dissociate patients + 17 patients with VAWP longer than AVWP) of the total 54 patients (92.5%) had better AV than VA conduction. In addition, a significant direct relationship was seen between LVEF and VAWP (p value = 0.036, r = 0.4; the Pearson correlation test).

Table 3. Logistic model for absence of VA conduction in patients under evaluation for ventricular tachyarrhythmia

Variable	P value	Odds Ratio	95% CI
AVWP (ms)	0.030	0.990	0.980-0.999
PR (ms)	0.248	0.989	0.971-1.008
HV (ms)	0.287	0.972	0.922-1.024

VA, Ventriculoatrial; CI, Confidence interval; AVWP, Atrioventricular Wenckebach point; PR, PR interval; HV, His-ventricular interval

## Discussion

The prevalence of VA conduction in this study was 38.9%. This finding was almost similar to that of the Westveer study.<sup>9</sup> The mean electrophysiological measurements in the said study are also nearly similar to our findings. This might be due to the similarities between the samples; that is both groups of the patients were candidates for EPS to evaluate ventricular tachyarrhythmia.

In our study, VA conduction was slightly more common

in the men. Indeed, 9 (81.8%) of the 11 women in our study were VA dissociate. In the Akhtar study, only 3 females were included in the study and none of them had VA conduction.<sup>20</sup> A more thorough judgment about this hypothesis requires larger study populations with different cardiac diagnoses.

In our study, prolonged PR interval, AVWP, and AERP-AVN were related to VA dissociation. Prolonged PR interval has been shown to correlate with VA dissociation in other studies.<sup>15, 20, 21</sup> Westveer reported a significant relation of prolonged PR, AH, and AERP-AVN with VA dissociation.<sup>9</sup> Unlike the Westveer study, a trend toward more prolonged HV and QRS was observed in our study. The best predictor among these parameters was AVWP. These results suggest that VA dissociation probably has a stronger association with impaired conduction within the AV node rather than in the distal conduction system. This seems to be a strong association rather than a causative link.

Narula suggested that retrograde conduction when present was better than antegrade conduction.<sup>21</sup> Akhtar posited that in patients with retrograde conduction only one third had better retrograde than antegrade conduction. Most of these patients had dual AV node pathway or bypass tract.<sup>20</sup> As we expected, most (92.5%) of our patients had better antegrade conduction than retrograde conduction.

## Conclusion

The presence of VA conduction cannot be predicated based





on such clinical and paraclinical characteristics as age, IHD, LVEF, and diastolic function. As we expected, AV conduction was better than VA conduction in most patients.

Among the electrophysiological parameters, prolonged PR interval, AVWP, and AERP-AVN were correlated with VA dissociation, with AVWP being the most important predictor. In this study, the men had a slightly higher prevalence of VA conduction than the women.

First and foremost among the limitations of the present study is its relatively small sample size, which is due to the invasive nature of EPS. Additionally, a more thorough evaluation of the gender difference in VA conduction, which was found in the present study, requires more data series. This study group was comprised of patients suspicious of ventricular arrhythmia, and more than 70% of them had a history of IHD with an overall mean LVEF of 32.8%; the results cannot, therefore, be generalized to a normal population.

Because the parameters of AV and VA conduction can be measured in any electrophysiologic study (regardless of the reason for the study), a coordinated multicenter program to evaluate these parameters in a large cohort of patients with different underlying heart disease can help to evaluate the finding of this study in the future.

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