

# The Predictive Accuracy of the RR Interval Distribution Pattern in the Detection of Dual AV Node Physiology in Patients with Chronic Atrial Fibrillation

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**Introduction:** Modification of atrioventricular node (AVN) conduction with radiofrequency energy delivered at the slow pathway area seems to be an effective mode of therapy in patients (pts) with chronic atrial fibrillation (AF) and rapid ventricular response. Success or failure of this method to control the ventricular rate may be associated with the presence or absence respectively of dual AVN physiology, a concept that has not been assessed yet in pts with chronic AF. In this study we assess the predictive accuracy of a non invasive method, the RR interval distribution pattern analysis, for the detection of the presence or the absence of dual AVN physiology.

**Methods:** Thirty-eight pts with chronic AF who underwent successful external or internal cardioversion were included in this study. The mean age was  $63,5 \pm 4,8$  years. No severe heart disease was present and all antiarrhythmic drugs including digitalis were discontinued. Twenty-four hour ambulatory ECG recordings were obtained and from the analysis of all 24 h RR intervals, heart rate stratified histograms (HRSH) were constructed. The RR distribution pattern that derives from the final analysis of HRSH may be unimodal, bimodal or trimodal. Two to six days later and while all the pts maintained sinus rhythm, an electrophysiologic study (EPS) was performed in each pt in order to assess the presence or the absence of dual AVN physiology, using standard criteria.

**Results:** Eighteen pts presented a bimodal pattern (B) of RR distribution, 19 pts demonstrated a unimodal pattern (U) and one pt had a trimodal distribution pattern (T). Fourteen out of 18 pts with B had dual AVN physiology while in 17 out of 19 pts with U the duality was absent. The pt who presented the T had 2 "jumps" recorded during the EPS. This pt was finally categorized in the pts group with B and dual AVN physiology. The sensitivity of this method for the detection of dual AVN physiology is 88%, the specificity is 80% while the positive and the negative predictive value of the method was 79% and 89% respectively.

**Conclusion:** In pts with chronic AF the RR interval distribution pattern is highly sensitive and specific for the detection of the presence or the absence of dual AVN physiology. This method may be proved useful in the selection of pts with chronic AF who require modification of AVN conduction.

**R**ecent studies have demonstrated that delivery of radiofrequency (RF) energy in the posteroseptal region of the tricuspid annulus may slow the ventricular rate during atrial fibrillation (AF)<sup>1-4</sup>. It has been suggested that selective ablation of the slow AV nodal pathway is a possible mechanism of slow-

ing the ventricular response in AF<sup>5,6</sup>. In that case, success or failure of this method to control the ventricular rate may be associated with the presence or absence respectively of dual AV node physiology, a concept that has not been assessed yet in patients with chronic AF. Thus, confirmation of the presence or absence

of dual AV node physiology in patients with chronic AF might be extremely useful since it can affect decision making regarding the choice of therapy. Electrophysiologic study (EPS) is a highly precise tool in the detection of dual AV node physiology during sinus rhythm<sup>7,8</sup>. On the other hand it has been suggested that a bimodal pattern of RR interval distribution is associated with the presence of dual AV node physiology in patients with AF<sup>9-11</sup>. Thus, we conducted this study to determine the ability of RR interval distribution pattern to predict the presence or absence of dual AV node physiology using the EPS as a gold standard.

## Methods

The subjects of the study were 38 patients with chronic AF and rapid ventricular response who underwent either external or internal direct current cardioversion and maintained sinus rhythm for several days. The duration of AF was  $4.6 \pm 3.9$  months (range 1-18 months) and the mean and maximum ventricular rate were  $108 \pm 16$  bpm and  $164 \pm 20$  bpm respectively. There were 23 men and 15 women with a mean age of  $63.5 \pm 4.8$  years (range 51 to 73). Before enrollment each patient gave verbal and written informed consent and the study protocol was approved by the Human Research Committee. The patients had a history of coronary artery disease without evidence of acute ischemia (4 pts), cardiomyopathy (5 pts), hypertension (9 pts) and mild valvular heart disease (4 pts). Sixteen patients had no history or evidence of structural heart disease. Ten patients were taking thiazide diuretics and 4 patients angiotensin converting enzyme (ACE) inhibitors, the dosage of which was kept constant during the study. Left ventricular ejection fraction was  $0.55 \pm 5.3$  (range 0.44-0.62). After discontinuation of all antiarrhythmic drugs, including digitalis, for a period  $>5$  half lives and before conversion to sinus rhythm a 24-hour ambulatory ECG recording was obtained from each patient for RR interval analysis.

The method of heart rate stratified histogram was used for analysis of the distribution of RR intervals during AF<sup>12</sup>. This type of analysis results in a single dimension table constructed from all RR intervals in msec, obtained over a 24-hour period. This table represents the entire 24-hour ECG recording. The data of this table are further analyzed in a computer as follows: (1) The table (recording) is divided

into sequences of 64 consecutive RR intervals. (2) For each sequence the average heart rate is calculated. (3) The average heart rate during these sequences is used to organize these sequences in groups for each 10 bpm - wide average heart rate level (i.e. 60-70 bpm, 70-80 bpm, e.t.c.). (4) For each 10 bpm - wide average heart rate level, an RR interval histogram is constructed which includes RR intervals that belong to the sequence with an average heart rate within this level. The RR distribution pattern may be unimodal, bimodal or multimodal. (5) If the RR distribution pattern is bimodal in at least two consecutive heart rate levels (i.e. 60-70 bpm, 70-80 bpm) the protocol proceeds as follows: In histograms presenting bimodal distribution the RR value of the intersection point of the two RR populations is used in order to discriminate the 1 RR population from the other. All individual RR intervals below the intersection point of the two RR populations are identified as short (S) intervals, while values above this point are identified as long (L) intervals<sup>11</sup>.

## Electrophysiologic study

Two to 6 days after cardioversion and while the patients maintained sinus rhythm, an EPS was performed in each patient in order to assess the presence or absence of dual AV node physiology by using the standard technique. Briefly, 2 6F venous sheaths were placed in the femoral vein and 2 quadripolar electrode catheters were positioned in the high right atrium and His bundle region respectively. Pacing was performed with a programmable stimulator. The stimulation protocol included the introduction of single and double extrastimuli from high right atrium at 3 paced cycle lengths. Dual AV node pathway physiology was defined as a discontinuous AV nodal conduction curve during atrial extrastimulus testing ( $\geq 50$  ms increase in  $A_2$ - $H_2$  interval for a 10 ms decrement in the  $A_1$ - $A_2$  interval). Whenever a second jump in  $A_2$ - $H_2$  followed the first 1 during the progress of the extrastimuli testing, a second slow pathway was considered to be present. Two patients developed atrioventricular node reentry tachycardia (AVNRT) during the EPS and no patient demonstrated evidence of an accessory pathway. Initially the EPS was performed at baseline conditions. During EPS when the presence of AV nodal duality was not revealed, pharmacological intervention was performed (atropine 1 mg,i.v.).

## Results

During RR intervals analysis 18 patients (47%) demonstrated a bimodal RR distribution pattern and 19 patients (50%) presented a unimodal pattern. The remaining patient exhibited a trimodal pattern (Table 1). A representative graph of a bimodal and a unimodal pattern is shown in figure 1. Dual AV node physiology was present in 14 patients out of 18 patients with bimodal distribution pattern and absent in 17 pts out of 19 with unimodal pattern. Two discontinuous AV nodal curves were observed in the patient with trimodal pattern and he was included in the subgroup of patients with bimodal RR distribution pattern and dual AV node physiology. Sensitivity, specificity and predictive value of RR interval distribution pattern was determined using the EPS data as reference. The distribution pattern of RR

intervals had an 88% sensitivity (15 of 17 pts) and 80% specificity (17 of 21 pts) for the detection of dual AV node physiology. Further statistical analysis revealed that positive and negative predictive value of RR interval distribution pattern regarding the detection of AV nodal duality is 79% (15 of 19 pts) and 89% (17 of 19 pts) respectively (Figure 2).

## Discussion

The main finding of this study is that in patients with chronic AF and rapid ventricular response the distribution pattern of RR intervals is highly sensitive and specific for the detection of dual AV node physiology.

Recently, the concept of dual AV node physiology has become particularly attractive mostly because of studies that provided evidence that after delivery

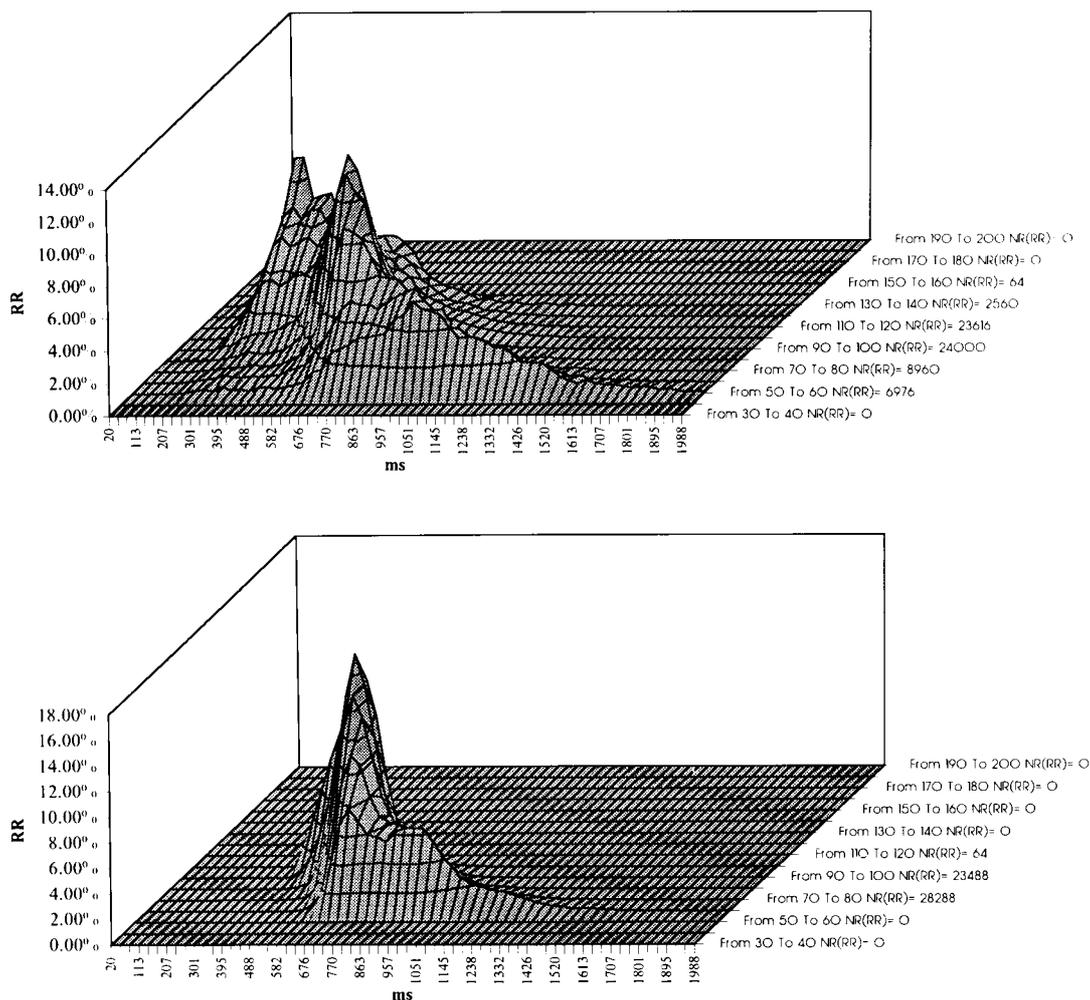


Figure 1. A representative graph of a bimodal (top) and a unimodal pattern (bottom) is shown.

**Table 1.** Detection of the presence or absence of dual AV node physiology by EPS versus distribution pattern of RR intervals.

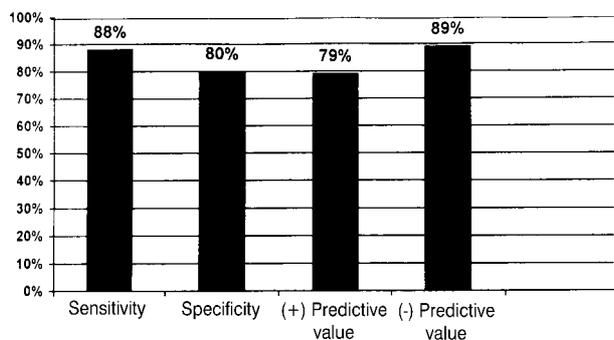
EPS	Pattern of RR Intervals			
	Bimodal	Unimodal	Trimodal	
DAVN (+)	14	2	0	16
DAVN (-)	4	17	0	21
DAVN (++)	0	0	1*	1
Total	18	19	1	38

DAVN (+), (-) = Presence and absence of dual AV node physiology respectively.

DAVN (++) = Presence of dual slow pathways.

\* The single patient with DAVN (++) and trimodal pattern has been included in the group of DAVN (+) and bimodal pattern for the purpose of statistical analysis.

of RF energy in the posteroseptal region of the tricuspid annulus in patients with AF and rapid ventricular response, abrupt slowing of the ventricular rate is achieved<sup>1-4</sup>. It is suggested that the most likely mechanism of heart rate reduction is the selective elimination of the slow AV nodal pathway<sup>5,6</sup>. Other investigators have proposed that, this effect might be due to partial damage of the compact AV node<sup>4</sup>. Implicit in the first hypothesis is that success of this procedure to control the ventricular rate may depend on the percentage of patients with AF in whom dual AV node physiology exists. By contrast, failure to achieve rate control may be anticipated when dual AV nodal transmission is absent. Thus, knowing a priori the presence or absence of AV nodal duality, we may be able to select those patients who are considered appropriate candidates for RF modification of AV nodal conduction instead of AV junction ablation.



**Figure 2.** Bar graphs of percent sensitivity, specificity and positive and negative predictive values are plotted. These demonstrate 88% sensitivity, 80% specificity, 79% positive and 89% negative predictive value of RR interval distribution pattern for detecting dual atrioventricular node physiology.

Evidence arising from the analysis of RR interval distribution pattern in patients with AF suggests that a bimodal pattern is consistent with the presence of dual AV node pathways<sup>9-11</sup>. Cai et al<sup>12</sup> have constructed heart rate stratified histograms from patients with AF and interpreted both the resulting RR populations of a bimodal pattern as corresponding to conduction via a slow and a fast atrionodal route. On the other hand at heart rate levels at which one of the two RR populations vanishes, orthodromic impulse propagation utilizes only one of the conduction routes.

The relatively low specificity (80%), observed in this study, is due to 4 cases with bimodal RR pattern and absence of AV node duality at EPS. It is possible that a continuous AV node function curve may consist of 2 distinct components representing both fast and slow AV node pathways even when the typical discontinuity is absent.<sup>13</sup>

The presence of dual AV node physiology in the population is 10-15%. Patients with chronic atrial fibrillation are specific subgroup and possibly the presence of dual AV node physiology is higher. Abnormal anisotropy in the region of AV node may be an explanation.

Our results suggest that the presence or absence of dual AV node physiology in patients with AF can be defined by using the non-invasive method of 24-hour RR interval analysis. Our relatively small sample size will require confirmation by further studies. However, this report is the first that makes a distinction between the presence and the absence of dual AV node physiology in patients with AF by means of the distribution pattern of RR intervals.

In conclusion, considering the EPS as a reference, the RR interval distribution analysis is a sensitive and specific method for the detection of dual AV node physiology. This method may be proved useful in identifying patients who are candidates for AV nodal modification as opposed to AV nodal ablation.

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