

# Some Important R-R Interval Based Paroxysmal Atrial Fibrillation Predictors

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## Abstract

*Atrial fibrillation is the most common sustained cardiac arrhythmia. The result of series of machine learning experiments is detection of some promising paroxysmal atrial fibrillation predictors. Based on ratio of short and long R-R intervals there is a possibility to generate rules for PAF screening and predicting. For PAF screening the calculated ratio were 2.00 for successive R-R intervals. The problem of imminent PAF prediction is much more difficult and the concept of normalisation had to be implemented. The optimal seems to be ratio between the shortest and the longest R-R interval, which was at least 1.75 times larger than ratio during the normalisation time for the same patient. Also it was detected that maximal distance of the longest and the shortest R-R intervals should be up to six R-R intervals.*

## 1. Introduction

Atrial fibrillation (AF), the most common sustained cardiac arrhythmia results from simultaneous re-entrant wavelets. The pathophysiology of AF is not entirely clear and does not provide an explanation for some individuals develop this arrhythmia.

It is now recognized that AF can be initiated by a variety of mechanisms that share the ability to cause extremely rapid, irregular atrial electrical activity. Once initiated, AF causes alterations in atrial electrical properties so called electrical remodelling. Electrical remodelling decreases the atrial refractory period in a heterogeneous way, thus decreasing the size and stability of potential functional atrial re-entry waves and promoting multiple-circuit-re-entry [1]. Paroxysmal atrial fibrillation (PAF) may be started by one or two non-stable circuit re-entry. The recognizable small irregular baseline undulations of variable amplitudes and morphology, probably do not represent total atrial activity but depict only the larger vectors generated by the multiple wavelets of depolarisation that occur at any given moment.

According to the multiple-wavelet hypothesis, AF is characterized by fragmentation of the wave

front into multiple daughter wavelets that wander randomly through the atrium and give rise to new wavelets that collide with each other in a perpetual activity [3].

The autonomic nervous system may also play an important role as a trigger for the spontaneous onset of PAF [4]. The trigger mechanisms and pathophysiology of AF may be different between patients with and without organic heart disease and in various clinical situations.

A lot of new methods have been recently developed to detect abnormalities in R-R intervals that are not predictable by traditional analysis methods.

The goal of this work was to reveal possible alterations in the abnormalities on R-R interval behaviour before the spontaneous onset of PAF.

## 2. Methodology

### 2.1. PAF screening

The inhomogeneous propagation of sinus impulses is well known characteristics in patients with PAF. The purpose of PAF screening is to search for possible electrocardiography markers that could serve predictors of idiopathic paroxysmal atrial fibrillation. For PAF screening the maximum ratio between short and long successive R-R intervals were measured. The border ratio calculated with Inductive machine Learning by Logic Minimisation (ILLM) was 2.00 [2]. When the long interval is two or more times longer than successive short R-R interval, the paroxysmal atrial fibrillation is possible.

### 2.2. PAF prediction

For PAF prediction the maximum ratio between the longest and the shortest R-R interval, which are separated by not more than six R-R intervals, was measured.

First, it was calculated the ratio in a stable situation, without PAF, during the five minute ECG recording. This ratio was assumed as «normal» in stable situation. After that, the maximum ratio

during the five minute just before onset of PAF was calculated. During prediction phase, every computed ratio was divided (normalised) by this normal value. Only if new ratio is more than 1.75 times larger than the normal ratio, imminent PAF is predicted. If normalization was not used, ratio of long and short R-R interval should be greater than 3.00.

### 3. Results

#### 3.1. PAF screening

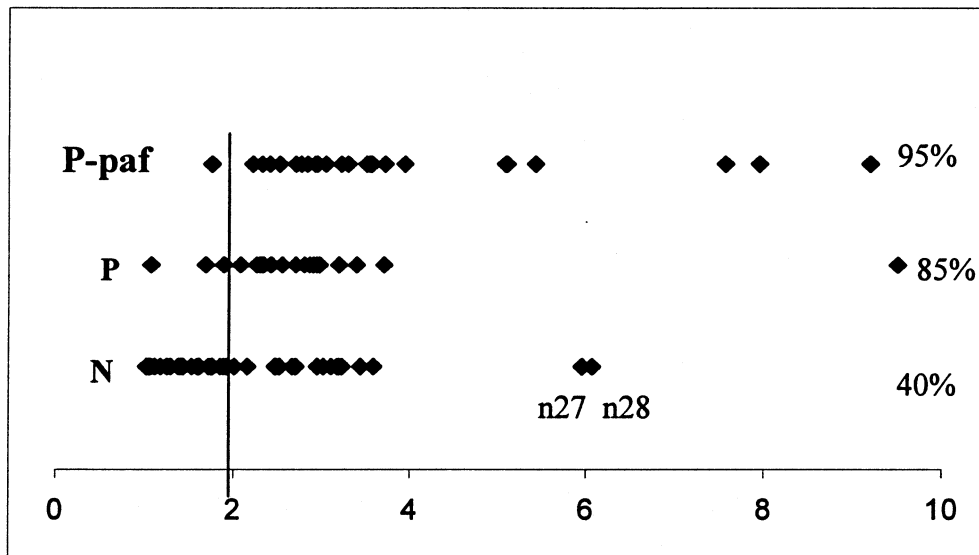
The « rule » for PAF screening estimated by ILLM is that border ratio of short and long

successive R - R intervals have to be more than 2.00.

The rule was implemented on all 50 patients. When we tested this rule on ECG recording from patient's data, we got some interesting results.

For the group of patients (P-paf), imminent before the PAF, the marker for PAF risk detection was about 95 %, and for the group in stable situation (P), the risk detection was about 85 % [Figure 1].

The rule has high sensitivity (about 90%), but its specificity is low (60%). Estimated positive predictive value is about 70 %. Score at the test set was 30 out 50 subjects, or 60 %.

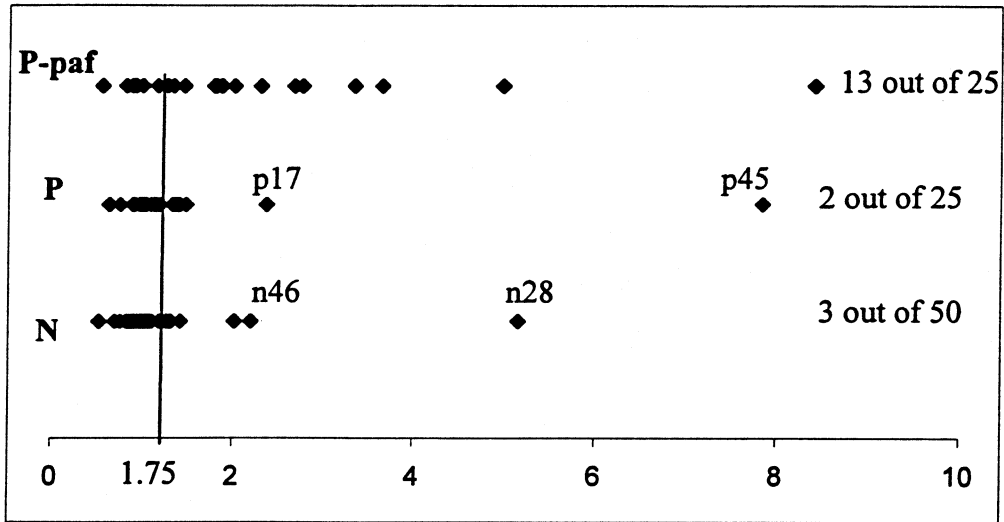


**Figure 1.** PAF screening: Rule «ratio of successive long and short R-R intervals larger than 2.00.» P-paf and P= PAF positive cases (P-paf - cases with proximately detected PAF); N= cases for which PAF have never been detected; n 27 and n 28 are most important cases with incorrect classification

#### 3.2. PAF prediction

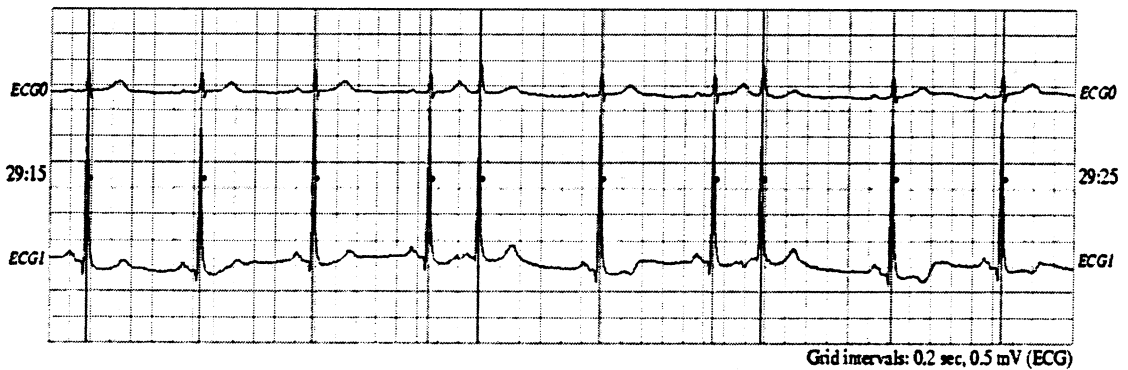
The «rule» for PAF prediction estimated by ILLM was implemented also on all 50 patients. The patients with imminent detected PAF had ratio more then 1.75 in about 50 % cases. For the group of patients, which they have experienced PAF, but

not immediately, and for the patients, which PAF have never been detected, the PAF prediction is less than 10 % [Figure 2]. The rule has low sensitivity but its specificity is high (about 90%). Estimated positive predictive value is about 70%. Score at the test set was 39 out 50, or 78 %.



**Figure 2.** Proximately PAF predicting: Rule «normalised ratio of a long and a short R-R interval which are separated by not more than 6 R-R intervals is greater than 1.75». P-paf= positive PAF cases; P and N= negative cases (P have experienced PAF but not immediately); p 17, p 45, n 46, and n 28 are most important incorrect classifications.

### 3.3. Example of PAF screening and PAF prediction



**Figure 3.** ECG recording (P-paf; patient number 14)

It was analysed the ECG recording 35 seconds before the onset of PAF. Two very short intervals were followed by the one long R-R interval [Figure 3]. The absolute ratio between first short interval and the long one is 2.44, and for second short

interval 2.70. The «normal» ratio calculated in the stable situation, approximately 25 minute before was 1.17. The normalized ratio values were 2.08 and 2.30, which are both PAF predictable because they are greater than 1.75.

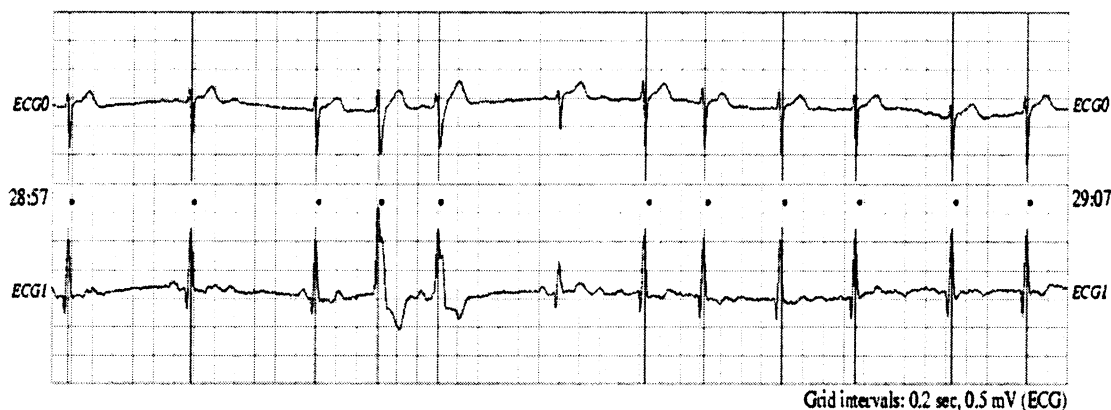


Figure 4. (ECG recording; P-paf; patient number 32)

This is a pattern of ECG recording in approximately 55 seconds before the onset of PAF.

Two short R-R intervals were followed by a very long interval [Figure 4]. The ratio between shorts and long interval was 3.45 and 3.54. Normal ratio calculated in the stable situation was 2.18.

But, if we normalize those ratios, the calculated values are 1.58 and 1.63, which are both less than «normal» ratio 1.75. So, it was necessary to use recommended six R-R intervals. Then, the ratio should be greater than 4.00, and after normalizing greater than 2.00. It means that criteria's for PAF predicting would be satisfied.

#### 4. Conclusions

This work demonstrates a use of ILLM in discovering detectable changes in the ECGs before PAF. The performed experiments demonstrate how the synergy of medical and ILLM expertise of R-R interval dynamics helps to detect the spontaneous onset of PAF [2]. Further studies are needed to determine the pathophysiological correlates of these measures.

#### References

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