Dynamics of heart rate and blood pressure in hypertensive patients

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Abstract. *Hypertension represents an important condition that affects the adult population worldwide; it contributes significantly to morbidity and mortality from stroke, heart failure, coronary heart disease and renal failure. Although the pathogenesis of most hypertension is unclear, imbalance of the autonomic nervous system has been implicated in its development. Heart rate variability (HRV) has emerged as a practical, non-invasive tool to quantitatively investigate cardiac autonomic imbalance in hypertension. The aim of our study was to highlight the complex heart rate modulation in hypertension and to analyze the behaviour of RR intervals dynamics compared to normotensives subjects. Beside the now consecrated well known heart rate variability parameters, it seems that new parameters like ΔHR (b/min) and ΔSBP (mmHg) can offer data related to the involvement of the circadian rhythm in hypertension.*

Keywords: Hypertension, heart rate variability, nonlinear analysis, circadian rhythm

1. Background

Hypertension represents an important condition that affects the adult population worldwide; it contributes significantly to morbidity and mortality from stroke, heart failure, coronary heart disease and renal failure [1]. There are a lot of studies and data that suggest that the autonomic nervous system plays an important role in blood pressure regulation and in the development of hypertension [3]. Early identification of individuals prone to hypertension, may allow for early interference such as: lifestyle modifications, regular exercise and weight loss, targeted at reducing the risk factors for hypertension, and reducing sympathetic nervous system activation [2].

Abnormalities of autonomic nervous system function (ANS) exist in patients with hypertension and have been considered as one of the important factors in developing of essential hypertension. Lower HRV was associated with greater risk for developing hypertension [4].

The sympatho-vagal balance is altered in the resting conditions of numerous pathophysiological processes. It is the case of essential arterial hypertension (Guzzetti *et al.* 1988), even in the presence of arterial pressure values still in the high normal range (Lucini *et al.* 2002).The ability of decreased heart rate variability to predict incident hypertension has not been well studied, and there are no studies of whether hypertension leads to changes in heart rate variability [5].

2. Method

The study was performed at the Cardiology Clinic of the Emergency County Hospital Timis, University of Medicine and Pharmacy "V. Babes "Timisoara, starting from a former study performed by one of the authors at the Riga Eastern Clinical University Hospital, Latvia. The study group (n: 47, men: 23, women: 24, mean age: 54.2 yrs) has included hypertensive patients with stage II and III of essential hypertension. A control group of twenty normotensives subjects (men: 11, women: 9, mean age: 46.7 yrs) was selected to compare the clinical data and autonomic tone parameters. ECG signal analysis and blood pressure measurements have been done using a EC-3H/ABP Combined Holter System, Labtech Ltd. The system performs simultaneously recording of the ECG signal and measurements of the blood pressure.

Twenty four hours of combined ECG and blood pressure monitoring has been performed and more than 90 % of the signals and measurements are eligible for the study. Artefacts and noise was manually removed from the signals.

All ECG analysed signals are in sinus rhythm and analysis of heart rate variability was performed in time domain, mean RR intervals (ms), standard deviation of all RR intervals (ms) and frequency domain, very low frequency (VLF, 0.01-0.05 Hz), low frequency (LF, 0.05 -0.15 Hz) and high frequency (HF, 0.15-0.50 Hz), LF/HF ratio. Kubios v. 2.1, Finland (http://kubios.uku.fi/) was used for the measurement of the nonlinear parameters of the RR series. Approximate Sample entropy, detrended fluctuation analysis and Poincare plots; have been used for the study of the behaviour of the heart rate dynamics in both groups.

Trends of heart rate (b/min) and blood pressure (mmHg) have been recorded for both groups.

Left ventricular ejection fraction (LVEF, %) has been measured echocardiography by an independent member of the team.

3. Statistical analysis

For the statistical analysis we have used Graph Pad Prism. All numeric variables were expressed as mean and the statistical analysis was performed using Student's t-test and correlation analysis by Pearson method. A p value < 0.05 was considered statistically significant.

4. Results and Discussions

In the hypertensive group the gender distribution is almost equal, suggesting a higher incidence of essential hypertension in the women population and probably that the men are much earlier hypertensive than women. In the study group, women had mean age: 57 yrs. compared to men mean age: 50.4 yrs. ($p<0.005$). Differences have been noticed also in relation to the mean heart rate. Women are more tachycardic than the men hypertensive population (mean heart rate: 87 b/min vs. 80 b/min), but the differences are not statistically significant. Considering only the gender aspects, in the hypertensive group, the left ventricular ejection fraction (LVEF %) seems to be preserved, LVEF: 60 %, mean LVEF in the men population: 58 % compared to the women mean value: 61 %. In the hypertensive group, those with events have a lower left ventricular ejection compared with the events free hypertensive population (LVEF: 48 % vs. 68 %, $p< 0.005$). All the clinical data are resumed in table 1.

Table 1. Main clinical characteristics of the study and the control group.

	Hypertension	Control	P
N	47	20	0.05
Age (yrs.)	54.2	46	0.05
Mean heart rate (b/min)	86	73	0.05
LVEF (%)	60	72	0.05
Systolic Blood Pressure (mmHg)	160	127	< 0.005
Diastolic Blood Pressure (mmHg)	105	75	< 0.005
N	47	20	0.05
Age (yrs.)	54.2	46	0.05
Mean heart rate (b/min)	86	73	0.05

Analyzing the hypertensive group, we noticed differences between the dynamics of heart rate and systolic blood pressure as a measure of the circadian rhythm. The difference between day/night heart rate and blood pressure is considered a useful parameter of the influence of the circadian rhythm (table 2).

Table 2. The influence of arrhythmic events and heart failure in the hypertensive group

	Hypertension + events	Hypertension - events	P
N	18	29	
Age (yrs)	60.5	49.7	0.05
Mean heart rate (b/min)	85	84	Ns
LVEF (%)	48	68	0.005
SBP (mmHg)	163	160	Ns
DBP (mmHg)	97	107	Ns
ΔHR (b/min)	9.65	15.62	0.005
ΔSBP (mmHg)	27.8	23.72	0.05

During the study we have not observed significant differences between the absolute values of the systolic blood pressure inside the hypertensive group. Despite this fact some parameters like the difference between day and night mean heart rate can suggest important modulations of the autonomic tone in hypertension. More of this, ΔHR (b/min) and ΔSBP (mmHg), the later as expression of the day-night differences in systolic blood pressure, seems to correlate.

The correlation between ΔHR (b/min) and ΔSBP (mmHg), opens the opportunity to analyze the influence of the autonomic tone in the modulation of heart rate and blood pressure in the hypertensive population.

The role of the autonomic tone in essential hypertension is assessed using linear and nonlinear parameters. Heart rate variability and nonlinear dynamic parameters like entropy and detrended fractal analysis was applied to the ECG signals obtained from hypertensive patients. Even in a limited and selected group of patients it is difficult to identify vulnerable

hypertensive patients. It seems adequate to perform nonlinear analysis in hypertensive patients to identify vulnerable patients. Not all parameters will have spectacular changes but approximate entropy (ApEn) and detrended fluctuation analysis parameter (DFA α1) confirm the capacity to identify risk patients even in apparently stable patients, like in essential hypertension [6, 7]. An important aspect regarding the value of these parameters is related to the coexistence of co morbidities.

5. Conclusions and limitations

The aim of the study was to offer significant data about the complex mechanisms involved in essential hypertension. The most important aspect of this study is that even in the presence of early stages of essential hypertension, the autonomic tone mechanisms are involved in the outcome and prognosis of these patients and are detectable by non-invasive methods.

Beside the now consecrated well known heart rate variability parameters, it seems that new parameters like ΔHR (b/min) and ΔSBP (mmHg) can offer data related to the involvement of the circadian rhythm in hypertension.

The study has two major limitations, one is related to the relatively small number of patients included in the study, and the other is that all the patients in the study have been under complete medical treatment.

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