

Changes in Distributional and Long-Range Correlation Characteristics of Pulse Pressure Variation in Patients with Essential Hypertension

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ABSTRACT. In this paper we show that the degree of symmetry of probability distribution of pulse pressure variation (PPV) increases in patients with third stage of essential hypertension (EH). Moreover, typical of healthy group random-like process of PPV becomes more and more persistent in patients with (EH). These findings provide evidence on dynamical changes of PPV in the form of increased long-range correlations in hypertension. © 2008 Bull. Georg. Natl. Acad. Sci.

Key words: hypertension, pulse pressure, long-range correlations.

Over the last two decades, increased attention in the hypertension literature has been paid to the quantitative analysis of dynamics of blood pressure variation. This is quite reasonable in the light of well-accepted concepts on close relationship between distortion of pressure variation and risk to human health. This is why we aimed to investigate the dynamics of PPV in patients with different stages of hypertension.

The data sets of PPV used in this research were calculated from 24h ambulatory monitoring of blood systolic and diastolic pressure recordings of 160 patients at 15 min sampling time. The age of patients varied from 30 to 70. Monitoring was carried out on the monitor: MOBLOGRAF (IEM, Germany). All patients under study were not given medicines for 2-3 days preceding the examination. Blood pressure recording was carried out in calm environment, in sitting position, according to the standard method provided by hypertension guideline. The 24 hr monitoring of blood pressure was carried out from 11.00 a.m. to 11.00 a.m. of the next day, taking into consideration the physiological regime of the patients.

After, from these recordings of individual patients amalgamated data sets were compiled as consecutive sequences of appropriate data sets of each patient from the considered groups. Integral time series of PPV for each investigated group contained about 1300 data. For illustrative purposes the united data set of all available PPV time series containing data from the healthy group as well as for patients with first, second and third stage of hypertension (sequentially) is presented in Fig. 1.

Conventional statistical moments calculation and probability distribution as well as modern multi-scaling memory testing data analysis tools have been used. These modern methods have opened up a new approach for studying and understanding the characteristics of complex dynamics including cardiovascular processes [1-3]. They differ from the conventional linear methods because they are designed to assess the quality, scaling, and nonlinear correlation properties of processes rather than the magnitude of variability. Thus, multi-scaling and memory testing methods are most reliable for analysis of PPV dynamics in patients with different

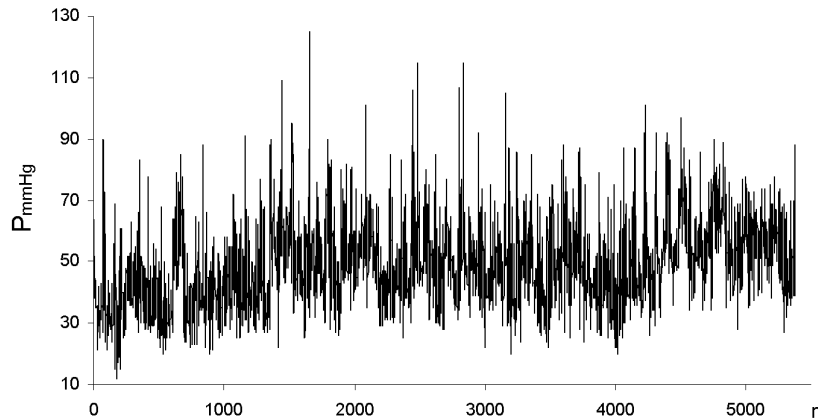


Fig. 1. Typical amalgamated pulse pressure data sets for all investigated groups.

Table 1

Statistical moments of pulse pressure variation time series

Value \ Group	Healthy	Hypertension		
		First stage	Second stage	Third stage
Min	12	22	20	25
Max	91	125	115	101
Mean	40.7	51.6	47.3	55.2
Standard deviation	10.95	12.09	11.45	11.74
Coeff. of variation	0.26	0.23	0.24	0.21
Skewness	0.91	1.02	0.89	0.33
Kurtosis	1.57	2.61	2.57	0.16

stages of (EH). The results of R/S or Hurst exponent calculation [3] are presented in this paper.

As it follows from Table 1, though the first moments of PPV in hypertension increase, second moments remain almost unchangeable. At the same time distributional characteristics are rather different. Indeed, decrease of skewness and kurtosis points out that in pathology picked, long-tailed right hand type distribution of PPV becomes closer to normal. Similar conclusion can be drawn from Fig. 2, but additionally it is also visible that in contrast to

the normal distribution PPV still preserves an essential long-tailed property. This last finding points to the possible increase of long-range correlations of PPV in the third stage of hypertension. At the same time in the first and second stages of hypertension the situation looks like being the other way round. This means that, based only on statistical analysis, it could not be answered whether memory effects may increase in pathology and special methods should be used. Indeed, as is shown in Table 2, the values of Hurst exponents, calculated for

Table 2

Hurst exponent values of pulse pressure variation time series

Investigated group	Healthy	Hypertension		
		First	Second	Third
Hurst exponent (H)	0.430 ± 0.050	0.830 ± 0.010	0.890 ± 0.010	0.990 ± 0.020

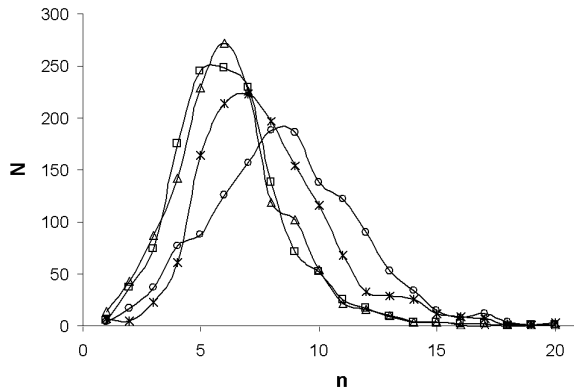


Fig. 2. The shape of probability distribution of pulse pressure values: healthy group (asterisks), hypertension - first stage (squares), second stage (triangles), third stage (circles). N – number of values, n – number of gradations.

amalgamated series of the investigated groups, significantly increases in pathology. The latter, together with the results in Table 1, can be considered as a clear indication of increased long-range correlations in PPV at all stages of hypertension. It is worth mentioning that the dynamics of PPV becomes clearly persistent according to the condition of pathology, which is in good agreement with the earlier increase, found of order in myocardial function in pathological states including hypertension [1, 4, 5]. This may be explained as caused by decrease of adaptability in hypertension, while a defining feature of healthy function is adaptability, i.e. the capacity to respond to unpredictable stresses and stimuli.

Thus it was concluded that PPV in patients with hypertension becomes long-range correlated and persistent, as compared to the healthy group.

ექსპერიმენტული მედიცინა

პულსური წნევის განაწილებითი და ხანგრძლივი კორელაციების მახასიათებლების ცვლილება ესენციური ჰიპერტენზიის მქონე პაციენტებში

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სტატიაში ნაჩვენებია, რომ პულსური წნევის ალბათური განაწილება ნორმასთან შედარებით უფრო სიმეტრიული ხდება მესამე ხარისხის ესენციური ჰიპერტენზიის მქონე პაციენტებში. უფრო მეტიც, პათოლოგიაში პულსური წნევის ცვალებადობის პროცესი უფრო პერსისტენტულია. ეს ყოველივე მიუთითებს ჰიპერტენზიული პაციენტების პულსური წნევის ვარიაციის პროცესში ხანგრძლივი კორელაციების არსებობაზე, ნორმისაგან განსხვავებით.

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