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Medical Sciences

Recurrence Quantification Analysis of Arterial Blood Pressure and Heart Rate Variability in Patients with Essential Hypertension

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(Presented by Academy Member N. Kipshidze)

ABSTRACT. In the present research we have investigated the dynamics of systolic and diastolic arterial pressure and heart rate variability in three groups of patients with different stages of hypertension. Essential increase of extent of order in systolic and diastolic arterial pressure, as well as in heart rate variability have been observed using recurrence quantitative analysis (RQA) approach. Both measured and compiled from original data SDH time series have been investigated. We conclude that increase of order in blood pressure and heart rate variation in hypertension reflect general features of changes in heart dynamics and are not caused by unavoidable local trends in the analyzed physiological data sets. *© 2009 Bull. Georg. Natl. Acad. Sci.*

Key words: *hypertension, blood pressure, heart rate, RQA, dynamics.*

It is widely accepted that physiological signals derived from humans are extraordinarily complex [1]. These signals reflecting ongoing processes involve very complicated regulation mechanisms, and commonly are used to diagnose incipient pathophysiological conditions. Unfortunately, the presence of noises and trends in series of measured physiological signals, make traditional data analysis tools not always effective. We often fail to discriminate basic dynamical changes in physiological processes related to pathological conditions [2 - 4]. This is why over the last the decade increased attention has been paid to the investigation of the dynamics of physiological data sets using modern time series analysis methods. In the present research we have continued investigation of dynamics of blood pressure and heart rate variability time series from healthy persons and patients in different stages of hypertension. In particular, to test our earlier results on increased order in blood pressure variation, observed in patients with hypertension [4-6], we used a modern data analysis method recommended for investigation of complex dynamics of physiological process. Namely recurrence quantitative analysis (RQA) method [7], which is recognized as one of the most effective quantitative approaches used for relatively short and noise physiological data sets.

In this study we used data of measured systolic and diastolic pressure as well as heart rate variability data sets. These data have been obtained 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 of mentioned physiological data sets was carried out on the monitor: MOBILOGRAF (IEM, Germany). All participants of the 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

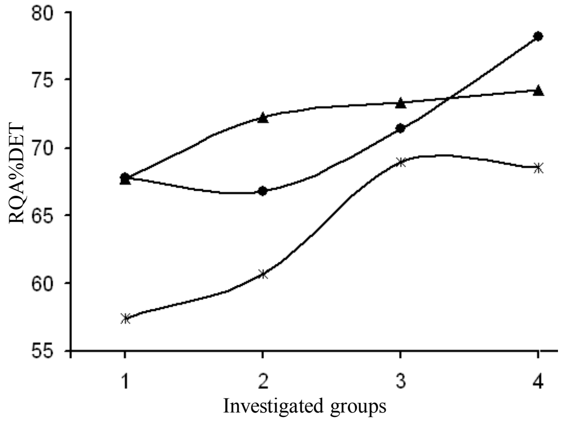

Fig. 1. Calculated RQA%DET values of blood pressure and heart rate variability. Healthy group (1), hypertension - first stage (2), second stage (3), third stage (4). Systolic (circles) and diastolic (asterisks) blood pressure, heart rate variability (triangles).

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 participants of study. As described earlier [6], from these recordings of individual patients combined data sets were compiled as consecutive sequences of appropriate data sets of each patient from the considered groups. Integral time series for each investigated group contained about 1300 data.

Fig. 1 shows that the extent of order (%DET RQA characteristic) in blood pressure variation dynamics increases in pathology. It is worth mentioning that systolic blood pressure variation is always much more regular than diastolic. Heart rate variation also becomes more regular in pathology. It is noticeable from Fig. 1 that the extent of order in the heart rate variation increases mainly at the first stage of hypertension, as compared to the healthy group. At the second and third stages of hypertension we observe much smaller increase in the regularity of heart rate variability. On the other hand, as compared to the healthy group, the main change in dynamics of systolic blood pressure variation took place at the second and third stages of hypertension, while in dynamics of diastolic pressure variation at the first and mainly second stages of pathology.

The observed differences in dynamics of blood pressure and heart rate variability for different stages of hypertension call for additional analysis. Indeed it is necessary to find out whether the changes mentioned above concern general heart dynamics, and whether unavoidable trends in the analyzed data may affect our conclusions about the investigated physiological process.

To this end we prepared the so-called vector SDH data sets calculated from three measured physiological

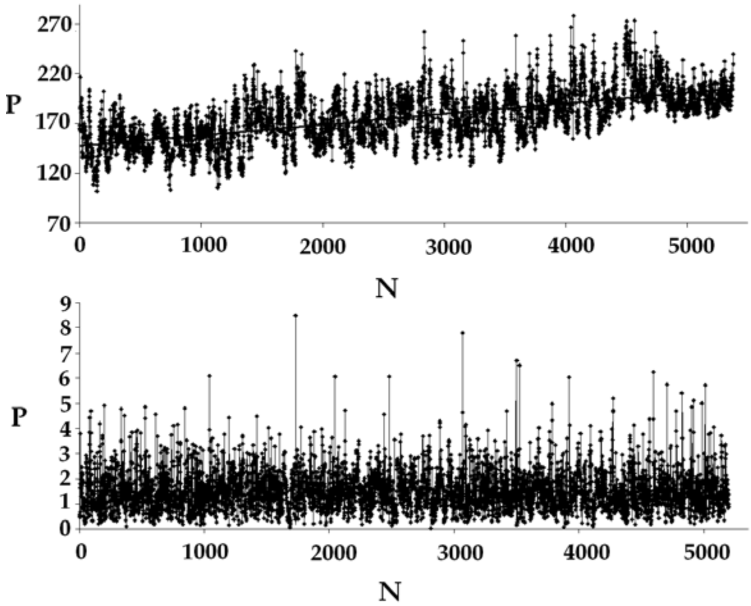

Fig. 2 . Original and normalized SDH data sets compiled from systolic pressure, diastolic pressure and heart rate time series.

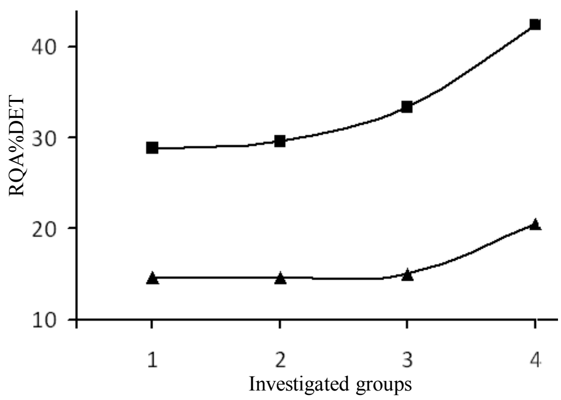

Fig. 3. Calculated RQA%DET values of SDH data sets. Healthy group (1), hypertension - first stage (2), second stage (3), third stage (4).Normalized SDH (squares) and nonnormalized (triangles).

characteristics (systolic, diastolic blood pressure and heart rate time series) (see Fig. 2).

In Fig. 3, calculated %DET RQA values of SDH time series are presented. We see that the extent of regularity in heart dynamics indeed increases essentially in pathology, which is in complete agreement with earlier findings [1, 2, 4, 5]. As far as SDH comprises all three measured physiological data sets, it can be concluded that the observed changes are not related to separate physiological features (such as blood pressure or heart rate) and characterize the general dynamics of heart functioning. What is most important, the results from normalized data shown in Fig.3 b, lead to the same conclusion. This means that increase of order in heart dynamics could not be regarded as caused by local trends which may always be present in physiological time series.

As repeatedly stated in scientific publications [1, 2, 3] increase of order in heart dynamics in pathology (here in hypertension) can be explained as caused by decrease of adaptability. In that case sinus rhythms will be affected lesser by external influences and thus order in heart dynamics, will increase.

Thus we conclude that increase of order in blood pressure and heart rate variation in hypertension reflects general features of changes in heart dynamics and are not caused by unavoidable local trends.

სამედიცინო მეცნიერებანი

ესენციური ჰიპერტენზიის მქონე პაციენტებში არტერიული წნევისა და გულის რიტმის ცვალებადობის დინამიკის რეკურენტული რაოდენობრივი ანალიზი

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ნაშრომში გამოკვლეულია სისტოლური და დიასტოლური წნევების, აგრეთვე გულისცემის ცვალებადობის დინამიკა არტერიული ჰიპერტენზიის მქონე პაციენტებში. რეკურენტული რაოდენობრივი ანალიზის მეთოდის გამოყენებით ნაჩვენებია, რომ პათოლოგიაში სისტოლური და დიასტოლური წნევების და გულისცემის ცვალებადობის დინამიკა უფრო მოწესრიგებული ხდება. გამოვიკვლიეთ როგორც გაზომილი, ასევე მათგან შექმნილ მონაცემთა ხელოვნური ვექტორული მასივები. გამოკვლევის შედეგები გვიჩვენებენ, რომ არტერიული ჰიპერტენზიის მქონე პაციენტებში სისტოლური და დიასტოლური წნევების, აგრეთვე გულისცემის ცვალებადობის დინამიკაში მოწესრიგების ხარისხის ზრდა ფიზიოლოგიური პროცესის ბუნებას ასახავს და არ არის განპირობებული მონაცემთა მასივებში ლოკალური ტრენდების არსებობით.

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