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Assessment of Functional Relationship between the Arterial Pressure and Heart Rate Variability in Patients with Arterial Hypertension

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ABSTRACT. In this report we present results of analysis of functional relationship between arterial pressure and heart rate variations in patients with arterial hypertension. We used the method of mutual information calculation which enables to assess both linear and nonlinear correlations in analyzed data. It was found that functional relationship between systolic and diastolic pressure increases at the first and second stages of arterial hypertension, while at the third stage of disease it decreases to the initial value. On the other hand, changes in the extent of functional relationship between arterial pressure and heart rate variability were not detected at increased severity of arterial hypertension. *© 2010 Bull. Georg. Natl. Acad. Sci.*

Key words: *hypertension, arterial pressure, heart rate, mutual information measure, dynamics.*

For the last decade different aspects of the variation of long-term fractal components in dynamics of myocardial characteristics have been reported along with deterioration in conventional clinical characteristics of patients with arterial hypertension [1-4]. Namely, gradual increase of extent of order in both systolic and diastolic arterial pressure as well as heart rate variability was observed in arterial hypertension, using different modern methods of complex data sets analysis [5]. At the same time the question about the character of functional relationship between these physiological characteristics at changed dynamical conditions remains not completely clear. In the present research we aimed to investigate correlations between systolic and diastolic arterial pressure as well as heart rate in patients with arterial hypertension. For this purpose, in spite of linear correlation we have assessed nonlinear correlations between arterial pressure and heart rate data sets. In particular, the linear coefficient of correlation and nonlinear correlations measure – so-called mutual information (MI) between data sets of systolic and diastolic pressure, systolic pressure and heart rate variability as well as between diastolic pressure and heart rate data sets have been calculated [6]. As described in our previous studies, these data were obtained from 24 hr ambulatory monitoring of arterial systolic and diastolic pressure recordings of 160 patients at 15 min sampling time. The age of patients varied from 30 to 70. Monitoring of the mentioned physiological data sets was carried out on the monitor: MOBILOGRAF (IEM, Germany). All persons participating in this study were not given medicines for 2-3 days preceding the examination. Recording of arterial pressure was carried out in calm environment, in sitting position according to the standard method provided by hypertension guideline. Continuous 24 hr monitoring of arterial 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

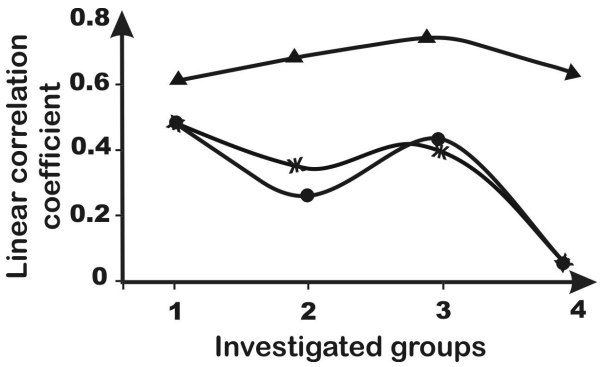

Fig. 1. Coefficient of correlation calculated for paired data sets at different stages of arterial hypertension. ▲– systolic pressure-diastolic pressure, ✳– systolic pressure-heart rate, ●– diastolic pressure-heart rate. Healthy group (1), hypertension - first stage (2), second stage (3), third stage (4).

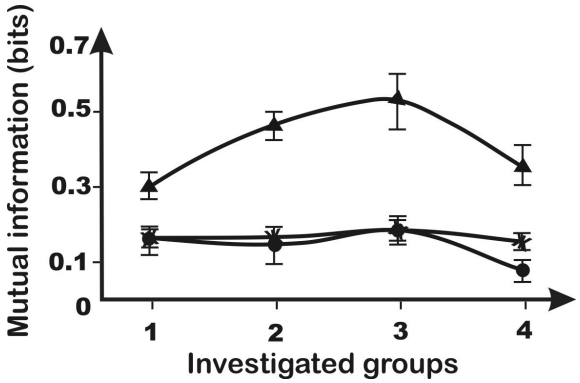

Fig. 2. Mutual Information values calculated for paired data sets at different stages of arterial hypertension. ▲– systolic pressure-diastolic pressure, ✳– systolic pressure-heart rate, ●– diastolic pressure-heart rate. Healthy group (1), hypertension - first stage (2), second stage (3), third stage (4).

participants of the study. As we reported previously, 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 [7]. Pooled time series compiled for each investigated group contained about 1300 data.

As we see from Fig. 1, calculated values of linear correlation between the above-mentioned pairs of data sets reveal some changes in linear functional relationship, depending on the stage of arterial hypertension. It seems that correlation between systolic and diastolic pressure variation is somehow increased at the first and second stages of arterial hypertension. At the same time these changes are not significant. Thus we can not make any conclusion on the features of functional relationship between heart rate and blood pressure characteristics based only on assessment of linear characteristics. This is not surprising in the light of the well established over the last decades nonlinear dynamical structure of different physiological processes [1, 4, 5].

In order to involve nonlinear correlations in our analysis we used mutual information calculation procedure which is widely used for reconstruction of state space of different complex processes including physiological ones [1]. As is presented in Fig. 2, significant increase of functional relationship between systolic and diastolic pressure according to severity of arterial hypertension is well demonstrated. It is important that functional relationship decreases to the initial (i.e. observed in healthy group) value at the third stage of hypertension disease. Moreover, we have not detected changes in the character of functional relationship between pressure (both systolic and diastolic) and heart rate variability (see lower curves in Fig. 2).

სამედიცინო მეცნიერებანი

არტერიულ წნევასა და გულის რიტმის ცვალებადობას შორის ფუნქციონალური კავშირის შეფასება არტერიული ჰიპერტენზიის მქონე პაციენტებში

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ნაშრომში წარმოდგენილია არტერიული ჰიპერტენზიით დაავადებულ პაციენტებში არტერიულ წნევასა და გულის რიტმის ცვლილებებს შორის ფუნქციონალური კავშირის კვლევის შედეგები. ჩვენ გამოვიყენეთ ერთობლივი ინფორმაციის გამოთვლის ალგორითმი. ერთობლივი ინფორმაცია საშუალებას იძლევა შესასწავლ პროცესში გავითვალისწინოთ როგორც წრფივი, ისე არაწრფივი კორელაციები. კერძოდ, სისტოლური და დიასტოლური წნევების ცვლილებებს შორის ფუნქციონალური კავშირი არტერიული ჰიპერტენზიის პირველი და მეორე ხარისხის მქონე პაციენტებში დაავადების მიმდინარეობაში მატულობს, ხოლო მესამე ხარისხის მქონე პაციენტებში ნორმის მნიშვნელობას უბრუნდება. მეორეს მხრივ, არტერიული ჰიპერტენზიის მქონე პაციენტებში არტერიულ წნევასა და გულის რიტმის ცვალებადობას შორის ფუნქციონალური კავშირი არ გამოვლინდა.

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