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FEATURES OF HEART RATE VARIABILITY IN PATIENTS WITH HYPERTENSION WITH VARIOUS TYPES OF LEFT VENTRICULAR MYOCARDIAL REMODELING

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ABSTRACT

The article is devoted to the definition of cardiac arrhythmias and the establishment of the relationship of the identified arrhythmias with changes in the geometric model of the heart in patients with arterial hypertension (AH).

Material and methods of research. The study included 75 patients with AH. All the examined patients underwent daily ECG monitoring. The structural and functional parameters of LV were evaluated using echocardiography (EchoCG). As a result of the conducted studies, changes in the geometric model of the heart were revealed in the overwhelming number of examined patients with hypertension. However, there were certain features of heart remodeling (HR) in each group of patients. Patients with concentric hypertrophy (CH) of LV dominated - 25 patients (33.3%). Eccentric hypertrophy (EH) of LV was detected in 20 patients (20%), concentric remodeling (CR) of LV-in 14 patients (18.7%). Normal heart geometry was observed in 21 patients (28%). The analysis of daily ECG monitoring revealed the following types of arrhythmias: supraventricular extraa systole (SVE)-35%, ventricular extra systole (VE)-13%, SVE=VE-45%, without rhythm disturbances-7%. When studying the heart rate variability indicators depending on the types of left ventricular remodeling, the heart rate variability indicators are the lowest in the group of patients with concentric hypertrophy and the proportion of very low frequency waves (VLF) was the highest.

Key words: arterial hypertension, left ventricular remodeling, heart rate variability, circadian index, cardiac arrhythmias.

INTRODUCTION

Arterial hypertension (AH) is one of the most significant medical and social problems in most developed countries of the world. This is due to both the wide spread of hypertension – the most important risk factor for major cardiovascular and cerebrovascular diseases: myocardial infarction and acute cerebrovascular accident, which determine high mortality and disability of the population, and the lack of sufficiently clear views about the etiology and pathogenesis of hypertension [2,5].

The most important risk factors for the occurrence and development of AH are disorders of the functional condition of the central and autonomic nervous system (ANS) [6].

In recent years, it has been shown that heart rate variability (HRV) is an informative method for assessing the overall activity of regulatory mechanisms, neurohumoral regulation of the heart, the relationship between the sympatic and parasimpathic parts of the ANS and allows us to obtain both integral indicators reflecting the functional condition of the cardiovascular system and to identify systemic relationships, including cardio-cerebral and cardiovascular ones [1,2].

It is known that the influence of hemodynamic and non-hemodynamic factors leads to the development of cardiac remodeling in hypertension [5].

The most common classification of left ventricular remodeling types in hypertension is the A. Ganau (1992) classification [4], which is based on the determination of the left ventricular myocardial mass index (LVMI) and the relative wall thickness (RWT) of this ventricle. Four different types of geometric adaptation of the left ventricle to hypertension are distinguished depending on the level of LVMI and RWT:

1) concentric hypertrophy of the left ventricle (increased LVMI and RWT);
2) eccentric hypertrophy (increase in LVMI with normal RWT);
3) concentric remodeling (increase in RWT with normal LVMI);
4) normal geometry of the left ventricle.

The aim of our study was to study the features of heart rate variability in patients with hypertension, depending on the geometric parameters of the left ventricular myocardium and the features of cardiac arrhythmias.

Material and methods of research. The study included 75 patients aged 45 to 75 years (average age 61.1±8.9 years), of these 44 men (58.7%) and 31 (41.3%) women. The prescription of AH was 8.5±1.1 years. Stage 1 hypertension was observed in 21 (28%) patients, stage 2 was in 38 (50.7%), and stage 3 was in 16 (21.3%) subjects. A high risk of cardiovascular complications was observed in 22 (29.3%), a very high risk in 53 (70.7%) patients. CAD, stable angina, FC III was observed in 38 (50.6%) of the examined patients, and the duration of coronary artery disease was 5.6± 0.9 years. Dyscirculatory encephalopathy was observed in 33 (44%), obesity in 32 (42.7%) patients.

Daily ECG monitoring was carried out using the computer system “Poly-Spectrum-SM-154”. According to the DMECG data, the total number of ventricular ectopic contractions (VEC) and their quantitative distribution in the form of single ventricular extrasystoles (VES), paired VES, ventricular allorhythmias, group VES and unstable paroxysms of ventricular tachycardia (VT) were studied, as well as the determination of the class of VES by the method. The average, minimum and maximum values of heart rate (HR), circadian index (CI) HR=HR aver. during the day/HR aver. at night were revealed.

Statistical indicators of time analysis were evaluated: SDNN, ms - standard deviation of the average value of RR intervals during the day; SDANN, ms is the average value of standard deviations of all five-minute RR intervals during the day; pNN50, % is the percentage of consecutive RR intervals that differ by more than 50 ms; rMSSD, ms is the square root of the average sum of squares of the difference between adjacent normal RR intervals. During spectral analysis, the heart rate wave variability was determined with the calculation of the spectral power density by frequency ranges and indices: VLF - very low frequencies - 0.015-0.04 Hz; LF - low frequencies - 0.04-0.15 Hz; HF - high frequencies - 0.15-0.4 Hz; LF/HF - sympatho-vagal index; TP–(Total power) – the total power of the spectrum oscillations. Overall HRV was assessed by SDNN and TP, sympathetic activity – by SDANN, LF, LF/HF, parasympathetic - by pNN50, rMSSD, HF, humoral regulation - by VLF.

The structural and functional parameters of LV were evaluated using echocardiography (EchoCG). Echocardiography was performed on a Toshiba SSH-YO (60)A (Japan) device by the transthoracic method in M- and B-modes in accordance with the recommendations of the American Association of Echocardiography.

The left ventricular myocardial mass index (LVMI) was calculated-the ratio of the mass of the left ventricular myocardium to the size of the patient's body surface area, g/m^2. The relative thickness of the myocardial walls (RWT) was calculated, values of 0.45 or more were taken as an increase in RWT. Based on this criterion, the distribution into concentric and eccentric types of LV geometry was carried out according to the recommendation of A. Ganau (1992) [4]. The geometric model of LV was evaluated by indicators of LV RWT and LVMI. With LV IMM<the indicators of the control group with LV RWT<0.45 were evaluated as normal myocardial mass. With LV IMM>control parameters and LV

RWT<0.45 were considered as eccentric left ventricular hypertrophy (LV EH). With LV IMM>control group data and LV RWT>0.45 - as concentric hypertrophy of the left ventricle (LV CH). With LV IMM<control values and LV RWT>0.45, it was evaluated as concentric remodeling of the left ventricule (LV CR) [17]. LV myocardial hypertrophy was diagnosed with LV IMM values greater than or equal to 125 g/m^2 for men and 110 g/m^2 for women.

Results and discussion. As a result of the conducted studies, changes in the geometric model of the heart were revealed in the overwhelming number of examined patients with hypertension. However, there were certain features of HR in each group of patients. LV CH dominated in 25 patients (33.3%). LV EH was detected in 20 patients (20%), LV CR-in 14 patients (18.7%). Normal heart geometry was observed in 21 patients (28%) (Table 1).

Table 1.

Indicators of the geometric model of the heart in patients with AH

Indicator	Normal geometry n=21 (28%)	Concentric remodeling n=14 (18,7%)	Eccentric hypertrophy n=15 (20%)	Concentric hypertrophy n=25 (33,3%)
EDD, sm	4,84±0,26	4,48±0,28***	5,00±0,22	4,88±0,255,
ESD, sm	3,14±0,23	2,96±0,26*	3,05±0,20	3,10±0,21
IVST, sm	0,9±0,08	1,1±0,08***	1,07±0,23**	1,31±0,05***
LVPWT, sm	0,97±0,07	1,16±0,06***	1,12±0,17**	1,30±0,06***
LA, sm	3,11±0,23	3,38±0,16***	3,27±0,27	3,65±0,22***
RWT	0,39±0,04	0,51±0,03***	0,44±0,08**	0,54±0,03***
LVMM, g	183,9±22,35	213,0±31,71**	246,24±69,1**	302,7±32,3***
iMMLV, g/sm^2	94,4±11,48	109,4±16,3**	126,42±35,5**	155,4±16,6***
EDV, ml	111,43±8,96	93,93±4,01***	120,69±5,94***	112,2±9,14
ESV, ml	39,8±7,5	35,71±5,14	41,4±6,0	536,8±7,05
SV ml	71,7±8,11	58,21±6,39***	79,27±7,48**	75,4±8,41
EF %	64,4±5,75	61,92±5,61	65,67±4,93	67,23±5,34

As can be seen from the table, a significant difference in structural and geometric indicators by types of remodeling was noted in terms of RWT and IMM LV.In the study of HRV in patients with hypertension, the indicators of total heart rate variability (TP,SDNN) were significantly reduced (p<0.05), which is the result of a decrease in the influence of the parasympathetic and sympathetic nervous systems. Moreover, the influence of the sympathetic nervous system prevailed over the parasympathetic (p <0.05). It was also revealed that VLF increased the proportion of very low frequency by 2 times, which indicates a high role of RAAS in the development of the disease.

Table 2 shows HRV indicators in patients with hypertension depending on the type of heart remodeling.

Table 2

Features of temporal and spectral analysis of heart rate variability in patients with hypertension and various types of left ventricular remodeling.

Indicator	Normal geometry n=21 (28%)	Concentric remodeling n=14 (18,7%)	Eccentric hypertrophy n=15 (20%)	Concentric hypertrophy n=25 (33,3%)
SDNN,ms	105,6±24,9	81,3±19,67	78,1±17,5	58,1±13,4*
SDANN, ms	92,2±21,8	66,8±12,8	77.4±11,6	44,8±12,2*
TP, мс^2	1602,8±681,3	1358,7±563,6	1110,7±652,3	1002,5±478,9
LF, ms^2	448,3±99,2	242,7±59,1	203,5±102,5	163,9±72,5**
HF, ms^2	146,8±53,5	117,3±22,8	72,8±24,4	56,9±19,9
VLF, ms^2	688,52±171,3	795,2±245,9	855,8±215,2	1174,6±316,7
LF/HF	3,30±1,03	2,45±0,62	3,05±2,14	2,95±0,57
CI	1,20±0,06	1,09±0,32	1,18±0,16	1,11±0,15

Note: *-p<0.05; **p<0.01;

As can be seen from Table 2, in terms of SDNN and SDNN, the highest indicator was observed in patients with normal geometry (105.6 ±24.9 and 92.2±21.8, respectively). A significant difference in SDNN (58.1±13.4) and SDANN (44.8±12.2) was observed in the group of patients with concentric type hypertrophy (p<0.05). In the group of patients with concentric remodeling and eccentric hypertrophy, there was also a decrease in overall heart rate variability, but these results were not reliable (p>0.05).

When analyzing the TP indicators (the total power of the HRV spectrum in ms^2), it was revealed that in the group of patients with normal geometry it was 1602.8±681.3 ms^2, in patients with concentric remodeling type 1358.7±563.6 ms^2, in the group of patients with eccentric hypertrophy 1110.7±652.3 ms^2, and finally the lowest indicator was in the group with concentric hypertrophy - 1002.5±478.9 ms^2. This difference is not significant, although there is a tendency to decrease in TP indicators in the group of patients with concentric hypertrophy, which indicates a violation of autonomic regulation and a decrease in the ability to adapt to stress factors in all the patients.

Indicator LF (power of the spectrum of the low-frequency component of variability) in patients with normal geometry was 448.3±99.2ms^2 with concentric remodeling - 242.7±59.1 ms^2 with eccentric hypertrophy - 203.5±102.5ms^2. A significant difference in the LF index was observed in the group of patients with concentric hypertrophy and was equal to 163.9±72.5 ($p<0.01$). This indicates a moderate level of mobilizing potential in patients with normal geometry. A low level of mobilizing potential was noted in all other groups.

A significant difference in different groups of patients was also observed in terms of HF (the power of the spectrum of the high-frequency component of variability): HF in patients with eccentric hypertrophy was almost two times lower (72.8±24.4 ms^2) than in patients with normal geometry (146.8 ± 53.5 ms^2), and in patients with concentric hypertrophy - almost three times (56.9 ±19.9 ms^2). This indicates a low influence of the parasympathetic nervous system and a low level of recovery potential.

In terms of VLF (the power of the spectrum of a very low frequency component of variability), the data in the groups were different. The highest rates were observed in the group of patients with eccentric (855.8±215.2) and concentric hypertrophy (1174.6±316.7).

Data on the ratio of the sympathetic and parasympathetic nervous system LF/HF (The ratio of the average values of the low-frequency and high-frequency component of HRV) there were no significant differences in the groups. The highest index was observed in the group of patients with normal geometry (3.30±1.03), and the lowest - in the group with concentric remodeling (2.45± 0.62). In all examined patients with AH, there was a decrease in CI (circadian index), which indicates a violation of the vegetative link of HRV regulation. As well as in the LF/HF indicators, the highest indicator was observed in the group of patients with normal geometry and the lowest indicator in the group with concentric remodeling (1.20±0.06 and 1.09±0.32, respectively).

Thus, the analysis of the results of our study showed that when studying the heart rate variability indicators depending on the types of remodeling of the left ventricle in the group of patients with concentric hypertrophy, the heart rate variability indicators are the lowest. In the group of patients with normal geometry, there were minor changes in heart rate variability. Considering the revealed features of HR in the examined patients, it was found that ventricular arrhythmias were significantly more often recorded with hypertrophic types of HR (CH and EH), while supraventricular arrhythmias with non–hypertrophic types (CR). Changes in the geometric model of the LV and an increase in LV MM that occur with hypertension contribute to a violation of the diastolic function of the heart, and therefore, the atrial systole is disrupted. An increase in pressure in the cavity of the left atrium can provoke, on the one hand, an increase in its size and, on the other, the occurrence of supraventricular rhythm disturbances.

The analysis of daily ECG monitoring revealed the following types of arrhythmias: in the examined patients, ventricular arrhythmias were much more common and were represented by various variants: SVE -35%, VE - 13%, SVE = VE -45%, without rhythm disturbances -7%/

As can be seen from the presented data, during daily monitoring of ECG, 47.7% of patients had I–graded VE, 36.4% had II-graded, 6.8% had III-graded, and 9.1% had IVa-graded VE. In the examined patients, IVb and V gradations of VE were not registered.

It has been established that the main direct cause of sudden death is ventricular arrhythmias, which account for 80% of cases. Ventricular arrhythmias occur significantly more often in patients with LV hypertrophy than without it [3,6,7,].

This is confirmed by the results of our study: high grades of VE were observed mainly in patients with hypertrophic types of LV remodeling - in groups 3 and 4.

Thus, the analysis of the results of our study showed that when studying the heart rate variability indicators depending on the types of remodeling of the left ventricle, the heart rate variability indicators are the lowest in the group of patients with concentric hypertrophy. There were minor changes in heart rate variability in the group of patients with normal geometry.

An inverse correlation of weak strength (g=-0.14) was found between the indicators of TP and SVE+VE, which indicates that the lower indicator of the overall heart rate variability leads to the higher frequency of SVE+VE. A direct correlation of weak strength (g=0.28) was found between the VLF and the SVE+VE indicators, which suggests that the more SVE+VE are noted at the higher indicator of very low frequency waves. A direct correlation of average strength (g=0.31) was also found, which confirms that the number of supraventricular and ventricular extrasystoles increases with increasing LF/HF. There is an inverse correlation of average strength between MMLV and TP, i.e. the greater the mass of the left ventricular myocardium, the lower the overall heart rate variability (r=-0.55). A direct correlation of average strength (r=0.32) was revealed between the indices of MMLV and VLF, i.e. the higher the indices of very low-frequency waves, the greater the mass of the left ventricular myocardium.

Conclusion

1. A direct correlation of average strength between MMLV and LF\HF was revealed (r=0.41), the greater the ratio between the sympathetic and

parasympathetic nervous system, the greater the mass of the left ventricular myocardium ($p<0.05$).

2. In the examined patients, against the background of a general decrease in heart rate variability, there was a significant imbalance in the influence of the parasympathetic and sympathetic nervous systems with the predominance of the latter, as well as a 2-fold increase in the proportion of very low VLF frequency, which indicates the predominant regulatory role of RAAS in the development of the disease. The indicators of the overall variability of TP are in inverse correlation with SVE+ VE and MMLV, and with VLF and LF\HF in direct correlation. This indicates the leading role of the formation of LV hypertrophy and changes in centrogenic effects on the heart rhythm in reducing HRV in patients with hypertension.

Thus, the results obtained allow us to expand the existing understanding of heart rate variability in patients with arterial hypertension with different types of left ventricular geometry. The revealed interrelations of heart rate variability indicators with clinical data, indicators of the structural and functional condition of the left ventricular myocardium justify the need for doctors to conduct a comprehensive examination of a patient with arterial hypertension to choose adequate therapy. It is proved that considering the indicators of a comprehensive analysis of heart rate variability can serve as an additional criterion when selecting antihypertensive therapy for patients with arterial hypertension and evaluating its effectiveness.

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