ВАРИАБЕЛЬНОСТЬ РИТМА СЕРДЦА БОЛЬНЫХ ИНФАРКТОМ МИОКАРДА С ЗУБЦОМ Q ПРИ СТАНДАРТНОЙ ТЕРАПИИ И НУТРИТИВНОЙ ПОДДЕРЖКОЙ ОРГАНИЧЕСКИМ СЕЛЕНОМ

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Цель. Оценка взаимосвязей уровня селена, показателей вариабельности ритма сердца (ВРС), биохимических и реологических характеристик крови у пациентов с Q-инфарктом миокарда (Q-ИМ) на фоне стандартной медикаментозной терапии и диетической коррекции органическим селеном на разных стадиях заболевания.

Материалы и методы. Проведено открытое сравнительное клиническое исследование с участием 90 больных (средний возраст 58,3±1,4, из них 71 мужчин и 19 женщин) с диагнозом острый коронарный синдром с подъемом сегмента с исходом в Q-ИМ. Пациенты разделены на 2 сопоставимые группы: контрольная получала стандартную терапию, основная – в дополнение к ней диетический продукт, обогащенный органическим селеном. На острой, подстрой и стадии рубцевания Q-ИМ проводилась регистрация и математический анализ динамических рядов кардиоинтервалов с помощью комплекса «Варикард 2,51», оценивали ряд биохимических показателей крови, селеновый статус, реологические свойства крови.

Результаты. На этапе стационарного лечения в основной группе зарегистрировано снижение частоты сердечных сокращений (с 68,8±1,7 до 64,0±1,3 уд./мин; p<0,05). Исходно уровень SDNN в обеих группах был в пределах критических значений (25,0±1,3 мс), а показатель стресс-индекса (SI) в несколько раз превышал норму (1356,2±390,6 усл. ед.) и к концу наблюдения ни в одной группе оба показателя не достигали нормальных значений. Коэффициент вариации (CV) в обеих группах определялся ниже нормальных значений на протяжении всего лечения, хотя в динамике имелась некоторая тенденция к росту. Мощность спектра кривой, огибающей динамический ряд кардиоинтервалов (HF), в контрольной группе увеличилась почти в 2 раза (p<0,05). Корреляционный анализ взаимосвязи биохимических показателей крови, коагулограммы и уровня селена сыворотки крови с различными параметрами математического анализа ритма сердца выявил различные по уровню и направленности взаимосвязи.

Заключение. Использование диетического продукта, обогащенного селеном, положительно влияющего на трофотропные функции организма, в комплексе со стандартной терапией приводит к снижению напряжения адаптационных механизмов и увеличивает адаптационной потенциал организма, что способствует улучшению прогноза и уменьшению рисков.

Ключевые слова: *острый коронарный синдром; Q-инфаркт миокарда; селен; диетический продукт; вариабельность сердечного ритма.*

VARIABILITY OF HEART RHYTHM IN PATIENTS WITH MYOCARDIAL INFARCTION WITH Q WAVE WITH STANDARD THERAPY AND NUTRITIVE SUPPORT WITH ORGANIC SELENIUM

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Aim. Assessment if the interrelation of the levels of selenium, parameters of heart rate variability (HRV), biochemical and rheological characteristics of blood in patients with Q-myocardial infarction (Q-MI) taking standard medicinal therapy and dietary correction with organic selenium in different stages of the disease.

Materials and Methods. An open comparative clinical study was conducted with involvement of 90 patients (the average age 58.3±1.4, of them 71 men and 19 women) diagnosed with acute coronary syndrome with elevation of Q-segment with outcome into Q-MI. The patients were divided to two comparable groups: control group that received standard therapy, and the main group that additionally received dietary product enriched with organic selenium. In acute, subacute and cicatrization stages, the dynamic series of RR intervals were recorded and mathematically analyzed on Varicard 2.51 complex, some biochemical parameters of blood, selenium status, rheological properties of blood were assessed.

Results. In the stage of hospital treatment, reduction of the heart rate (from 68.8±1.7 to 64.0±1.3 beat/min; p<0.05) was recorded in the main group. The initial level of SDNN in both groups was within the critical range (25.0±1.3 msec), and stress index (SI) several time exceeded the norm (1356.2±390.6 conv.un.); by the end of the observation both parameters did not achieve normal values in both groups. The coefficient of variation (CV) stayed below normal values throughout the whole treatment period, although in the dynamics it showed some tendency to growth. The spectrum power of the curve enveloping the dynamic series of RR intervals (HF) almost twice increased in the control group (p<0.05). Correlation analysis of the interrelation of biochemical parameters of blood, coagulogram and selenium of blood serum with different parameters of mathematical analysis of the heart rhythm revealed interrelations of different levels and direction.

Conclusion. Use of dietary product rich in selenium having a positive effect on the trophotropic functions of an organism, in complex with standard therapy, reduces tension of adaptation mechanisms and enhances adaptation potential of an organism that improves the prognosis and reduces risks.

Keywords: *acute coronary syndrome; Q-myocardial infarction; selenium; dietary product; heart rate variability.*

Within the recent years, the morbidity structure of the adult population underwent cardinal changes. According to the report of the World Health Organization, annual death rate from the cardiovascular diseases (CVD) is 17.7 million of cases worldwide, of them 7.4 million result from ischemic heart disease (IHD) [1]. In patients with past myocardial infarction (MI) the risk for repeated events and morbidity persist and even increases. The risk of cardiovascular complications (CVC) is maximal within the first 3-6 months, with a

steady linear growth in the subsequent years [2,3]. The secondary and tertiary risk factors increase the risk for repeated CVC.

The search for predictors of fatal events in patients with acute coronary syndrome (ACS) remains an actual problem. The importance of the autonomic regulation of cardiac activity for predicting the immediate and long-term outcomes of MI is being actively studied. Over the past two decades, significant relationships have been found between the condition of the autonomic nervous system (ANS) and mortality from CVC, including sudden death. Pathogenetic mechanisms of MI, the most life-threatening clinical variant of IHD, cannot be imagined without the participation of the autonomic regulation of the cardiovascular system [4].

Organic alterations of the myocardium, in particular, Q-MI, induce considerable changes in the regulatory processes of the ANS. Reduction of the heart rate variability (HRV) is a meaningful predictor of mortality and of fatal arrhythmias in patients with past Q-MI [5]. A study of HRV will improve our understanding of physiological phenomena, effects of medical drugs and mechanisms of developments of the disease [6]. The theory of adaptation of H. Selye is one of the fundamental directions of the modern biology and physiology that substantiates the leading role of depletion of regulatory systems in acute stressful influences. This approach is based on understanding of HRV as an integral result of the influence of many regulatory mechanisms (nervous, humoral and local) on the circulatory system.

Extremely important and promising is investigation of poorly studied dietary factors and microelements in the prevention and treatment of ACS and Q-IM. Along with high-tech approaches, attention has recently been paid to the nutritional support of patients, including the study of the metabolic status of patients with coronary heart disease [7,8]. The use of obligate antioxidants in the diet for primary and secondary prevention of CVD, including emergency conditions, is being actively discussed in the scientific literature [9]. Of key importance as the powerful antioxidant is selenium, which can modulate the risk of development of the disease and to influence outcomes by acting on the epigenome [10]. Meanwhile, it was found that selenium increases the adaptive reserves of the human body [11], produces an inhibitory effect on inflammatory processes, which are essential for development of atherosclerosis and ACS [12]. It should be noted that there is little data concerning the possible effect of certain elements, in particular, of selenium, as a component of the antioxidant system, on the functional state of the body of Q-MI patients in terms of autonomic balance and neurohumoral regulation, as well as in the relationship of biochemical metabolic parameters and rheological characteristics of blood.

Thus, the *aim* of the given clinical study was evaluation of interrelations between the level of selenium, heart rate variability, biochemical, rheological characteristics of blood of patients with Q-myocardial infarction using standard medicinal therapy and dietary correction with selenium, in different stages of the disease.

Materials and Methods

In the period from September 2011 by March 2015, open comparative clinical study was conducted with participation of 90 patients with ACS with elevation of ST segment (ACS↑ST) with outcome to Q-MI. The study was conducted with observance of the Good Clinical Practice rules.

Inclusion and exclusion criteria, laboratory and instrumental methods of examination of patients, as well as methods of the conducted therapy according to the standard of management of patients with ACS↑ST were in detail described earlier [13]. One of the main criteria of inclusion was the presence of sinus rhythm. In addition to the standard examination methods, analysis of HRV on the Varicard 2.51 device was used.

In analysis of HRV, of importance is physiological and clinical interpretation of the

results. Nevertheless, there is no uniform opinion of interpretation of the results of HRV analysis. In our work, the following parameters of HRV evaluation were used:

- pulse rate (HR),
- standard deviation of all NN intervals (SDNN),
- coefficient of variation of all NN intervals (CV)
- stress index – index of tension of regulatory systems (SI),
- average value of spectral power of high-frequency component of HRV in ms-2 (HFav),
- average value of spectral power of low-frequency component of HRV in ms-2 (LFav),
- average value of spectral power of very low-frequency component of HRV in ms-2 (LFav),

Patients were divided into 2 groups by random sampling: the main group (n=45,80%

of men, average age 58.3±1.3 years) received standard therapy according to clinical recommendations and nutritional support for 30 days with a dietary therapeutic product – jam (Russian Federation Research Institute of Fishery and Oceanology, RFRIFO), containing kelp (laminaria), dried apricots, selenium-containing fermentolizate of food yeast. The comparison group (n=45, 77.8% of men, average age 58.2±1.5 years) was prescribed only standard therapy. The groups were comparable in gender and age, risk factors, concomitant pathology, types and severity of myocardial infarction, and duration of hospitalization. At the same time, among those who received standard therapy, high-tech treatment methods, thrombolytic therapy (TLT), and percutaneous coronary interventions (PCI) were used more often. Clinical and demographic characteristics of the patients are presented in Table 1.

Table 1

Characteristics of Studied Patients

Studied Parameter	Main Group (n=45)	Comparison Group (n=45)	p
Age, years, M±m	58.3±1.3	58.2±1.5	0.90
Men, abs. (%)	36 (80)	35 (77.8)	0.73
Body mass index, kg/m^2, M±m	28.1±0.6	29.9±0.6	0.39
Anterior localization of MI, abs. (%)	20 (44.4)	25 (55.6)	0.09
Postinfarction cardiosclerosis, abs. (%)	8 (17.8)	10 (22.2)	0.48
Tobacco smoking, abs. (%)	21 (46.7)	25 (55.6)	0.50
Intake of alcohol more than once a week, abs. (%)	10 (22.2)	17 (37.8)	0.15
Positive heredity for IHD, abs. (%)	8 (17.8)	12 (26.7)	0.35
Type 2 diabetes mellitus and disorders in tolerance to glucose, abs. (%)	5 (11.1)	5 (11.1)	0.10
Acute cardiovascular event in history, abs. (%)	2 (4.44)	4 (8.88)	0.41
Chronic obstructive pulmonary disease, abs. (%)	1 (2.22)	2 (4.44)	0.56
Pathology of gastrointestinal tract, abs. (%)	12 (26.7)	11 (24.4)	0.82
Chronic heart failure: I FC, abs. (%)	13 (28.9)	0 (0)	0.51
II, abs. (%)	29 (64.4)	32 (71.1)	0.65
III, abs. (%)	0 (0)	0 (0)	0.10
IV, abs. (%)	0 (0)	0 (0)	0.10
Arterial hypertension, abs. (%)	44 (97.8)	43 (95.6)	0.89
TLT, abs. (%)	27 (60)	31 (68.9)	0.75
PCI, abs. (%)	7 (15.6)	13 (28.9)	0.03
Time before hospitalization, hours, M±m	10.1±2.3	7.2±1.5	0.55
Average bed-day, days, M±m	15.0±0.2	15.6±0.4	0.35

Note: FC – functional class

A study of HRV was conducted in all the patients within 5 min. in three visits: the first – on the 2nd-3rd day of MI (after transfer from the resuscitation and intensive therapy department to the common ward), second – on the 10th-14th day (before discharge from hospital), the third – in a month after the onset of MI. Thus, examination of HRV was conducted in three phases of MI: acute, subacute and scarring.

Selenium content in blood serum was determined in RFRIFO by the microfluorimetric method on the apparatus using the internationally certified human serum standard «Seronorm» (Denmark). Venous blood biochemical parameters were determined on an autoanalyzer: glucose, total protein, total bilirubin and its fractions, creatinine, urea, aspartate- (AsAT) and alanine aminotransferase (AlAT), creatine phosphokinase (CPK) and its MB fraction (CPK-MB), potassium, sodium, total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLP cholesterol), low density lipoprotein cholesterol (LDLP cholesterol), fibrinogen, prothrombin index (PI), international normalized ratio (INR), activated partial thromboplastin time (APTT).

Statistical processing of the results was carried out using the application software package Statistica 10.0 (Stat Soft Inc., USA). All parameters of the studied data sets had a normal distribution. Mann-Whitney U-test, Wilcoxon test, Student coefficient, Spearman correlation relationships were used. The statistical significance of differences in the qualitative variables was evaluated using Pearson χ2 test. Differences were considered statistically significant at $p < 0.05$.

Results and Discussion

In our previous studies [13], a critically low selenium deficiency in blood serum was found in the acute period of Q-MI, followed by a regular increase in the subacute and scarring periods under the influence of nutritional support with selenium in a daily dose of 20 mg. High bioavailability of selenium as a part of the tested product was also shown, which made it possible to recommend selenium to patients with Q-MI with low selenium status and to achieve its increase in blood serum to optimal and suboptimal values in 4 weeks [13].

Along with standard methods of examination of patients with ACS, of no less importance were the results of analysis of HRV of the studied patients of comparable groups (Table 2).

Table 2

Dynamics of Parameters of Statistical and Spectral Analysis in Compared Groups

Parameter	Group	Initial Visit	Visit in 2 weeks	Visit in Month
HR, beat/min.	main	68.8±1.7	**64.0±1.3***	66.0±2.0
	control	71.2±2.0	67.8±1.5	65.4±2.4
SDNN, ms	main	26.6±1.9	27.0±2.0	30.5±2.7
	control	24.9±1.9	26.2±2.0	**31.5±3.5***
HF, ms^2	main	134.2±40.1	146.3±33.6	250.6±108.4
	control	110.2±27.0	90.0±16.1	**292.7±94.8***
LF, ms^2	main	161.8±28.3	124.2±20.0	193.6±60.7
	control	141.0±28.4	170.9±45.3	231.3±66.0
VLF, ms^2	main	188.6±37.7	147.0±41.6	173.5±33.2
	control	126.8±20.2	183.7±42.7	195.4±52.8
CV, %	main	2.9±0.2	2.9±0.2	3.2±0.2
	control	2.8±0.2	2.8±0.2	3.2±0.3
SI	main	663.9±93.2	551.8±81.5	447.4±117.1
	control	1356.2±390.6	727.6±121.6	561.4±159.6
IC, conv. un.	main	5.4±0.9	3.4±0.5	3.0±0.5
	control	4.9±0.5	**5.6±1.1****	4.0±0.9

Notes: * – p<0.05, comparison with initial level, ** – p<0.05, Wilcoxon test for two dependent samples

As can be seen from the data of Table 2, most HRV parameters were comparable both at the beginning, and at the end of treatment. In all the studied patients, HR decreased with the standard medicinal treatment, in particular, with use of beta-adrenoblockers. However, at the stage of hospital treatment, dietary treatment of the main group with selenium reliably reduced parameters by the end of the second week (from 68.8±1.7 beat/min. to 64.0±1.3 beat/min.; p<0.05); in the control group no such differences were noted throughout the study.

One of important parameters of cardio-intervalometry – SDNN – has normal values within 40-80 msec. Increase or decrease in SDNN may be associated with both autonomic and central regulation. Reduction of SDNN value indicates enhancement of the activity of sympathetic division of the ANS, that is, increase in the influence of respiration on the heart rhythm. With SDNN below 35 ms the risk increases 10-fold [14]. In all the studied patients the initial level of SDNN was about 25±1.3 ms (critical value!) and by the end of study it did not reach the norm in a single patient, which confirms the severity of MI.

In MI, as in other types of stressful effects on the body, energy and metabolic resources are mobilized through the sympathetic division of the ANS. According to our results, the coefficient of variation (CV) in both groups was below normal values (norm is 3-12%) throughout the observation; only a tendency to growth was noted, which may indicate a shift in the autonomic balance towards the predomination of the tone of the sympathetic division of the autonomic nervous system of MI.

It was found that with increase in the parasympathetic functions, the tension simultaneously decreases, that is, the balance shifts towards the parasympathetic division. This circumstance indicates an active recovery process and buildup of adaptation potential, which is of great significance in the social adaptation of a patient. A high level of tension of regulatory systems in the acute period of MI not only signals tension of adaptation mechanisms, but also reduction of adaptation reserves. This condition may be evaluated by SI. In angina, SI reaches 600-700 conv. un., and in preinfarction condition – 900-1100 units [15]. In all the studied patients, SI parameter in the acute period of MI several times exceeded the norm (50-150 conv.un.) and reached 1356.2±390.6 conv.un. Despite the conducted treatment, in the first days and even after a month (stage of scarring) SI parameter did not reach the norm not in a single patient which evidences severity of disorders in this disease.

The parameters of spectral analysis of HRV of both groups of patients showed an obvious increase in the spectral power of the curve that envelopes the dynamic series of cardiointervals in HF range. According to one of hypotheses, the activity of the regulatory levels increases with increase in power of the respective slow-wave components of the curve spectrum that envelopes the dynamic series of cardiointervals [16]. Therefore, the shift of the period of the spectral component towards increase may be interpreted as transition of control to a higher level with involvement of additional components into the process, while predomination of the spectral power of the oscillatory process in the high frequency range indicates reduction of tension and increase in the adaptation resource. In our research, high-frequency fluctuations of the heart rhythm (HF) almost twice increased in the course of study which is a sign of improvement of the patients' condition.

The best studied periodicity of the heart rhythm – low-frequency component (LF) – is associated with the activity of the vasomotor center and characterizes the baroreflex reaction of the arterial pressure to impulses from receptors of the carotid artery. In analysis of the data obtained, a tendency was observed to increase in LF parameters, which, although unreliable, was more expressed in the control

group. At the same time, in the main group this parameter decreased on the second visit. The power of VLF fluctuations of HRV is a sensitive indicator of control of metabolic processes and well reflects energy-deficient conditions. As a rule, these waves are associated with the activity of suprasegmental sections of the brain in regulation of the heart activity. High level of VLF in comparison with the norm may be interpreted as a hyperadaptation condition, while the reduced level of VLF indicates energy-deficient condition. VLF may be used as a reliable marker of the extent of the connection of the autonomic segmental levels of regulation of circulation with suprasegmental levels including pituitary-hypothalamic and cortical levels. In the course of treatment, the main group showed the tendency to reduction of this parameter, while in the control group, on the contrary, it increased.

Heart rhythm is not only an indicator of the function of the sinus node, but also an integral marker of the condition of many systems responsible for homeostasis of an organism, with the main modelling influence of the ANS. The mathematical parameter of the heart rhythm reflects the condition of the regulatory systems of the heart and eventually characterizes adaptation reserve of an organism, according to the traditional concept of W. Cannon about the sympathetic division mainly performing ergotropic functions, associated with use of different energy-consuming mechanisms to enable an organism to respond to the environmental demands, while the parasympathetic division is performing trophotropic, that is, regenerating, functions.

On the whole, the heart rhythm is reflection of the activity of one of elements of the transport mechanisms of the blood supply system which delivers nutrients, oxygen, etc., to all body tissues, without any exclusions, and provides transport of metabolites and CO_2 to excretory organs. In this connection, we also performed a correlation analysis of the interrelation of biochemical parameters of blood, coagulogram, and of the level of selenium, with different parameters of mathematical analysis of the heart rhythm, with the results presented in Figs.1 and 2 in the form of correlation pleiades.

On visit 1, 18 reliable correlation relationships were determined (Figure 1). Some correlations have an evident physiological interpretation. Thus, positive correlations SDNN-APTT (r=0.28); SDNN-PTI (r=0.25) and negative SI-APTT (r=-0.3), SI-PYI (r=-0.25) are noted that reflect the interrelation of parasympathetic/sympathetic regulatory component and decrease/increase of the coagulation potential of the system of hemostasis, respectively. Positive correlation SI-glucose is evident (r=0.25) that reflects the influence of stress-realizing system on the level of glycemia. Some correlations of biochemical parameters with HRV require a more complicated analysis: for example, CPK-MB parameters negatively correlate with SDNN (r=-0.25) which probably reflects the role of trophotropic (parasympathetic) influences of the ANS in reduction of the concentration of markers of the myocardial damage; the level of potassium negatively correlates with the activity of stress-realizing system (negative correlation K-SI, r=-0.23). It is important that selenium probably enhances trophotropic mechanisms positively correlating with the level of potassium (r=0.36) and negatively – with markers of myocardial damage CPK (r=-0.3).

The number of correlations by visit 2 (subacute stage of MI) insignificantly decreased (to 17). On visit 2 (Figure 2) the interrelations restructured but the tendencies remained the same. Positive interrelations of parameters of atherogenesis should be emphasized. Thus, total cholesterol (TC) positively correlates with HR r=0.28), SI (r=0.28) and negatively with SDNN (r=-0.23), LF (r=-0.24), VLF (r=-0.28). LDLP positively correlate with HR (r=0.2). To note, on the first visit there was also a negative correlation of
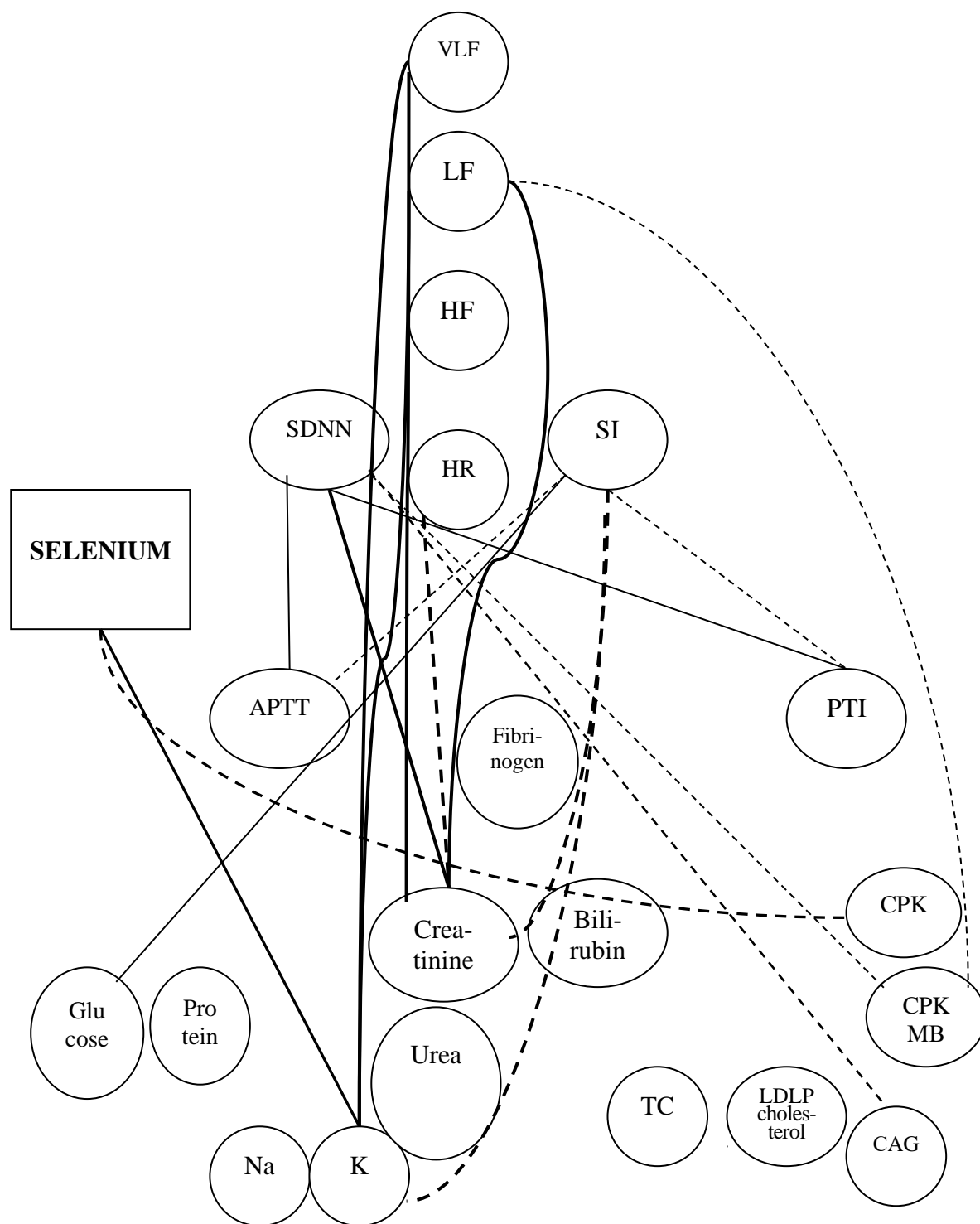
Fig. 1. Correlation pleiade that reflects the character of correlation interrelations between biochemical parameters, level of selenium, rheological properties of blood and mathematical analysis of the heart rhythm on visit 1

Note: Direct correlations are presented in solid lines, negative – in dotted lines. Thickness of lines reflects the force of correlations. Na – sodium of venous blood serum, K – potassium of venous blood serum, CAG – results of coronary angiography
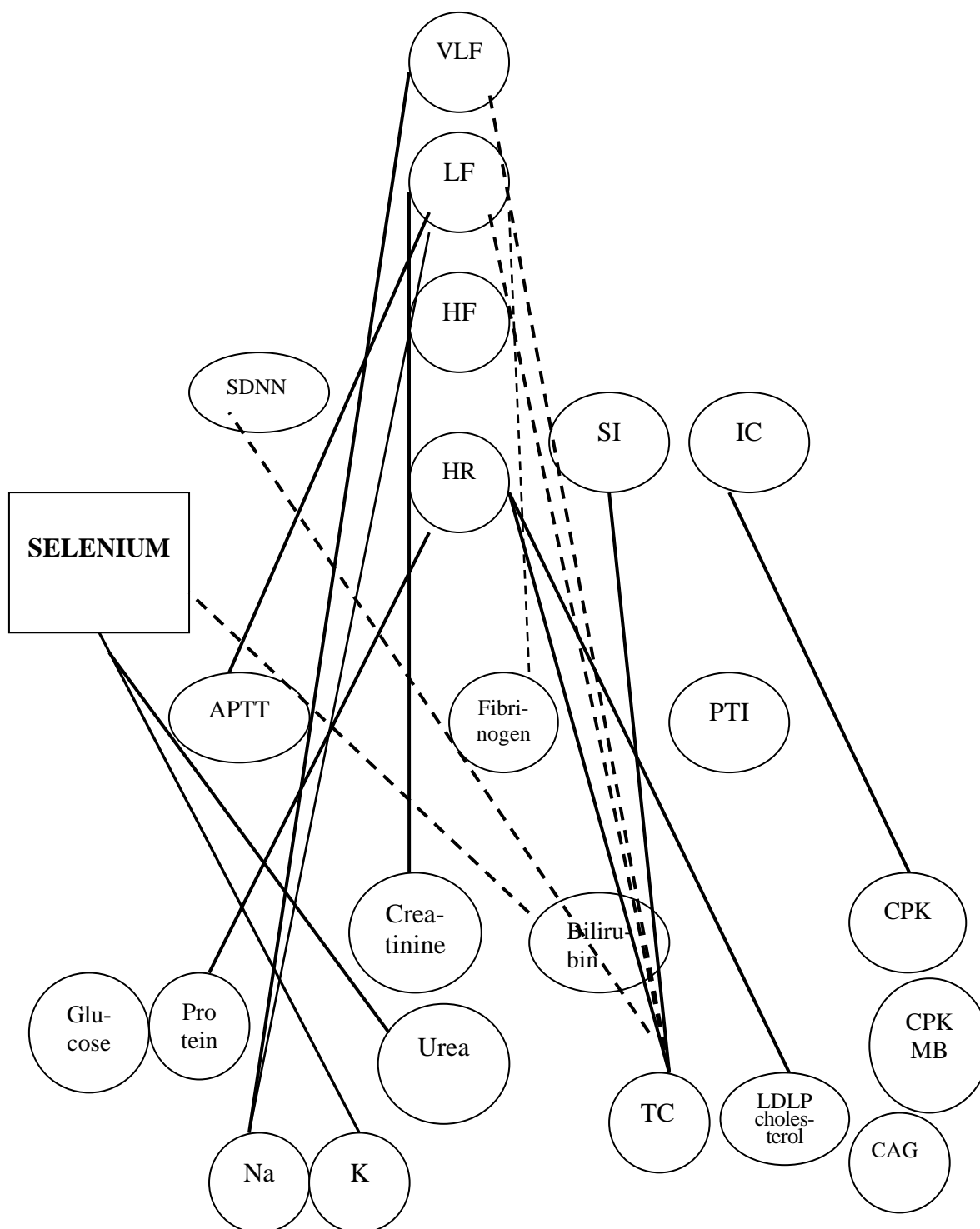
Fig. 2. Correlation pleiade that reflects the character of correlation relationships between biochemical parameters, level of selenium, rheological properties of blood and mathematical analysis of the heart rhythm on visit 2

Note: Direct correlations are presented in solid lines, negative – in dotted lines. Thickness of lines reflects the force of correlations. Na – sodium of venous blood serum, K – potassium of venous blood serum, CAG – results of coronary angiography

atherogenicity coefficient with SDNN (r=-0.3) and selenium (r=-0.16). All this reflects the influence of not only sympathetic/parasympathetic regulatory components on increase/decrease in the proatherogenic fractions of lipoproteins, but also of selenium that positively influences the lipid profile and processes of atherogenesis.

By visit 3 (scarring stage of MI) the number of correlations considerably decreases. Thus, bilirubin negatively correlates with HR (r=-0.36) and selenium (r=-0.2), fibrinogen negatively correlates with SDNN (-0.5), LF (r=-0.47) and positively with SI (r=0.51), and triglycerides with IC (r=-0.4). If to consider the complex of studied parameters as a system, then reduction in the number of correlations reflects increase in the degrees of freedom in it, that is, reduction of the tension inside the system. This may indicate positive influence of selenium in this aspect, since during the whole study, from visit 1 to visit 3, patients continued to take standard medicinal treatment and dietary product enriched with selenium.

The data presented show that the parameters of mathematical analysis of the heart rhythm in a certain way correlate with biochemical parameters. This confirms the important position of systemic physiology about the level of metabolism in tissues as a determining factor of self-regulation of physiological functions, also in case of the development of a particular pathology (in our case, in patients with Q-IM). Our studies revealed the practical absence of significant correlation relationships between the level of selenium and parameters of autonomic regulation of the heart. This shows that the effect of selenium on the activity of the heart is mainly realized through the modulation of metabolic processes in tissues, which is evidenced by the detected correlation relationships between its level in blood and some biochemical parameters (CPK, atherogenic coefficient, potassium, creatinine, bilirubin).

Conclusion

Use of dietary products enriched with selenium, in complex with standard therapy, leads to reduction of tension of regulatory systems and increases adaptation potential of an organism, produces a positive influence on the trophotropic functions of an organism that is reflected in the biochemical parameters of metabolism.

Taking into account evident correlation relationships between parameters of mathematical analysis of the heart rhythm and some biochemical parameters of blood reflecting pathogenetic factors of pathological processes in myocardial infarction, this method can be recommended as an addition to the diagnostic standard for monitoring of condition of patients with this pathology.

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Литература

1. Вишневский А. Андреев Е., Тимонин С. Смертность от болезней системы кровообращения и продолжительность жизни в России // Демографическое обозрение. 2016. Т. 3, №1. С. 6-34. doi:10.17323/demreview.v3i1.1761

2. Estel Ch., Conti Ch.R. Global Burden of Cardiovascular Disease // Cardiovascular Innovations and Applications. 2016. Vol. 1, №4. P. 369-377. doi:10.15212/CVIA.2016.0029

3. Оганов Р.Г. Сердечно-сосудистые заболевания в начале XXI века: медицинские, социальные, демографические аспекты и меры профилактики // Федеральный справочник. Здравоохранение России. Т. 13. С. 257-264. Доступно по: http://federal-book.ru/files/FSZ/soderghanie/Tom%2013/IV/Oganov.pdf. Ссылка активна 05.12.2019.

4. Luria M.H., Sapoznikov D., Gilon D., et al. Early heart rate variability alterations after acute myocardial infarction // American Heart Journal. 1993. Vol. 125, №3. P. 676-681. doi:10.1016/0002-8703(93)90157-5

5. Dambrink J.-H.E., Tuininga Y.S., van Gilst W.H., et al. Association between reduced heart rate variability and left ventricular dilatation in patients with a first anterior myocardial infarction. CATS Investigators. Captopril and Thrombolysis Study // British Heart Journal. 1994. Vol. 72. P. 514-520. doi:10.1136/hrt.72.6.514

6. Бирюкова Е.В., Василюк Н.А., Андрианов В.В. Гендерные особенности вариабельности сердечного ритма и гемодинамического обеспечения учебной деятельности студентов // Российский медико-биологический вестник имени академика И.П. Павлова. 2019. Т. 27, №2. С. 188-196. doi:10.23888/PAVLOVJ2019272188-196

7. Allingstrup M., Afshari A. Selenium supplementation for critically ill adults (Review) // Cochrane Database of Systematic Reviews. 2015. №7. CD003703. doi:10.1002/14651858.CD003703.pub3

8. Низов А.А., Сучкова Е.И., Гиривенко А.И., и др. Возможности применения метформина для коррекции эндотелиальной дисфункции и адаптационных резервов организма у больных метаболическим синдромом // Российский медико-биологический вестник имени академика И.П. Павлова. 2019. Т. 27, №4. С. 458-467. doi:10.23888/PAVLOVJ2019274458-467

9. Flores-Mateo G., Navas-Acien A., Pastor-Barriuso R., et al. Selenium and coronary heart disease: A meta-analysis // The American Journal of Clinical Nutrition. 2006. Vol. 84, №4. P. 762-773. doi:10.1093/ajcn/84.4.762

10. Speckmann B., Grune T. Epigenetic effects of selenium and their implications for health // Epigenetics. 2015. Vol. 10, №3. P. 179-190. doi:10.1080/15592294.2015.1013792

11. Зилова И.С., Лапкин М.М., Карасев Р.П., и др. Физиологические и психологические методы оценки влияния биологически активных добавок к пище на функциональное состояние организма человека // Вестник новых медицинских технологий. 2004. Т. 11, №1-2. С. 8-9.

12. Dhalla N.S., Temsah R.M., Netticadan T. Role of oxidative stress in cardiovascular diseases // Journal of Hypertension. 2000. Vol. 18, №6. P. 655-673. doi:10.1097/00004872-200018060-00002

13. Радченко Е.Н., Низов А.А., Иванова А.Ю., и др. Клинико-функциональные и биохимические показатели больных инфарктом миокарда с зубцом Q (Q-ИМ) на фоне диетической коррекции селеном и стандартной терапии // Кардиология и сердечно-сосудистая хирургия. 2017. Т. 10, №5. С. 20-25. doi:10.17116/kardio201710520-25

14. Баевский Р.М., Иванов Г.Г., Чирейкин Л.В., и др. Анализ вариабельности сердечного ритма при использовании различных электрокардиографических систем (методические рекомендации) // Вестник аритмологии. 2001. Т. 24. С. 65-87.

15. Баевский Р.М., Берсенева А.П. Оценка адаптационных возможностей организма и риск развития заболеваний. М.: Медицина; 1997.

16. Баевский Р.М. Прогнозирование состояний на грани нормы и патологии. М.: Медицина; 1979.

References

1. Vishnevsky A, Andreev E, Timonin S. Mortality from cardiovascular diseases and life expectancy in Russia. *Demographic Review*. 2016;3(1):6-34. (In Russ). doi:10.17323/demreview.v3i1.1761

2. Estel Ch, Conti ChR. Global Burden of Cardiovascular Disease. *Cardiovascular Innovations and Applications*. 2016;1(4):369-77. doi:10.15212/CVIA.2016.0029

3. Oganov RG. Serdechno-sosudistyye zabolevaniya v nachale KHKHI veka: meditsinskiye, sotsial'nyye, demograficheskiye aspekty i mery profilaktiki. *Federal'nyy spravochnik. Zdravookhraneniye Rossii.* 13:257-64. Available at: http://federalbook.ru/files/FSZ/soderghanie/Tom%2013/IV/Oganov.pdf. Accessed: 2019 December 05. (In Russ).

4. Luria MH, Sapoznikov D, Gilon D, et al. Early heart rate variability alterations after acute myocardial infarction. *American Heart Journal*. 1993;125(3):676-81. doi:10.1016/0002-8703(93)90157-5

5. Dambrink J-HE, Tuininga YS, van Gilst WH, et al. Association between reduced heart rate variability and left ventricular dilatation in patients with a first anterior myocardial infarction. CATS Investigators. Captopril and Thrombolysis Study. *British Heart Journal*. 1994;72:514-20. doi:10.1136/hrt.72.6.514

6. Biryukova EV, Vasilyuk NA, Andrianov VV. Gender peculiarities of heart rate variability and hemodynamic basis of students' educational activity. *I.P. Pavlov Russian Medical Biological Herald*. 2019; 27(2):188-96. (In Russ). doi:10.23888/PAVLOVJ2019272188-196

7. Allingstrup M, Afshari A. Selenium supplementation for critically ill adults (Review). *Cochrane Database of Systematic Reviews*. 2015;(7):CD003703. doi:10. 1002/14651858.CD003703.pub3

8. Nizov AA, Suchkova EI, Girivenko AI, et al. Possibilities of use of metformin for correction of endothelial dysfunction and adaptation reserves of an organism in patients with metabolic syndrome. *I.P. Pavlov Russian Medical Biological Herald.* 2019;27(4):458-67. (In Russ). doi:10.23888/PAVLOVJ2019274458-467

9. Flores-Mateo G, Navas-Acien A, Pastor-Barriuso R, et al. Selenium and coronary heart disease: A meta-analysis. *The American Journal of Clinical Nutrition*. 2006;84(4):762-73. doi:10.1093/ajcn/84.4.762

10. Speckmann B, Grune T. Epigenetic effects of selenium and their implications for health. *Epigenetics*. 2015; 10(3):179-90. doi:10.1080/15592294.2015.1013792

11. Zilova IS, Lapkin MM, Karasev RP, i dr. Fiziologicheskiye i psikhologicheskiye metody otsenki vliyaniya biologicheski aktivnykh dobavok k pishche na funktsional'noye sostoyaniye organizma cheloveka. *Journal of New Medical Technologies*. 2004;11(1-2):8-9. (In Russ).

12. Dhalla NS, Temsah RM, Netticadan T. Role of oxidative stress in cardiovascular diseases. *Journal of Hypertension*. 2000;18(6):655-73. doi:10.1097/00004872-200018060-00002

13. Radchenko EN, Nizov AA, Ivanova AYu, et al. Clinicofunctional and biochemical values in Q-wave myocardial infarction (QMI) patients on background

of dietary correction with selenium and standard treatment. *Russian Journal of Cardiology and Cardiovascular Surgery.* 2017;10(5):20-5. (In Russ). doi:10.17116/kardio201710520-25

14. Bayevskiy RM, Ivanov GG, Chireykin LV, et al. Analiz variabel'nosti serdechnogo ritma pri ispol'zovanii razlichnykh elektrokardiografi-

cheskikh sistem (metodicheskiye rekomendatsii). *Vestnik Aritmologii.* 2001;24:65-87. (In Russ).

15. Bayevskiy RM, Berseneva AP. *Otsenka adaptatsionnykh vozmozhnostey organizma i risk razvitiya zabolevaniy.* Moscow: Meditsina; 1997.

16. Bayevskiy RM. *Prognozirovaniye sostoyaniy na grani normy i patologii.* Moscow: Meditsina; 1979.

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