ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

# Mathematical Modeling Of Heart Rhythm Variability In Estimation Of Cardiovascular System Adaptation Capabilities In Patients With Type 2 Diabetes And Arterial Hypertension.

**Sudakov O, Gladskikh N, Alexeev N*, Bogacheva E, Sudakov D, Kretinina L, Fursova E, and Trofimova T.**

Voronezh State Medical University named after N.N. Burdenko Russia, Voronezh Voronezh State University Russia, Voronezh

**ABSTRACT**

It is possible to assess the adaptation reserves of the cardiovascular system, based on the heart rate variability indicators. This paper shows the development of a mathematical model based on the indicators of a statistical analysis of rhythmograms: PNN50, RMSSD, SDSD, SDNN, NN50. The developed mathematical models were tested in outpatient department, and showed high accuracy in determining the functioning of the cardiovascular system.
**Keywords:** heart rhythm variability, diagnostic features, mathematical model

**Corresponding author*

ISSN: 0975-8585

**INTRODUCTION**

The increase in mortality from cardiovascular diseases determines the relevance of research aimed at preserving the health of the population, and predicting the course of the pathological process. Coronary heart disease is common in all age groups, causing a high incidence of disability and mortality. Finding predictors of the ischemic myocardial damaging, and especially in patients with comorbidities, improves the quality of care even in the absence of clinical manifestations.

The aim of this work was the mathematical modeling of the functioning the cardiovascular system in patients with diabetes mellitus and ischemic heart disease based on a study of heart rate variability.

Heart rate variability makes it possible to measure the autonomic nervous system functioning, allows us estimate the state of the body's regulatory systems, which is highly important if the patient has a combined somatic pathology. Diabetic cardiac neuropathy in a patient with diabetes mellitus masking clinical manifestations, increases the risk of vascular catastrophes like myocardial infarction, stroke.

We considered 35 indicators of rhythmograms obtained during the daily recording of cardio intervals, including the indicator of the daily rhythm variability (TAKVR). Records were conducted in groups of patients with various functional classes of angina pectoris.

At the first stage of the study, the most informative indicators were selected on the basis of the correlation analysis to build a model of autonomic nervous dysfunction. Statistically significant correlation coefficients with the strongest coupling were selected. To build the model, the expert estimation method was used. Then weighted weights for the selected indicators

The values of the calculated model are in the range from zero to one and, depending on the obtained model value, a conclusion is made about the state of the adaptive capabilities of the patient's cardiovascular system within the functional class of angina. In the model developed by us, the normalized values of the indicators are substituted.

Table1 $CBBP_{1rp}$=0,353*SDNNind+0,24*NN50+0,24*PNN50+0,176*RMSSD (1)

**Table1: Criteria of functioning of the developed model**

| The normalized value of the indicator | |
|---|---|
| Unsatisfactory level | 1 |
| Satisfactory level | 0,333 |
| Good level | 0 |

Prognostic model of the index of heart rate variability of SVVR in patients with I FC angina. SDNN ind (the correlation coefficient is statistically reliable and equal to 0.58), NN50 (the correlation coefficient is statistically reliable and equal to 0.77), PNN50 (the correlation coefficient is statistically reliable and equal to 0.78), RMSSD (correlation coefficient reliable and equal to 0.62).

UHVR = f (SDNN ind, NN50, PNN 50, RMSSD)

Table 2: $CBBP_{2rp}$=0,516*PNN50+0,226* RMSSD+0,258*SDSD (2)

**Table 2: Expert ranking of HRV indices in patients with angina pectoris FC I**

| Expertestimates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Indicator | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| SDNNind | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 |
| NN50 | 2 | 2 | 2 | 2 | 1 | 2 | 3 | 3 |
| PNN50 | 2 | 3 | 2 | 1 | 2 | 3 | 3 | 1 |
| RMSSD | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |

Prognostic model of the index of heart rate variability of SVVR in patients of the second group. PNN50 (the correlation coefficient is statistically reliable and equal to 0.74), RMSSD (the correlation coefficient is statistically reliable and equal to 0.72), SDSD (the correlation coefficient is statistically reliable and equal to 0.76) were selected as indicators.

CBBP=f(PNN50,RMSSD,SDSD)

Table 3: $CBBP_{3rp}$=0,4332* SDNN +0,366* NN50+0,2*PNN50(3)

**Table3: Expert ranking of indicators of HRV in patients with angina pectoris FC II**

| Expert estimates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Indicator | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| PNN50 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| RMSSD | 2 | 3 | 3 | 2 | 1 | 1 | 3 | 2 |
| SDSD | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

The models of the state of the adaptive capacities of the cardiovascular system developed by us were tested in clinical conditions and showed high accuracy in determining the state of functioning of the cardiovascular system [1-21].

**Table4: Predictive model values**

| model values | |
|---|---|
| norm | 0..0,333 |
| Tense adaptation | 0,34..0,666 |
| Breakdown of adaptation | 0,67..1 |

**REFERENCES**


[1] Application of neural network modeling to support decision-making in the diagnosis of chronic heart failure / E.A. Fursova, E.I. Novikova, O.V. Sudakov // System analysis and management in biomedical systems.2009.T.8.№ 2.P.410-413.

[2] Modeling of severe forms for acute toxic hepatitis / N.Yu. Alekseev, N.Yu. Kuzmenko, O.V. Sudakov // System analysis and management in biomedical systems.2012. T.11. № 2. P.481-484.

[3] Models construction of the of the adaptation potential for the patients with type 2 diabetes and arterial hypertension / O.V. Sudakov, T.P. Kuchkovskaya, A.V. Sviridova, G.M. Panyushkina, E.A. Studenikina // System analysis and management in biomedical systems. 2014. T.13.№ 2. P. 447-452.

[4] Construction of an adaptive algorithm for the treatment of patients with diabetes mellitus and arterial hypertension / O.V. Rodionov, E.N. Korovin, O.V. Sudakov, E.A. Fursova, D.V. Sudakov // System analysis and management in biomedical systems. 2014. T.13. No. 3. P. 688-690.

[5] Construction of the mathematical model for the type selection of medical impact in patients with a diabetic stop syndrome by the results of the informations preliminary processing / D.V. Sudakov, O.V. Rodionov, E.N. Korovin, O.V. Sudakov // System analysis and management in biomedical systems. 2012. No. 11.P. 869-872.

[6] Health monitoring of participating youth on the basis of computer technologies \ I.E. Esaulenko, T.N. Petrova, O.V. Sudakov \\ System analysis and management in biomedical systems. 2014. T. 13. No. 2. P. 483-487.

[7] Choice of tactics for the treatment of complications of diabetes mellitus on the basis of neural network modeling \ D.V. Sudakov, E.N. Korovin, O.V. Rodionov, O.V. Sudakov, E.A. Fursova \\ System analysis and management in biomedical systems. 2014. Vol. 13. No. 3. P. 592-597.

[8] Mathematical model used for the variabilities study of heart rhythm in long-term intervals \ Sviridov AV, Sudakov OV, Rodionov OV, Alekseev N.Yu.\\ System analysis and management in biomedical systems. 2007. V. 6. No. 1. P. 109-113.

[9] Construction of a prognostic mathematical model based on the parameters of the heart rhythm for estimation of the height of heart diseases \ Sudakov O.V. \\ System analysis and management in

biomedical systems. 2007. Vol. 6. No. 1. P. 201-208.

[10] Comparative analysis of the health of student youth's health depending on the university profile \ Petrova T.N., Sudakov O.V. \\ System analysis and management in biomedical systems. 2012. Vol. 11. No. 3. P. 804-809.

[11] Mathematical Support For The Formation Of Informative Signs Dictionary For The Probabilistic Estimates Calculation Of The Repeated Stroke \ Sudakov, O.;Gladskikh, N.; Alexeev, N. and others \\ RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES Vol. 9. № 4. P.393-399: JUL-AUG 2018.

[12] Method And Algorithm For Calculating The Probabilistic Evaluation Of Stroke Recurrence \ Sudakov, O.; Gladskikh, N.; Alexeev, N. and others \\ RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES Vol. 9. №4. P. 400-404: JUL-AUG 2018.

[13] Software Implementation the Methodology for Calculating Integral Indicators Rehabilitation Potential of Patients with Schizophrenia \ Shtankov, S.; Shiryaev, O.;Sudakov, O. and others \\RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES Vol. 9. №1. P. 950-953: JAN-FEB 2018.

[14] Possibilities Of A Personified Approach To Diagnosis Of Obesity Based On The Developed Genetic Tests And Determining The Sensitivity To Phenyltiokarbamide \ Petrova, T. N.; Popov, V., I; Kolesnikova, E. N. and others \\RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES Vol:8. № 6. P.713-717 :NOV-DEC 2017.

[15] Polymorphic Genetic Markers of Obesity and Their Associations with Clinical and Metabolic Indicator \ Kolesnikova, E. N.; Petrova, T. N.; Sudakov, O. V. and others \\RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES Vol. 8. №6.: P. 726-729. NOV-DEC 2017.

[16] Estimation of Adaptable Possibilities of Medical Students Based on Climatic Factors \ Alexeev, N.; Sudakov, O.; Kuzmenko, N. and others \\ RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES Vol.8. № 2. P. 2693-2697. MAR-APR 2017.

[17] Genetic and Clinic-Pathogenetic Peculiarities of Prediction of Development and the Effects of Obesity at Young Persons \ Esaulenko, I. E.; Petrova, T. N.; Kolesnikova, E. N.; \\ RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES. Vol. 8. №3. P. 1368-1374. MAY-JUN 2017.

[18] Gladskikh N.A. Development of methods of classification-prognostic modeling in the system of staffing of territorial health care / dissertation for the degree of candidate of technical sciences / VSTU. Voronezh. 2008, 211 pp.

[19] Assessment of the risk of recurrent stroke in patients with type 2 diabetes and hypertension / N.A. Gladskikh, O.V. Sudakov, E.V. Bogacheva, N.Yu. Alekseev, E.A. Fursova// System analysis and management in biomedical systems. T.15.№ 1.C.C. 123-127.

[20] Construction of a mathematical model for choosing the type of coronary angioplasty in patients with coronary heart disease and diabetes mellitus / A.I. Borodulin, A.V. Sviridov, O.V. Sudakov, E.A. Fursova, N.Yu. Alekseev // Applied information aspects of medicine. 177. № 2.C.56-58.

[21] Esaulenko I.E. Information system for the selection of diagnostic signs of autonomic syndrome. I.E. Esaulenko, N.A. Gladskikh, S.I. Shtankov, M.A. Zheleznyakov // System analysis and management in biomedical systems. 2011. T. 10. № 4. Pp. 864 -869.