INVESTIGATION OF CARDIOVASCULAR SYSTEM WITH HELP OF ENERGY APPROACH

Qawasma R. A., Sushkova L. T., Kuznetsov A. A.

Vladimir state university, Vladimir, Russia

ramziq@mail.ru, ludm@vpti.vladimir.ru

In this paper it is offered to investigate a functional condition of heart of the person on the basis of the energy and interquantile methods. Interquantile method of analysis of RR-intervalograms gives trustworthy information at an estimation of regulation processes and stability of dynamic of a cardiac rhythm. The energy method is based on an estimation of the areas defined by space between RR-intervals on an axis of time and between isoelectric and zero lines on an axis of amplitude. On the received areas by means of the program "SADR" so called S_{RR}-intervalogram was plotted. Also were plotted histograms of distribution RR- and S_{RR}-intervalograms and their correlation were estimated. The factor of correlation of histograms RR- and S_{RR}-intervalograms is a quantity indicator of a rhythm of heart in norm. Any divergence on factor of correlation considered cardiointervalograms testifies to presence of pathology in heart's work.

Introduction

Dynamics of heart rhythm is extremely difficult and now does not give in to the formal description. The heart rhythm reduction is the most accessible to registration of the physiological parameters reflecting processes of vegetative regulation in cardiovascular system and an organism. Dynamic characteristics of heart rhythm allow estimating expressiveness of shifts sympathetic and parasympathetic activity of vegetative nervous system at change of a condition of the patient. The classical approach in cardiology is based on existential, statistical, spatial - spectral methods for reception of diagnostic parameters of a functional condition of heart [1, 2].

In cardiology results of the analysis of heart rhythm are used as basic forecasting parameter at an estimation of risks at ischemic illness, arrhythmia, a sharp heart attack of a myocardium, insufficiency of blood circulation, etc. It is known, that the electrocardiogram is analyzed under its form, duration, orientation, interposition peaks and segments. However, at transition to analysis RR-intervalograms we receive trustworthy information not only about the processes proceeding in the heart and blood system, but also in various functional conditions of an organism. Thus, managing parameter is the interval of time between R-peaks. Development of new physical methods allows approaching to searches of laws in heart arrhythmia on the basis of methods of the theory of chaos, nonlinear dynamics and mathematical modeling [3].

The purpose of the given work is definition of a functional condition of heart rhythm of the person by an energy method [4], ordering heart arrhythmias by analogy to the circuit of transition from irregular rhythms to the chaos, existing in the mathematical theory of dynamic systems and search of the laws connecting results with problems of forecasting of stability of dynamics heart rhythm.

Materials and methods

The energy method of the analysis of heart rhythm is based on an estimation of the areas limited to RR-intervals on a time base and isoelectrical and zero lines on an axis of amplitude. Thus, the conditional - zero line should not cross graphic realization of an electrocardiogram.

It is offered, that at change of free energy of system process cardiocycle should vary and its topological structure. At this, heart as the system of regulation, aspires to keep it in norm due to changes of frequency of reduction, width separate peaks, correction of amplitudes and isoelectrical line positions. For example, the increase in amplitude of R-peak or a rising of ST complex promotes indemnification of reduction of energy [4].

In such representation the general area under a curve electrocardiogram makes full free energy for heart work within the framework of registration. This energy organizes internal structure of everyone given cardicycle and the electrocardiogram.

The analysis of heart rhythm was carried out by an energy method under electrocardiograms of different groups of people. The electrocardiograms were registered at clinical healthy 50 young people (students of 18-20 years old) in a digital code by means of Holter monitoring. For 30 students the electrocardiogram were registered, taking lectures (intense condition), and for 20 students – laying (quiet condition). Research also included 50 patients with various pathologies. The electrocardiogram was registered on second Einthoven leads as thus on an electrocardiogram R-peak is most expressed [5].

It is known, that the recommended volume of the minimal sample is 50 … 250 values of RR-intervals. Also it is known, that at sample in volume less than 100 cardiointervals statistical reliability of results of

ISSN: 1727-1983

estimation falls [6]. For definition of optimum volume of sample autocorrelation function and a spectrum of autocorrelation function (ACF) were under construction. The most left on a frequency axis peak on spectrum ACF will define (determine) scope of sample under formula Nikewist: $\Delta h = \frac{1}{2 f_{\min}}$ [7]. Low frequencies for all 50 clinical healthy researched people are in a range (2 – 10) $\cdot 10^{-3}$, $\frac{1}{2n}$. It corresponds the minimal volume of sample from 50 up to 250 cardiointervals and coincides with the recommended volume.

After the primary processing electrocardiogram, the received data in a digital code were entered into a database of a computer. With the help of specially developed program «the System Analysis of Dynamics Rhythm of heart» (SADR) [8] each file from a database was analyzed for identification and fixing of values of R-peaks. At this stage noise and artifacts are reduced to a minimum. Further the areas of flat figures between RR-intervals were defined, and new sample of the data consisting of sequentially read out areas of flat figures – S_{RR}-intervalogram was created (figures 1, 2, 3) [9].

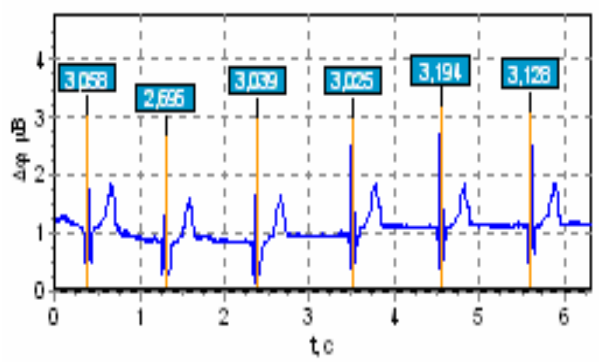

Figure 1: Fragment of the computer version of ECG. Definition of the maximal values R-peaks

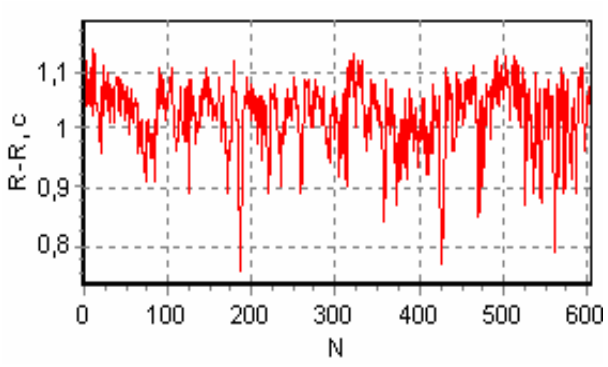

Figure 2: RR-intervalogram (RR-intervals)

Appeared, that S_{RR}- and RR-intervalograms all clinically healthy people qualitatively coincide in the field of the big and average emissions of amplitudes. Discrepancies are defined by areas of small emissions.

For each electrocardiogram under developed program "SADR" were under construction histograms (figure 4) of RR- and S_{RR}-intervalograms and their correlation was estimated.

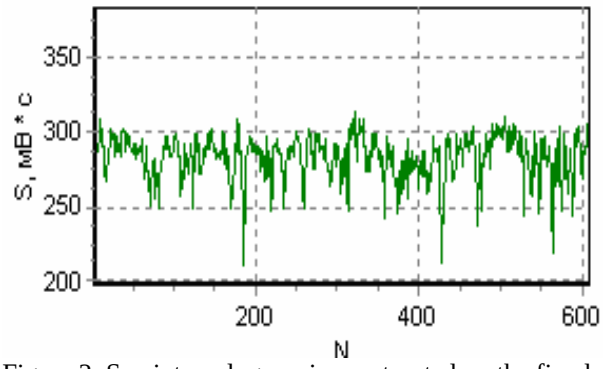

Figure 2: S_{RR}-intervalogram is constructed on the fixed areas between RR-intervals

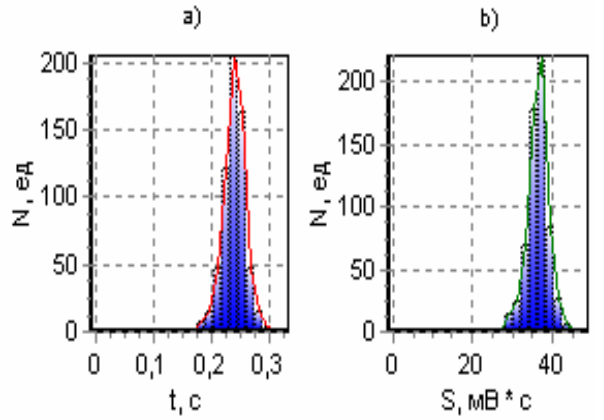

Figure 4: the constructed histograms of RR- (a) and S_{RR}-intervalograms (b)

Interquantile method

Existential methods are not sufficient for the description of all features of RR-intervalogram. In this connection, it is offered to apply interquantile method in processing cardiosignals [11].

Without dependence from type of distribution of the density of RR-intervals, RR-intervalogram is divided on vertical Interquantiles intervals (energy levels) which quantity is determined with help of Sturges formula [12]. Thus, each energy level gets own probability estimation and it is represented by own sample of values.

The spectral analysis was done for all range values of RR-intervals, and for every one of interquantiles intervals. The interquantile approach for each level is used for researches of interquantile gaps, their phase portraits, autocorrelation functions (ACF) and spectra ACF.

On figures 4 and 5 results of an interquantile method in a graphic kind are presented: on figure 4 – for clinically healthy person (student of VSU, 18 years old); on figure 5 – for the sick person with the diagnosis an acute peritonitis (RCH of Vladimir). The researched level is marked on histograms.

ISSN: 1727-1983

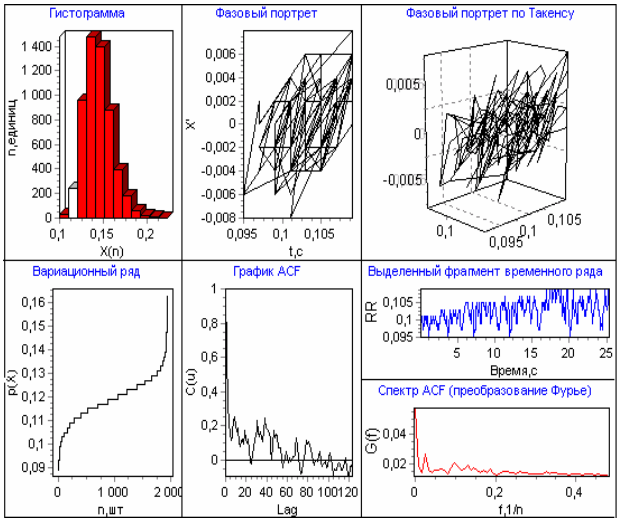

Figure 5: Diagrams of the analysis interquantile intervals according to fragment RR-intervalogram for a case of clinically healthy person.

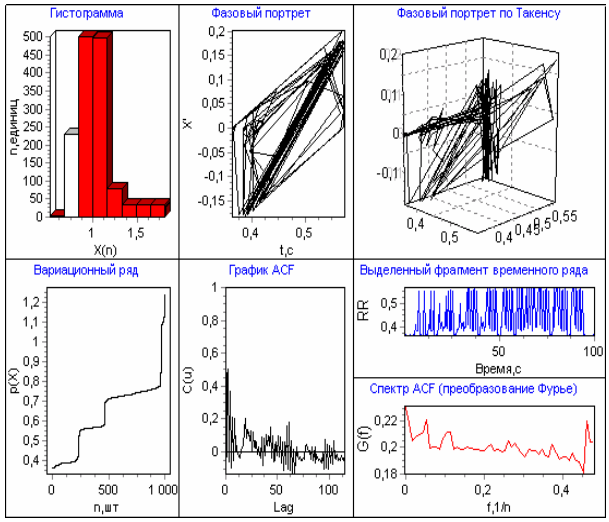

Figure 6: Diagrams of the analysis interquantile intervals according to fragment RR-intervalogram for a case of the sick person

In the table comparative results of the diagrams analysis of figures 4 and 5 are given:

	Healthy person	Sick person
Enveloping histograms	Bending around comes nearer under the form to normal Gaussian distribution. The factor of excess = 1.828	Strong asymmetry is observed. The factor of asymmetry = -0,039
Variation series	Curve of variation series has the S-shaped smooth form	Curve of variation series has the step form
Phase portrait	Phase portrait represents attractor as "hedgehog" or a ball with homogeneous filling trajectories of movement of a representing point	In the increased scale attractor degenerates in dot area about which simple geometrical figures are formed
Autocorrelation function (ACF)	ACF fades slowly with the significant period. Well gives in to visual interpretation as a source of the information on the maximal periodicity of time lines	ACF has the smaller tendency to attenuation and it is steady on small values about zero. Has difficultly interpretive form and demands presence of the spectral analysis
Fourier Spectrum	Broadband spectrum with the expressed maximum on about zero frequencies	The maximum on about zero frequencies falls. On a tail of a spectrum, in some cases, there are "splashes"
Spectrum ACF	On a spectrum one characteristic maximal frequency on energy is allocated	On a spectrum the maximal frequencies on energy are allocated some

Results and conclusions

The lead researches have shown, that at all researched clinically healthy young people the value of factors of correlation of histograms RR- and S_{RR}-intervalograms were in an interval 0.7÷1. By a correlation estimation of histograms RR-and S_{RR}-intervalograms high value of factor of correlation is observed at record of an electrocardiogram in the rest condition, and on the contrary reduction of value of factor in the intense condition. For clinicly healthy people in the rest condition the symmetric histogram is registered. Asymmetry forms specify a rejection of a rhythm of heart from norm [10]. Preliminary researches in case of sick people show, that the factor of correlation sharply falls.

Thus, the opportunity of research of an electrocardiogram by parallel analysis RR-and S_{RR}-intervalograms is offered.

By results of given work we can draw the following conclusions:

1. The minimal volume of sample for definition of a functional condition of heart is established on the minimal information frequency in a range 50 … 250 cardiointervals.

2. RR- and S_{RR}-intervalograms contain identical information about the functional condition of the organism. The factor of correlation of histograms RR- and S_{RR}-intervalograms is a quantity indicator of a rhythm of heart in norm. Any divergence on factor of correlation considered cardiointervalograms testifies to presence of a pathology in heart's work;

ISSN: 1727-1983

3. For clinicly healthy organisms at preventive inspections it is possible to pass from research of an electrocardiogram to analysis RR- and S_{RR}-intervalograms;

4. The offered energy approach and the developed program of analysis "SADR" can be used as express-preventive maintenance rhythm of heart in norm;

5. Interquantile method of analysis of RR-intervalograms gives trustworthy information at an estimation of regulation processes and stability of dynamic of a cardiac rhythm.

References

[1] BOKERYA L. A. Tachyarrhythmia: Diagnostics and surgical treatment. –L.: Medicine, 1989. –296 p.

[2] BAEVSKIY R. M., KIRILOV O. I., KLETSKIN S. V. The mathematical analysis of an intimate rhythm at stress. –M.: the Science, 1984. –219 p.

[3] AKSELROD S., GORDON D., UBEL F. A., et. al. Power spectrum analysis of heart rate fluctuation: a quantitative probe of beat to beat cardiovascular control. Science 1981, 213: 220-222.

[4] QAWASMA R. A., KUZNETSOV A. A., SUSHKOVA L. T. The analysis of an electrocardiogram on the basis of the energy approach // Proceedings of the fifth international scientific-practical conference «Health and education in XXI century», Moscow. 21-23 October 2004, 157 p.

[5] HUMAN PHYSIOLOGY. Part 2: Translation with English / under R.Schmidt and G.Tevsa's edition. –M.: Mir, 1996. –313 p.

[6] BAEVSKIY R. M., IVANOV G. G. Variability of heart rhythm: theoretical aspects and opportunities of clinical application. –M.: 2000. - http://www.ecg.ru

[7] PRIESTLY M.B. Spectral analysise and tine series. Academic Press, London, V.2. 1981. – P.869.

[8] QAWASMA R. A., PLEHANOV A. A. The program of the system analysis of dynamics rhythm of heart // XII International scientific conference of students, post-graduate students and young scientists «Lomonosov-2005», Moscow. 12-16 April 2005.

[9] QAWASMA R. A., KUZNETSOV A. A., SUSHKOVA L. T. About an opportunity of research heart's work on the basis of analysis RR-intervalograms // XI international conference «New medical technologies and quantum medicine». Moscow. 24-27 January 2005, 89-90 p.

[10] KALAKUTSKIJ L.I., MANELIS E.S. Equipment and methods of clinical monitoring. –M.: Vysh. shk., 2004. – 156 p.

[11] QAWASMA R. A., KUZNETSOV A. A., SUSHKOVA L. T., PLEHANOV A. A. Interquantile method of processing RR-intervalograms // VI International scientific and technical conference «Perspective technologies in means of transfer of the information», Vladimir 20-22 April 2005. 209 – 211 p.

[12] SERGIENKO V. I., BONDAREV I. B. Mathematical statistics in clinical researches. –M.: GEOTAR-MED. - 2001. – 265 p.

ISSN: 1727-1983