HEART VARIABILITY ANALYSIS

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ABSTRACT

HRV analysis is a method for assessing the state of the mechanisms of regulation of physiological functions in the human body, in particular, the overall activity of regulatory mechanisms, neurohumoral regulation of the heart, the relationship between the sympathetic and parasympathetic divisions of the autonomic nervous system.

Keywords: heart variability, ECG, R-waves

The current activity of the sympathetic and parasympathetic divisions is the result of the reaction of a multi-circuit and multi-level system of blood circulation regulation, changing its parameters over time to achieve an optimal adaptive response, which reflects the adaptive response of the whole organism.

Adaptive reactions are individual and are realized in different individuals with varying degrees of participation of functional systems, which, in turn, have feedback that changes over time and has a variable functional organization. The method is based on the recognition and measurement of time intervals between ECG R-waves (RR-intervals), the construction of dynamic series of cardiointervals and subsequent analysis of the obtained numerical series using various mathematical methods. The dynamic series of cardiointervals is called a cardiointervalogram (CIG).

The dynamic series of cardio intervals can be classified as stationary or non-stationary. Stationary processes are called random processes that proceed approximately uniformly and have the form of continuous oscillations around a certain average value. Stationary processes are characterized by ergodicity, i.e. averaging over time corresponds to averaging over a set of realizations. In other words, at any time interval, we should receive the same characteristics. Non-stationary (or transient) processes have a certain trend of development in time and their characteristics depend on the origin. Almost every cardiointervalogram contains elements of non-stationarity (fractal components). In these guidelines, the cardiointervalogram is considered as a stationary random process with an appropriate interpretation of the data obtained as a result of its analysis. In recent years, methods of nonlinear dynamics have been actively developed to evaluate the fractal components of a cardiointervalogram.

When analyzing the dynamic series of cardiointervals, one should distinguish between short-term (“short”) and long-term (“long”) records. The latter, as a rule, is understood as data obtained during 24 and 48-hour ECG monitoring (Holter monitoring). The so-called "short" records include data from studies conducted over minutes, tens of minutes, or several hours.

Time series of cardiointervals can be obtained by analyzing any cardiographic records (electrical, mechanical, ultrasound, etc.), however, this document only considers data from the analysis of electrocardiosignals.

HRV analysis includes three steps:

1. Measuring the duration of RR-intervals and presenting the dynamic series of cardiointervals in the form of a cardiointervalogram (Fig. 1);

2. Analysis of dynamic series of cardiointervals;

3. Evaluation of the results of the HRV analysis.

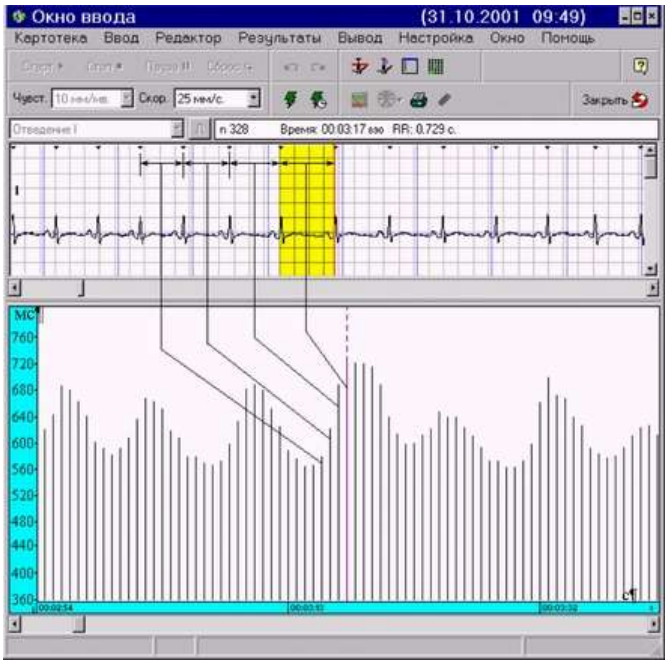

Fig. 1. Formation of a cardiointervalogram (CIG) when entering an electrocardiographic signal. Above - electrocardiogram (ECG), below - CIG (along the ordinate axis - the duration of cardiointervals in milliseconds; along the abscissa axis is the time of registration of cardiointervals (hours, minutes, sec). The arrows mark the elements of the CIG corresponding to the intervals between the RR-waves of the ECG.

Measurement of the duration of RR intervals is performed by hardware or software with an accuracy of 1 millisecond. The problem of recognition of ECG R-waves in various hardware and software systems is solved in different ways. Representation of dynamic series of cardiointervals is carried out in numerical or graphical form.

Methods for analyzing time series of cardiointervals can be divided into visual and mathematical. Mathematical methods of analysis can be divided into three large classes:

- study of general variability (statistical methods or time analysis).
- study of periodic components of HRV (frequency analysis).
- study of the internal organization of the dynamic series of cardiointervals (autocorrelation analysis, correlation rhythmography, methods of nonlinear dynamics).

The numerical values obtained as a result of the HRV analysis (HRV indicators) are evaluated differently by different researchers, depending on the scientific and theoretical concept used.

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