Information Function of the Heart. A Measurement Model

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***Abstract**. The paper deals with a measurement model of various diseases the semantics of which is embedded in electrocardiosignals. The development of the model described included: measuring the basic parameters of the electrocardiosignals, creating an alphabet of the symbols corresponding to available versions for the dynamics of measurement parameters of each subsequent cycle with respect to a previous on, encoding no less than 600 recorded signals in their serial stream, selecting combinations of symbols of the 100% occurrence which can be met in the patterns of healthy people and patients with different diseases, getting on these basis of these symbols code images (below called "patterns") of the norm and particular diseases. The experience gained in applying the patterns of the norm and diseases as diagnostic standards, has shown their high efficiency in the diagnostics of diseases.*

Keywords: Information Function of the Heart, Electrocardiosignals, Measurement Model, Semantics of Diseases

1. Introduction

The reliable diagnostics of diseases, particularly at early stages, is one of the most important tasks of the contemporary medicine. In the scientific literature there are some publications the authors of which describe their experience in diagnosing diseases on the basis of an analysis of the pulse [1]-[3]. However, these works are supported with some other measurement models the diagnostic capabilities of which are constricted by limits of the functional diagnostics.

In [4], [5] published in 2008, a biophysical reasoning of the information function of the heart is given, and a measurement model containing patterns of the norm and diseases, used as the basis of the computer diagnostic system providing an information analysis of electrocardiosignals, is suggested.

The medical testing of the computer diagnostic system for analyzing information the electrocardiosignals contain has shown its high efficiency in diagnosing the norm and diseases most widely spread, as well as the possibility to apply this system both in biology and medicine for analyzing the semantics of signals of any biophysical nature.

2. The object and methods

To perform investigations a special electrocardiography complex, "KAD-3", was developed and produced in Russia according to technical requirements [5]. This device differs from regular cardiographs in its broader frequency band of input signals (from 0.5 to 500 Hz) and higher accuracy. Electrocardiographs with such parameters are not produced in the world.

Therapeutic investigations of the QRS-ventricular complexes, which demonstrate the electrical activity of the heart, are applied in everyday medical practice. Usually, time intervals *Tn* between the QRS-ventricular complexes are measured, and the configuration of signals is visually estimated. The accuracy of such measurements is not sufficient for solving the problem. According to conventional procedures (with the exception of ECG-monitoring),

5 - 15 cardiocycles are recorded, which does not enable obtaining information for diagnostics of the whole body diseases.

In the process of investigations, there was established a set of the electrocardiosignal parameters, which, at the minimum, were required for performing measurements. For each patient, 2 parameters are measured in addition to *Tn* (Table 1):

- amplitude or swing of the QRS-ventricular complexes taking into account their configuration;
- value of $tg\alpha$, where α is the conventional angle between a "zero" line of the QRS-complexes and the straight line drawn from the beginning of the interval *Tn* to the point corresponding to the maximum value of the signal that completes the interval.

The uncertainty of amplitude or swing measurements is no more than 5 mkV, while the uncertainty of *Tn* measurements is no more than 0.01 ms. To obtain reliable information, the electrocardiosignals are registered in a number of 600 (in a continuous mode). The readout of electrocardiosignals is performed within the time interval from 5 to 12 min depending on the pulse frequency of persons to be examined.

Comparison of the given set of three parameters (amplitude or swing, *Tn*, and $tg\alpha$) of each subsequent signal with respect to corresponding parameters of the previous signal allows the electrocardiosignals variation in time to be characterized. From all versions of changes experienced by the relationship of the cardiosignal parameters, six versions of them were selected as the main ones. Such signals were coded by symbols from which an alphabet was formed: A, B, C, D, E, F. Each symbol of the alphabet shows one of possible versions of the parameter dynamics for two adjacent QRS-complexes. Processing of the signals is performed with the help of special software.

The data base of the study included the electrocardiosignals obtained from both 198 healthy persons and 2760 patients with various internal diseases of a noninfectious nature. An overall diagnostics of patients under observation was simultaneously done using clinical and laboratory-instrumentation methods.

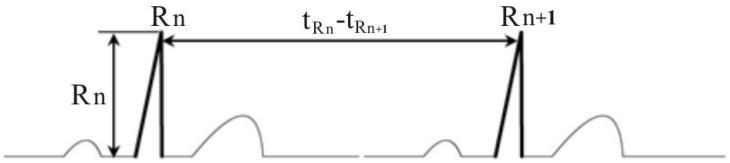
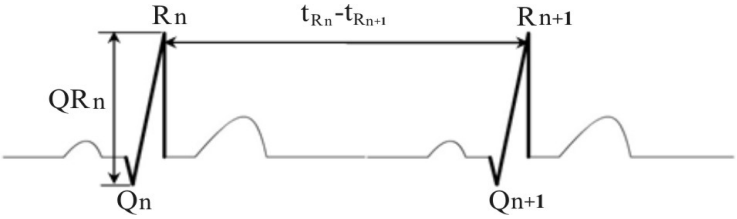
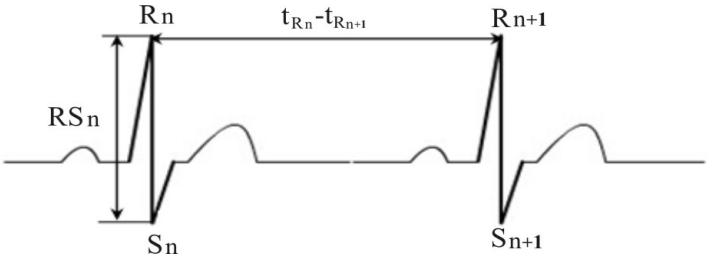
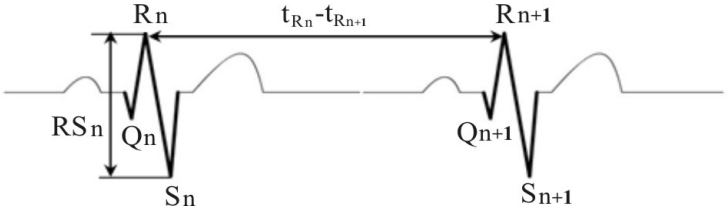
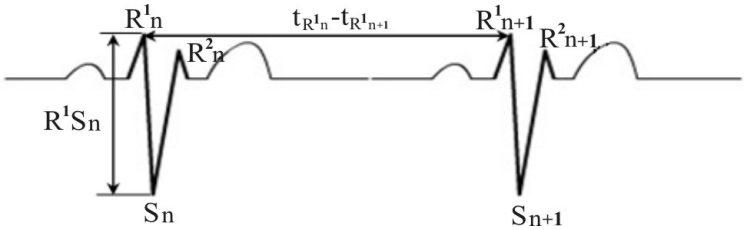
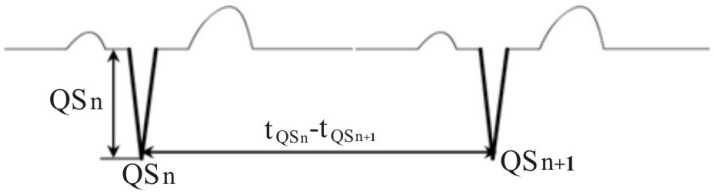
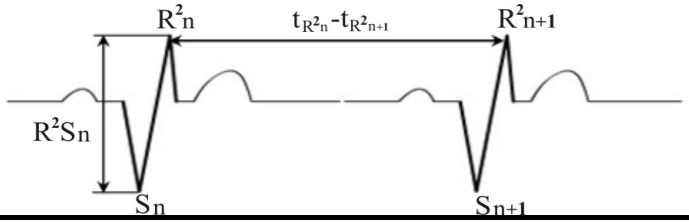
3. Results

The positive sequential coding of the parameter dynamics in a massive of 600 electrocardiocomplexes allows a pattern to be obtained. Some sets of combinations, which contained no less than three symbols with the 100 % occurrence in the corresponding groups of patients being observed, were revealed with the help of the comparative analysis of patterns belonging to the groups of observed healthy persons and patients with internal diseases. The sets of such combinations taken as patterns, i.e., specific standards of the norm and 23 widespread internal diseases, constituted a data base of diagnostic standards for the computer diagnostic system of the first generation. These diseases include, for example, diabetes, cholelithiasis, essential hypertension and ulcer, and many others.

As an example some patterns of the cholelithiasis (FAA, FFA, FCA, AAF, ADF, AFF, AEF, DFA, FBA, AAD, DFC, CAD, ACF, EFF) and those of the diabetes (AFC, CAF, AFA, FAE, AFB, BAF, BAD, EFC, EFA, CFC) are given.

In the process of testing the diagnostic system, it was found that in no less than 90 % of cases, the patterns of the norm and diseases allowed the diseases of patients recognized as ill people on the basis of traditional observation results to be identified. At the same time, in 98 % of cases the corresponding diagnoses coincided. The reproducibility of the diagnostics results was 80 – 100 %.

Table 1. The basic types of the QRS ventricular complex and versions of measurements of their main parameters.

No	QRS complex	Measurements
1		Amplitude Rn Time interval $Tn=t_{Rn}-t_{Rn+1}$
2		Swing QRn Time interval $Tn=t_{Rn}-t_{Rn+1}$
3		Swing RSn Time interval $Tn=t_{Rn}-t_{Rn+1}$
4		Swing RSn Time interval $Tn=t_{Rn}-t_{Rn+1}$
5		Swing R^1Sn Time interval $Tn=t_{R^1n}-t_{R^1n+1}$
6		Amplitude QSn Time interval $Tn=t_{QSn}-t_{QSn+1}$
7		Swing R^2Sn Time interval $Tn=t_{R^2n}-t_{R^2n+1}$

4. Discussion

The biophysical specific features of electrocardiosignals registered within an input signal frequency band from 0,5 to 500 Hz, are characterized by a probabilistic variability of the signal amplitude and frequency. This corresponds to a random transient (stochastic) process of modulation of these parameters in accordance with information about the health state [5]. The same properties are intrinsic to the pulses of a magnetic and hydrodynamic nature, which are generated by the heart. The experience gained in using the patterns as the specific diagnostic standards of the norm and diseases, obtained with the help of the proposed measurement model of processing the electrocardiosignals, completely agrees with a centuries-old experience of the China pulse diagnostics [1]. The hydrodynamic pulses (pulse waves) generated by the heart are subjected to modulation simultaneously with electrical and magnetic pulses. All this is an evidence of the uniformity of mechanisms participating in generating information that is introduced into the pulses. The specific pulse wave patterns used in the pulse diagnostics, perform the function similar to that they fulfill in the technology of the information analysis of electrocardiosignals.

The theory of information function of the heart the author suggests completely agrees with the main principles of the modern information theory as well as the theory of signals and their propagation. However, the transformation (modulation) of cardiopulses into signals of the magnetic and hydrodynamic nature, channels of signal propagation in an organism and mechanisms of perceiving information (semantics of the norm and diseases) introduced into cardiosignals by organs, have specific features peculiar to the biological system alone and, particularly, to the organism of man [5]. They are the objects for further investigations.

5. Conclusion

The measurement model suggested by the author provides a basis for information analysis of electrocardiosignals with the purpose to diagnose the norm and internal diseases. It takes into account the biological features of the information function of the heart and can be used in biology and medicine in analyzing pulse signals of any biophysical nature.

References

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