

INFORMATION FUNCTION OF THE HEART. BIOPHYSICAL SUBSTANTIATION OF TECHNICAL REQUIREMENTS FOR ELECTROCARDIOBLOCK REGISTRATION AND MEASUREMENT OF ELECTROCARDIOSIGNALS' PARAMETERS ACCEPTABLE FOR INFORMATION ANALYSIS TO DIAGNOSE INTERNAL DISEASES

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Abstract. The biophysical substantiation of technical requirements to electrocardioblock for registering and measuring parameters of electrocardiosignals acceptable for information analysis for diagnosing internal diseases was given. It must be significantly different from electrocardiographs used in nowadays medical practices. It should have the frequency range up to 0,1-500 Hz, measure more precisely the amplitude of QRS-complexes and the time intervals between them, achieve robust immunity to interference by an adequate digital filtering, eliminate impulse distortion and the possibility of occurrence of impulse-interference during the whole period of cardiosignals registration

Keywords: Information Function of the Heart, electrocardiosignal measurement, technical requirements to electrocardioblock.

1. INTRODUCTION

In 2008 biophysical substantiation of the heart information function was given in publications [1, 2]. An approved technology for diagnosis of non-infectious internal diseases, based on electrocardiosignals information analysis, was offered. A measurement model [3], which underlies the information analysis technology revealed the uselessness of electrocardiographs used in practical medicine and cardiology for registration and measurement of electrocardiosignals parameters acceptable for information analysis. In the harmonic spectrum of a normal ECG at the pulse rate of 60-70 beats per 1 minute 34 harmonics in the range 0,5-120 Hz were marked out, which determined the frequency range of most modern electrocardiographs used in medical practice. However, rapid pulse expands the ECG harmonic spectrum. The harmonics of higher frequencies up to 470 Hz appear there. At a slow heart rate lower frequencies harmonics appear. For information analysis of electrocardiosignals it is important to measure precisely amplitudes of the QRS-complexes of an ECG and the time intervals between them with subsequent analysis of their dynamics [2, 3] at any pulse rate. This requires a frequency range covering all possible cardiosignal

harmonics. At a rapid pulse rate the absolute values of amplitude and repetition rate of ECG QRS-complexes become very similar and a higher level of measurements is required to differentiate them. These facts have identified the need to develop technical specifications for specialized electrocardioblock (cardiograph) intended for recording and measuring electrocardiosignal parameters acceptable for information analysis and disease diagnosis.

2. THE OBJECT AND METHODS

Materials for investigations were electrocardiograms of 600 cardio cycles obtained from 22 healthy volunteers before and after exercise and from 160 patients with various heart rates. Normal state and disease in patients were verified with a comprehensive examination using modern laboratory and instrumental methods.

Electrocardiosignals of all healthy volunteers and patients were registered and measured with an electrocardiograph with a frequency range 0,5-120 Hz used in cardiology practice as well as with experimental electrocardiographs with a frequency range 0,5-200, 0,5-300 and 0,1-500 Hz. Diagnosis was carried out with the help of information analysis technology [2, 3]. The diagnostic results obtained applying information analysis technology and modern research methods were compared taking into account the electrocardiographs frequency range.

3. RESULTS

With healthy people, when an electrocardiograph with a frequency range 0,5-120 Hz was used, the standard rate at rest was confirmed in all examined and only in 7 out of 22 (31.8%) after exercise, heart rate of which not exceed 84 beats per 1 minute. When using an electrocardiograph with a frequency range 0,1-500 Hz the standard is confirmed in 18 of 22 healthy people after exercise (91.8%). With patients at using all variants of electrocardiographs diagnoses

matched only in 23 people with the heart rate within 56-78 beats per 1 minute. When using only an electrocardiograph with a frequency range 0,1-500 Hz a complete match of diagnoses occurred in 131 out of 137 patients (95,6%). When using an electrocardiograph with a frequency range 0,5-200 0,5-300 the diagnoses were confirmed respectively in 62 out of 121 (51.2%) and 84 out of 126 (66.7%) patients. The remaining patients showed incomplete diagnoses match. A distinct relationship is revealed: at pulse rate 80 beats per 1 minute the maximum diagnostic accuracy is achieved using only an electrocardiograph with a frequency range 0,1-500 Hz. When examining 73 patients with heart rate exceeding 100 beats per 1 minute using an electrocardiograph with a frequency range 0,5-120 Hz, only single matches of some diseases were found, which showed its non-efficiency.

4. DISKUSSION

Heart has an information function [1, 2]. It generates electrical, magnetic and hydrodynamic impulses (pulse waves) propagating in a human body. Cardioimpulses have properties of a signal: amplitude vibration, repetition rate (Fig. 1) and phase deviation correspond to random non-stationary (stochastic) process and reflect their amplitude and frequency and phase modulation. Cardioimpulses are modulated (transformed) into signals when the sinus node generates them. Electrical, magnetic and hydrodynamic impulses are modulated at the same time. Cardioimpulses modulation does not depend on the central nervous system, and is equally performed by a donor heart after transplantation. Heart information function is on permanently. It is independent of a person's states or diseases. Cardiosignals contain information programs of a standard and non-infectious disease. The theory of the heart information function is fully consistent with the basic provisions of modern information theory and the theory of signals and their propagation.

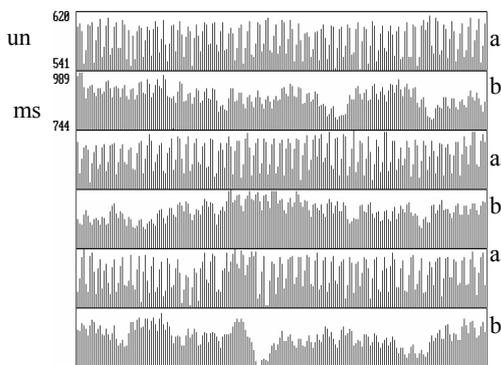


Fig. 1. Probabilistic variability of QRS-complexes amplitude (amplitudogram – a) and time intervals between them (intervalogram – b).

Technology of electrocardiosignals information analysis takes it possible to diagnose non-infectious diseases (its analog is the Chinese method of diagnosing diseases by heart rate, the hydrodynamic impulse).

Measurement model [2, 3], includes 3 stages:

1-st stage is the measurement of the amplitudes (R_n) of an electrocardiogram QRS-ventricular complexes with precision of up to 5 mkV, and time intervals (T_n) between QRS-complexes with precision of up to 0,01 ms and $tg\alpha$, where α is a “phase” angle, opposite to the R_n-R_{n+1} time interval, preceding amplitude R_{n+1} (Fig. 2);

2-nd stage is the comparison of a given set of parameters of each subsequent signal with similar parameters of the previous one, sequential coding of possible variants of comparison with symbols A, B, C, D, E, F in an array of 600 electrocardiocomplexes and obtaining the primary codogram (Fig. 3);

3-d stage is selection in codograms of healthy volunteers and patients with certain diseases of combinations of symbols of 100% occurrence and obtaining from them “code images of” a norm and certain diseases.

Comparison of a primary codogram with the reference standards of a norm and diseases opens up the possibility of internal disease diagnosis. Approbation of the information analysis technology showed that the accuracy of diagnosis depends on the accuracy of measurements of QRS-ventricular complexes of the electrocardiogram.

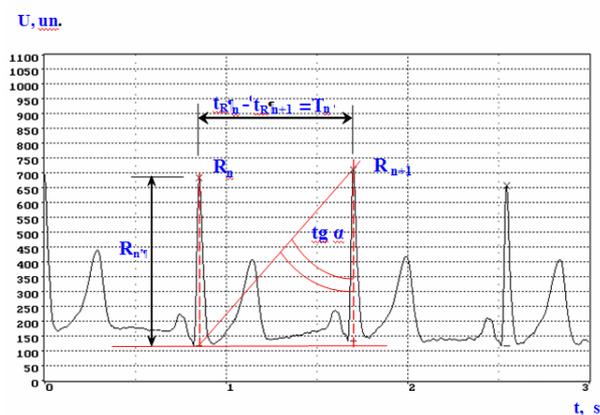


Fig. 2. The electrocardiogram of the healthy person. The measured parameters of electrocardiosignals: R_n – amplitude of the QRS- ventricular complexes, T_n – time intervals between t_{R_n} and $t_{R_{n+1}}$, $tg\alpha$ angle.

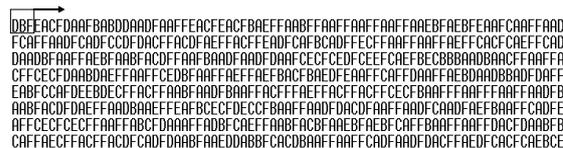


Fig.3 Primary codogram Coding symbols are three dimensional: amplitude dynamics, R_n time interval $t_{R_n}-t_{R_{n+1}}$ and $tg\alpha$ angle.

The findings of the research suggest that the electrocardiograms used in medical practice can not ensure the required accuracy of registration and measurement of electrocardiosignals acceptable for information analysis. Electrocardioblock for information analysis should have a frequency range of 0,1-500 Hz. High sampling rate of an input signal is determined by its band in conjunction with a large dynamic range of 60 dB, which is provided by the corresponding bit grid ACP, allow to measure accurately the parameters of QRS-complex of cardiosignals and evaluate the dynamics of even their minor change.

5. CONCLUSION

For information analysis of electrocardiosignals to diagnose internal diseases it is necessary to register them using an electrocardiograph with characteristics significantly different from those of conventional electrocardiographs used for ECG. The fundamental difference is the expansion of the frequency range up to 0,1-500 Hz, and a more precise measurement of the amplitude of QRS-complexes and the time intervals

between them, the achievement of robust immunity to interference by an adequate digital filtering, elimination of impulse distortion and the possibility of occurrence of impulse-interference during the whole period of cardiosignals registration.

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