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Physiological Basis and Limitations of Diagnosis of Synchronous Registration of Surface Electrocardiogram of Patients with Cervical Cancer

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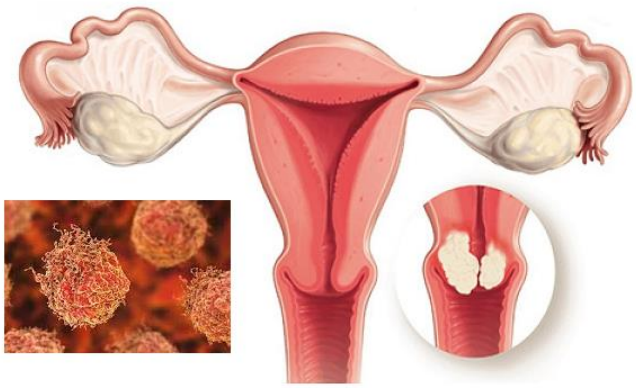
ABSTRACT

This study highlights one of the areas of modern electrophysiology of the human heart in health and in case of cervical cancer - multichannel synchronous registration of an electrostatic field on the patient's body surface. The physiological basis of the research method, hardware, methods of data analysis and presentation of results are briefly discussed. It has been shown that the limitations of diagnosis of the proposed method of analysis and interpretation of the results of electrocardiographic study can be useful in the early diagnosis of comorbid pathology of patients with cervical cancer.

GRAPHICAL ABSTRACT



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Introduction

Numerous studies indicate that comorbid pathology, when there is malignant neoplasms, requires close and timely attention of doctors, which actualizes the improvement of functional diagnostic methods [1-8]. Despite the emergence of new effective technologies for testing the functional state of the heart, electrocardiography (ECG) remains in the ranks of the leading diagnostic methods [9].

A modern ECG cannot be imagined without the use of computer technology. Thanks to such technology, an acquisition and an automatic processing of normal and long-term ECGs is carried out, a digital coding of the received signals is implemented, and effective methods of filtering and signals analysis, mathematical and electronic modeling, and mapping of electronic potentials are applied [10-15]. Because of an increase in the level of automation of ECG study using computer technology, the speed of ECG processing increased with an increase in the completeness and an increase in the convenience of using data with the use of individual storage cards of information for individual use, universal modems, network solutions, etc [16-18]. The organization of a large data archive is provided. The use of ECG data integration with the results of other examination methods (phonocardio-, rheography, measurement of blood pressure, of respiratory parameters, etc.) has been facilitated [9]. However, with the computerization of the ECG, the classical approaches to the registration and interpretation of the surface ECG have not lost their popularity and significance.

Under the "classical" or standard ECG, we mean the registration of electrical activity of the heart in 12 leads with electrodes located on the surface of the body. Common leads include three standard Einthoven limb leads (I, II, III), three Goldberger enhanced limb leads (aVR, aVL, aVF) and six Wilson chest leads (V1, V2, V3, V4, V5, V6) [19].

An important addition to the "classic" ECG is the simultaneous synchronous recording of all twelve leads, the so-called synchronous ECG. Much attention is paid to the development of means of such an ECG recording system, and it is carried out in devices of excellent companies «Siemens», «Hellige», «Bioset» (Germany), «HewlettPackard», «Schiller» (Switzerland), «FucudaDensi», «NihonKohden» (Japan), «Biomedica» (Italy).

When assessing the capabilities of a synchronous ECG, timesavings during the study and the possibility of comparing reflections in different leads of the same bioelectric heart pattern are noted. However, attention is drawn to the fact that the proposed schemes for analyzing the results of a synchronous ECG practically do not differ from the traditional ones used for single-channel sequential information acquisition. In particular, there are recommendations to determine the duration of the course of certain electrical processes in the myocardium, using the temporal characteristics of the corresponding interval in one of the valid leads.

In the literature, no strict justification has been found for the selection of leads for an adequate characterization of the duration of electrical processes occurring in the heart. The main task of the ECG study, in our opinion, should be the determination of the time of the course of electrical processes in the myocardium (quantitative physiologically meaningful analysis). The implementation of this approach is possible with a complex time analysis of the results of registration of a synchronous multichannel ECG.

The purpose of our study was to develop new methodological approaches for analyzing the results of synchronous ECG in health and in pathology, particularly those of patients with cervical cancer.

Material and methods

The study was carried out in the laboratory of electrophysiology of the course of normal physiology of the Biomedical Disciplines Department of the Medical Institute of Belgorod State National Research University.

During the study three groups of women were examined: 112 women without signs of any pathology according to the results of prophylactic medical examination (group 1), 22 patients with cervical cancer without signs of comorbid pathology (group 2) and 19 patients with cervical cancer with the presence of ischemic heart disease (IHD) (group 3). When forming groups of subjects, it seemed that the myocardium of

individuals from groups 1 and 2 has "normal" functional activity, and the myocardium of patients of group 3 - low functional capabilities. All women with verified locally advancedcervical cancer (T2bNxM0, T3bNxM0) underwent combined radiation therapy according totraditional methods excluding polychemotherapy in thetreatment regimen. Remote irradiation was carried onROKUS-M (^{60}Co), and Agat B (^{60}Co) was used for intracavitary irradiation.

All patients with IHD (group 3) had angina of effort of functional class I according to the classification of the Canadian Society of Cardiology [20].

The age of patients in group 1 was 49, 2±0, 2 years (28÷59 years), in group 2–49, 3±0, 3 years (28÷60 years), in group 3–51, 6±1,7 (31÷67 years).

ECG was performed on the hardware-software complex "Poly-Spectrum-EFSR" ("NeuroSoft" company, Ivanovo, Russia). Next, we intended to analyze a part of the polycardiographic study performed on the 12-channel ECG unit of the device. The nomenclature of indicators in processing primary ECGs was traditional [10]. In the course of the work, new indicators were proposed that characterize the time of depolarization of the atria and ventricles, the time of excitation from the sinoatrial node to the working myocardiocytes of the ventricles, the duration of the electric systole. Statistical data processing was performed using the STATISTICAforWindows8.0 software package (StatSoft, Inc.).

Result and Dissection

The A multichannel computerized system for receiving and processing ECGs has increased the volume and quality of information. The greatest interest for characterizing the bioelectrical activity of the heart muscle, both in normal conditions and with pathology, was the measurement of the P wave width, RR, PQ (R), QRS, and QT intervals. The hardware-software complex used made it possible to determine the above-mentioned intervals for all 12 standard leads automatically. Nevertheless, when forming a conclusion, it was required to rely on one of the many indicators that characterized the same process in fact.

Most researchers propose to determine temporal indicators in standard lead II [19]. The reason for choosing lead II as the main one in time analysis is obvious - more often in this lead, the ECG waves are most well expressed, which was confirmed by the analysis of the data obtained. If the electrical axis of the heart deviates from the “normal” position to the right or left, another lead may become “the best” for temporal analysis. The proposal of some authors to estimate the width of the waves and the duration of the intervals from the lead where these parameters have the greatest value did not fully satisfy [19].

ECG in different leads can be represented as a time sweep of the vector loop on the axis of this lead. The section of the vector loop can be perpendicular to the axis of the lead, and therefore form a section of the isoline on the ECG of this lead. In other leads, the same section of the cardiogram vector will form a wave. Registration of the onset of depolarization or repolarization should occur at the beginning of the "earliest" wave, and the end of the bioelectric process - at the end of the "latest" wave.

We have noted that the waves with the highest amplitude, as a rule, are also the widest, but this is not always the case. This discrepancy more often refers to the QRS complex and less often to P, T waves. A decrease in the amplitude of the QRS complex often leads to its expansion. To characterize the time of atrial de-polarization, we used the longest P wave and our method. In 97 ± 2% of observations, the amplitude of P wave was the highest in standard lead II, here P wave is easier to identify and measure its duration. Amplitude P wave≤0.25 mV was observed only in 28.3% of cases, while it was not inferior in duration to P wave in other leads.

The time of passage of excitation from the sinoatrial node to the working myocardium during synchronous ECG analysis should be defined as the interval from the beginning of the earliest P to the beginning of the earliest Q or R. Selective analysis is difficult, because you cannot choose either the shortest or the longest interval. Should the choice stop at the shortest? However,

with an isoelectric beginning of P wave, the value of this indicator can be unnecessarily "shortened". The mechanism of "shortening" of the indicator was noted only in 1 patient with IHD. The average values of indicators in all groups, the time according to the proposed method in all groups turned out to be less, but only in groups 2 and 3 this decrease was statistically significant. The time of ventricular depolarization in synchronous analysis was defined as the interval from the beginning of the earliest Q(R) to the end of the latest (R)S.

In selective analysis, preference was given to wide QRS complexes. The value of this indicator in the selective analysis was less than or equal to the value of the indicator determined in the synchronous analysis. In all surveyed cases, the time of ventricular depolarization was significantly longer when determining this indicator using the proposed method.

The duration of the electric systole of ventricular depolarization in synchronic analysis was determined as the interval from the beginning of the earliest Q(R) to the end of the most recent T. The value of this indicator, determined in the selective analysis, was greater than or equal to the value of the indicator determined by the proposed method. In all groups, the average time the ventricles were in a state of depolarization was significantly longer when determining this indicator using the proposed method.

The quantitative characteristic of the processes in the heart muscle according to the traditional method and according to the proposed one were more often different. The study of the operating characteristics of the compared approaches has established that the traditional ECG analysis is inferior in accuracy and reproducibility to the proposed method. Traditional and proposed methods of analysis of synchronous ECG were tested in clustering of morphological and functional states of the myocardium according to the ECG data. The results of the temporal analysis are grouped into clusters. In-group 1, the unification distance grows the least in-group 3–4, especially in-group 2. The results of the analysis in different groups in 3-dimensional space are consistent with the results of cluster analysis. According to the results of multidimensional scaling, the results of ECG analysis by different methods in the first group of patients have a common location in the 3-dimensional space (1A, 1B, 1C). The same can be said for other groups. The results of the analysis by different methods in groups 2 and 3 differ more than in-group 1.

When conducting factor analysis by the method of principal components, 3 significant main factors were identified. The grouping of the results of interpretation of synchronous ECGs corresponds to the results obtained in the cluster analysis and multivariate scaling. Differences in ECG interpretation methods were manifested in patients with IHD and fewer healthy.

Conclusion

The proposed methodological approaches make it possible to more reliably determine changes in the bioelectrical activity of the heart in patients with IHD. The development of an approach to the analysis of a synchronous classical ECG can become a conceptual basis for the creation of means for processing ECG data, algorithms and programs for automatic analysis of the state of the myocardium in patients with cervical cancer in the course of specific treatment.

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Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

We have no conflicts of interest to disclose.

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