Analysis of coupling between autonomic control loops of blood circulation in patients with Covid-19

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***Abstract*— This work aims to analyze the coupling between autonomic control loops of blood circulation in patients with Covid-19. In this work, we assessed the degree of coupling between the mechanisms of autonomic control using non-invasive signals of the cardiovascular system - RR-intervals signals and photoplethysmogram signals. Statistical evaluation of the study results using the methods of phase synchronization analysis did not reveal significant differences between the sample of patients with Covid-19 and healthy subjects of the corresponding age group.**

Keywords—autonomic control, cardiovascular system, phase synchronization, Covid-19

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I. Introduction

Cardiovascular diseases are the leading cause of death in all developed countries of the world [1]. Insufficient knowledge of the cardiovascular system (CVS) and the elements of its regulation, and the lack of efficient methods for early and rapid diagnosis of pathological changes, are significant problems in the fight against these diseases. Most of the existing and widely used methods for diagnosing the state of organs and body systems are based on the study of morphological manifestations of pathologies [2]. In turn, the diagnosis of functional disorders is a new and promising direction in the development of medicine since the study of deviations in the functional collective interaction of systems will prevent the further occurrence of pathological changes in organs. The analysis of the state of autonomous control of blood circulation has proven to be promising in clinical diagnostics as a sensitive marker of the development of pathologies of various organs and systems at early stages [3-8].

It should be noted that the signals of the activity of the autonomic control of blood circulation can be easily obtained non-invasively from the signals of the cardiovascular system, for example, the sequence of RR-intervals, arterial pressure oscillations according to the signals of the photoplethysmogram (PPG) and the finapress [3,9,10]

The dangerous consequences of the spreading COVID-19 pandemic forced many researchers to focus on this problem, study the features of internal systems' work in the process of infection progress, and develop diagnostic and therapeutic methods.

II. Material and methods

In this work, we obtained some experimental signals of RR-intervals and photoplethysmograms of blood vessels from patients with Covid-19 aged 25 to 68 years and healthy subjects of the corresponding age group. A standard certified polyrecorder EEGA-21/26 “Encephalan-131-03” (Medikom MTD Ltd, Taganrog, Russia) recorded the signals from patients with Covid-19. The sampling frequency was 250 Hz, the filtering bandwidth was 0.016-250 Hz for the maximum possible low-frequency transmission. The electrocardiogram was registered in 1 standard lead, according to Einthoven. The sensor for recording the photoplethysmogram was provided with an infrared emitter and was located on the ring finger of the subjects [11-12].

A standard certified recorder AngioScan-01 (Angioscan, Russia) recorded the signals from healthy subjects. Registration of the photoplethysmogram was carried out with the same parameters. RR-intervals were obtained from the photoplethysmogram signals.

In this work, the main tools were the methods of phase dynamics analysis (calculation of the coherence coefficient – RO and the previously proposed estimate of the total percentage of phase synchronization – *S*, %) [13-18]. The determination of the phase synchronization intervals in the last method was based on a linear approximation of the phase difference in a moving window. This index S (%) is the ratio of the sum of the synchronization interval lengths to the total length of the recording.

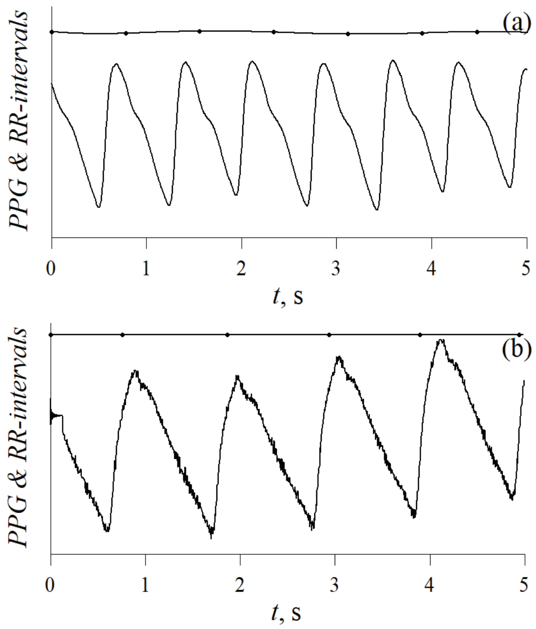

Fig. 1. Time series of RR-interval signals and photoplethysmogram for a patient with Covid-19 (a) and a healthy subject (b).

III. Results

Assessment of the phase synchronization of the processes of nervous control of heart rate (RR-intervals) and vascular tone (PPG) did not reveal significant differences between patients and healthy subjects.

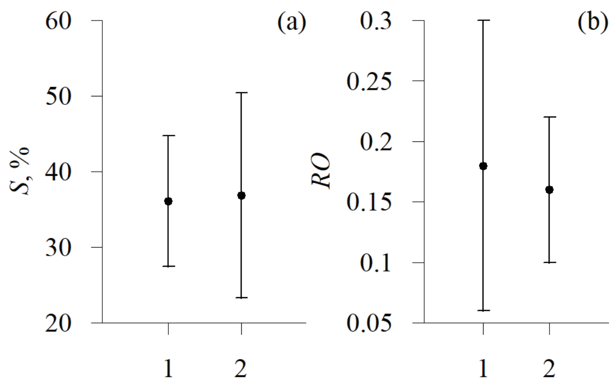

Fig. 2. The mean values of the S, % (a) and RO (b) estimates and their standard deviation for patients with Covid-19 (1) and healthy subjects (2).

IV. Conclusion

Thus, analysis of phase dynamics did not make it possible to determine the features of coupling between autonomic control loops in patients with Covid-19. This can be explained by the mild degree of infection. Since changes in the work of autonomic control were shown earlier in the study of severe patients with mechanical ventilation, which was associated with the depletion of the resources of the autonomic nervous system due to the virus. [19].

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