

# Choosing parameters for the analysis of synchronization of the autonomic regulatory contours of blood circulation in newborns

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**Abstract**—In this paper, we studied the features of the autonomic regulatory system of the heart rate and the tone of the arteries in newborns. During the experiment, we obtained 15 records of synchronous electrocardiograms and photoplethysmograms of newborns. A spectral analysis was conducted, the results of which revealed a number of features, including the presence of an LF peak at a lower frequency than is common in adult subjects. Based on these results, we have chosen new parameters to assess the degree of synchronization of the autonomic regulatory contours of the blood circulation in newborns, which contribute to the greater significance of the results.

**Keywords**—autonomic regulatory system, blood circulation, newborns

## I. INTRODUCTION

Recently, more and more attention has been attracted to methods of analyzing functional diagnostics of body systems. In turn, the state and degree of interaction between the subsystems of the regulation of the cardiovascular system (CVS) is a sensitive indicator, reflecting the degree of development of various pathologies both in the CVS and in the organism as a whole [1-5]. So, the method of estimating the degree of synchronization of the contours regulating blood circulation with characteristic frequencies of about 0.1 Hz has proven itself in practice [2-7]. When analyzing the state of the autonomous system of blood circulation regulation, special attention should be paid to the choice of method parameters, including the need to correctly determine the frequency ranges related to the influence of the sympathetic regulation system. This issue is important because the authors of this work, as well as other colleagues have identified features of the interaction of regulation systems in newborns, which makes it impossible to use the recommended methods of analyzing signals from adult patients with standard parameters and requires their correction in order to analyze the condition of this category of patients as newborns and children [9-10].

## II. MATERIAL AND METHODS

In a study of the features of the autonomic regulation of blood circulation in newborns, we conducted a series of experiments and carried out 15 records of electrocardiogram and photoplethysmogram signals during the first 3 days after birth. The ECG was a signal recording in 1 lead, the sensor of the signal of the PPG was placed on the head of the newborn. For the analysis of heart rate variability, a sequence of RR intervals (cardiointervalogram - CIG) was extracted from the ECG signal.

Analyzing the power spectrum of CIG and PPG signals in newborns, we determined the LF-peak, mainly associated with the influence of the sympathetic system, in lower frequency range (about 0.04-0.1 Hz). In adult healthy data, the LF-peak is typically located around 0.1 Hz (the recommended range is 0.04-0.15 Hz) [8].

For the method of estimating the degree of synchronization of autonomic regulatory contours of heart rate and arterial tone of adult subjects, the experimental signals are pre-filtered by band-pass filters in the range of [0.05-0.15] Hz, which allows to select only those components that are mainly associated with the influence of the sympathetic control loop in adults.

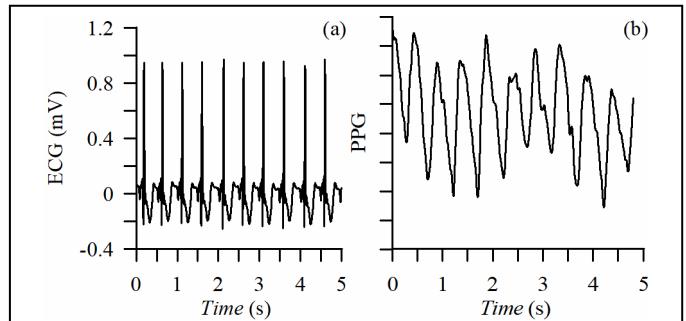


Fig. 1. The typical examples of simultaneous experimental signals for newborn A, duration 5 second: (a) — ECG, (b) — head's PPG.

However, as previously stated, in newborns the LF-peak is observed at a lower frequency than in adults. During the analysis of the degree of synchronization of the circuits of the sympathetic regulation of blood circulation in newborns, two filtration bands were chosen: 0.05-0.15 Hz and 0.04-0.1 Hz. The tables below show values of the total percentage of phase synchronization for all subjects, along with the level of significance for the two filtering options.

TABLE I. THE VALUES OF THE TOTAL PERCENTAGE OF PHASE SYNCHRONIZATION BETWEEN CONTOURS OF THE AUTONOMIC REGULATION OF HEART RATE AND VASCULAR TONE IN NEWBORN

№	Filtration band [0.05-0.15] Hz		Filtration band [0.04-0.1] Hz	
	S (%)	p	S (%)	p
1	33.16	0.06	34.30	0.81
2	25.15	0.23	40.68	0.37
3	27.37	0.46	46.18	0.35
4	14.21	0.94	31.33	0.88
5	22.80	0.83	34.29	0.90
6	19.51	0.63	50.41	0.10
7	17.22	0.82	31.55	0.65
8	13.07	0.95	28.55	1.00
9	19.97	0.86	33.14	0.76
10	24.06	0.51	<b>57.91</b>	<b>0.02</b>
11	23.03	0.53	<b>78.19</b>	<b>0.01</b>
12	18.32	0.84	20.43	0.92
13	18.40	0.74	24.84	0.89
14	16.37	0.83	<b>55.17</b>	<b>0.04</b>
15	<b>45.47</b>	<b>0.01</b>	33.26	0.59

It should be noted that when selecting the shifted filtering band [0.04-0.1] Hz, the number of significant values of the total percentage of phase synchronization increases — S (20% significant for the [0.04-0.1] Hz band and 7% significant for the [0.05-0.15] Hz band).

The average value of S is equal to 40.01 at the [0.04-0.1] Hz band and 22.54 at the [0.05-0.15] Hz band.

## III. RESULTS

Based on the obtained results on the shift of the LF-peak to a lower frequency range, we have chosen new parameters for estimating the degree of phase synchronization of the autonomic regulation of heart rhythm and vascular tone in

newborns. The selection of new filtration band [0.04-0.1] Hz increases the significance of the results.

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