

Phase Synchronization of Skin Blood Flow Oscillations under Deep Controlled Breathing in Human

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Abstract : The development of respiration-dependent oscillations in the peripheral blood flow may occur by at least two mechanisms. The first mechanism is related to the change of venous pressure due to mechanical activity of lungs. This phenomenon is known as 'respiratory pump' and is one of the mechanisms of venous return of blood from the peripheral vessels to the heart. The second mechanism is related to the vasomotor reflexes controlled by the respiratory modulation of the activity of centers of the vegetative nervous system. Early high phase synchronization of respiration-dependent blood flow oscillations of left and right forearm skin in healthy volunteers at rest was shown. The aim of the work was to study the effect of deep controlled breathing on the phase synchronization of skin blood flow oscillations. 29 normotensive non-smoking young women (18-25 years old) of the normal constitution without diagnosed pathologies of skin, cardiovascular and respiratory systems participated in the study. For each of the participants six recording sessions were carried out: first, at the spontaneous breathing rate; and the next five, in the regimes of controlled breathing with fixed breathing depth and different rates of enforced breathing regime. The following rates of controlled breathing regime were used: 0.25, 0.16, 0.10, 0.07 and 0.05 Hz. The breathing depth amounted to 40% of the maximal chest excursion. Blood perfusion was registered by laser flowmeter LAKK-02 (LAZMA, Russia) with two identical channels (wavelength 0.63 μm ; emission power, 0.5 mW). The first probe was fastened to the palmar surface of the distal phalanx of left forefinger; the second probe was attached to the external surface of the left forearm near the wrist joint. These skin zones were chosen as zones with different dominant mechanisms of vascular tonus regulation. The degree of phase synchronization of the registered signals was estimated from the value of the wavelet phase coherence. The duration of all recording was 5 min. The sampling frequency of the signals was 16 Hz. The increasing of synchronization of the respiratory-dependent skin blood flow oscillations for all controlled breathing regimes was obtained. Since the formation of respiration-dependent oscillations in the peripheral blood flow is mainly caused by the respiratory modulation of system blood pressure, the observed effects are most likely dependent on the breathing depth. It should be noted that with spontaneous breathing depth does not exceed 15% of the maximal chest excursion, while in the present study the breathing depth was 40%. Therefore it has been suggested that the observed significant increase of the phase synchronization of blood flow oscillations in our conditions is primarily due to an increase of breathing depth. This is due to the enhancement of both potential mechanisms of respiratory oscillation generation: venous pressure and sympathetic modulation of vascular tone.

Keywords : deep controlled breathing, peripheral blood flow oscillations, phase synchronization, wavelet phase coherence

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