mechanisms of lung tissue restoration. In all probability PN-II is the cambial cell with the highest proliferative potential, and providing the basis for the formation of new alveoli and restoration of the air-blood barrier.

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REACTIONS OF SKIN MICROVESSELS TO LIMB BLOOD FLOW CHANGES STUDIED BY PHOTOPLETHYSMOGRAPHY AND LASER DOPPLER FLOW

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KEY WORDS: photoplethysmography; laser doppler flowmetry; microvessels; noradrenalin; occlusion

An important theoretical and practical aspect of the problem of arterial hypertension is the study of the functional state of the microcirculatory bed, which may be evaluated on the basis of the character of responses of the microvessels to physiological factors: vasoactive substances, a change of temperature or arterial blood pressure, and so on [2-4]. Our own investigations have demonstrated altered vascular reactions of the skin to noradrenalin (NA) in patients with arterial hypertension of varied etiology: essential hypertension (EH) and pheochromocytoma [2, 6]. Vascular responses were assessed by photoplethysmography (PPG), based on measurements of the intensity of reflected monosomatic light with a wavelength of 580 nm, transformed into an electrical signal. The new, noninvasive method of studying the microcirculation, namely laser doppler flowmetry (LDF), is based on the principle of measurement of the frequency shift of monochromatic red light of wavelengths 633 nm (generated by a helium-neo laser), arising during reflection from moving blood cells [5]. This method differs

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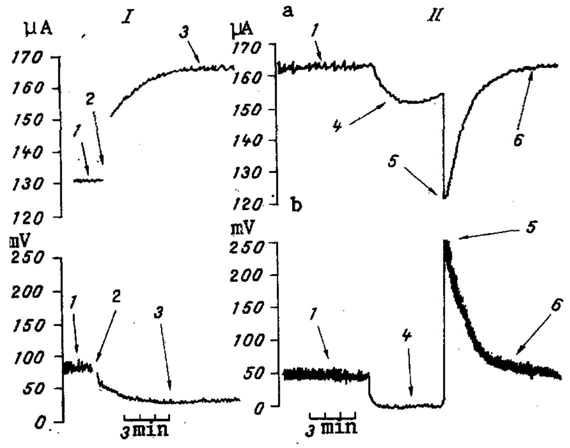

Fig. 1. Vasoconstriction in response to intradermal injection of noradrenalin (I) and reactive hyperemia (II), recorded by photoplethysmography (a) and by laser doppler flowmetry (b). 1) Background; 2) injection of nonradrenalin (NA, 10^{-6} h); 3) maximum of response to NA; 4) compression of arm by pneumatic cuff; 5) vasodilatation; 6) Restoration of blood flow. Ordinate: a) photoplethysmograph current (in μA); b) LDF signal (in mV).

from PPG in that it can be used to determine a value close to the blood flow in the surface layer of skin, as the averaged product of number of moving particles in a test volume of tissue and their velocity.

The aim of this investigation was to compare the possibilities of the PPG and LDF methods for evaluation of vasoconstrictor and vasodilator reactions of the skin of the forearm, using quantitative analysis of microvascular responses to intradermal injection of NA and to circulatory arrest in the forearm (arterial occlusion for 5 min).

EXPERIMENTAL METHOD

Tests were carried out on 25 persons: 2 clinically healthy men, 13 patients with EH of stage IB-IIA, and 10 patients with EH in stage IIB. The subjects' age varied from 25 to 50 years. The blood volume in the cutaneous vessels was measured by a PPG technique developed at the All-Union Cardiologic Scientific Center, Academy of Medical Sciences of the USSR [2]. The cutaneous blood flow was measured by the LDF method in a neighboring area of skin by means of the Periflux ("Perimed," Sweden) instrument. No medication was given during the investigation, which was conducted in the morning, before breakfast, on a recumbent subject, in the laboratory in which the air temperature was 21°C. Transducers of PPG and LDF were fixed to the skin of the medial surface of the forearm at an appropriately marked site. After measurement of the basic values of blood volume and flow, NA was injected intradermally in a dose of 10^{-6} g in 0.1 ml physiological saline, and changes in the parameters to be studied were recorded for 30 min. The amplitude of the response by the PPG method was calculated as the ratio of the maximal change in the intensities of reflected light to the basic value (Δ%), and by the LDF method, as the ratio of the maximal decrease in blood flow to the basic level (Δ%) (Fig. 1, I, a, b). Skin vasodilation was measured during reactive hyperemia after a 5-minute occlusion of arterial blood flow using a pneumatic cuff. The amplitude of the reaction was calculated by the PPG method as the difference between the maximum decrease in intensity of reflected light and the basic value, and by the LDF method as the difference between the maximum blood flow after relief of the occlusion and the basic value of blood flow (Fig. 1, II, a, b).

EXPERIMENTAL RESULTS

In all subjects, in response to intradermal injection of NA a decrease in the cutaneous blood flow, which varied in degree, was recorded by the LDF method, whereas an increase in the intensity of reflected light was recorded by the PPG method, evidence of a decrease in

TABLE 1. Parameters of Photoplethysmography and Laser Doppler-Flowmetry of Skin of Forearm before and after Intradermal Injection of NA in a Dose of 10^{-6} g

Patient	Age, years	Diagnosis	Photoplethysmography			Laser doppler-flowmetry		
			injection of NA		Δ%	injection of NA		Δ%
			before, μA	after, μA		before, mV	after, mV	
P-o	42	EH, stage IIA	130	195	48,0	69	16	76,8
T-v	26	The same	105	150	42,0	38	6	82,4
Z.	29	» »	122	164	38,4	40	11	72,5
Ts.	56	» »	150	195	30,0	36	22	38,9
Z.	29	» »	114	180	57,0	77	15	80,5
P-o	42	» «	148	198	28,8	22	18	20,0
P-o	46	EH, stage IIB	112	142	30,0	53	20	62,3
S.	49	The same	149	195	30,8	45	12	73,3
T-n	52	» »	115	194	68,6	136	24	82,4
D-v	35	» »	150	190	26,0	38	32	15,8

the blood volume in the skin area studied (Table 1). Correlation analysis revealed positive linear correlation between the amplitudes of the vasoconstrictor responses to NA recorded by the PPG and LDF methods ($r = 0.7$: $p < 0.05$; Fig. 2a).

When the blood flow in the forearm was arrested by arterial occlusion, a rapid decline of the LDF signal to zero was observed (Fig. 1, II, b, segment 4), reflecting cessation of movement of the erythrocytes in the skin microvessels. After removal of the occlusion, a marked increase in the LDF signal was recorded (Fig. 1, II, b, segment 5), evidence of an increase in the velocity of the blood flow, proportional to the degree of vasodilatation. The half-recovery time of the cutaneous blood flow ($T^1/_2$) was 1.1 ± 0.3 min (Fig. 1, II, b, segment 6). By PPG, in the period of arterial occlusion, against the background of a significant reduction of the cutaneous blood flow, a decrease in the intensity of reflected light was observed in virtually all the subjects tested (Fig. 1, II, a, segment 4). The value of this decrease was particularly great in cases when the rate of rise of pressure in the occluding cuff was reduced to 30-100 mm Hg/sec. If the rate of rise of pressure in the cuff was 200 mm Hg/sec, the amplitude of segment 4 was reduced. Evidently in the case of a low rate of compression of the forearm, the decisive factor in the decrease in the intensity of light was deposition of blood in the skin in the phase of total venous and incomplete arterial occlusion. With high rates of occlusion, the decrease in the intensity of reflected light may have been due to a change in the color of the blood under conditions of tissue ischemia. Differences in the amplitude of this segment which were observed in patients with EH can probably be explained by individual differences in the time course of tissue oxidation-reduction processes, capillary to tissue diffusion of oxygen, and O_2 utilization by the tissues [1].

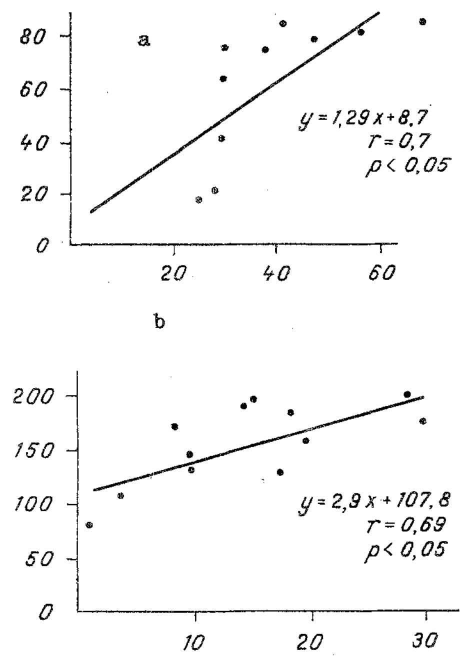

Fig. 2. Correlation between amplitude of vascular response, calculated from change in intensity of reflected monochromatic light (abscissa) and to doppler frequency shift (ordinate) during laser constriction (a) and reactive hyperemia (b).

Reactive hyperemia on the photoplethysmogram corresponded to a rapid decrease in the intensity of reflected light (Fig. 1, II, a, segment 5) followed by recovery to the initial level in the course of 1-3 min. Values of the maximal vasodilator responses obtained by PPG and LDF methods correlated with one another ($r = 0.69$; $p < 0.05$; Fig. 2b).

Parameters of vasoconstrictor (induced by noradrenaline) and vasodilator responses (reactive hyperemia), determined by methods of laser doppler fluxometry and photoplethysmography thus correlate with each other. Either of the two methods is adequate for studying cutaneous vascular reactions and can be used independently. A combination of both methods may, however, increase the reliability and informativeness of the investigation.

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MORPHOMETRY OF GIANT MULTIPOLAR NEURONS OF THE BRAIN-STEM RETICULAR FORMATION OF RATS CARRIED ON BOARD THE BIOSATELLITE "KOSMOS 1667"

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KEY WORDS: gigantocellular nucleus of reticular formation; space flight factors; quantitative analysis of neuron geometry.

Investigation of the brain of animals taking part in space flight is necessary in order to discover the mechanisms of the effect of weightlessness on the CNS. Investigations of the morphology of the nervous system in animals on board biosatellites have been published, but no attempt has been made to study the dendritic ramifications of brain neurons in such animals.

We studied giant multipolar neurons (GMN) of the gigantocellular nucleus of the brain-stem reticular formation (GNRF), which is known to be concerned with two brain functions that may be disturbed in flight: motor and vestibular. In our view, GMN are integratively-triggering "premotor cells," triggering motor responses organized at that particular brain level by consolidation into a single functional system of the corresponding number of neurons at different levels of the brain [3, 6]. These cells receive powerful vestibular afferentation [10] although their extensive dendritic territory is such that the most widely different afferent impulses can be integrated [3]. Their afferentation from the somatic [1, 6, 7] and visceral [9] brain systems has in fact been demonstrated.

The aim of this investigation was to study the geometry of the dendrites and bodies of giant multipolar neurons of GNRF of the brain stem in rats kept for 7 days on the biosatellite "Kosmos 1667" during space flight and in control experiments.

EXPERIMENTAL METHOD

Experiments were carried out on four groups of male Wistar-SPF rats (seven animals in each group): a flight group (F), the animal house control to the flight group (AC1), the ground control experimental group (GCE), and the animal house control to that group (AC2). The animals were decapitated and within 3 min a frontal block of brain tissue 4 mm thick was

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