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EFFECT OF CAROTID SINUS DENERVATION ON THE DEVELOPMENT OF HIGH-ALTITUDE ACUTE PULMONARY EDEMA

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Chemoreceptor modes, which react precisely to changes in the gas composition of the blood and which have an important influence on parameters of the hemodynamics and gas exchange in the pulmonary circulation in various hypoxic states are located in the carotid bodies [1-3, 5, 8]. The elucidation of the effect of their level of function on the oxygen balance of the body would shed light on the mechanisms of the course of pathological processes in the lungs in a hypoxic environment.

In this investigation an attempt was made to study the effect of denervation of the carotid bodies on the development of high-altitude acute pulmonary edema (HAAPE) and on the various disturbances of function in this condition.

EXPERIMENTAL METHOD

Experiments were carried out on 12 male chinchilla rabbits weighing 3.2-4.2 kg. The animals were used in the experiment 6-8 days after surgical pericarotid denervation. The rabbits were kept in a climatic pressure chamber, in which the pressure corresponded to an altitude of 5.5-6 km and the appropriate meteorological factors (temperature, air humidity, UV irradiation, velocity of the air flow, etc.) were reproduced. To study the function of the cardiovascular systems the right and left sides of the heart, aorta, and pulmonary artery were catheterized. Pressure was measured by means of a Mingograf-81 electromanometer (Elema, Sweden); the ECG was recorded in standard lead II on a 6NEK-401 instrument (East Germany). The cardiac output (CO), central blood volume, velocity of the blood flow between the right heart and ear, and the circulating blood volume (by a dye method) also were determined. The respiratory minute volume (RMV), quantity of absorbed oxygen, and respiration rate were studied at the same time.

To determine the diffusion capacity of the lungs, the blood gases and O_2 and CO_2 concentrations in the expired and alveolar air were studied.

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TABLE 1. Change in Respiration and Hemodynamics during "Ascent" of Control Animals to a High Altitude

Parameter	Initial data	Duration of exposure, min					
		60	120	180	240	300	360
Respiration rate, cycles/min	129,4±21,0	151,5±18,6**	162,0±20,5**	180,4±31,0**	176,0±24,3**	170,5±20,8**	172,0±18,9**
RMV, ml	670,0±90,6	898,6±95,0**	870,4±90,5**	845,0±102,0**	895,4±112,3**	790,0±100,6**	865,0±110,0**
O_2 concentration in expired air, percent	17,1±0,7	16,3±0,8**	16,9±0,6*	16,7±0,8*	16,7±0,9*	17,7±1,1	18,2±1,3**
O_2 concentration in alveolar air, percent	15,3±0,6	16,0±0,3**	15,7±0,5*	14,2±0,4**	13,4±0,7**	14,0±0,8**	13,8±0,4**
CO_2 concentration in expired air, percent	3,48±0,4	3,91±0,6*	4,15±0,7**	4,0±0,5**	4,0±0,64**	3,12±0,29	3,29±0,32*
CO_2 concentration in alveolar air, percent	4,9±0,3	4,6±0,7*	4,3±0,9**	4,7±0,68*	4,6±0,53*	5,0±0,67	5,7±0,41**
O_2 saturation of arterial blood, percent	89,7±3,9	58,0±5,1**	60,1±5,6**	57,6±4,6**	58,2±7,1**	56,3±5,0**	54,5±4,4**
Heart rate, beats/min	214,7±14,09	241,0±14,3*	243,0±17,0*	243,4±16,9*	249,7±13,6*	242,0±10,6*	245,6±10,2*
CO, ml/min	645,0±66,5	975,0±83,0**	963,0±105,0**	905,5±79,0**	870,5±73,5**	884,0±52,0**	879,5±73,6**
Pressure in pulmonary artery, mm Hg	13,4±2,0	18,7±2,4*	17,6±2,4*	20,3±3,2**	24,6±3,9**	22,2±3,0**	25,1±3,1**
Velocity of blood flow, sec	2,9±0,5	2,7±0,6	2,6±0,6	3,3±0,8*	4,2±0,6*	5,2±1,1**	5,6±1,2**
Pulmonary blood volume, ml	12,7±2,2	11,5±1,5	13,4±1,5	18,6±1,3*	21,7±2,4*	24,8±2,0**	25,0±2,1**

Legend. Here and in Table 2: *P < 0.05, **P < 0.02

TABLE 2. Changes in Gas Exchange and Hemodynamics during "Ascent" of Rabbits with Denervated Carotid Bodies to a High Altitude

Parameter	Initial data	Duration of exposure, min					
		60	120	180	240	300	360
Respiration rate, cycles/min	144,46±28,57	150,9±27,79*	146,6±29,77	142,69±30,92	143,3±27,9	139,61±31,26	142,15±32,48
RMV, ml	721,15±154,88	730,38±179,79	683,84±171,45*	680,0±160,48*	681,15±172,03**	645,76±128,18**	665,79±147,66*
O_2 concentration in expired air, percent	17,14±0,27	16,92±0,38**	16,89±0,44**	17,16±0,3	17,47±0,35**	15,57±0,31**	17,68±0,25**
O_2 concentration in alveolar air, percent	15,62±0,66	15,78±0,62	15,46±0,68	15,06±0,75**	14,78±0,62**	14,36±0,72**	14,21±0,60**
CO_2 concentration in expired air, percent	3,89±0,29	4,10±0,33*	4,06±0,30*	3,77±0,27**	3,36±0,26**	3,24±0,27**	3,13±0,20**
CO_2 concentration in alveolar air, percent	6,03±0,38	5,92±0,43*	5,83±0,44**	6,06±0,41	6,37±0,40**	6,56±0,37**	6,68±0,37**
O_2 saturation of arterial blood, percent	92,07±4,21	68,0±7,51**	62,23±8,8**	61,3±8,47**	59,53±8,7**	58,0±8,86**	56,3±7,85**
Heart rate, beats/min	264,8±47,1	263,8±55,4	259,9±55,9	254,4±49,1*	244,3±49,2*	240,4±47,5*	242,4±54,6*
CO, ml/min	604,6±126,8	619,6±130,7	601,9±147,0	592,7±163,9	595,7±152,6	581,9±152,4	574,2±147,6*
Pressure in pulmonary artery, mm Hg	13,9±4,0	16,2±5,1*	12,8±3,9	16,6±7,3*	18,0±7,9*	17,2±6,3*	15,7±4,9*
Velocity of blood flow,	3,22±0,6	3,10±0,4	3,10±0,4*	3,28±0,6	3,47±0,7**	3,65±0,6**	3,58±0,5**
Velocity of blood flow, sec ume, ml	17,8±2,3	16,5±3,1	16,0±3,4*	18,7±3,0	21,4±3,9**	18,9±2,0*	20,4±2,3**

All parameters were recorded in the initial state and every 60 min throughout the 6-h period of exposure. After a stay of 6 h in the climatic pressure chamber the animals were decapitated, the lung coefficient and dry residue of the lungs [5] were determined, and histological sections were prepared for diagnosis of the degree of pulmonary edema. A parallel study was made of the same parameters in a group of (10) intact rabbits for the control.

EXPERIMENTAL RESULTS

Comparison of some parameters of the hemodynamics and gas exchange showed that changes in the parameters studied during the ascent to a high altitude in the experimental group did not coincide with those in control animals.

For instance, in a medium with lowered oxygen concentration the ventilation of the lungs was intensified in the control animals and the respiration rate was increased. At the same time the function of the cardiovascular system was strengthened, CO was increased, the pulmonary blood volume was gradually increased, and the pressure in the pulmonary vessels rose (Table 1).

By contrast, in animals with denervated carotid sinuses no significant enhancement of the function of the oxygen supply systems could be observed, and toward the end of their stay at a high altitude, they showed a tendency for the ventilation function of the lungs to be depressed. The same can also said about the parameters of the hemodynamics (Table 2). In this connection the impression is created that in the group of animals with denervated carotid bodies no appreciable adaptive reactions aimed at improving the oxygen supply to the body were present.

It is an interesting fact that despite the marked increase in the intensity of gas exchange and strengthening of the hemodynamics in animals of the control group, the oxygen saturation of their arterial blood did not exceed the corresponding level in rabbits of the experimental group. This can probably be explained by a marked disturbance of correlation between ventilation of the lungs and their perfusion when the gas exchange function of the lungs is exposed to high loads.

Histological study of sections and determination of the dry residue of the lungs showed that HAAPE developed in only two cases in the experimental group (17%), whereas in the intact series it was found in four of the ten animals (40%). These results indirectly confirm data in the literature showing that the lower frequency of HAAPE in the indigenous population can be partly explained by a decrease in functional activity of the carotid chemoreceptors. HAAPE is considered to be a disease of disadaptation, i.e., it is linked with exceeding of the usual limits of adaptive changes, so that an excessive increase in adaptive responses may provoke the development of pathological states [4]. Denervation of the carotid chemoreceptor node, a key component in the regulation of the gas composition of the blood, evidently reduces the flow of afferent impulses, with the result that both "disturbing" shifts in the pulmonary system which sometimes lead to the development of HAAPE do not arise.

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