INCREASING THE RESISTANCE OF ANIMALS TO DECOMPRESSION DISEASE BY ADAPTATION TO ANOXIA AT NORMAL BAROMETRIC PRESSURE

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UDC 617-001.12-092.9-084

Preliminary adaptation of albino mice for 12 days in a medium containing 15-16% and 10-11% oxygen increases the latent period of decompression disease, alleviates its course, prolongs the survival period of the experimental animals, and lowers their mortality. The greatest increase in resistance is obtained by the use of a nitrogen — oxygen mixture containing 10-11% oxygen.

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Experiments have shown [3, 5, 7, 10] the beneficial effect of adaptation to anoxia in increasing resistance of the body to extreme factors such as a low partial pressure or toxic concentration of oxygen, ionizing radiation, and severe thermal burns.

The object of this investigation was to study the effect of adaptation to anoxia on the development and course of decompression (caisson) disease.

EXPERIMENTAL METHOD

Experiments were carried out on 668 female albino mice weighing 16-26 g. The experimental animals were kept in a closed chamber, 2.5 m^3 in volume, for 12 days in an atmosphere containing 15-16% (group 1) or 10-11% (group 2) oxygen. These oxygen concentrations in the chamber were produced by diluting the atmospheric air with gaseous nitrogen, and were maintained throughout the experiment by periodic ventilation with gas mixtures of appropriate composition. These mixtures were made up beforehand from nitrogen and compressed air in 40-liter cylinders. To absorb the carbon dioxide eliminated by the animals a granulated chemical absorbent was placed in the chamber.

TABLE 1. Morbidity and Mortality of Control and Experimental Animals (2nd day after adaptation)

Group of animals	Pressure (atm)	No. of expts.	No. of animals			
			total	dev. disease (col., convuls., paralys.)	died	survived
1	14	4	30	20	19	11
	15	5	32	28	27	5
	16	3	30	30	29	1
Control	14	4	30	25	24	6
	15	5	32	30	29	3
	16	3	30	30	30	—
2	14	5	30	8	5	25*
	15	3	30	18	17	13*
	16	4	30	28	26	4
Control	14	5	30	28	26	4
	15	3	30	30	29	1
	16	4	30	28	29	1

* $P<0{,}001$.

The control animals were kept under ordinary animal house conditions, receiving the same food and water as the experimental mice.

On the 2nd, 15th, and 30th days after completion of the adaptation period the animals were placed in a decompression chamber with a volume of 100 liters, the pressure in which was raised by introduction of a 4% nitrogen — oxygen mixture (4% O_2 and 96% N_2) to 14, 15, or 16 atm (130, 140, and 150 mm water, respectively). The compression time was 60 sec. The animals remained at maximal pressure for 15 min, after which decompression was carried out without interruption to normal atmospheric pressure within 25 sec. The latent period and clinical picture of the developing decompression disease and also the times of death and the mortality of the animals were recorded.

From 5 to 10 experimental (adapted) mice and the corresponding number of control mice of the same weight were used simultaneously in each experiment.

Department of Physiology of Underwater Swimming, S. M. Kirov Military Medical Academy, Leningrad. (Presented by Academician of the Academy of Medical Sciences of the USSR I. R. Petrov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 68, No. 9, pp. 26-29, September 1969. Original article submitted February 19, 1969.

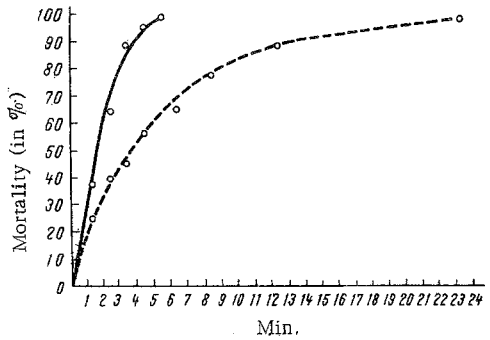

Fig. 1. Dynamics of death of animals after end of decompression (pressure 16 atm, exposure 15 min). Continuous line represents control mice, broken line experimental mice.

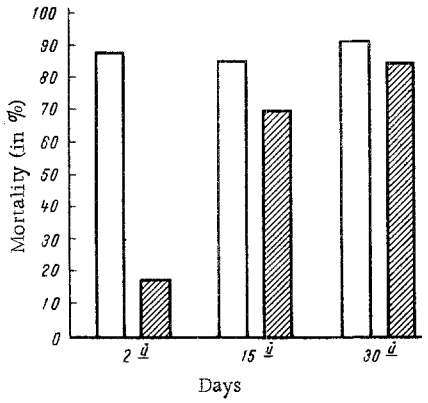

Fig. 2. Mortality of mice from decompression at various time after end of adaptation to anoxia. Unshaded columns, control; shaded columns, experimental animals.

EXPERIMENTAL RESULTS

The results given in Table 1 show that in experiments performed on the 2nd day after the end of adaptation to anoxia the resistance of the experimental animals to decompression disease was higher in every case than that of the control mice. The most marked positive effect of adaptation, manifested by a decrease in morbidity and mortality among the experimental animals, was observed when a gas mixture containing 10–11% oxygen was used.

The decrease in the positive adaptation effect with an increase in the maximal pressure was a regular phenomenon, and was explained by the progressive increase in the final saturation of the body tissues with nitrogen of the artificial gas mixtures.

The experiments also revealed a marked difference in the clinical picture of decompression disease in the control and experimental animals. Whereas the former died as a rule as a result of the development of a rapidly progressive, convulsive form of disease, in the experimental animals, on the other hand, the disease mainly developed more slowly, followed a protracted course, and took the form of collapse, paralyses of the limbs, etc. Corresponding differences were also found between the latent periods of the disease. For example, while the eventual mortality was in fact identical, of the 30 control animals 26 (86.7%) developed symptoms of a severe form of the disease (convulsions, collapse, paralysis) during the first 3 months after decompression from a pressure of 16 atm, whereas only 12 animals (40%) from among the experimental mice of group 2 developed the disease in the same period.

The positive action of adaptation to anoxia was also shown by an increase in the survival period of the experimental animals.

In the experiments at a maximal pressure of 16 atm, for instance, the mortality of the control mice and the experimental mice of group 2 was practically the same, but considerable differences were found in the time of death. The results shown in Fig. 1 demonstrate, for example, that, whereas 50% of the control animals died in the first 1.5 min after decompression, it was about 3.5 min before 50% of the experimental animals died.

Experiments carried out on the 15th and 30th days after the end of adaptation to anoxia revealed a progressive decrease in the acquired resistance of the experimental animals to decompression disease. By the 15th day after the end of adaptation (Fig. 2), the differences in mortality between the control and experimental mice of group 2 were no longer significant, and on the 30th day their mortality was 84.4 and 90%, respectively, i.e., practically the same. The disappearance of the differences was more marked still in the experiments with the animals of group 1. However, it should be emphasized that the tendency, referred to above, for an increase in the latent period of the disease and in the survival period of the experimental animals was still present in these experiments, although less marked.

Investigations of the blood and weight of the animals revealed definite changes in the experimental mice of group 2, presumably caused by their 12-day stay in a medium with a reduced (10–11%) oxygen content. These changes consisted of the development of compensatory erythrocytosis and leukopenia and a slower increase in body weight than in the control animals. These indices in the control and experimental animals two weeks after the end of adaptation were not significantly different.

The increase in resistance of the animals to decompression disease was evidently based on a complex group of changes developing in the body during adaptation to anoxia, including stimulation of the adaptive responses of the body (cardiovascular system, external respiration, red blood cells), the intimate mechanisms of tissue adaptation to anoxia, and readjustment of metabolism. This is confirmed by the results of extensive investigations [1, 6, 9, 11] indicating, in particular, the very marked adaptive powers of the cardiovascular and respiratory systems, changes in the acid-base balance, and an increase in the activity of respiratory enzyme systems in the energy metabolism of the tissue cells, and many other reactions of the body to exposure to low partial pressures of oxygen. All these changes are directed toward protection against anoxia, maintenance of an adequate oxygen supply to the cells and tissues, and economic utilization of oxygen in metabolism. Nevertheless, the leading element in the pathogenesis of decompression disease is anoxia of the organs and tissues developing through the widespread formation of intravascular and extravascular gas bubbles [4, 12]. It may therefore be considered that preliminary adaptation to a reduced oxygen concentration in the air is in the case under discussion a specific factor preparing the animal for exposure to acute anoxia and strengthening its adaptive reactions in this direction. The possibility likewise cannot be ruled out that the increased resistance to the disease may be partially due to the development of a state of nonspecifically increased resistance in the adapted animals [2, 8], leading to an increase in their resistance to oversaturation with an inert gas.

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