THE EFFECT OF ATMOSPHERIC PRESSURE REDUCTION ON THE CARDIAC ACTIVITY OF ANIMALS AT REMOTE PERIODS AFTER PNEUMONECTOMY

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In order to characterize the adaptive potentials of an organism that has undergone a pneumonectomy, it is of essential importance to study the reaction of its cardio-vascular system to hypoxia. In this work, we studied the effect of hypoxia (experiments in a barometric chamber) on rabbits at 10-26 months after a left sided pneumonectomy (27 trials on 19 rabbits) and on 17 control rabbits.

EXPERIMENTAL METHOD AND RESULTS

Reduction of the atmospheric pressure was carried out at a rate corresponding to an "altitude rise" of 1 km per 3 minutes, and then the pressure was maintained at the given level for 2-2½ minutes. Recordings were made of the electrocardiogram, and (in the majority of cases), synchronously, of the respiratory movements, both before and during the experiment for each kilometer of "altitude."

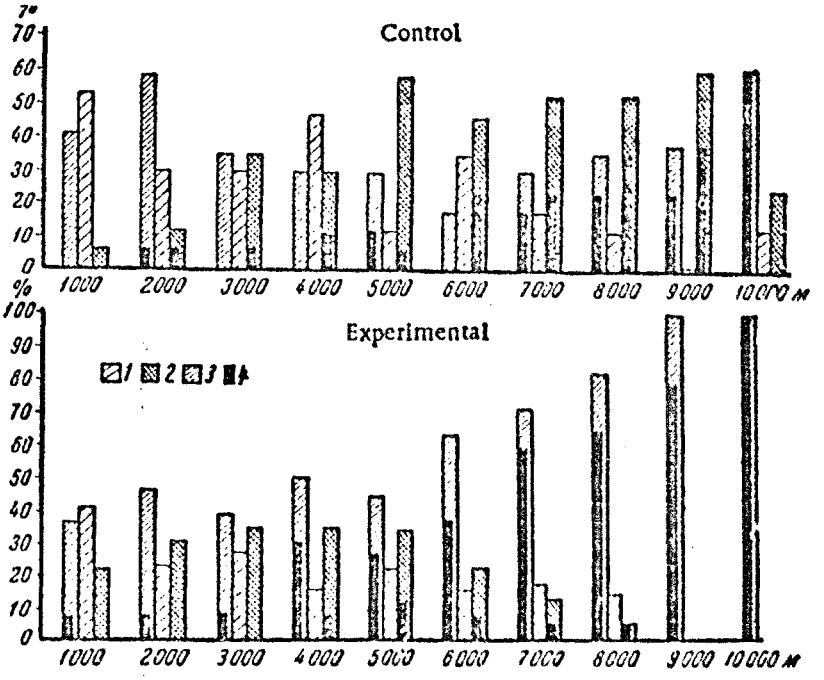

Fig. 1. Dynamics of the changes in the cardiac contraction frequency in animals with one lung, and in control animals, during reduction in the atmospheric pressure. 1) Absence of changes (ranging within the limits of ± 2% of the rhythm at the beginning of the individual experiment); 2) acceleration of the rhythm; 3) slowing of the rhythm; 4) markedly significant (more than by ± 10%) shifts in the rhythm from the original level. Height of the columns indicates the percent of experiments against their total number, the latter being taken for each "altitude" as 100%.

In many cases, at a "height" of 6-8 km the pneumonectomized rabbits showed more intense, irregular, respiratory movements and backward motions of the head. It gave the impression that the act of respiration was a heavy physical strain for the animal. In the control animals, manifest belaboring and straining of the respiration was more often observed at an "altitude" of 9-10 km. Change in the frequency of the cardiac contractions was regarded as one of the numerical criteria for appraising the circulatory reaction to hypoxia [1, 3, 4, 6, et al.]. A search of the literature failed to disclose any description of the type of reaction of the cardio-vascular system in animals with one lung to lowering of the atmospheric pressure.

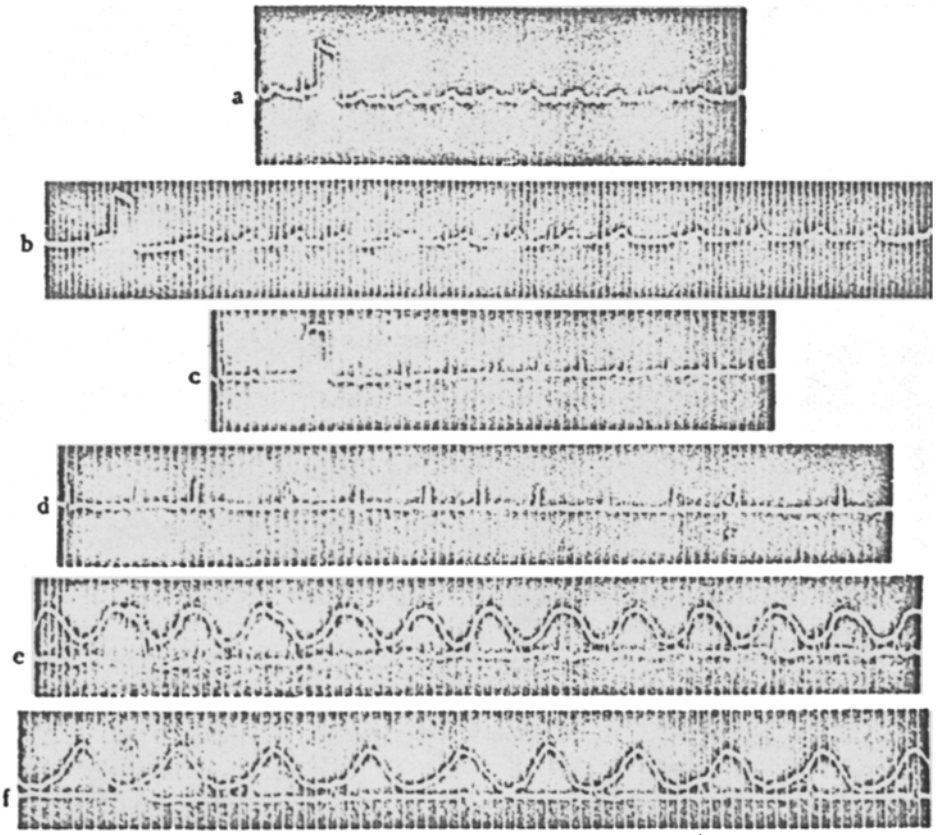

Fig. 2. Electrocardiograms and respiratory tracings for the experimental rabbits. Rabbit No. 54 (at 14 months after the operation) prior to the trial (a) and at a "height" of 6 km (b); rabbit No. 56 (at 15 months after the operation) prior to the trial (c) and at a "height" of 6 km (d); rabbit No. 163 (at 10½ months after the operation) prior to the trial (e) and at a "height" of 10 km (f).

In the pneumonectomized animals, a small acceleration of the cardiac rhythm was observed at a "height" of 1-2 km more often than in the controls (Fig. 1). However, at an "altitude" of 6 km, the number of animals in which an acceleration in the rhythm was still observed decreased sharply. At a "height" of 6-7 km, a slowing of the rhythm occurred in the overwhelming majority of rabbits, and at a "height" of 9-10 km, the slowed rhythm was observed in all the animals. In the majority of experiments, an acceleration in the cardiac rhythm was observed in the control group at a height of 5-9 km. However, at 6 km a number of the subjects showed a change from the accelerated rhythm to a slowed one, just as in the experimental group. Nevertheless, even at a height of 9 km, many of these animals still did not manifest a slowed rhythm.

It must be added that in the experimental animals, because of a major disturbance in the cardiac rhythm and a poor general state, the "altitude rise" was discontinued at a "height" of 6 km (2 trials), 7 km (2 trials), 8 km (5 trials), and 9 km (8 trials). For the same reason, the "altitude rise" for the control group of experiments was stopped at a "height" of 8 km for 3 of the rabbits, and at 9 km for one. In the majority of cases involving the pneumonectomized animals, slowing of the cardiac rhythm was associated with a manifest sinus arrhythmia which was not related

to the respiratory movements (Fig. 2f). The arrhythmia was probably functional in character: elevation of the pressure in the barometric chamber led to rapid normalization of the rhythm. In the animals of the control group, the arrhythmia was observed relatively rarely, at a great height (8-10 km), and was less apparent.

In the experimental group, changes in the electrocardiogram waves were seen in some of the trials, manifested by lowering of the voltage of the R wave, displacement of the RS – T segment level, and changes in the height and direction of the T wave (see Fig. 2). In 7 of the trials, we noted a shift in the mean electrical axis of the QRS complex (in 6 of these, it was displaced to the right). In the control, a shift in the axis was observed in 2 of the trials (displaced to the left).

In addition to the aforementioned facts, it was noted that in some of the pneumonectomized animals the changes in cardiac activity differed very little from the reaction observed in the controls, which indicated that there were still very significant reserve capacities in some of the experimental animals.

The data presented, and the results of other laboratory investigations (N. N. Gorev and co-workers [2,5]) show that for a long time the experimental animals retain, within certain limits, the compensatory state for the disrupted functions that is arrived at after the operation. However, the capacities of the cardiovascular system in adaptation of the organism to stress conditions markedly decreases, in the majority of cases, at remote periods after the operation. With lowering of the atmospheric pressure, acceleration of the cardiac rhythm is replaced relatively quickly by slowing, complicated by other disturbances in cardiac activity. The time interval for appearance of the adaptive reactions decreases.

SUMMARY

Changes of the circulation reaction in conditions of hypoxia were investigated in experiments on pneumonectomized rabbits. The cardiac rhythm was seen to reduce with declining atmospheric pressure (at the altitude of 9-10 km) in conjunction with a marked sinus arrhythmia. ECG exhibits a reduction of the R wave voltage, displacement of the RS – T segment level, the change of the value and direction of the T wave.

Experiments carried out demonstrated that experimental animals retain the state of compensation of disturbed function (to a certain limit). However, the ability of the cardiovascular system to adapt itself to difficult conditions at remote periods after the operation shows a marked reduction in most of the cases. Thus, with the reduction of the atmospheric pressure, increased rhythm is relatively soon replaced by its diminution, complicated by other disturbances of the cardiac activity.

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