REPRODUCTION AND ROENTGENOLOGIC STUDY OF ADRENALIN EDEMA OF THE LUNGS IN RATS

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From a combination of indices of gas exchange (shape of the oxygen utilization curve, body temperature, respiratory quotient) in a modified atmosphere, the possible manner of development of adrenalin edema of the lungs can be predicted. The roentgenologic characteristics of the state of the lungs, heart, and blood vessels in edema are described.

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To produce edema of the lungs, adrenalin is usually injected intramuscularly or intraperitoneally in large doses (4-8 mg/kg) [1-4, 6, 7], because small doses of adrenalin do not always cause edema to develop. The reproduction of edema of the lungs by minimal doses of adrenalin is of considerable interest.

Observations have shown that the development of adrenalin edema of the lungs in rats depends on the general gas exchange. Data allowing this relationship to be obtained in a more concrete form are described below.

EXPERIMENTAL METHOD

The general gas exchange was determined with a Buelau's spirometer in an experimental chamber for 16-20 min before the experiment began with the animals able to move freely [5]. The ventilation rate of the chamber was 0.5 liter/min. The body temperature was measured in the rectum with an electrothermometer.

Adrenalin (1:1000) was injected intramuscularly (2.5 mg/kg) after fixation of the rats. Altogether 69 experiments were carried out on female rats of different weights. The roentgenologic picture was studied in 20 experiments. Gas exchange in these rats was determined 2-3 h before the experiment. Edema was produced after the control roentgenogram had been taken. Technical conditions of roentgenography: 55-60 kV, 5 mA, 0.08-0.1 sec, magnification twice. A second roentgenogram of the chest was taken at the height of development of edema. Holding of the breath followed by complete exclusion of abdominal respiration were used as signs of development of severe pulmonary edema. The whole series of roentgenograms was processed simultaneously in the developing and fixing solutions.

EXPERIMENTAL RESULTS

Under experimental conditions changes took place in the composition of the atmosphere in the chamber. Carbon dioxide accumulated (up to 1-2.5 vol. %) and the oxygen concentration fell slightly. The animals differed in their degree of adaptation to the medium. The gas exchange, and also the body temperature, showed an increase and decrease.

It is known that rats with the same shape of gas-exchange curve and similar values of oxygen demand and respiratory quotient (RQ), and a similar respiration rate, develop edema of the lungs of about equal severity after injection of adrenalin. However, rats with identical indices of gas exchange are not often found. Analysis of the data showed that 4 types of dynamics of gas exchange can be distinguished: I) increasing, with maximum O_2 demand at end of experiment; II) balanced, remaining at the same level

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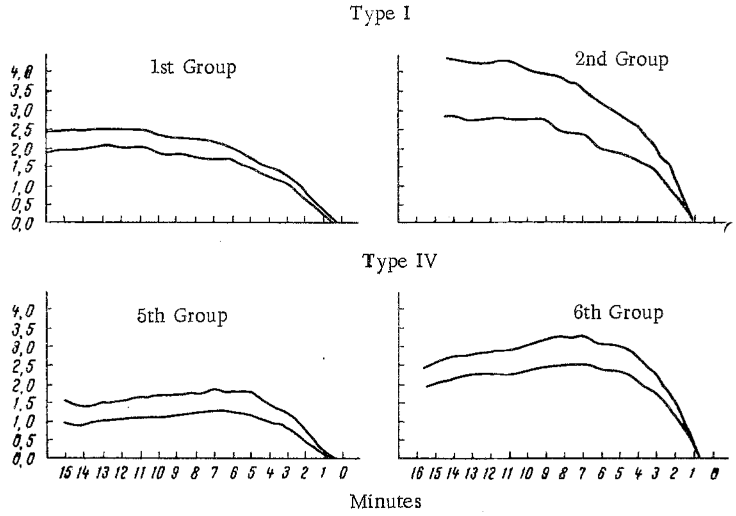

Fig. 1. Dynamics of general gas exchange of types I and IV in rats. Top curve shows O_2 deficit; bottom curve shows CO_2 concentration (in vol. %) in atmosphere of chamber (reading from right to left).

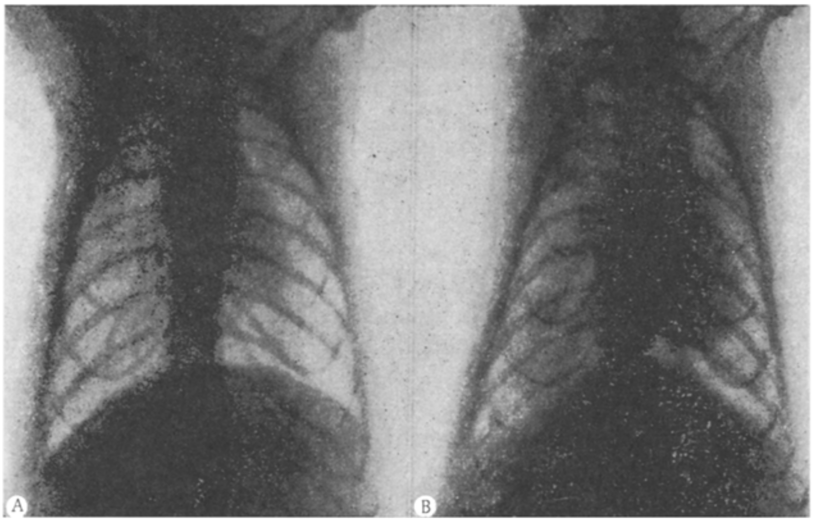

Fig. 2. Roentgenograms of rat's chest before injection of adrenalin (A) and at height of development of edema of the lungs (B).

steadily or with slight fluctuation; III) falling at the end; and IV) falling at the beginning of the experiment (Fig. 1). All changes in gas exchange were determined relative to the 6th minute of the experiment, which was taken as the initial level, when definite separation of the gas-exchange curves was usually present. Differences in the state of respiration were also taken into account: regular, mixed (regular with short bursts of periodic respiration), and with a predominantly periodic, arhythmic type of respiration.

Clearer results were obtained on rats with gas exchange of types I and IV. The pulmonary coefficient (PC) for the control rats was 0.65±0.04, and the dry residue of the lungs 20.7±0.35%.

In rats with gas exchange of type I, animals with a high body temperature and high RQ constituted group 1. After injection of adrenalin these rats developed severe edema of the lungs (Table 1). In rats of group 2, with a high body temperature and relatively higher oxygen demand, but with low RQ, edema of the lungs did not develop. In all rats of groups 3 and 4 with a lower body temperature, but with the same level of oxygen demand, marked edema of the lungs developed, following a more severe course in the rats of group 3 with higher RQ.

TABLE 1. Development of Edema of the Lungs in Fixed Female Rats in Relation to Indices of General Gas Exchange Following Intramuscular Injection of Adrenalin

Group (number of experiments)	Dynamics of gas exchange: type	Dynamics of gas exchange: Degree of change (in %)	Initial body temperature (in deg.)	O_2 demand (in ml/100 g body weight/min)	RQ	PC (in %), $M \pm m$	Dry residue of lungs (in %), $M \pm m$	Rhythm of respiration
1 (3)	I	+(33—35)	37,4—37,7	0,7—0,73	0,75—0,85	2,3±0,2	13,8±0,8	Periodic and mixed
2 (5)		+(15—40)	37,2—37,9	0,8—1,1	0,62—0,67	0,8±0,09	20,9±0,4	Regular and mixed
3 (5)		+(25—50)	36,2—36,9	0,64—0,8	0,71—0,77	1,8±0,25	16,0±0,3	Mixed
4 (4)		+(12—35)	35,6—36,4	0,56—0,96	0,6—0,67	1,2±0,3	16,5±0,4	Variable
5 (4)	IV	−(10—14)	36,2—37,4	0,84—1,1	0,7—0,79	2,0±0,23	14,2±0,5	Regular and mixed
6 (8)		−(12—40)	36,6—37,9	0,85—1,1	0,73—0,85	1,45±0,2	15,7±0,7	Regular and mixed
7 (3)		−(27—36)	36,6—37,0	1,0—1,1	0,62—0,67	0,7±0,06	20,4±0,3	Regular

In rats with gas exchange of type IV, the decrease in gas exchange began at the 5th-7th minute of the experiments and varied considerably. The gas-exchange indices of groups 5 and 6 varied within identical limits, and only the shape of the curve differed. Gas exchange of rats of group 5 had a small decrease and tendency to rise at the end of the experiment. The course of the edema in these animals was more severe, and stasis of blood was more marked than in the rats of group 6, in which a larger fall of gas exchange took place mainly toward the end of the experiment. Rats with low RQ and low limits of body temperature and oxygen demand were placed in group 7. After injection of adrenalin they developed edema of the lungs. The results indicate a close relationship between the toxic action of adrenalin and the level and dynamics of the total gas exchange.

Acute emphysema of the lungs was observed roentgenologically in all rats 5-10 min after injection of adrenalin. The transverse diameter of the chest was increased by 12-20%, the diaphragm was depressed, and the costophrenic angles were broadened. Edema of the lungs was manifested by a varied degree of uniform loss of translucency of the lung tissue, from a slight "veil" to an intense, diffuse shadowing (Fig. 2). A definite relationship was found between the decrease in translucency of the lung tissue and the emphysema, on the one hand, and the severity of edema on the other. Against the background of modified lung tissue, light bands due to the large bronchi could be seen. Dilatation of branches of the pulmonary artery indicated an increase in filling of the pulmonary vessels with blood.

In all experiments acute dilatation of the heart was found. Its transverse diameter was increased by up to 35% and its vertical diameter by 25%. In severe edema of the lungs, marked bulging of the pulmonary arch was observed, reflecting a disturbance of the outflow of blood from the right ventricle. The width of the vascular bundle consisting of aorta and vena cava was moderately increased.

LITERATURE CITED

1. V. V. Kovanov, Farmakol. i Toksikol., No. 3, 287 (1966).
2. N. V. Lazarev, in: Reproduction of Disease in Animals for Experimental Therapeutic Investigations [in Russian], Moscow (1954), p. 259.
3. D. F. Pletsityi and A. M. Monaenkov, Dokl. Akad. Nauk SSSR, 141, No. 6, 1515 (1961).
4. I. A. Serebrovskaya and E. P. Rudin, Byull. Éksperim. Biol. i Med., No. 8, 25 (1965).
5. A. I. Ulovich, in: Simulation, Methods of Study, and Experimental Treatment of Pathological Processes [in Russian], Part 3, Moscow (1967), p. 252.
6. G. Csakany, L. Varga, and I. Szam, Z. Kreisl.-Forsch., 49, 999 (1960).
7. I. Szam, I. Nikolits, I. Desi, et al., Acta Med. Acad. Sci. Hung., 21, 149 (1965).