ROLE OF LEVEL OF SEROTONIN ACTIVITY IN THE "SHOCK LUNG" SYNDROME

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Experiments on rats showed that the level of serotonin activity influences the formation of the "shock lung" syndrome. In hypoactivity tachyhypopnea is observed and the lung shows a pathomorphological picture characterized by numerous atelectases; in hyperactivity there is a corresponding tachyhyperpnea and a very small number of atelectases.
KEY WORDS: serotonin; "shock lung"; atelectasis; tachyhyperpnea; tachyhypopnea.

The pathomorphology of "shock lung" has now been adequately studied and congestion, atelectases, obstructive and functional emphysema, hemorrhages into the lung substance, edema, and so on have been observed macro- and microscopically [6, 10]. These changes, ranging from changes in the qualitative characteristics of the surfactant to the "hepatization" of lung tissue, have been studied in particular detail by Haider et al. [13].

In previous investigations [1, 7] the present writers showed that serotonin (5-HT) plays a definite role in the formation of respiratory responses to hemorrhage and shock. In connection with these facts and statements [12, 14] to the effect that 5-HT has an unfavorable action on the lung in shock, an investigation was undertaken to study the effect of this biogenic amine on the formation of the "shock lung" syndrome.

EXPERIMENTAL METHOD

Experiments were carried out on 300 albino rats of both sexes weighing 200-300 g. Traumatic shock was produced by Cannon's method. Indices of the serotoninergic reaction of the blood (5-HT activity) and monoamine oxidase (MAO) activity were determined as follows: 5-HT by a modified biological method [11] and MAO by Soloimskaya's method [9]. Blood and the lungs were taken from the animals after decapitation. In view of data in the literature [6, 10] showing that both rapid and deep respiration as well as rapid and superficial respiration can be observed during shock, the main criterion for assessing differences in the pathomorphological picture of the lungs was the number of foci of atelectasis in the lung tissue. Histological sections were stained with hematoxylin–eosin and by Van Gieson's method and impregnated by Foot's method. They were assessed visually. Ten fields of vision were examined in each preparation and the number of foci of atelectatic tissue counted in these zones and the mean number determined. To clarify the exact role of 5-HT in the formation of the pathomorphology of the "shock lung" an excess of 5-HT was produced artificially in some animals by injecting exogenous 5-HT in a dose of 100 μg/kg body weight daily for 7 days [2], and a deficiency in others by feeding the animals with reserpine in a dose of 2 mg/kg [8] and by partial depancreatization [3, 7]. The blood pressure in the carotid artery was measured with an electrotonometer. The amplitude and frequency of the respiratory movements were recorded by a thermoresistographic method on a 4EEG-1 electroencephalograph and the activity of the diaphragm, the main inspiratory muscle, calculated as the product of the frequency of impulses per second and the square of the amplitude and expressed as a percentage of the initial level, was recorded by means of steel needle electrodes. The ECG and EEG also were recorded. The latter served to reflect the severity of the animal's condition. The numerical data were subjected to statistical analysis. Significance of the differences was determined by Student's criterion.

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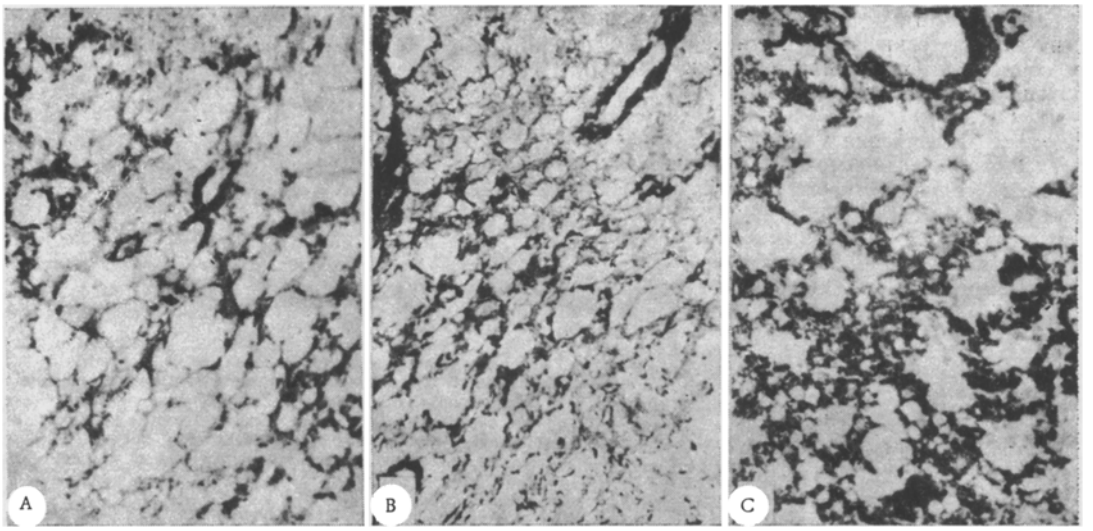

Fig. 1. Pathomorphology of the shocked lung. A) Control: normal lung tissue (impregnated by Foot's method, 63 ×); B) traumatic shock: areas of atelectasis (impregnated by Foot's method, 63 ×); C) traumatic shock: hemorrhage into stroma, areas of atelectasis absent (hematoxylin–eosin, 56 ×). Remainder of explanation in text.

EXPERIMENTAL RESULTS AND DISCUSSION

Indices of the blood serotoninergic reaction in the control group of intact animals were: 5-HT 0.99 ± 0.012 μg/ml, MAO 2.6 ± 0.068 $\mu g/ml \cdot h^{-1}$, and no changes were found in the morphological picture of the lung (Fig. 1A). In the animals with traumatic shock the blood serotoninergic reaction showed two tendencies in its development: in one group of animals (group 1) the activity of the blood serotoninergic reaction was increased (5-HT 1.98 ± 0.074 μg/ml, MAO 6.4 ± 0.236 $\mu g/ml \cdot h^{-1}$), whereas in the other group (2), conversely, it was reduced (5-HT 0.02 ± 0.004 μg/ml, MAO 1.2 ± 0.098 $\mu g/ml \cdot h^{-1}$). The morphological picture of the lung was characterized by hemorrhages into the stroma and lumen of the bronchi, edema of the peribronchial and alveolar tissue, desquamation of the bronchial epithelium, and so on. However, a detailed study revelaed differences in the pathomorphology of the lung in the animals of groups 1 and 2. In the animals of group 1 (with increased activity of the blood serotoninergic reaction) areas of functional emphysema were found in the lungs and the number of atelectases was extremely small, namely 1.4 ± 0.086 in ten fields of vision. In the animals of group 2 (with weakening of the blood serotoninergic reaction) the number of atelectases in ten fields of vision was 5.6 ± 0.138. Areas of emphysematous tissue were found extremely rarely.

It was suggested that this correlation between the pathomorphology of the lungs and the serotoninergic reaction of the blood may be linked with the functional state of the serotoninergic system. To test this hypothesis experiments were carried out on animals with an artificially induced excess and deficiency of 5-HT in the body. In animals with an experimental 5-HT deficiency the indices of the serotoninergic reaction of the blood in the initial state were: 5-HT 0.21 ± 0.006 μg/ml, MAO 1.2 ± 0.138 $\mu g/ml \cdot h^{-1}$, and in a state of traumatic shock: 5-HT 0.008 ± 0.0004 μg/ml, MAO 0.4 ± 0.012 $\mu g/ml \cdot h^{-1}$. Investigation of the pathomorphology of the lung revealed, in addition to other changes, a large number of areas of atelectatic tissue (7.2 ± 0.538 in ten fields of vision; Fig. 1B). Normalization of the blood serotoninergic reaction in the animals of this group occurred 14-16 days after trauma, and normalization of the pathomorphological picture of the lung by the 15th-16th day.

In the animals with an artificially induced excess of 5-HT the indices of the serotoninergic reaction were initially: 5-HT 1.86 ± 0.084 μg/ml, MAO 4.1 ± 0.134 $\mu g/ml \cdot h^{-1}$, and in a state of traumatic shock: 5-HT 2.19 ± 0.096 μg/ml, MAO 5.8 ± 0.636 $\mu g/ml \cdot h^{-1}$. Besides other changes, investigation of the morphological picture of the lung revealed areas of atelectatic tissue (0.9 ± 0.036 in ten fields of vision; Fig. 1C). Normalization of the blood serotoninergic reaction in the surviving animals of this group took place by the eighth to ninth day after trauma and normalization of the pathomorphological picture of the lung by the ninth to tenth day after trauma.

Investigations by Sergievskii et al. [8] and by one of us [7] showed that the level of 5-HT biological activity affects the activity of the respiratory system.

This conclusion was tested in the present experiments. In animals with an artificially induced excess of 5-HT tachyhyperpnea with an increase in the electrical activity of the respiratory muscle (diaphragm) to 176 ± 8.3% was observed during traumatic shock, whereas in animals with an experimental 5-HT deficiency tachhypopnea was observed and the electrical activity of the diaphragm was reduced by 45 ± 4.2%.

In traumatic shock changes in 5-HT activity thus evidently determine whether the activity of the respiratory system shall be of the tachyhyperpneic or tachyhypopneic type. These disturbances must ultimately affect the pathomorphological picture of the lung: In some cases the number of foci of atelectasis is very small; in others these areas predominate.

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