CHANGES IN EXPIRED AIR COMPOSITION DURING ELECTRICAL STIMULATION OF THE VENTRAL MEDULLA

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Chemosensitive structures whose activation by acid cerebrospinal fluid leads to a marked increase of ventrilation, are located in the rostral part of the ventral surface of the medulla [6]. Electrical stimulation of structures located 0.5-1 mm deeper than the chemosensitive surface (the region of the lateral paragigantocellular nucleus) causes a rise of systemic blood pressure [2, 3]. Comparative analysis of the time course of the gaseous composition of the expired air during stimulation of superficial and deep structures of the ventral portions of the medulla has not yet been undertaken.

The aim of this investigation was to study changes in composition of the expired air during electrical stimulation of structures of the rostral and caudal zones of the ventral parts of the medulla, located at different depths from the surface of the brain stem.

METHOD

Acute experiments were carried out on 6 cats weighing 2.1-2.5 kg, anesthetized with urethane (1.1 g/kg intravenously), under open chest conditions, with artificial respiration by the "VITA" apparatus and injection of heparin (1000 U/kg). The frequency and volume of respiration of the experimental animals in each experiment were chosen individually on the basis of monitoring of the composition of the expired air with an MKh-6202 mass spectrometer ($pCO_2 = 2.5 \pm 0.3\%$; $pO_2 = 17.7 \pm 0.6\%$) and of the acid-base state of the arterial blood by the BMS 3MK2 gas analyzer ("Radiometer") in the femoral artery (pH = 7.280 ± 0.020; $p_aCO_2 = 36.9 \pm 2.0$ mm Hg; $p_aO_2 = 102.6 \pm 5.3$ mm Hg). The electrodes were inserted into the brain from the ventral aspect of the brain stem. The middle of the exit of the roots of the hypoglossal nerves was taken as the zero level for determination of the points of insertion of the electrodes. A monopolar platinum electrode, covered with fluorine plastic (diameter of tip 100 μ) was inserted into the brain stem by a step manipulator 4 mm laterally to the midline and 2 mm rostrally and caudally to this point. For description a point located rostrally to the reference level will be qualified in this paper by a "plus" sign, a point caudally with a "minus" sign. The brain was stimulated by an electric current from an ÉST-14 electrical stimulator with constant frequency and duration (50 Hz, 0.5 msec) and with a current of 100-120 μA, in agreement with data in the literature [5]. The duration of electrical stimulation was 4-5 min. The systemic blood pressure was recorded in the femoral artery by means of an ID-2K pressure indicator and recorded on an N-325 automatic writer. The animal's body temperature was maintained at 37.5°C by means of an electric heater. The numerical results were subjected to statistical analysis by Student's *t* test.

RESULTS

During electrical stimulation of structures in the caudal part of the ventral zones of the medulla (at the —2 mm point) the systemic blood pressure rose from 98.3 ± 3.7 mm Hg, by 11.0 ± 3.4%; no changes could be found in the gas composition of the expired air and acid-base state of the arterial blood under these circumstances.

During electrical stimulation of structures in the ventral parts of the medulla at the —2 mm point, at a depth of 1500 μ, the systemic blood pressure rose by 36.8 ± 4.9% ($p < 0.001$); simultaneously with this an increase was

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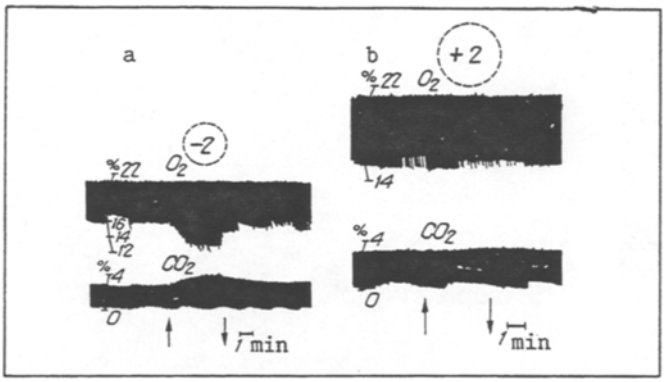

Fig. 1. Oxygen and carbon dioxide concentrations in end portion of expired air during electrical stimulation of structures of caudal (a) and rostral (b) parts of ventral medulla. Stimulation: a) at —2 mm point at a depth of 1500 μ; b) at +2 mm point at a depth of 1500 μ. From top to bottom: O_2 (oxygen concentration (in %) in expired air; CO_2) carbon dioxide concentration (in %) in expired air. Arrows indicate beginning and end of brain stimulation.

observed in the CO_2 concentration in the end portion of the expired air from 2.5 ± 0.3% to 3.6 ± 0.3% ($p < 0.05$) and a decrease in the oxygen concentration from 17.7 ± 0.6% to 15.7 ± 0.8% ($p < 0.05$) (Fig. 1a). At the 5th minute of electrical stimulation of structures at the —2 mm point and at a depth of 1500 μ the partial CO_2 pressure in the arterial blood rose from 36.9 ± 2.0 mm Hg to 43.7 ± 2.1 mm Hg ($p < 0.05$), the oxygen concentration fell from 102.6 ± 5.3 mm Hg to 92.4 ± 2.7 mm Hg ($p < 0.05$), whereas the hydrogen ion concentration was unchanged (pH = 7.240 ± 0.020). When electrical stimulation of structures in the caudal part of the ventral zones of the medulla at a depth of 1500 μ ceased, the partial pressures of O_2 and CO_2 in the arterial blood and the gas concentrations in the final portion of expired air and the systemic blood pressure level were restored after 10 min.

Thus, during electrical stimulation of structures of the caudal part of the ventral zones of the medulla at the —2 mm point and at a depth of 500 μ the systemic blood pressure rises and parameters of the gas composition of the expired air and the acid-base state of the blood are unchanged. A significant ($p < 0.05$) increase in the CO_2 concentration and a decrease in the oxygen concentration in the end portion of expired air were observed during electrical stimulation of structures at the —2 mm point at a depth of 1500 μ; under these circumstances, the systemic blood pressure and the partial pressure of CO_2 both rise whereas the O_2 concentration in the arterial blood falls. Changes in O_2 and CO_2 concentrations in the arterial blood and expired air in response to stimulation of structures in the caudal part of the ventral zones of the medulla at a depth of 1500 μ may conjecturally be caused by the effect of the latter on the animal's energy metabolism. The group of AI-noradrenergic neurons is situated in the caudal part of the ventral zones of the medulla [4]; their activation may perhaps be one cause of the change in systemic blood pressure and gas composition of the expired air and of the partial pressures of CO_2 and O_2 in the arterial blood. The rise of CO_2 and fall of O_2 in the expired air may be caused by reciprocal relations between oxygen and carbon dioxide. Since in the experiments described above the level of pulmonary ventilation remained constant due to the use of an artificial respiration apparatus, one cause of the increase in partial pressure of CO_2 in the arterial blood could be a decrease in the circulating blood volume in response to activation of catecholaminergic structures of the ventral medulla. This hypothesis is supported by data in the literature [1] on the influence of ventral medullary structures on filtration-absorption equilibrium in some organs.

In response to electrical stimulation of structures on the ventral surface of the medulla at the +2 mm point and at depths of 500 and 1500 μ, no significant changes ($p > 0.05$) were found in the O_2 and CO_2 concentrations in the end portion of expired air (Fig. 1b) or in the arterial blood; the systemic blood pressure in response to stimulation of structures at the +2 mm point and at depths of 500 and 1500 μm, increased by 10.8 ± 3.2% ($p < 0.005$) and 39.6 ± 7.8% ($p < 0.001$) respectively. Thus structures in the ventral zones of the medulla influenced not only systemic blood pressure and the regional blood flow [1, 2, 3], but the investigation showed that structures whose electrical stimulation, on the one hand, raises the CO_2 concentration in the arterial blood and end portion of the expired air,

on the one hand, and lowered the oxygen concentration in the expired air and arterial blood, on the other hand, in the caudal part of the ventral zones of the medulla at a depth of 1500 μ.

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