INFLUENCE OF NARCOSIS ON SORPTION PROPERTIES OF CEREBRAL CORTICAL CELLS

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In the present investigation an attempt was made to establish changes in the sorption properties of the cerebral cortical cells with reduced excitability of the cortex in the state of narcosis.

EXPERIMENTAL METHODS

In the experiments the method devised earlier by us [2, 3] of studying the sorption properties of the cerebral cortex in conditions of the organism was used. The experiments were conducted on white mice reared under uniform conditions. In the animal under ether narcosis the upper parts of the frontal and parietal regions of the cortex of the large hemispheres were exposed. Postoperatively, the animal recovered from narcosis in 15 minutes in a thermostat at a temperature of 33°C. The exposed section of the cortex was plunged into Ringer solution at 36-37°C, and then into a solution of vital dye at 36-37°C. Staining of the brain lasted for 45 minutes. The following vital dyes were used: neutral red at a concentration of 0.05% made up in Ringer solution without sodium carbonate, and phenol red at a concentration of 0.04%, also in Ringer solution. The experimental animals during the staining of the cerebral cortex were under narcosis and the controls were not narcotized. After 45 minute staining, the behavior of the control mice was almost indistinguishable from the behavior of the animals under narcosis. The stained sections of the parietal and frontal regions, always of uniform area and depth, were placed in acidified alcohol. The alcoholic dye extracts from the brain were subjected to colorimetry with a Pulfrich photometer. The findings obtained on the content of dye in the extract, designated by the letter "E" were multiplied by 1000 in order to facilitate statistical treatment. Statistical treatment of the data was conducted in the usual way [2,3]: the arithmetical mean was established from a series of experiments (Me) and also from a series of controls (Mc). While the difference between the arithmetical means of the experiments and controls (M) was statistically reliable (threefold error of difference) the arithmetical mean of the experiments was related to the mean of the controls. and this relation was expressed in a percentage ($\frac{Me}{Mc} \times 100$).

EXPERIMENTAL RESULTS

In the first series of experiments we studied the influence of deep ether narcosis on the absorption of the basic granular dye, neutral red, by the cerebral cortex. After rest the exposed cortex was dipped in an 0.05% solution of the dye, simultaneously the experimental mouse was narcotized. Narcosis was maintained during the entire period of staining of the brain*. The results of the experiments are presented in Table 1 from which it is clear that absorption of the neutral red by the cerebral cortex under deep ether narcosis exceeded by 69.2% take up of this dye by the cortex of the nonnarcotized control animals.

In the following series of experiments the influence of another narcotic substance, urethane, on the absorption of neutral red by the cerebral cortex was studied. Urethane is an intermediate type soporific acting on the cortex and subcortex. The narcotic dose of urethane for the mice in our experiments was 2 mg per 1 g mouse weight**. The experimental animals at the eighth minute of rest were subcutaneously given 10% solution of urethane in Ringer solution at a dose of 2 mg per 1 g weight. In 2-3 minutes the mouse was already under deep narcosis. After 15 minutes rest the exposed section of the cortex was plunged into 0.05% solution of neutral red. The temperature of the solution was maintained at a level of 36-37°C. Staining lasted 45 minutes. The control animals at the 8th minute of rest were given subcutaneously 0.5-0.6 ml Ringer solution at 36°C. The results of the experiments of this series are given in Table 2. The average amount of dye absorbed by the cortex of the experimental animals was 164.4% in relation to the controls. Consequently, in deep urethane narcosis an increase in comparison with the control of 64.4% in take up of neutral red is observed.

TABLE 1

E x 1000 Experiments	E x 1000 Controls
137	76
168	108
187	56
161	76
131	71
102	119
108	81
Me = 142 ± 11.9	Mc = 83.9 ± 8.5

$$M = +58.1$$
$$= \pm 14.6$$
$$\frac{Me}{Mc} \times 100 = 169.2\%$$

TABLE 2

E x 1000 Experiments	E x 1000 Controls
208	149
222	114
301	137
284	168
201	97
237	168
276	149
276	237
Me = 250.6 ± 13.5	Mc = 152.4 ± 14.9

$$M = +98$$
$$= \pm 20.1$$
$$\frac{Me}{Mc} \times 100 = 164.4\%$$

Narcosis in mice induced by ether and urethane, substances differing in chemical structure, was accompanied by an identical change in absorption of neutral red by the cerebral cortex. This demonstrates that intensification of take up of dye by the cortex in general narcosis cannot be explained by the specifically chemical interaction of the given narcotic with neutral red (since the chemical structure of the narcotics differed); it is due to identical physicochemical changes taking place in the cerebral cortex in a state of narcosis. Here, however, deep narcosis induced by various narcotics was accompanied by an almost equal intensification of take up of dye by the cerebral cortex (in ether narcosis by 69.2% and in urethane narcosis by 64.4%.

Thus, with a sharp reduction in the excitability of the cerebral cortex during narcosis a considerable intensification of take up of neutral red by the cortical cells is observed.

In the following series of experiments the influence of a subnarcotic concentration of urethane on take up of the dye by the cerebral cortical cells was studied. The dose of urethane taken was half the narcotic dose, i.e., 1 mg per 1 g body weight. After subcutaneous introduction of urethane the animal within 5-7 minutes lay on its side; its reflex excitability had considerably declined. The cerebral cortex was stained with 0.05% neutral red solution. As Table 3 shows, with a subnarcotic concentration of urethane, an increased take up of dye by the cortical cells of 22.5% in relation to the control cells was noted.

Thus, in narcosis and in deep sleep the cortical cells take up the dye more strongly than the cells. Here the subnarcotic dose of urethane (1 mg per 1 g weight) produces intensification of dye take up which

* In this series of experiments postoperative rest lasted 45 minutes, staining of the cerebral cortex 30 minutes.

** Such a dose of urethane induces in 2-3 minutes deep narcosis lasting from 9 to 27 hours. This condition is reversible if during the narcosis the mouse is kept at a temperature of 33°C.

is 2.8 times less than with the narcotic dose of urethane (2 mg per 1 g weight), i.e. the more the excitability of the cortex falls, the greater the take up of neutral red by the cortical cells.

TABLE 3

E x 1000 Experiments	E x 1000 Controls
155	137
181	194
134	131
187	136
194	137
181	125
161	131
181	
187	
Me = 173.4 ± 6 1	Mc = 141.5 ±8.0

$$M = +31.9$$
$$= \pm 10.3$$
$$\frac{Me}{Mc} \times 100 = 122.5\%$$

TABLE 4

E x 1000 Experiments	E x 1000 Controls
347	301
333	376
393	280
357	268
310	215
310	292
409	310
Me = 351. 3 ± 13.6	Mc = 277. 4 ± 11.7

$$M = +73.9$$
$$= \pm 17.7$$
$$\frac{Me}{Mc} \times 100 = 122.6\%$$

The increase in the take up of the basic granular dye, neutral red, under narcosis still does not directly indicate increase in the sorption properties of the cortical cells. The intensification of granule formation in the cells, possibly occuring under narcosis, may also produce an increase in take up of the granular dye.

In order to clarify the mechanism causing intensification of take up of neutral red in narcosis the following series of experiments was carried out. In the experiments of this series in order to stain the cortex we used phenol red, 0.04% in Ringer solution. Phenol red, an acid dye, which thoroughly stains protoplasm, does not form granules [7]. The conditions of the experiments were the same as in the previous series. Urethane at a dose of 2 mg per 1 g mouse weight was used as narcotic. The results of the experiments are presented in Table 4.

As is seen from Table 4, with urethane narcosis a 23.3% increase in take up of phenol red in relation to the control was observed. Consequently, even in conditions of absence of granules of the dye in the protoplasm, intensification of take up of phenol red is observed. This suggests an increase in the sorption capacity of the protoplasm of the cortical cells under narcosis.

Thus, intensification of take up of vital dyes under narcosis is caused by an intensification of the sorption properties of the protoplasm of the cortical cells and not by stimulation of granule formation. This conclusion is consistant with the fact that the increase in take up of vital dyes with reduced excitability of the cerebral cortex cannot be explained by change in pH of the protoplasm possibly taking place under narcosis. The intensification of take up under narcosis both of the basic and acid dyes cannot possibly be explained by a change in pH.

Thus, merely with subnarcotic concentrations of the narcotic, when the reflex excitability is reduced, there takes place an increase in the sorption properties of the cortical cells. With an increase in dosage of the narcotic and with fall in reflex excitability the sorption properties of the cerebral cortex increase. All this suggests that underlying the state of the cortical cells, functionally manifest in a fall in excitability, are physicochemical changes in the protoplasmic albumen in the cortical cells. These changes are reflected in an intensification of sorption properties and consist obviously in the initial denaturated transformations of the protoplasmic albumen.

The facts presented are in agreement with the findings of E. F. Ivanenko [1].

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