MORPHOLOGY AND PATHOMORPHOLOGY

The Role of Various Hierarchic Structures of the Brain in Psychoemotional Stress

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The hypothalamus is the brain structure the most involved in the formation of the stress reaction.

Key Words: *psychoemotional stress, cortex, limbic system*

The integrative role of the nervous system in the development of adaptive and compensatory manifestations at the molecular, cellular, organic, and systemic levels during extreme states (stress) is generally recognized [1,4].

However, the priority of particular brain structures in the development of the stress reaction and the maintenance of homeostasis is under debate [3,7,8].

Our objective was to evaluate the role of various hierarchic structures of the brain in maintaining homeostasis during psychoemotional stress.

MATERIALS AND METHODS

Psychoemotional stress was induced in male albino Wistar rats weighing 200-220 g by repeated (6 h every 3 days) immobilization in specially designed boxes. The animals were decapitated on days 7, 14, 21, and 30 of the experiment (groups 1, 2, 3, and 4, respectively, six animals in each). Intact rats served as a control (group 5). The brain was fixed in Bouin's fluid. Serial frontal sections were stained with hematoxylin and eosin and after Nissl. The following structures were studied: the cortex, hippocampus, and amygdaloid complex (Table 1) [2]. For objective evaluation of the state of neurons and of neurosecretory elements morphometric methods (karyometry, measuring of the area occupied by neurons, and determination of the cytoplasmic index) and an Opton microvideomat were used. The degree of neuronal damage was also assessed [5].

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RESULTS

There were no dystrophic changes in the occipital and temporal areas of the cortex. Stereometric parameters of the neurons in these areas were virtually the same as those in the control group. On day 21, moderate dystrophic changes in layers III-V of the cortex were revealed in the anterior parietal area (Fig. 1). Similar changes were found in the middle field of the anterior parietal area. In the parietal area proper slight dystrophic changes were observed in layers IV-V.

On day 30, pronounced dystrophic changes were revealed in all six layers of the cortex in the posterior frontal area. Similar dystrophic processes were evident in the frontal lobe (Fig. 2).

In all four major parts of the limbic area dystrophic changes in neurons were slight but diffusely distributed. Areas with pronounced dystrophic processes in neurons of layers II-V were found in the structures transitional between the neocortex and the limbic system.

Thus, zones in the rat brain cortex where dystrophic processes were most pronounced on days 21-30 of the experiment were defined: posterior

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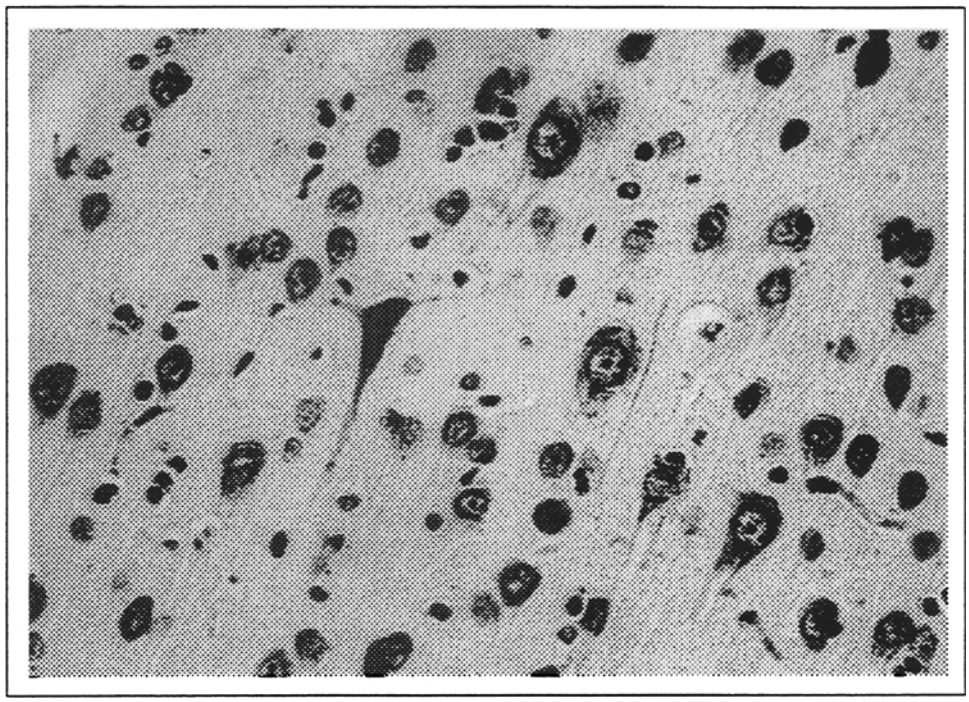

Fig. 1. Anterior parietal area of the cortex (layers III–V). Day 21 of experiment. Moderate hypertrophy of neurons. Occasional hyperchromatous neurons. Here and in Figs. 2 and 3: staining with hematoxylin and eosin, ×400.

frontal area, frontal lobe, and structures located between the limbic and neocortex areas (Table 1).

Repeated immobilization during a 30-day period induces dystrophic changes in the neurons of the hippocampus. However, they were not diffuse and did not occur in all cells, predominating in CA1 and CA3 zones (Fig. 3, *a*, *b*).

In should be mentioned that on day 7 neurosecretory activity of practically all nuclei of the hypothalamus was increased. On day 14, dystrophic changes were observed in the neurons of the paraventricular, supraoptic, suprachiasmatic, and dorsomedial nuclei. Signs of enhanced functional activity (nuclear hypertrophy and increased cell surface area) were seen in most neurons of premammillary and postmammillary nuclei. On day 21, dystrophic processes were more pronounced, particularly in the paraventricular, supra-

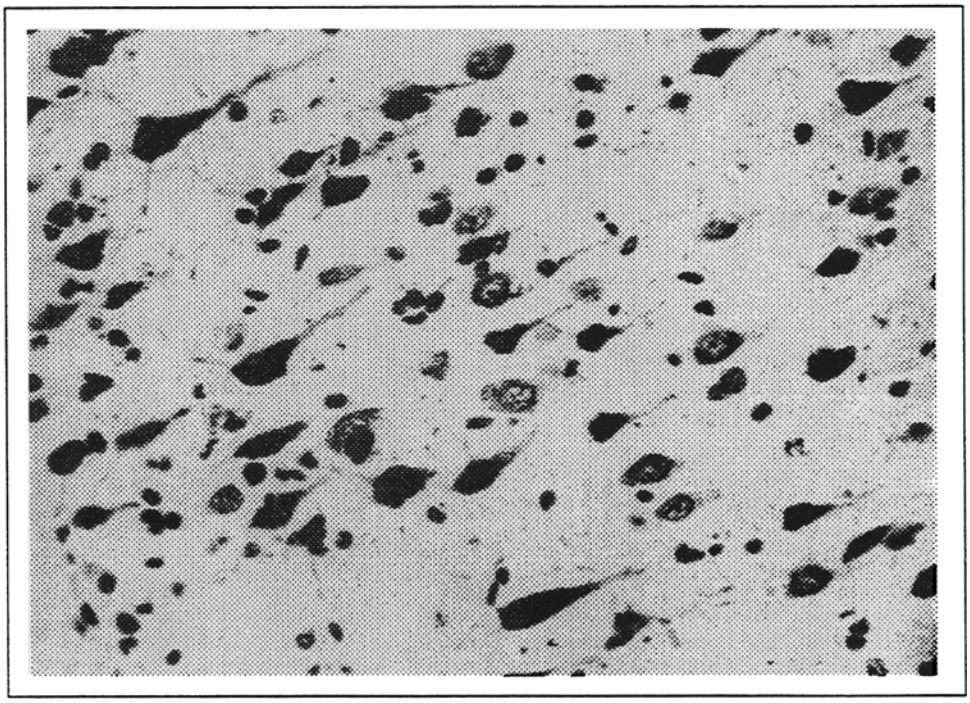

Fig. 2. Frontal lobe (layers III–V). Day 30 of experiment. Pronounced hyperchromatosis of neurons.

chiasmatic, and dorsomedial nuclei as well as in the anterior, posterior, and lateral hypothalamic fields. Most neurons in the premammillary, mammillary, supraoptic, and arcuate nuclei displayed increased functional activity. On day 30, pronounced dystrophic changes were seen in the paraventricular and dorsomedial nuclei and hypothalamic fields (Table 1).

The activity of neurons in the amygdala was increased practically throughout the experiment, only on days 21-30 some neurons with dystrophic changes being seen (Table 1).

From the analysis of morphometric and morphological data in terms of modern concepts on the morphofunctional organization of the central nervous system it was concluded that:

First, only in the hypothalamus do the most pronounced compensatory-adaptive processes occur at the beginning of the experiment, while dystrophic processes prevail at the end.

Second, dystrophic processes in the brain cortex are confined to the zones associated with the motor analyzer and overlapping of interoceptive and proprioceptive reception (frontal lobe). Zones associated with homeostasis, vision, and hearing are practically undamaged [1].

Third, the neurons of the amygdala respond by a moderate increase in functional activity, while in

TABLE 1. Degree of Neuronal Damage in the Brain of Rats Subjected to Psychoemotional Stress

Brain structure	Degree of neuronal damage, %			
	day 1	day 14	day 21	day 30
Cortex				
occipital area	0	0	2-3	2-3
temporal area	0	0	1-3	1-3
anterior parietal area	0	0	2-3	2-3
limbic system with neocortex	0	8-12	16-18	25-31
marginal areas of neocortex	0	0	0	1-2
structures between limbic system and neocortex	0	1-2	3-4	5-8
parietal area proper	0	0	0	1-3
posterior frontal area	3-4	12-16	20-24	30-36
frontal area proper	0	8-10	20-25	28-30
Hippocampus:				
zone CA1	0	5-8	15-18	24-30
zone CA2	0	0	0	3-4
zone CA3	1-2	10-12	20-25	30-40
zone CA4	0	0	1-2	3-4
Hypothalamus:				
paraventricular nucleus	1-2	8-12	30-34	55-60
supraoptic nucleus	0-1	3-4	8-12	18-24
suprachiasmatic nucleus	2-4	8-12	20-24	28-32
dorsomedial nucleus	0-2	16-20	24-28	32-40
ventromedial nucleus	0	0	0-4	4-8
arcuate nucleus	0	0	0-2	0-4
anterior hypothalamic field	0	12-14	20-24	30-40
posterior hypothalamic field	0	8-10	10-14	18-24
lateral hypothalamic field	0-1	10-12	16-18	22-26
premammillary nuclei	0	0	0-1	0-1
mammillary nuclei	0	0	0-4	8-12
Amygdala:				
lateral amygdaloid nucleus	0	0	0-1	0-2
basal amygdaloid nucleus	0	0	0-2	0-1
cortical amygdaloid nucleus	0	0	0-1	0-1
medial amygdaloid nucleus	0	0	0-2	0-1

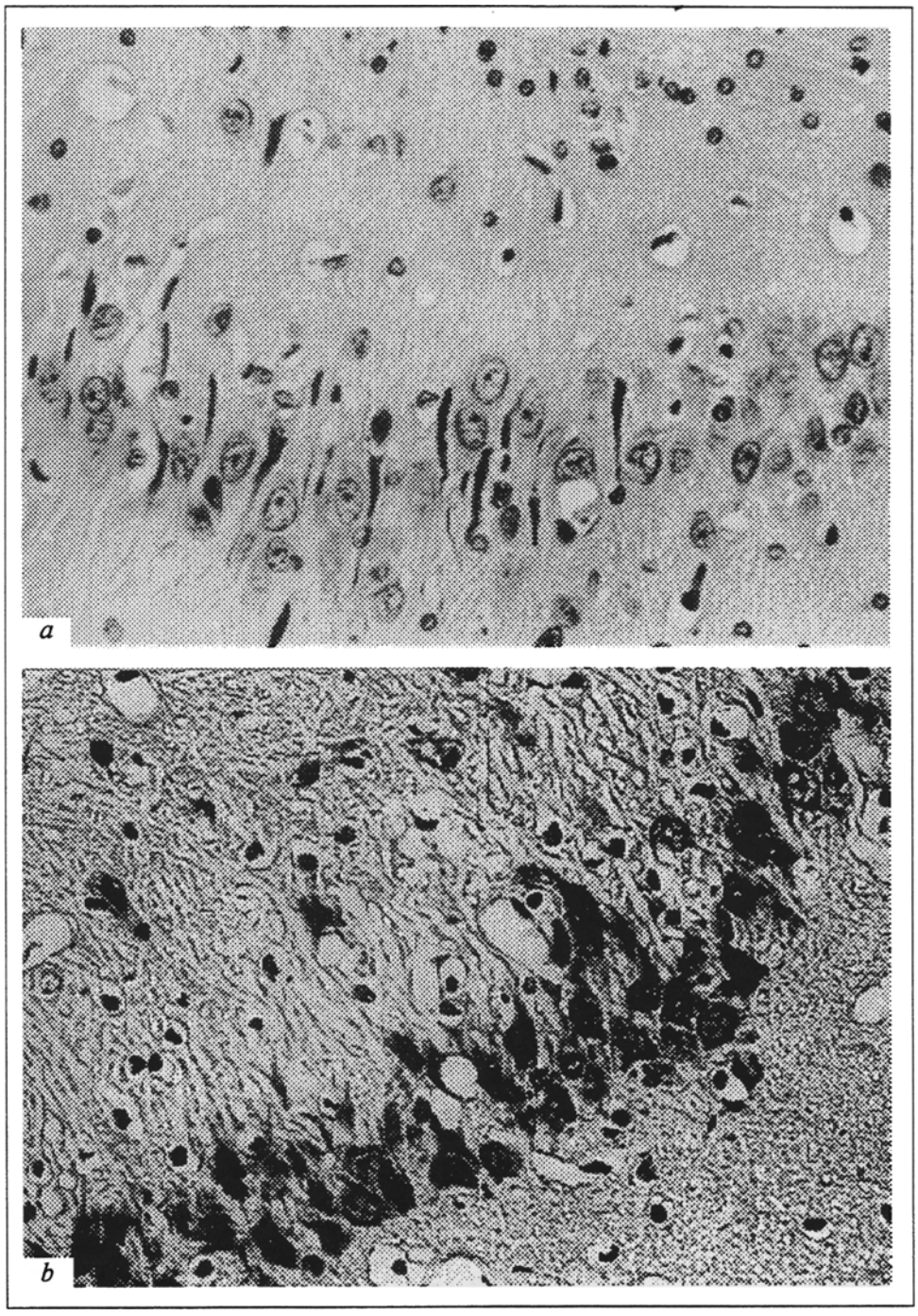

Fig. 3. Hippocampus (CA1 zone) on days 14 (*a*) and 30 (*b*) of experiment. *a*) occasional hyperchromatous neurons; *b*) pronounced hyperchromatosis of neurons.

the hippocampus (CA1 and CA3 zones) dystrophic changes develop only at the end of prolonged psychoemotional stress.

Thus, our experiments confirm that the hypothalamus has a key role to play in the response to psychoemotional stress.

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