RESPONSE OF THE HYPOTHALAMIC-PITUITARY SYSTEM OF CATS TO STIMULATION OF THE VERVICAL SYMPATHETIC NERVE AND AFFERENT FIBERS OF THE VAGUS NERVE

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Data on the functional morphology of the hypothalamic-pituitary neurosecretory system of cats during the stimulation of the cervical sympathetic nerve and afferent fibers of the vagus nerve are described. Stimulation of the sympathetic nerve selectively activates the supraoptic nucleus and causes a discharge of neurohormones from the posterior lobe of the pituitary, whereas the infundibular part of the gland contains large amounts of neurosecretory material. In response to stimulation of the vagus nerve all parts of the neurohypophysis are cleared of Gomori-positive material; both the supraoptic and the paraventricular nuclei are activated.

KEY WORDS: hypothalamic-pituitary neurosecretory system; vagus nerve; sympathetic nerve.

The influence of the hypothalamus on blood vessels is exerted mainly through the secretion of vasopressin [13]. The vascular effects of this substance are recorded in response to stimulation of the hypothalamus, sciatic nerve, and afferent fibers of the vagus [7-9].

The hypothalamic-pituitary neurosectetory system (HPNS) is activated by stimulation of the cervical sympathetic nerve [1, 6], the vagus [2, 3], and also by intraventricular injection of acetylcholine and adrenalin [3, 4]. However, there is no information in the literature on changes in the HPNS during the course of vascular reflexes.

The object of this investigation was to study responses of the HPNS to stimulation of the cervical sympathetic and afferent fibers of the vagus nerve, leading to changes in vascular tone.

EXPERIMENTAL METHOD

The hypothalamic region and neurohypophysis of cats constituted the experimental material. The cranial end of the vagus nerve, divided in the neck, was stimulated in 8 animals and the cervical sympathetic nerve in another 8 animals under chloralose anesthesia. Both series of experiments were carried out at the same time of day (from 12 noon to 3 p. m.) in October-November. In the course of the experiment five or six stimulations, each 30 sec in duration, were applied. The control animals were prepared for the experiments in the same way as the experimental animals (anesthesia, operation, dissection), but the nerves were not stimulated. At the end of the experiment the cats were killed by air embolism.

After fixation in Bouin's fluid and embedding in paraffin wax, stepwise sections through the hypothalamus and serial sections through the pituitary glands were stained by the Gomori–Gabe method and counterstained with azan by Heidenhain's method. The size of the nucleoli in the paraventricular and

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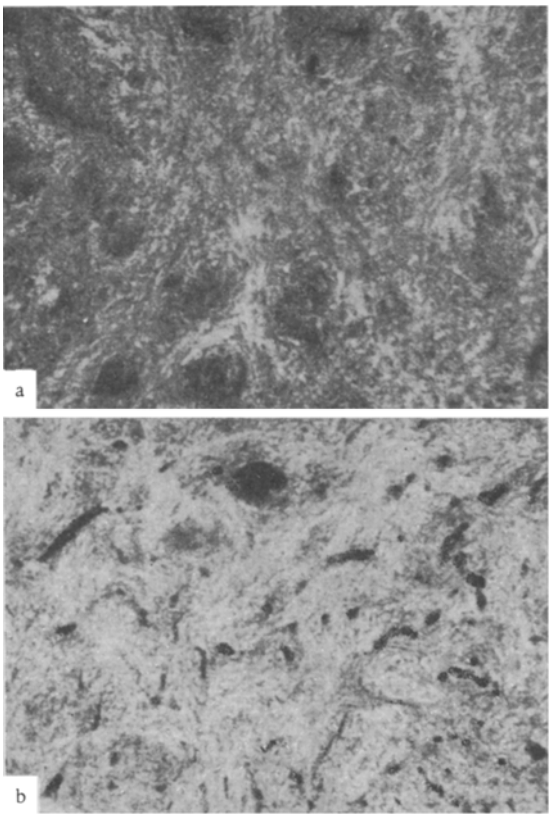

Fig. 1. Posterior lobe of pituitary (PLP) on cats. In a control animal (a) degree of filling of PLP with Gomori-positive material 3-3.5 points; neurosecretory material concentrated near blood vessel. After vagal stimulation (b) degree of filling of PLP estimated as one point, vessels strongly dilated. Stained by Gomori–Gabe method and counterstained with Heidenhain's azan, 15 × 12.5.

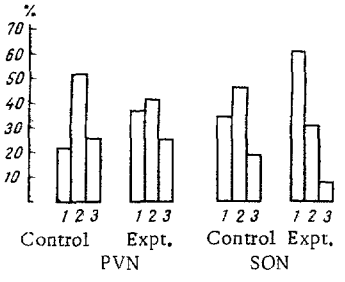

Fig. 2

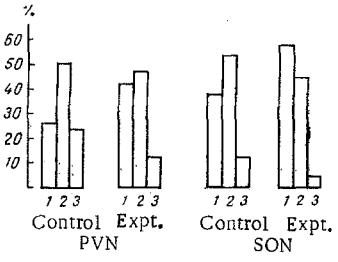

Fig. 3

Fig. 2. Distribution of neurosecretory cells by groups in animals in response to sympathetic nerve stimulation. No difference in ratios of groups of cells in control animals between supraoptic (SON) and paraventricular nucleus (PVN). Stimulation evokes activation of SON (an increase in number of group 1 cells with a corresponding decrease in the number of cells of groups 2 and 3) but has no effect on PVN. 1) Cells actively synthesizing and secreting peptide hormones; 2) darkly stained cells storing NSM; 3) small cells in a "resting" state.

Fig. 3. Distribution of neurosecretory cells by groups in animals in response to vagal stimulation. Stimulation causes activation of both nuclei (increase in number of group 1 cells with a corresponding decrease in number of cells of group 2 and 3), although SON is activated more strongly than PVN. Legend as in Fig. 2.

supraoptic nuclei and the width of the lumen of the blood vessels were measured, and the degree of filling of the posterior lobe of the pituitary (PLP) with neurosecretory substance was estimated visually (with an accuracy of 0.5 point). In addition, changes in the distribution of the neurosecretory cells by groups were assessed [5, 10-12].

EXPERIMENTAL RESULTS AND DISCUSSION

The degree of filling of PLP of the control animal with neurosecretory material (NSM) was estimated to be 3-3.5 points; NSM accumulated around the blood vessels (Fig. 1a).

In both series of experiments the content of NSM in PLP decreased in response to stimulation. In the case of sympathetic nerve stimulation the degree of filling with NSM was assessed at 1.5-2 points, but after stimulation of the vagus nerve it was 1-1.5 points (Fig. 1b). During vagal stimulation the infundibular part of the neurohypophysis contained hardly any fibers filled with NSM, whereas during the sympathetic nerve stimulation large amounts of it accumulated there, especially where the tract enters PLP. In response to sympathetic nerve stimulation the vessels of PLP were dilated by 22 ocular micrometer units (50.7 ± 2.4 in the control, 72.7 ± 1.8 in the experimental series), whereas the lumen of the vessels during vagal stimulation was the same as in the control animals. However, dissection of the vagus alone causes marked vasodilatation in PLP (to 75.4 ± 3.0 ocular micrometer units).

In response to sympathetic nerve stimulation the supraoptic nucleus was activated. The nucleoli were enlarged by a statistically significant degree (from 42.5 ± 1.6 ocular micrometer units in the control to 49.5 ± 1.8 in the experimental series) and the number of cells in group 1 increased, with a corresponding decrease in the number of cells of groups 2 and 3 (Fig. 2). In the control animals there was no difference in the distribution of neurosecretory cells between the supraoptic and paraventricular nuclei, and there was likewise no difference in the size of the nucleoli. Sympathetic nerve stimulation evoked different responses in these nuclei. In the experimental animals both indices of the state of the neurosecretory nuclei pointed to activation of the supraoptic nucleus, but no such changes were found in the paraventricular nucleus. These results are in full agreement with those obtained by V. V. Aleshin and co-workers [1].

Stimulation of the vagus nerve causes activation of the paraventricular nucleus to a statistically significant degree, as shown by changes in the distribution of neurosecretory cells and a slight change in size of the nucleolus. To judge from both criteria of the state of the neurosecretory nuclei, the degree of activity of the supraoptic nucleus was much higher during vagal stimulation than the degree of activity of the paraventricular nucleus (Fig. 3). In response to stimulation of both the vagus and the sympathetic nerve the supraoptic nucleus was activated equally. During vagal stimulation the paraventricular nucleus contained cells with larger nucleoli and more group 1 cells and with correspondingly fewer cells of groups 2 and 3 than during the stimulation of the sympathetic nerve. The greater activity of HPNS during stimulation of the vagus could also be reflected by the almost total emptying of all parts of the neurohypophysis in these animals.

The histophysiological data obtained in these experiments confirm the view that peptide neurohormones, vasopressin in particular, participate in the mechanism of vascular reactions.

LITERATURE CITED

1. B. V. Aleshin, The Histophysiology of the Hypothalamic-Pituitary System [in Russian], Meditsina, Moscow (1971).
2. A. A. Galoyan, "The participation of acetylcholine in the formation and liberation of neurosecretion by the cells of the hypothalamus," Probl. Éndokrinol., No. 2, 30 (1963).
3. A. A. Galoyan, Some Problems in the Biochemistry of Hypothalamic Regulation [in Russian], Erevan (1965).
4. M. S. Konstantinova, "The effect of adrenaline and acetylcholine on the hypothalamic-hypophyseal neurosecretion in the rat," Z. Zellforsch., 83, 549 (1967).
5. A. L. Polenov, Hypothalamic Neurosecretion [in Russian], Nauka, Leningrad (1968).
6. A. V. Tonkikh, "The question of experimental hyperthyroidism. I. Experiments with chronic stimulation of the sympathetic nerves," Fiziol. Zh. SSSR, 26, No. 5, 455 (1939).
7. A. V. Tonkikh, The Hypothalamic-Pituitary Region and Regulation of the Physiological Functions of the Body [in Russian], Nauka, Leningrad (1965).
8. A. V. Tonikh, A. I. Il'ina, and S. I. Teplov, "Pharmacological analysis of the mechanism of changes in the blood pressure and coronary circulation after nociceptive stimulation," Fiziol. Zh. SSSR, No. 12, 1456 (1960).

9. A. V. Tonkikh, A. I. Il'ina, and S. I. Teplov, "Changes in the coronary circulation and blood pressure in response to stimulation of the hypothalamic region," Fiziol. Zh. SSSR, No. 7, 802 (1961).
10. A. W. Cowly, E. Mono, and A. C. Guyton, "Interaction of vasopressin and the baroceptor reflex system in the regulation of arterial blood pressure in the dog," Circulat. Res., 34, 505 (1974).
11. R. E. J. Dyball, "Oxytocin and ADH secretion in relation to electrical activity in antidromically identified supraoptic and paraventricular units," J. Physiol. (London), 214, 245 (1971).
12. J. N. Hayward and D. P. Jennings, "Activity of magnocellular neuroendocrine cells in the hypothalamus of unanaesthetized monkeys. I. Functional distribution in the supraoptic nucleus and the internuclear zone," J. Physiol. (London), 232, 515 (1973).
13. J. N. Hayward and D. P. Jennings, "Activity of magnocellular neuroendocrine cells in the hypothalamus of unanaesthetized monkeys. II. Osmosensitivity of functional cell types in the supraoptic nucleus and internuclear zone," J. Physiol. (London), 232, 545 (1973).