FUNCTIONAL DIFFERENCES BETWEEN THE MAGNOCELLULAR NEUROSECRETORY HYPOTHALAMIC NUCLEI IN RATS

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The supraoptic (SON), paraventricultr (PVN), and postoptic (PON) nuclei of the hypothalamus were studied in rats after prolonged adaptation to hypoxia in a pressure chamber (exposure for 6 h daily for 3 months to a simulated altitude of 7600 m). Morphometric measurements showed that the functional activity of all three nuclei rises during the first 5 days of the experiments, but later differences are found in the response of the neurosecretory nuclei. By the 20th day the state of SON is back to normal, but in PVN and PON a reduction in the size of the nucleoli and in the content of neurosecretory substance is evidence of depression of the functional activity of these nuclei. Positive correlation also was found between the volume of the nucleoli in the cells of PON and PVN and the height of the follicular epithelium of the thyroid gland ($r = 0.82$ and 0.81 respectively, $P < 0.05$) whereas no such correlation was found for the cells of SON ($r = 0.5$, $P > 0.05$).

KEY WORDS: hypothalamic neurosecretion; thyroid gland; hypoxia.

The hypothalamic-hypophyseal neurosecretory system in mammals includes the paraventricular (PVN), supraoptic (SON), and postoptic (PON) (sometimes called retrochiasmatic) hypothalamic nuclei. However, most investigators of the neurosecretory system have concentrated their attention mainly on SON and PVN, possibly because PON is often regarded as part of SON [8, 9, 11]. Only comparatively recently have data been published on certain peculiarities in the response of PON [10, 12]. Differences in the response of SON and PVN to different experimental factors have often been described [1, 13, 14], but the state of PON has not been analyzed under these circumstances. Comparison of the response of all three magnocellular neurosecretory centers under experimental conditions is particularly interesting because the question of the functional identity of SON and PVN is still a matter for debate [7, 14, 15].

EXPERIMENTAL METHOD

Male Wistar rats in two series of experiments were adapted to hypoxia in a pressure chamber in which the simulated altitude was gradually raised from 2000 m on the 1st day to 7500 m on the 14th day of the experiment, after which it remained unchanged. The animals were kept in the pressure chamber for 6 h daily and the experiments continued for 3 months. The hypothalamic neurosecretory nuclei (SON, PON, PVN) were investigated in the same animals as those in which changes in the thyroid gland were described by the writer previously [5].

The diameter of the nucleoli of the neurosecretory cells of SON, PON, and PVN was measured in brain sections 6μ thick, stained with paraldehyde-fuchsin by the Gomori–Gabe method and counterstained with azan by Heidenhain's method. The volume of the nucleolus was calculated by the equation for the volume of a sphere.

EXPERIMENTAL RESULTS AND DISCUSSION

No marked changes could be found in the state of the neurosecretory cells of SON in the course of the experiments, although measurement of the nucleoli revealed a small increase in their volume during the first 5 days of the experiments. Meanwhile a small number (3-4%) of binucleolar cells was observed to appear. However, by the 30th day of the experiments the cells of SON were virtually indistinguishable from the control (Fig. 1A).

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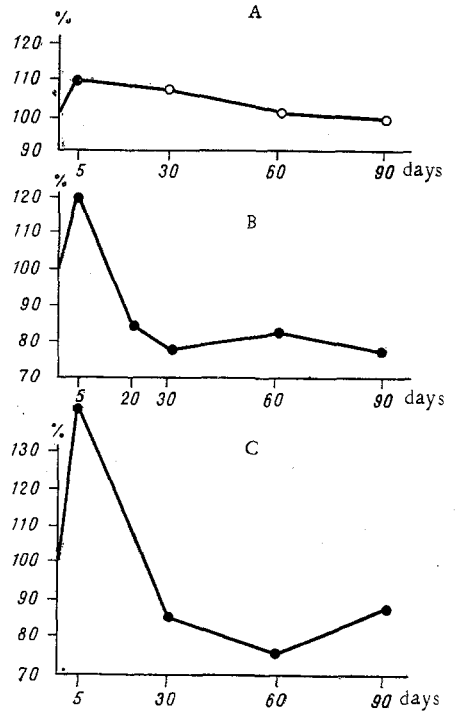

Fig. 1. Volumes of nucleoli of neurosecretory cells of supraoptic (A), paraventricular (B), and postoptic (C) hypothalamic nuclei during prolonged adaptation to hypoxia. Filled circles, $P < 0.05$; empty circles, $P > 0.05$. Abscissa, duration of experiments in days; ordinate, volume of nucleoli in % of control (100%).

The changes were clearest in PVN. During the first 7 days of the experiments many neurosecretory cells containing two or even three nucleoli were found (this is considered [8, 9] to be a sign of high functional activity of neurosecretory cells). The number of these polynucleolar cells in some rats in the experiments exceeded 30% (control 7%). By the 3rd day of the experiment there was a marked increase in the quantity of Gomori-positive neurosecretory material (NSM) in the perikarya and processes of PVN cells (Fig. 2).

A large number of neurosecretory fibers filled with NSM sometimes remained in the region of PVN until the 20th-30th day of the experiments, although by that time most cells had only a little NSM or were almost free from it. The nucleoli of the neurosecretory cells were reduced in size (Fig. 1B), the rim of Nissl's substance was narrowed, and the binucleolar cells had disappeared. By the end of the experiment, on the 90th day, all these changes were seen most clearly.

The changes in PON were in the same direction as those in PVN. At the beginning of the experiment the neurosecretory cells and their nuclei and nucleoli were enlarged, although the number of polynucleolar cells was increased less than in PVN. Many neurosecretory fibers containing NSM also appeared in the region of PON (Fig. 3). After the 7th day of the experiment the nucleoli were considerably reduced in size and less NSM was present in the neurosecretory cells and their fibers. This state of PON persisted until the end of the experiment (Fig. 1c).

Hence, in all three hypothalamic nuclei examined the changes at the beginning of the experiment (the first 5-7 days) were in the same direction and indicated intensive secretion formation (an increase in the volumes of the nucleoli and the appearance of polynucleolar cells). Later, however, differences appeared in the state of SON, PON, and PVN (Fig. 1). To judge from all the evidence the state of SON returned to normal, whereas the changes in the cells of PVN and PON point to depression of their function (a decrease in the volumes of the nucleoli, disappearance of the polynucleolar cells, a gradual decline in the NSM content in the cells and processes).

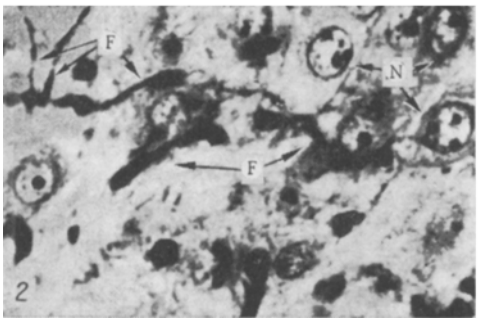

Fig. 2

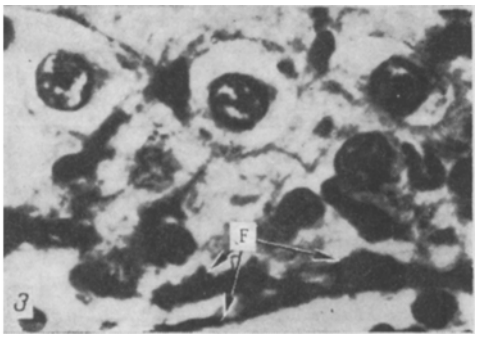

Fig. 3

Fig. 2. Paraventricular hypothalamic nucleus, 7th day of experiment. N) Polynucleolar neurosecretory cells; F) neurosecretory fibers filled with neurosecretory material. Fixation with Bouin's fluid; stained with paraldehyde-fuchsin by Gomori–Gabe method and counterstained with Heidenhain's azan; 60×.

Fig. 3. Postoptic hypothalamic nucleus, 7th day of experiment.

Comparison of changes in the volumes of the nucleoli of the neurosecretory cells with the height of the thyroid follicular epithelium in the same animals [5] showed positive correlation between these two parameters for PVN (coefficient of correlation $r = 0.82$, $P < 0.05$) and also for PON ($r = 0.81$, $P < 0.05$) but no correlation between the changes in the thyroid gland and in SON ($r = 0.5$, $P > 0.05$). These results support the view that the functions of PON, PVN, and the thyroid gland are connected and they contradict the notion that the mutual influences of SON and the thyroid gland are antagonistic in character [1, 2]. The results also show that during prolonged adaptation to hypoxia the responses of PVN and PON are similar. However, this one observation is insufficient for it to be deduced that these nuclei are functionally identical. It has already been shown that under other conditions changes in SON and PON are similar in character [6, 9, 11]. To sum up our own findings and those in the literature, it can be tentatively suggested that PON possesses certain special functional features which distinguish it both from PVN and from SON.

Investigations by many workers have shown that SON and PVN respond to a variety of short-term stressors similarly, by an increase in their functional activity [3, 4, 14]. That is perhaps why it has been widely accepted that the functions of these neurosecretory centers are completely identical, a view for which support has recently been given by immunohistochemical investigations [15]. However, long-term experimental procedures have revealed differences in the responses of SON and PVN [1, 3]. In the present investigation this pattern (the similarity of the response to short-term and differences in the response to long-term experimental factors) is demonstrated for all three hypothalamic neurosecretory centers studied.

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