LITERATURE CITED

1. G. V. Vygodchikov and L. B. Balayan, Zh. Mikrobiol., No. 12, 75 (1969).
2. M. A. Zakhar'evskaya and N. N. Anichkov, Byull. Éksp. Biol. Med., No. 6, 62 (1952).
3. O. B. Kuzovleva, in: Immunochemical Analysis [in Russian], Moscow (1968), p. 43.
4. N. T. Raikhlin and I. M. Shnaidman, Histochemistry of Connective Tissue in Silicosis [in Russian], Moscow (1970).
5. V. V. Serov, in: Proceedings of the 8th Plenum of the Council of the All-Union Society of Pathological Anatomists [in Russian], Tashkent (1975), p. 3.
6. I. A. Tarkhanova, in: Immunochemical Analysis [in Russian], Moscow (1968), p. 79.
7. C. De Duve and R. Wattiaux, Ann. Rev. Physiol., 28, 435 (1966).


# EFFECT OF EXTIRPATION OF THE CERVICAL SYMPATHETIC GANGLIA ON POSTNATAL DEVELOPMENT OF THE PARAVENTRICULAR HYPOTHALAMIC NUCLEUS IN RATS

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Experimental data on the role of adaptive and trophic influences of the sympathetic nervous system in the postnatal development of the hypothalamus are described. It was shown by karyocytometry that after extirpation of the cervical sympathetic ganglia (CSG) in rats ontogenetic development of the neurosecretory cells of the paraventricular nucleus (PVN) is delayed and changes are observed in the blood vessels. Manifestation of the effect of sympathectomy coincided with the onset of intensive growth of the cytoplasm of PVN cells. Sympathectomy was more effective in the case of extirpation of the CSG from young rats than from adult animals.

KEY WORDS: gangliectomy; development of the hypothalamus; paraventricular nucleus; neurosecretory cells; karyocytometry.

Several morphological investigations have been devoted to the study of the effect of the cervical sympathetic ganglia (CSG) on hypothalamic function in adult rats [1, 5, 7, 10]. However, there is as yet no information in the literature on the role of the CSG in the ontogenetic development of the hypothalamus.

The object of the investigation described below was to discover whether the CSG affect hypothalamic development and, in particular, the postnatal development of the paraventricular nucleus (PVN). Interest in this problem is due to the fact that when the CSG are extirpated in young rats, growth of the animals and the development of their motor activity are delayed [8, 9, 17], and later the generative functions are disturbed, and the hypothalamic PVN is known to be concerned in the regulation of these functions [13, 18].

## EXPERIMENTAL METHOD

Experiments were carried out on 26 intact and 20 gangliectomized male albino rats taken for investigation on the 10th, 20th, and 30th days after birth and at the age of 2, 3, and 5 months. The intact animals were investigated additionally at the ages of 1 and 5 days. One-stage bilateral extirpation of CSG (superior and middle) was carried out under ether anesthesia on young rats aged 1-5 days. Horner's syndrome was well marked in the sympathectomized rats during 5 months of observation.

The brain was fixed in Bouin's fluid and embedded in paraffin wax. Serial frontal sections (6 $\mu$) were stained with cresyl violet. The development of PVN in the intact and sympathectomized rats was compared by a morphometric method. According to data in the literature, in the course of ontogenetic maturation the volume

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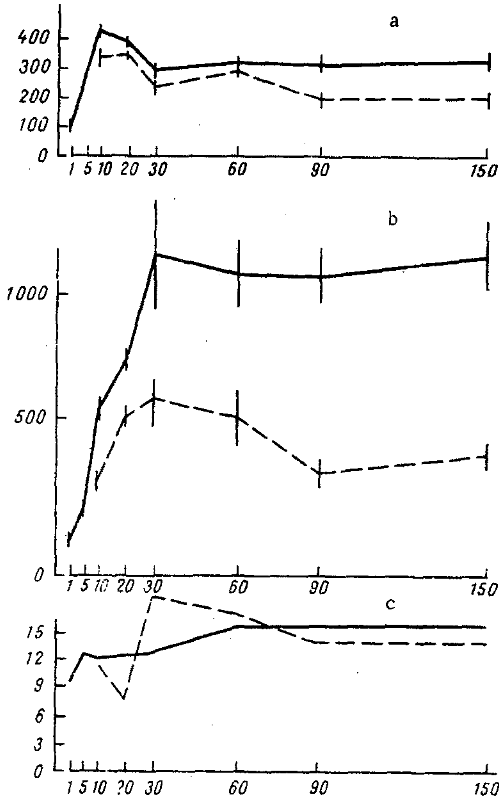


Fig. 1. Volume of nuclei (a) and cytoplasm (b) and total surface area of nucleoli (c) of PVN cells in intact animals (continuous line) and in rats after removal of CSG (broken line). Abscissa, age of animals (in days); ordinate; a, b) volume (in $\mu^3$), c) surface area (in $\mu^2$).

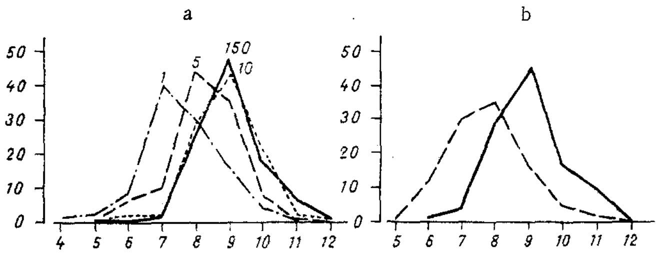


Fig. 2. Distribution of PVN cells by diameter of their nuclei. Abscissa, diameter of nuclei of cells of supraoptic nucleus (in $\mu$); ordinate, number of cells, in %. a) In intact animals at different stages of postnatal development: in adults (continuous thick line), in rats aged 1 day (line of dots and dashes), 5 days (broken line), and 10 days (dotted line); b) in intact rats (continuous line) and in rats after bilateral extirpation of CSG (broken line). Age of rats 3 months.

of the cells, and of their nuclei and nucleoli increases [2, 4, 15]. Increased activity of the neurosecretory cells was accompanied by hypertrophy of the bodies of the neurons and of their nuclei and nucleoli, whereas depression of functional activity is accompanied by a decrease in these parameters [12, 13]. The neurosecretory cells of the dorsal magnocellular part of PVN were measured. The volume of the cells and of their nuclei was calculated by the equation for an ellipsoid of rotation, after measuring two mutually perpendicular diameters.

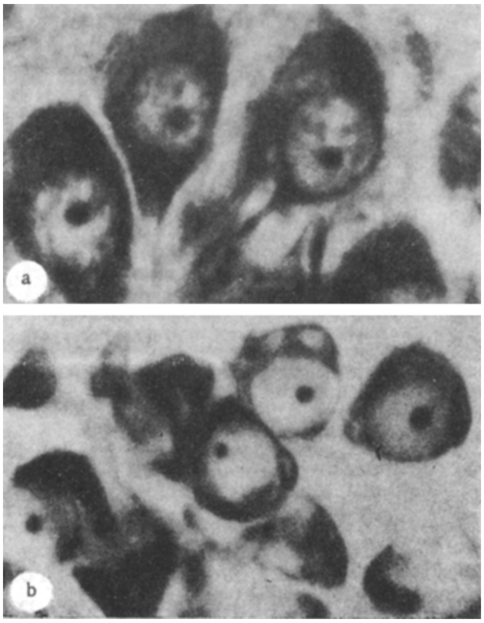

**Fig. 3.** Cells of PVN in intact rat (a) and in rat with extirpation of CSG at age of 3 days (b). Age of rats 20 days. Nissl's method, 1200 ×.

The volume and surface area of the nucleolus were calculated by the equations for a sphere and one diameter only was measured. For each time of investigation 150 cells of PVN were measured in at least 3 intact or sympathectomized animals. The results were subjected to statistical analysis by Student's t-test.

## EXPERIMENTAL RESULTS

In the course of ontogeny, from the 19th day of prenatal to the 30th day of postnatal development the total volume of PVN, according to data in the literature, increases by almost 3.5 times [3]. Although the volume of the cytoplasm of PVN cells in newborn rats is very small and the dimensions of the cell nuclei are less than in adult animals, in some cells of PVN neurosecretory granules can be detected in young rats even at this age [19].

The volume of the nucleus of the PVN cells in intact animals reached the adult size, according to the present experiments, by the age of 10 days (Fig. 1a). Analysis of curves of the distribution of the PVN cells by the diameter of their nuclei confirms that maturity was reached at this time. The predominant diameter in rats aged 1 day was 7 $\mu$, in rats aged 5 days 8 $\mu$, and in rats aged 10 days 9 $\mu$, the same as in adults (Fig. 2a). Later times of attainment of the definitive size, incidentally, are given in the literature: the 30th [2] and 41st days. After extirpation of CSG a significant difference in the volumes of the cell nuclei of the young rats was observed at the age of 10-20 days, and in sexually mature rats at the age of 3-5 months, whereas at the age of 1-2 months these differences were not observed. For instance, the volume of the nuclei of the PVN cells in intact rats aged 3 months was $329.2 \pm 16.2\ \mu^3$, compared with $209.5 \pm 19.3\ \mu^3$ in the sympathectomized rats of the same age ($P > 0.001$; Fig. 1a). The predominant diameter of the cell nucleus in intact rats aged 3 months was 9 $\mu$ and in the sympathectomized rats 8 $\mu$ (Fig. 2b).

The volume of cytoplasm of the PVN cells began to increase intensively in the postnatal ontogeny of the intact rats after the age of 5 days, and by the age of 1 month it was indistinguishable from that in adult animals: $1147.9 \pm 134$ and $1154.3 \pm 60.0\ \mu^3$ respectively. In the sympathectomized animals a marked delay in the growth of the cells was observed throughout the period of observation until the age of 5 months. The volume of the cytoplasm in these animals was 60-70% less than in intact animals. Whereas in the latter at the age of 3 months it was $1154.3 \pm 63\ \mu^3$, in the sympathectomized rats it was $434.7 \pm 24.1\ \mu^3$ (Figs. 1b and 3).

The largest number (68%) of polynucleolar cells was observed in the rats aged 5 days, and for that reason not only the total volume of the nucleoli, but also the total surface area in contact with the karyoplasm was increased. This latter factor is important for the synthesis of cytoplasmic proteins and secretory products of protein nature [15]. Later the number of polynucleolar cells decreased, and in the rats aged 1 month it was the same as in adults, namely 12%. Despite the fact that in rats aged 5 days the volume of each nucleus was only half that in the rats aged 1 month, the total surface area of the nucleoli in their nucleus was the same (Fig. 1c). The results show that intensive growth of the cytoplasm was preceded by the appearance of many polynucleolar cells, and not by the final differentiation of the cell nucleus [2]. In sexually mature animals the nucleolar surface area was increased mainly as a result of an increase in volume of the nucleolus.

In the sympathectomized rats, despite these considerable changes in the volume of the cytoplasm, the changes in the total surface area of the nucleoli were not so great. The direction of the changes in the total surface area of the nucleoli was similar to that of the changes in the cell nucleus. The total surface area of the nucleoli decreased after the operation in the rats aged 20 days and also in sexually mature rats aged 3-5 months. The fact that sympathectomy had its greatest effect at certain periods of ontogenetic development may perhaps be attributable to the characteristics of function of this structure. According to Danilova's observations [16], cholinesterase activity is high in the cells of PVN in rats during the first 2 weeks of life. In the period of sexual maturity of rats, oxytocin, one of the main sources of which is PVN, assumes special importance. According to Moiseev and Konstantinova [10], neurosecretory cells in an active functional state are most sensitive to desympathization in adult animals.

The effects of extirpation of CSG, it will be noted, are more marked in young rats than in adult animals. According to data in the literature, extirpation of CSG in adult animals produces only trivial changes or is not reflected in the morphological picture of PVN [1, 5, 7, 10]. The present experiments showed that the volume of the cytoplasm of PVN cells in rats aged 5 months undergoing sympathectomy at the age of 1-5 days was 72% less than in intact animals of the same age. If the rats were already adult when the operation was performed, the volume of the cytoplasm was reduced by only 16% and no changes were observed in the cell nucleus. This ontogenetic dependence coincides with the phylogenetic: The effect of sympathectomy is most marked in animals at lower levels of development [6, 10, 14].

Orbeli [11] regarded the influence of the sympathetic nervous system on the central nervous system as adaptive-trophic in character. The results of the present experiments are evidence of the importance of adaptive-trophic influences of the CSG in the ontogenetic development of the hypothalamus and, in particular, of its PVN during postnatal ontogeny in rats.

## LITERATURE CITED


1. B. V. Aleshin, Histophysiology of the Hypothalamic-Hypophyseal System [in Russian], Moscow (1971).
2. A. A. Voitkevich, I. I. Dedov, and V. I. Dedov, Arkh. Anat., No. 1, 20 (1973).
3. E. A. Gorshechnikova and G. A. Yakushin, in: Proceedings of the 9th Scientific Conference on Age Morphology, Physiology, and Biochemistry [in Russian], Part 1, Moscow (1972), p. 112.
4. A. S. Dog'el, Russk. Arkh. Anat., No. 2, 125 (1924).
5. S. V. Zhukova, Byull. Éksp. Biol. Med., No. 5, 55 (1962).
6. A. I. Karamyan, in: Problems in the Evolution of Functions and Enzyme Chemistry of Excitation Processes [in Russian], Moscow (1961), pp. 146-162.
7. M. S. Konstantinova, Dokl. Akad. Nauk SSSR, 140, 1431 (1961).
8. L. M. Lepekhina, Byull. Éksp. Biol. Med., No. 3, 5 (1972).
9. L. M. Lepekhina, Byull. Éksp. Biol. Med., No. 5, 24 (1975).
10. E. A. Moiseev and M. S. Konstantinova, in: The Evolution of Functions [in Russian], Moscow–Leningrad (1964), p. 37.
11. L. A. Orbeli, Lectures on the Physiology of the Nervous System [in Russian], Moscow–Leningrad (1938); reprinted in: Selected Works [in Russian], Vol. 2, Moscow–Leningrad (1962).
12. I. A. Okhonskaya (Krasnovskaya), Tsitologiya, No. 7, 925 (1972).
13. A. L. Polenov, Hypothalamic Neurosecretion [in Russian], Leningrad (1968).
14. T. N. Sollertinskaya, Abstracts of Proceedings of the 3rd Scientific Conference on Evolutionary Physiology [in Russian], Leningrad (1968), p. 181.
15. Ya. E. Khesin, Dimensions of Nuclei and the Functional State of Cells [in Russian], Moscow (1967).
16. O. A. Danilov, Histochemie, 28, 255 (1971).
17. J. T. Eayrs, J. Anat. (London), 85, 330 (1951).
18. E. Endroczi, S. Kovacs, and G. Szalay, Endokrinologie, 34, 168 (1957).
19. U. K. Rinne and E. Kivalo, Acta Neuroveg., 27, 166 (1965).