MORPHOLOGY AND PATHOMORPHOLOGY

THE RELATIONSHIP OF CELLS AND CAPILLARIES OF THE NUCLEI OF THE TRIGEMINAL NERVE IN THE POSTNATAL PERIOD OF DEVELOPMENT

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(Received June 20, 1955. Presented by Acting Member of the Acad. Med. Sci. USSR G. N. Speransky)

According to V. N. Klosovsky [1], the nerve cells of the cerebral hemispheres and the sources of their nutrition – the cerebrospinal fluid and blood transport systems – stand in close relationship to one another. In the early stages of intrauterine development of the cerebral hemispheres, the basic source of nutrition of the nerve tissue is the cerebrospinal fluid. In this period, the embryonic nerve cells are situated at the ventricular surface of the brain, i. e., immediately adjacent to the source of nutrition. As the cerebral hemispheres develop, the vascular network starts to function, and cerebrospinal nutrition of the nerve cells of the cortex of the hemispheres is replaced with cerebrospinal fluid-blood nutrition. With increase in the number of cells, and the increase in them of the rate of metabolic processes, the cells are shifted from the maternal layer on the surface of the brain to the soft brain membrane rich in blood vessels. In this part of the wall of the hemispheres, where the migratory nerve cells are concentrated, while formation of the cortex is in progress, the vascular network is formed which already in a 3-month human fetus is strongly developed and becomes the predominant source of nutrition of the nerve cells.

However, the process of development of the nerve tissue does not end in the embryonic period. After birth, there takes place further maturing of the nerve and gliosome cells of the conducting paths and receptors. Thus, for example, according to O. V. Beloborodova, myelinization of the peripheral nerves, not only of the auditory, but also of the vestibule analyzers, is completed within only about 2 months of postnatal development. The brain mass increases. T. P. Zhukova notes that the largest growth in the brain weight in kittens takes place in the first months of life. At about three months the weight of the brain of an adult animal is reached. The blood transport system also changes. Thus, according to E. V. Kapustina, development of the vascular network in the soft brain membrane of kittens continues up to 3 months of postnatal life. In the brain substance itself, as Z. N. Kiseleva points out, new growth of the capillaries in certain regions of the cortex takes place in kittens up to 4 months. In line with the works of E. V. Kapustina and Z. N. Kiseleva, it was noted by T. P. Zhukova (1954) that the amount of blood characteristic of the brain of an animal becomes established after only about 2-3 months of extrauterine life.

In connection with these findings, there arises the question as to how the regeneration of the vascular network and growth of the brain matter after birth influence the forms of mutual relations between the nerve cells and the surrounding capillaries developing in the embryonic period of development.

So far, the relationship of the nerve cells and capillaries has been studied only in adult animals. B. N. Klosovsky, E. N. Kosmarskaya and E. G. Balashova [2] established that the link between these components in adult animals is different in different parts of the central nervous system.

In this work we shall consider the processes of formation of this link between the nerve cells as the basic structure of the nerve tissue and the source of their nutrition – by the capillary network in the postnatal period of development. The relationship of the nerve cells and the capillaries has been investigated in the nuclei of the trigeminal nerve. The system of the trigeminal nerve is one of the first to engage in brisk activity from the moment of birth of the animal. This enabled us to trace the emergence of the relationship of the nerve cells and the capillaries and also the development of the vascular network in relation to the maturation of the nerve cells.

The investigation was conducted on 91 cats. We treated the brain of animals of different ages. For the purpose of studying the development of the vascular network, the brain in 42 cats was impregnated with silver according to the method of Klosovsky. The vascular network of the brain of 49 animals was injected with India ink in gelatin. The preparations obtained were stained according to the method of Nissl.

On comparing the relationship of the nerve cells and surrounding capillaries in newborn kittens and adult animals, we noted a big difference in the number of cells not in contact with the capillaries. In all the nuclei of the trigeminal nerve., i. e., in the motor and sensory nuclei and the nucleus of the root of the spinal nerve of the newborn kittens, the number of cells not in contact with the capillaries was considerably higher than in the same nuclei of adult animals. Thus, in the motor nucleus of the newborn kittens, to each 10 cells adjacent to the capillaries, there were 13 cells not in contact with them (see table). At the same time, in the adult cats, to each 10 cells in contact with the capillaries, there were altogether 6 cells separate from the capillaries. The same relationship exists in the sensory nuclei. For example, in a sensory nucleus of the newborn kittens, to each 10 cells in contact with the capillaries, there were 46 cells not in contact with them, and in the adult animals only 20 cells.

Growth Changes in Relation of Nerve Cells and Capillaries and Density of the Vascular Network in the Nuclei of the Trigeminal Nerve in Cats

Age of animal	Motor Nucleus		Sensory Nucleus		Nucleus of spinal root	
	Density of vascular network in volume 50x50x x210 μ^3 tissue	Number of cells separate from capillaries to ten cells with capillaries adjacent to them	Density of vascular network in volume 50x50 x210 μ^3 tissue.	Number of cells separate from capillaries to ten cells with capillaries adjacent to them	Density of vascular network in volume 50x50x x210 μ^3 tissue	Number of cells separate from capillaries to ten cells with capillaries adjacent to them
Newborn	13	10 : 13	15	10 : 46	—	10 : 40
Ten days	14	10 : 7	17	10 : 23	15	10 : 20
1 month	15	10 : 5	18	10 : 13	17	10 : 14
2 months	12	10 : 7	15	10 : 17	14	10 : 18
Fully grown animal	14	10 : 6	16	10 : 20	13	10 : 21

The above figures show that in the nuclei of the trigeminal nerve in the postnatal period of development the nerve cells and capillaries approach each other (Fig. 1).

Later we tried to establish those regenerations in the brain tissue, due to which the nerve cells and capillaries draw together. Upon investigations of the vascular network in the nuclei of the trigeminal nerve, a difference in its density in animals of different ages was noted. Thus, while in the motor nucleus in the newborn cats to a given volume of brain tissue there were 13 capillaries, in 10 day old cats in the same volume of tissue already 14 capillaries were counted (see table). The increase in the density of the vascular network also occurs in the sensory nuclei. During ten days of life of the kittens in the investigated volume of tissue of the sensory nucleus. the density of the vascular network increased by two capillaries. Later the number of capillaries continued to grow and reached the maximum in one-month-old kittens. At this age, to the same volume of tissue in the motor nucleus there were 15 capillaries and in the sensory nucleus 18. Increase in the density

of the vascular network in the nuclei of the trigeminal nerve in the postnatal period of development takes place by formation of new capillaries Upon inspection of the capillary network of the nuclei of this nerve in the preparations impregnated with silver, we found all the stages of growth of a new capillary, as described by B. N. Klosovsky [1].

The growth in the capillaries starts from the gemma stages when the newly forming capillary represents an adventitial cell with a large amount of protoplasm and protoplasmic outgrowths projecting into a paraplastic substance (Fig. 2, a). As the mass of adventitial cell grows, the newly forming capillary becomes increasingly stretched in length and assumes a shape resembling a polyp and then a hydra. The formation of the capillary ends with its "sealing in" in the wall of the already functioning capillary by means of any single, rarely two, protoplasmic outgrowth (Fig. 2, b). The latter, by joining with the functioning capillary, acquires a diameter peculiar to capillaries of this region and at the same time is canalized. All the remaining outgrowths disappear. As a result of the formation of capillaries by the method indicated above, there is an increase in the density of the vascular network; in other words, the number of capillaries per unit of brain tissue increases.

The histological findings described show that the increase in the density of the vascular network in the nuclei of the trigeminal nerve of kittens – from birth up to one month old – is carried out by the formation of new capillaries by gemmation. This process develops very intensely, and despite growth in the mass of the brain matter in the given age period, the number of capillaries does not decrease, but on the contrary, increases, which naturally is the cause of the drawing together of the capillaries with the bodies of the nerve cells.

The rate of formation of new capillaries in all the nuclei of the trigeminal nerve, as our investigations showed, in different ages is nonuniform. In the newborn kittens they are few, and in most cases they have short protoplasmic outgrowths. Starting from the 5-7th day, the number of newly forming capillaries increases and on the 10th day reaches the maximum. In 10 day old kittens the process of new formation of the capillarries is most intensive. Then, up to the 20-25th day, the number of growing capillaries drops and after the 25th day up to a month a new "outburst" of capillary formation is seen. However, the rate of the emergence of new capillaries in the last case does not exceed that in kittens 7-10 days old. As a result of the formation of new capillaries, the density of the vascular system of the nuclei is increased, and in month-old kittens, it reaches the maximum.

Corresponding to the regeneration of the vascular network, changes take place in the relation of the new cells and the capillaries. Thus, while in the motor nucleus of the trigeminal nerve of the newborn kittens to each 10 cells in contact with the capillaries there are 13 cells separated from the capillaries, in the 10-day-old animal the number of cells separated from the capillaries falls to 7, and in a month old kitten goes down to 5 (Table 1). The drawing together of the nerve cells and the capillaries takes place also in the sensory nuclei. For example, in a sensory nucleus of a newborn kitten, to each 10 cells in contact with the capillaries, there are 46 cells separate from the capillaries. In a 10 day old kitten the number of the latter decreases to 23, and towards a month of animal life, altogether there are 13 cells separate from the capillaries.

Development of the vascular network in the nuclei of the trigeminal nerve does not end towards 30 days. In the following months in the life of the kittens, there takes place a certain rarefaction of the vascular network, which is connected with a sharp fall in the number of newly forming capillaries with a simultaneous growth of the mass of the brain matter. However, despite the fall in the density of the vascular network, in the 2-month-old kittens the number of cells separate from the capillaries remains almost the same as in the month-old animals. This, which may appear at first sight to be a contradictory phenomenon, may be explained by the fact that at this age there takes place partial atrophy of the capillaries. The process of atrophy of the functioning capillary consists in reduction in its diameter to the size of a thread (Fig. 2, c) and its subsequent rupture (Fig. 2, d). From this moment, in the preparations treated according to the method of Klosovsky, the atrophying capillary represents a thread whose completeness has been disturbed and at whose site of attachment to the functioning capillaries there are remnants of the earlier existing capillary in the form of triangles. Atrophy chiefly causes the disappearance of those capillaries which are at a certain distance from the nerve cells and the capillaries which are in contact with them are maintained. As a result of this, despite the decrease in the density of the vascular network, the number of cells in contact with the capillaries remains as before.

The formation of the capillary network in the nuclei of the trigeminal nerve is basically completed in the kittens aged 2 months. This is indicated by the sharp fall in the number of newly forming capillaries. At about 2 months, the relation of the nerve cells and the capillaries is established which is characteristic for an adult

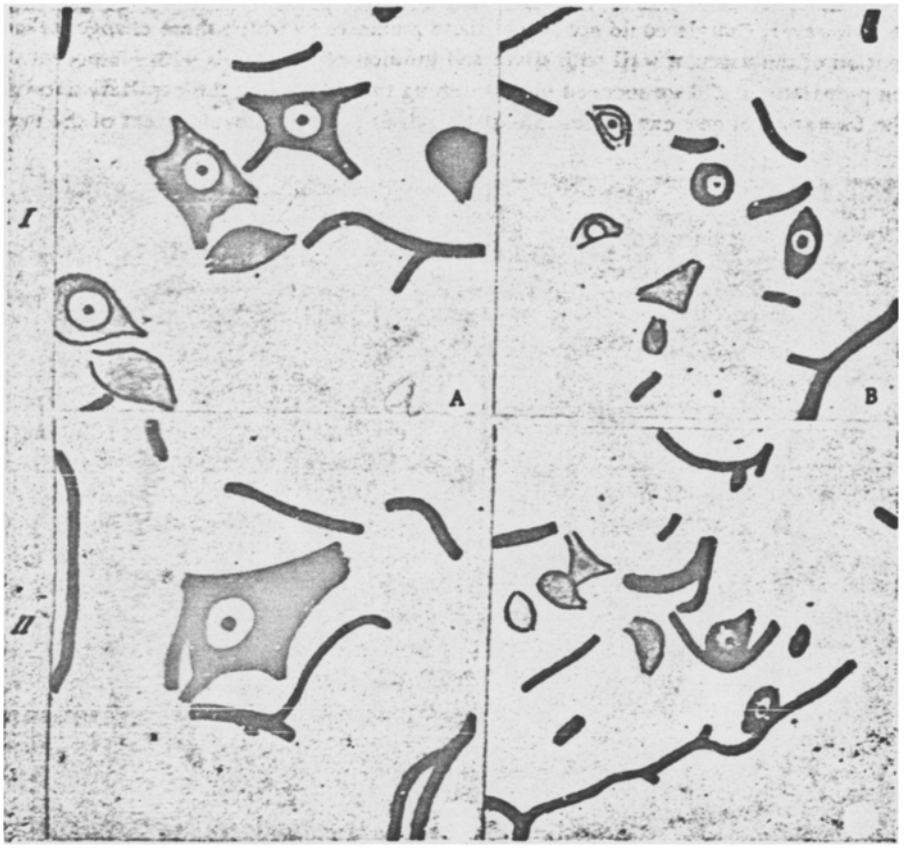

Fig. 1. Relation of nerve cells and capillaries in nuclei of trigeminal nerve of newly born kittens (I) and adult cats (II).
a) Motor nucleus; b) Sensory nucleus. Injection with India ink. Stained according to Nissl. Enlarged 400 times.

organism. It is true that later there nevertheless take place some changes, but they are less pronounced than those which occur in the first months of life of the kittens. Thus, single newly forming capillaries may be seen even in a 5-month-old animal.

It follows from all this that the relation of the nerve cells and the capillaries in the nuclei of the trigeminal nerve and the vascular network in them greatly change at given ages. Intense multiplication of capillaries in 10-day-old animals coincides with the opening of the eyes of the kittens, the cornea and lachrymal glands of which are innervated by the trigeminal nerve. In its action, there are involved the branches taking part in the pupil reflex [3]. In additon, according to E. V. Kapustina, at this time there is significant reduction of the role of the cerebrospinal fluid as a source of nutrition. Undoubtedly with an increase in the function of the nerve cells and also with a rebuilding of the vascular plexa, there takes place intense development of the capillary network and a drawing together of the nerve cells and capillaries. The improvement in vascularization of the nerve cells in the period from the 25th to 30th day is also connected with an intensification of the function of the nuclei of the trigeminal nerve. In this period, the animal goes over from consumption of mother's milk to independent feeding. Its food ration is varied and includes rough food. The latter must be ground in the mouth cavity and copiously moistened with saliva, secreted from the salivary glands innervated by the trigeminal nerve. In addition, the nerve cells of the nuclei of this nerve receive repeated stimulations from the mucous membrane of the mouth and nose cavities, the tongue, and the capillaries of the integument of the animal.

Certain data regarding the density of the vascular network of the nuclei of the trigeminal nerve in rats was obtained by Craigie [4]. Investigating the length of the capillaries in preparations with an injected vascular network, he noted growth fluctuations in the degree of vascularization of the tissue of the nuclei of the

trigeminal nerve. However, Craigie could not reveal those processes by which these changes takes place. Only by impregnation of the vascular wall with silver and infusion of the vessels with subsequent staining of the nerve cells in the preparations did we succeed in establishing that rebuilding the capillary network is carried out chiefly by the formation of new capillaries in early stages of postnatal development of the nervous system.

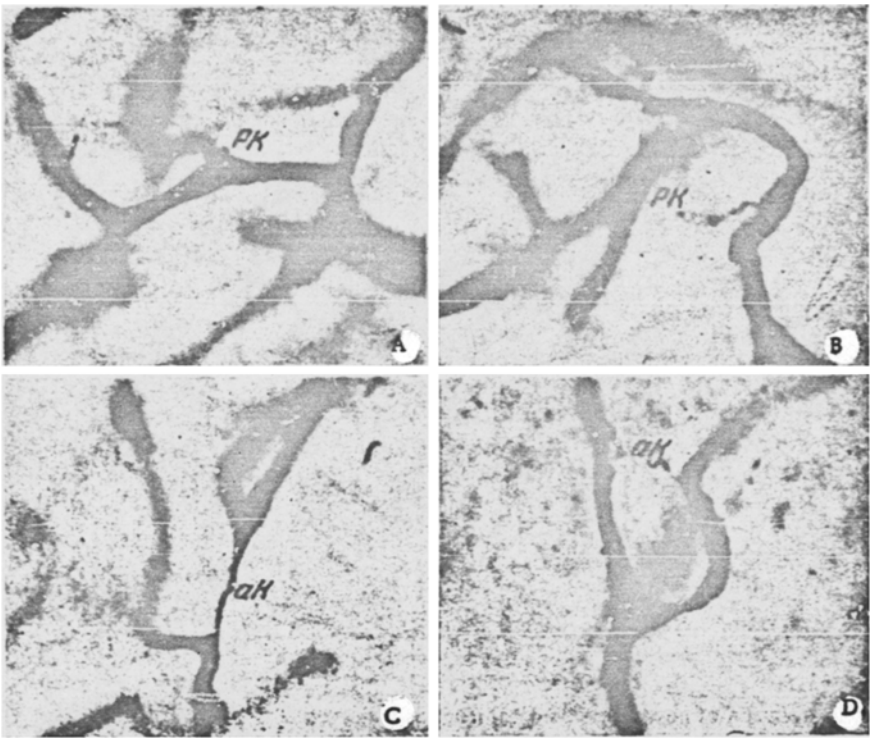

Fig. 2. Regeneration of capillary network in nuclei of trigeminal nerve.
a, b) stages of formation of new capillaries by gemmation; c, d) stages of atrophy of capillaries;
PK) Growing capillary; aK) Atrophying capillary.
Impregnation with silver according to Klosovsky. Enlarged 400 times.

The final result of this is an increase in the density of the vascular network in the adult animal. As a result of formation of new capillaries, their relations with the nerve cells change. In adult animals the majority of nerve cells come into contract with capillaries. In other words, the bodies of the nerve cells of the nuclei of the trigeminal nerve in adult animals are supplied with blood to a higher degree than are the nerve cells of the same nuclei in the newborn.

Formation of the relationship between the nerve cells and the capillaries takes place in line with the emergence and growth of complexity of the function of the nerve cells of the trigeminal nerve.

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