THE GROWTH OF CAPILLARIES IN THE BRAIN OF ADULT ANIMALS

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In the brain of man and of a number of animals (rats, rabbits, cats, dogs, etc.) the development of the vascular system continues for a long time after birth. Growth of capillaries by means of the outgrowth of buds, as described by B. N. Klosovskii [1] by his impregnation method, is an important process in increasing the general density of the capillary network and in forming the necessary relationships between the nerve cells and the capillaries in the postnatal period of development.

B. N. Klosovskii [2] considers that the newly formed capillary is derived from an adventitial cell passing along a vessel. The process of its transformation into a functioning capillary includes several states. These stages of development of the capillaries in the brain were designated the stage of "budding" (the earliest stage), the stage of "polyp formation" and the "hydriod" stage (Fig. 1, a, b, c). Starting with the earliest stage, the growing capillary or outgrowth has well-marked protoplasmic processes, emerging from the free end of the capillary, where the nucleus of the adventitial cell is usually situated. As it grows, the bud reaches a functioning capillary, permeable to the blood stream, and joins itself to the capillary by means of the protoplasmic processes (see Fig. 1, d). After the union of the growing capillary bud to the functioning capillary, the protoplasmic processes disappear and the newly formed capillary begins to function.

The formations of new capillaries in this manner takes place in the brain not only in the embryonic period but also for a long time after birth. In puppies and kittens, for instance, growing capillaries are found at the age of 4-5 months, in rats at the age of 2 months [2-4]. Capillary growth is particularly intensive in the first days of postnatal life of the animal; with age this process gradually subsides.

The question of the possible growth of capillaries in the brain of adult animals has remained unanswered, for it has not been possible to find the characteristic forms of capillaries in process of construction in these animals.

When investigating the influence of various agents on capillary growth in the brain of animals in the postnatal period of development, we first studied in detail a complete series of sections of the brain of normal adult rats, prepared by B. N. Klosovskii's method. Examination of the silver-impregnated preparations revealed growing capillaries in the brain of certain of the rats.

EXPERIMENTAL METHOD

For investigation of the brain for the presence of growing capillaries we took 10 sexually mature rats weighing from 225 to 310 g (4 males) and from 140 to 185 g (6 females). All the rats were sacrificed by decapitation. The brain was fixed in 10% formalin. Using B. N. Klosovskii's method [2], we prepared series of sections

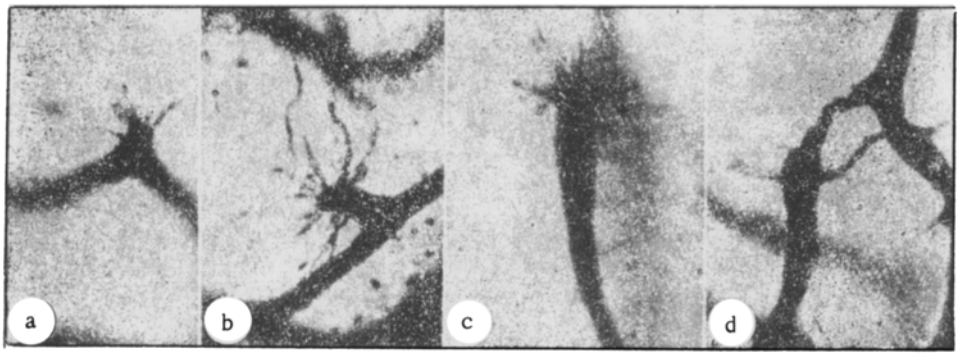

Fig. 1. Phases of growth of capillaries in the brain of normal 13-day old rats. a) "bud" stage; b) "polyp" stage; c) "hydriod" stage; d) union of the growing and functioning capillaries.

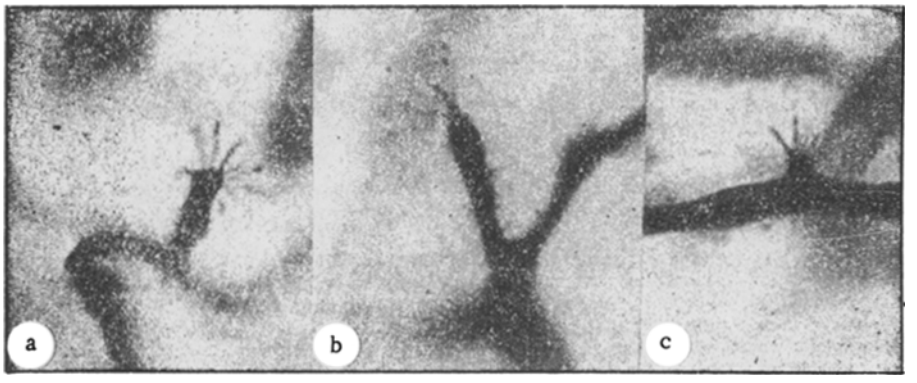

Fig. 2. Growing capillaries in the brain of normal adult rats. a, b) "hydriod stage"; c) "bud" stage.

through the whole brain to a thickness of 150 μ. The sections were examined under the microscope with a magnification 400x at all turns of the micrometer screw. This degree of magnification enabled the various forms of growing capillaries to be seen most clearly. Because of the small size of the rat's brain it was possible to examine the capillary network in all its divisions in a full series of sections.

EXPERIMENTAL RESULTS

In 6 of the 10 experiments we were able to find growing capillaries in various divisions of the brain (in 2 males and 4 females).

In contrast to developing animals, in which growing capillaries are found in large numbers in various divisions of the brain, in adult rats solitary growing capillaries were observed, and in only one part of the brain in each animal. For instance, growing capillaries were found in the olfactory gyrus at the level of the parietal region (one rat), in the frontal region -- in the first layers of the cortex (2 rats), in the parietal region of the cortex (one rat), in the optic tubercle (one rat) and in the cerebellum and medulla oblongata (one rat).

The growing capillaries in the brain of the adult rats were mainly in the "hydriod" stage (Fig. 2, a, b), but capillaries in the "bud" stage were encountered (see Fig. 2, c). In all the growing capillaries there were well-marked protoplasmic processes, as may be seen from the microphotographs (see Fig. 2), and a single nucleus. The diameter of the pedicle of the growing capillary was the same as that of the surrounding functioning capillaries.

Besides capillaries in no way distinguishable from the ordinary normal growing capillaries in young animals,

some were seen which showed atypical growth: these either had no protoplasmic processes at all, or they appeared to be greatly curtailed. In some cases the pedicle of the growing capillary was very slender, and at its end were seen 1-2 diminutive protoplasmic processes.

The findings described thus show that capillary growth may take place in the brain of adult animals by means of the outgrowth of buds. However, in the brain of adult animals, the number of growing capillaries is limited, and their growth is localized to any one area of the brain in each animal, and does not extend to other areas.

No explanation has yet been found of what is responsible for the growth of the capillaries, of what factors — local or general in character — stimulate the formation of new capillaries during the normal existence of the animal. It is most probable that capillary growth in each individual case is due to local factors such as the need for adaptation to the changing demands of the nerve cells. There is also the possibility, as pointed out by B. N. Klosovskii [1, 2], of a reaction to the disintegration or death of individual nerve cells.

The fact that new capillaries may be formed in the brain of adult animals gives grounds for the belief that in certain conditions and in pathological cases the vascularization of individual areas of the brain may be increased by some means or other, should this become necessary. The action of different chemical and physical factors on the formation of new capillaries in the brain of animals of various ages will be the subject of our further research.

SUMMARY

To reveal newly formed capillaries the brain of normal adult rats was impregnated with silver by B. N. Klosovskii's method.

The possibility of formation of new capillaries in various portions of the brain of adult rats was established. In 6 of the 10 cases newly developing individual capillaries were revealed. By their external appearance these did not differ in any way from those developing in the nervous system of young animals.

LITERATURE CITED

[1] B. N. Klosovskii, Development of the Capillaries of the Brain, Moscow, 1949 [In Russian].

[2] B. N. Klosovskii, The Circulation of the Blood in the Brain, Moscow, 1951 [In Russian].

[3] Z. N. Kiseleva, N. S. Volzhina, Zhur. Nevropatol. i Psikhiat., No.9, 71-77 (1952).

[4] E. N. Kosmarskaya, Yu. I. Barashnev, Med. Radiol., No. 1, 35-41 (1959).