# THE RELATIONSHIP BETWEEN NERVE CELLS AND CAPILLARIES IN THE BRAINS OF ADULT ANIMALS

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There is a wide range of literature devoted to the structure of the vascular-capillary net of the nervous system. However, the morphological connections between nerve cells and capillaries has until very recently been described only by speculative hypotheses.

B. N. Klosovsky [4], regarding the nerve cell as the most active component of nervous tissue, established a definite pattern in the disposition of the capillaries surrounding the cells of the great pyramidal tract nuclei in the cerebral hemispheres. According to his findings, in cats, dogs, and humans one of the capillaries, lying nearest to the pyramidal cell, curves around its body from base to axon tip and is the arterial knee, while another, the venous capillary, courses under the base of the cell body. An apparently similar type of structure of arterial and venous capillaries around the bodies of large pyramidal cells was discovered by T. I. Belov in the brain of the kangaroo, whose vascular system is built on the pattern of end vessels.

The form described is characteristic of the capillaries only around the pyramidal tract nuclei in the cerebral hemispheres. The nerve cells of other divisions of the nervous system have a different relationship with the capillaries surrounding them. Thus, E. N. Kosmarskaya and E. G. Balashova [5] have established that the large cells of the medulla are surrounded by large numbers of capillaries. These may bend around the nerve cell body from any side. Some of these capillaries actually touch the nerve cell body while others may lie at some distance from it. The same authors established another correlation between the small nerve cells forming the net of the medulla oblongata and the capillaries surrounding them. In the majority of instances there pass near the nerve cell only 1-2 capillaries, which frequently do not touch the cell body. E. G. Balashova [1, 2] described still another relationship between nerve cells and capillaries in the mesencephalic nucleus of dogs. It is characterized by the fact that the capillaries frequently form around the nerve cell a closed ring, the diameter of which corresponds to the nerve cell dimensions. As a result the capillaries are in contact with the bodies of the nerve cell for a very considerable distance. It was further noted that capillaries not only contact the surface of the nerve cell, but sink into the upper layers of its plasma, forming a groove on the body of the nerve cell, in which they lie.

On the basis of the indicated studies it can be said that the association between the nerve cell and the source of its nourishment – capillaries – varies in different divisions of the central nervous system.

In the present work we attempted to elucidate the features which characterize the association of nerve cell bodies with capillaries and to determine whether there is variation in the relationship of nerve cells with their capillaries from the viewpoint of the function of various nuclei.

Specifically there was investigated the trigeminal nerve system, which includes both motor and sensory nuclei, whose functioning has been very accurately determined at the present time. The studies were conducted on adult cats (21 animals), and small dogs and puppies aged 3-4 months (31 animals). Part of the material was worked up by the Klosovsky method. The vascular net of the brain in the remaining animals was injected with India ink suspended in gelatin while the nerve cells were stained by the Nissl method.

In studying many such preparations we established that there are 4 characteristic features in the correlation between nerve cells and capillaries: the number of capillaries surrounding the nerve cell; their distribution; the number of cells in direct contact with the capillaries; and also the distance for which this contact is maintained. In the last case it is essential to consider not only the size of that portion of the capillary which actually touches the body of the nerve cell, but also the manner of its disposition upon the cell body. In other words, it is essential to note whether the capillary merely grazes the surface of the cell body or whether the plasma under it is indented in the form of a groove.

The above indicators show the extent to which the intimacy of the union between the nerve cell and the source of its nourishment – the vascular system – is manifested. This association was studied by us on the trigeminal nerve nuclei, and found to vary. Thus, in the motor nuclei of grown cats we found a characteristic disposition aroung the bodies of the nerve cells, of 3-4 capillaries (Fig. 1, a). In preparations of a thickness of 60 $\mu$ they represented only short portions of the capillary knees. In the motor nucleus the majority of the nerve cells were in contact with the capillaries. Actual counts showed that in this nucleus, for every 10 cells having contact with the capillaries, there are 6 cells separated from the capillary by a distance not exceeding 25 $\mu$. At the same time the length of the contact of the capillary with the nerve cell amounted to only 1/4 of the cell's curcumference. Those capillaries which actually came into contact with the nerve cell, always were disposed on its surface.

Other relationships were observed between the nerve cells and the capillaries in the sensory nucleus of the trigeminal nerve of adult cats. Near the nerve cell body in the sensory nucleus lies, as a rule, one, rarely two, capillaries (Fig. 1, b). They usually do not curve aroung the nerve cell body, merely passing near-by and not altering their original direction. The majority of the nerve cells of a given nucleus do not come into contact with the capillary. Thus, for every 10 cells touching the capillaries, there are 20 cells not having contact with them. In those cases when the capillary touched the nerve cell body it also, as in the motor nucleus, merely lay on the surface. In the sensory nucleus the length of contact by the capillary with the nerve cell body does not exceed 1/4 of the cell's curcumference.

Similarities with the above relationships between nerve cells and capillaries also occur in the spinal nucleus of the trigeminal nerve in grown cats. Near the small cells of this nucleus lie 1-2 capillaries, which, as a rule, do not curve aroung the nerve cell body. The majority of the cells of a given nucleus also, as in the sensory nucleus, do not have contact with the capillaries. Thus, in the nucleus of the spinal root, for every 10 cells touching the capillaries there are 21 cells having no contact with them. The length of this contact, and mode of disposition of the capillaries in relation to the nerve cell bodies of the spinal nucleus are also similar to those which have been already described for the sensory nucleus of the same trigeminal nerve.

It is essential to devote special attention to the large cells in the spinal nucleus of adult cats. These cells usually touch the capillaries, and the length of the contact with the capillaries by the bodies of the nerve cells does not exceed 1/4 of the cells' circumference. The contact with the capillaries, as in the previously described nuclei, is a mere superficial lying upon the surface of the nerve cell.

Our investigations thus enabled us to establish that the functional differences between the various nuclei of the trigeminal nerve (motor and sensory) are characterized by special relationships between the nerve cells and capillaries. In the motor nucleus, in contradistinction to the sensory nuclei, there are observed a large numbe of capillaries surrounding the body of the nerve cells and a large number of cells coming in contact with the capillaries. In other words, the degree of the vascularization around the bodies of the nerve cells is greater in the motor nucleus than in the sensory nuclei.

It might be supposed that the more or less complex relationship between the nerve cells and capillaries depends on the deneseness of the vascular net, i. e., in the nuclei where the nerve and vascular components have the most intimate association the deneseness of the vascular net should be greater. However, the investigations have not confirmed this supposition. Actually, in the motor nucleus in a given volume of tissue ($50 \times 50 \times 210\ \mu^3$) there occur 14 capillaries, while in the sensory nucleus there are 16 capillaries.

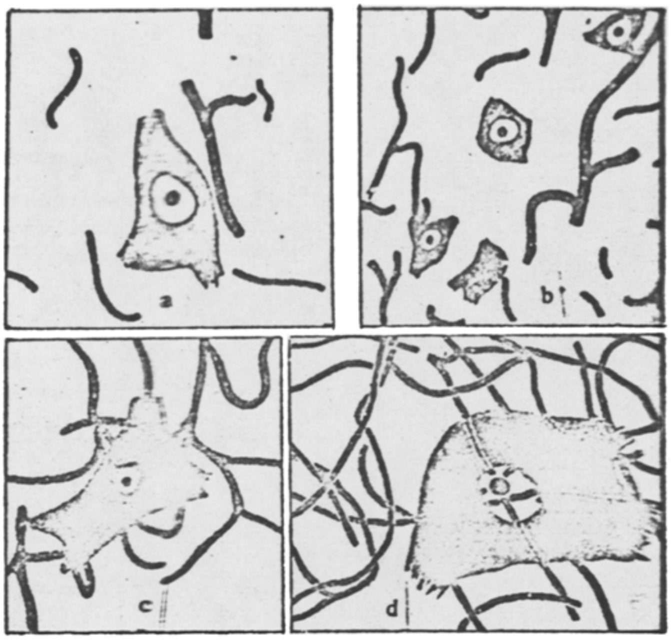


Fig. 1. The distribution of nerve cells and capillaries in nuclei. a) Motor nucleus trigeminal nerve; b) sensory nucleus trigeminal nerve; c) vasomotor center of the medulla oblongata of brain d) Deiter nucleus.

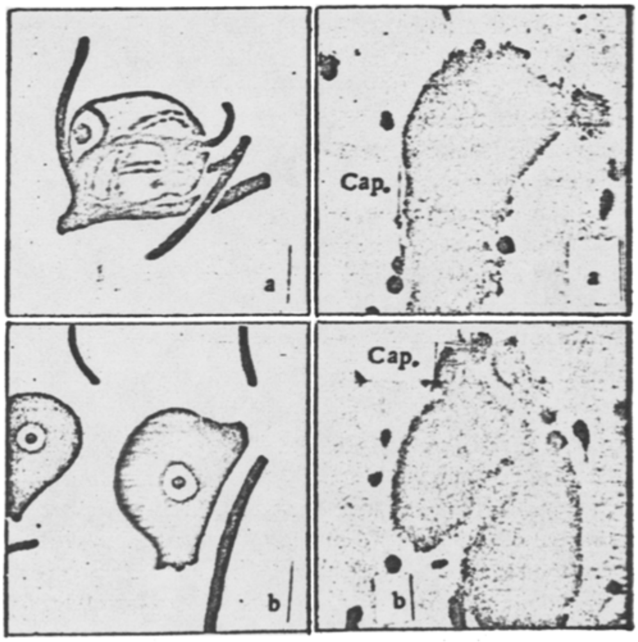


Fig. 2. The disposition of nerve cells and capillaries in the mesencephalic nucleus of the trigeminal nerve of dogs (a) and cats (b). Cap. – capillaries.

In the attempt to reveal the facts which would have a bearing on the relationship between the nerve cells and capillaries, we turned to the teachings of I. P. Pavlov as to the nerve cell being the most reactive element of nerve tissue. On the basis of this concept it could be surmised that the association between the nerve and vascular components is determined by the functional activity of the nerve cells themselves. The findings to be given below, obtained by morphological examination of tissues, in our opinion serve as some proof of this interdependence.

The investigations of the relationships between nerve cells and capillaries in other regions of the central nervous system have shown that the blood supply of nerve cells of the motor nucleus differs from the blood supply not only of other groups of sensory nuclei of the same nerve, but also from other nuclei. Thus, for example, in the vasomotor center, located in the medulla oblongata of the brain, around the nerve cell bodies there are disposed five to six capillaries, which in preparations of a thickness of 60 μ represent longer curvatures by the capillaries than occur in the motor nucleus of the trigeminal nerve (Fig. 1, c). Almost each large cell of the vasomotor nucleus is in contact with capillaries. The length of contact represents more than 1/4 the circumference of the nerve cell body.

A still closer relation between nerve cells and capillaries is found in Deiter's nucleus, where it can be noted that the concentration of capillaries is especially great aroung the nerve cell bodies, particularly the large ones. The capillaries located aroung the nerve cell of this nucleus in preparations of 60 μ represent complete knees. These last are connected with each other and not infrequently form completely closed rings, whose diameter is much greater than the dimensions of the nerve cell body (Fig. 2). As a result the cell touches only a part of the capillaries comprising this ring. The extent of contact between the capillary and the nerve cell in the Deiter nucleus equals half the circumference of its body. The touching capillary lies superficially upon the body of the nerve cell.

The most complex form of the relationship between nerve cells and capillaries was uncovered in the mesencephalic nucleus of dogs. In this nucleus the capillaries are concentrated around the nerve cells; therefore, near each nerve cell or group of cells there is formed its own capillary net. In previous investigations [1, 2] we have shown that capillaries disposed around the nerve cells of the mesencephalic nucleus of dogs represent complete knees, connected in closed circles. The diameter of these circles frequently corresponds to the size of the nerve cell body. (Fig. 2, a). In this case the capillary and the body of the nerve cell are in contact aroung the entire circumference. In addition the contact between them is increased as a consequence of the capillary being in a groove formed on the surface of the cell by the capillary (Fig. 2, a). In this way, in the nucleus of Deiter and in the mesencephalic nucleus of dogs, it is the body of the nerve cell which determines the number and the anatomic shape of the capillaries, while the varying degree of the blood supply to the bodies of nerve cells can be explained by the varying intensity of their activities. For example, in the motor nucleus of the trigeminal nerve the contact between nerve cells and capillaries is simple, as the nerve cells of this nucleus are in an active condition only for short intervals of time. Contrary to this, in the nucleus of Deiter, the nerve cells of which sustain the tone of the large muscular groups for lengthy periods of animal activity, there can be observed a much more intimate association of nerve cells and capillaries.

In this aspect it is of interest to examine the relation between nerve cells and capillaries in connection with the functioning of similar nuclei in different animals. Thus, while in the mesencephalic nucleus of dogs the capillaries form a net around each nerve cell, in cats, near the nerve cells of the same nucleus there pass only 1-2 capillaries, which do not curve around the cell and do not alter their original course (Fig. 2, b). The length of contact between the capillary and the nerve cell body in the mesencephalic nucleus of cats comprises only half the circumference of its body. According to the findings of B. N. Klosovsky [4], the mesencephalic nucleus participates in the regulation of breathing, which in dogs is very intensive, with the participation of the entire respiratory musculature, nasal and mouth regions. Therefore, the active state of the mesencephalic nucleus of dogs is vividly portrayed. This corresponds to the much better supply of these nerve cells.

As an example of the dependence of the anatomical structure of the vascular net upon the functioning of the nerve cells we can cite the large pyramidal cells of the nuclei of the cerebral hemispheres of the brain, which in connection with their active functioning not only need a liberal blood supply, but also have individual arterial and venous supply.

Summarizing the above considerations, it can be said that the blood supply of nerve cells varies in various nuclei. One of the factors determining the degree of the vascularization around nerve cells is the intensity of their activity.

## LITERATURE CITED

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