THE RELATIONSHIPS BETWEEN NERVE CELLS AND CAPILLARIES IN THE PHRENIC NERVE NUCLEUS AND THE ANTEROLATERAL GROUP OF CELLS IN THE SPINAL CORD OF THE ADULT CAT

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The systematic study of the blood supply of the various divisions of the brain and investigation of the relationship between the nerve cells and capillaries in these divisions both in adult animals and in the course of individual development [1-7] have led to the necessity of elucidating the special features of vascularization of the spinal cord by comparison with other divisions of the central nervous system from a consideration of individual nuclei and conducting pathways.

In this paper we present the results of research into the relationships between the nerve cells and capillaries in the anterior horns of the cervical division of the spinal cord of the adult cat.

The investigation was carried out on motor nuclei of the spinal cord with different functions, namely on the nucleus of the phrenic nerve, giving off its axons to the diaphragm, and on the anterolateral group of cells innervating part of the muscles of the shoulder girdle. The difference in function of these nuclei is brought about by the fact that the phrenic nerve nucleus in adult animals transmits rhythmic impulses to the diaphragm, whereas the anterolateral group of cells works irregularly and is in a state of activity for varying intervals of time.

EXPERIMENTAL METHOD

In order to study the relationships between the nerve cells and capillaries in the phrenic nerve nucleus and the anterolateral group of cells, we used continuous series of laterolateral longitudinal sections of the 5th-6th segments of the cervical division of the spinal cord of adult cats, the vascular network of which was injected with ink and gelatin, and the nerve cells stained with thionin.

The special features of the relationships between nerve cells and capillaries surrounding them were investigated by the routine method adopted in the laboratory of brain development. Under these circumstances the following signs were taken into consideration: the total length of the capillary network surrounding the cell to a distance of 25 μ the arrangement of the capillaries around the cell the number of cells in contact with capillaries, the extent of their contact, the distinctive arrangement of the capillary on the body of the nerve cell and the length of the genu of the capillary.

EXPERIMENTAL RESULTS

Before embarking on the description of the relationships between the nerve cells and capillaries in the motor nuclei of the anterior horns of the spinal cord, we must point out the considerable differences in the structure of the nuclei which we were studying and in the distribution of their capillary network.

Some authors [8, 9] have drawn attention to the fact that the phrenic nerve nucleus of the cat consists of unconnected groups of cells, drawn out in the form of a rod, in a direction parallel to the anterior longitudinal sulcus in the 5th-6th segments of the cervical division of the spinal cord. The cells of this nucleus are fusiform; besides large cells, small numbers of small cells are found in the nucleus, which are considered by these authors to be intercalary neurones. The dendrites of the cells are also directed longitudinally and form a dendritic "tract".

More detailed investigation has shown that the cells in each group lie close to each other, at a distance of less than 25 μ. They have a somatochrome type of structure. They vary in length from 80 to 150 μ and in width from 30 to 60 μ. The small cells forming a part of the nucleus also have a somatochrome type of structure. They measure 20-30 μ in length and 16-20 μ in width.

The characteristic feature of the structure of the cells of the phrenic nerve nucleus was the emergence of their processes in the majority of cases from the upper and lower poles of the cell (Fig. 1, a). As has already been mentioned, the cell processes formed a tract, directed along the long axis of the spinal cord. In contrast

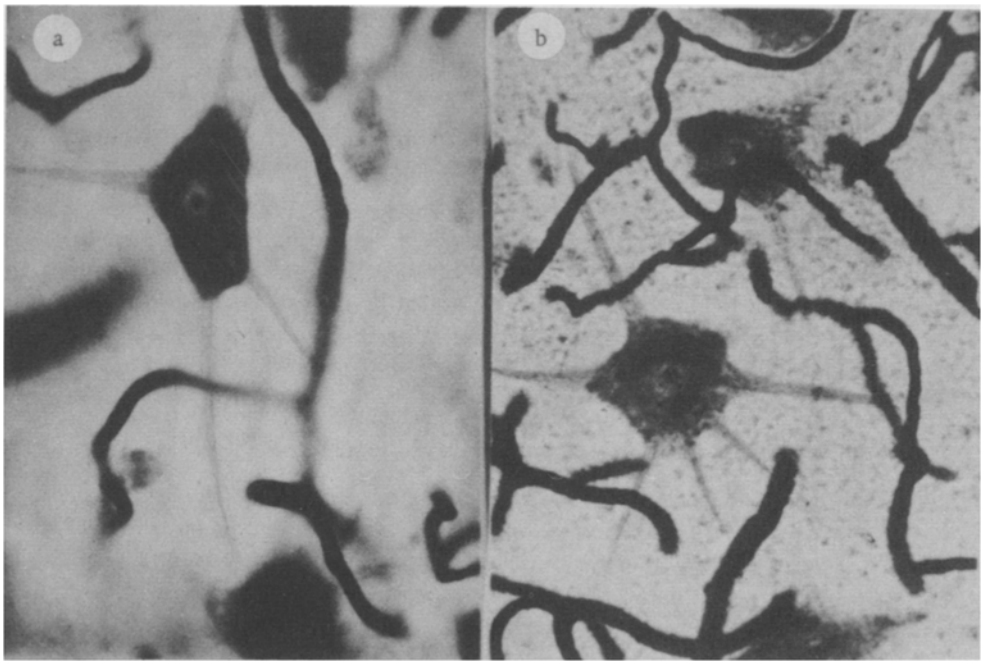

Fig. 1. Relationship of nerve cells to capillaries in the anterior horns of the spinal cord of the adult cat. a) Cell and capillary from the nucleus of the phrenic nerve; b) cell and capillary from the anterolateral group. Vascular network injected with ink and gelatin. Nerve cells stained with thionin. Magnification 400 times.

to the phrenic nerve nucleus, the cells of the anterolateral group were polygonal in shape and not above 60-70 μ in size. The cell processes had no particular orientation and went in various directions (Fig. 1, b). The characteristic feature of the structure of this group was the even distribution of the nerve cells in it, situated at a distance of more than 25 μ from each other.

The cell groups which we studied differed from each other not only by the arrangement of the nerve cells and their processes within them, but also by the individual structure of their vascular network and by the intimate relationships between the nerve cells and capillaries. The capillary network in the nucleus of the phrenic nerve, for instance, consisted of loops drawn out along the long axis of the spinal cord, and moreover the length of the capillary genu forming the loop and situated in the long axis of the brain reached 300 μ, but the capillaries situated in the transverse direction in the spinal cord were only 80-90 μ in length.

The capillaries in the phrenic nerve nucleus of the adult cat were characteristized by even and clear outlines. In preparations whose vascular network was injected with ink, their diameter was 4-5 μ. In these preparations it could be seen that, on account of the longitudinal arrangement of the vascular network, the phrenic nucleus could be distinguished clearly from the neighboring cell group (Fig. 2, a).

On comparison of the arrangement of the nerve cells and capillaries in the phrenic nerve nucleus, it could thus be observed that the longitudinal direction of the capillary network in the nucleus corresponded to the arrangement of the nerve cells therein.

As has already been pointed out, the cells in the phrenic nerve nucleus were arranged in groups. For this reason one capillary, passing to such a group, could simultaneously supply 2 or 3 cells. The capillaries around the cells formed open loops, stretched out along the cell bodies. It must be pointed out that in a few cases the

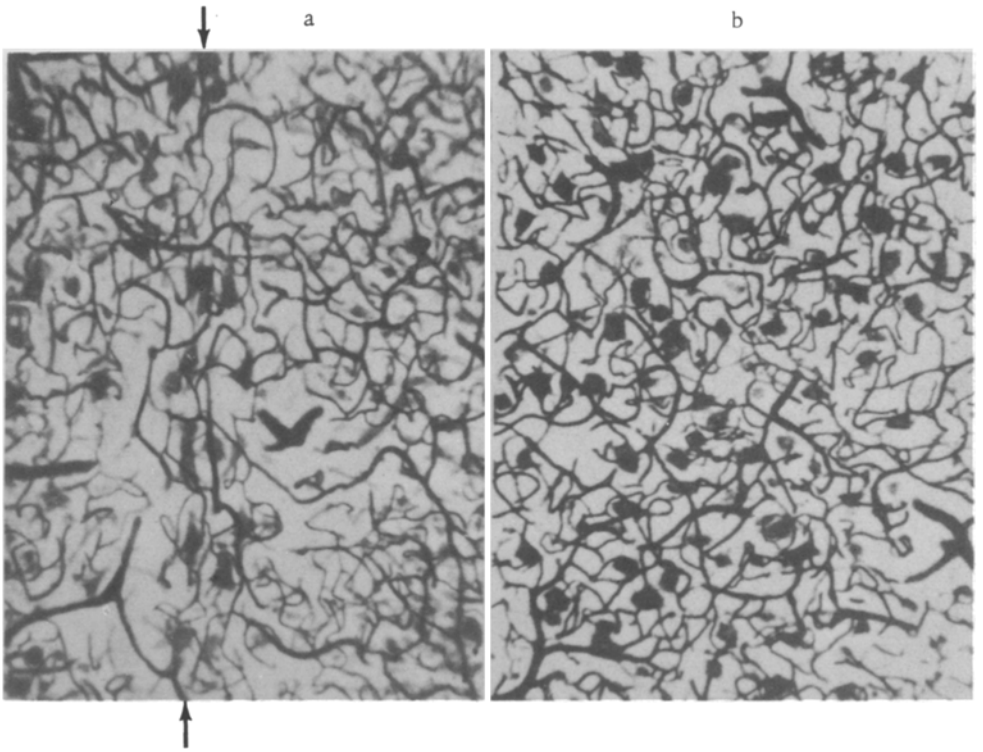

Fig. 2. Angioarchitectonics of the motor nuclei of the anterior horns of the spinal cord of the cat. Laterolateral longitudinal sections. a) Nucleus of the phrenic nerve, situated along the whole length of the preparation; b) anterolateral group of cells. Vascular system injected with ink and gelatin. Nerve cells stained with thionin. Magnification 80 times.

capillaries were in contact with the bodies of the cells (1-2 cells from each 10). The extent of contact of the capillary lying on the surface of the cell body amounted to 15% of the length of its perimeter.

In the phrenic nucleus we observed a special feature in the relationship of the capillaries to the cell processes. In some cases we could observe capillaries which accompanied the cell processes for a long distance. Moreover capillaries were seen to pass parallel to bands formed of a number of cell processes, at a distance of less than 25 μ from them. E. N. Kosmarskaya and E. G. Balashova [7] also observed that processes of nerve cells were accompanied by capillaries in the reticular substance of the medulla oblongata of the cat.

A different structure of the capillary network and relationship of nerve cells to capillaries was observed in the anterolateral group (Fig. 2, b). In contrast to the phrenic nerve nucleus, the capillaries in this group had no definite orientation and went in different directions. The length of the genu of the capillaries was roughly the same in all their planes of distribution, and was on the average 100-110 μ, so that the capillary loops were

polygonal in shape; they were composed of vessels having clear outlines and a uniform lumen. In preparations in which the vascular network was injected with ink, their diameter varied from 4 to 5 μ.

As has already been stated, the cells in the anterolateral group were separated from each other by a distance of over 25 μ. The capillaries arranged around each cell were therefore concerned with that cell alone, whereas in the group of cells of the phrenic nerve nucleus, as we have mentioned, one capillary supplied several cells. In contrast to the phrenic nerve nucleus, of each 10 cells of the anterolateral group, 6 cells were in contact with capillaries, and moreover the capillary was applied to the body of the cell for a comparatively long distance. The extent of contact of a capillary lying on the surface of the cell body amounted to 29% of the length of its perimeter.

On the example of the motor nuclei of the anterior horns of the spinal cord it could thus be seen that nuclei of different function, with sharp differences in their structure, were vascularized in a different manner. The nerve cells composing these nuclei had different relationships with the capillaries surrounding them.

SUMMARY

In an adult cat the phrenic nucleus and the anterolateral group of cells (the functionally different nuclei of the anterior horns of the spinal cord) differ not only by their structure, but also by vascularization of their cellular constituents. The structure of capillary network in the nucleus of the phrenic nerve corresponds to the longitudinal distribution of the nerve cells and their processes in the nucleus. In group distribution of the nerve cells in the nucleus of the phrenic nerve, each capillary simultaneously serves several cells of one group of nerve cells, without coming into contact with their bodies (in the majority of cases). In the event of a contact, the linear contact does not exceed 15% of the cellular perimeter. In contradistinction to the nucleus of a phrenic nerve, the capillary network in the anterolateral group has no definite orientation. The nerve cells in the latter are distributed uniformly and located at a distance of more than 25 micron from each other. Therefore, the capillaries located around each cell pertain to this cell. The number of cells in contact with capillaries and the linear extension of contact is greater in the anterolateral group than in the nucleus of the phrenic nerve.

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