MORPHOLOGICAL CHANGES OF THE SACRAL INTERVERTEBRAL GANGLIA ON APPLICATION OF HIGH LIGATURE OF THE PERITONEAL AORTA

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Temporary squeezing of the rabbit peritoneal aorta (Stannius' experiment), while producing necrosis of the grey matter of the caudal sections of the spine, does not essentially affect the intervertebral ganglia at the same levels [1, 4, 6 et al.]*. In connection with this, the view is prevalent that the nervous cells of the spinal ganglia in general show little sensitivity to blood supply disturbances, and consequently, in this respect sharply differ from the nervous cells of the central nervous system. However, in the literature there are references to the fact that the placing of a constant ligature on the peritoneal aorta of a rabbit (immediately below the emergence of the renal arteries) causes profound changes not only in the sacral section of the spine, but in the corresponding intervertebral ganglia [5]. Recently V. Yu. Pervushin repeated these experiments and obtained analogous results [2, 3]. Unfortunately, in the works mentioned, insufficient attention has been paid to these interesting and fundamentally important facts, as these works considered a number of incidental observations.

In the present investigation, an attempt was made to continue the study of the morphological state of the spinal ganglia with the application of analogous influences on the animal organism.

EXPERIMENTAL METHODS

A high ligature of the peritoneal aorta was applied in 12 rabbits and 6 cats. The ligature was placed through the peritoneum, just below the site of the emergence of the left renal artery.

In the rabbits immediately after operation, there appeared, as in Stannius' experiments, a persistent sluggish paralysis of the hind limbs and disturbance of urination (usually delay of urine).

The cats tolerated the ligature of the aorta with much greater ease. In one of them, no perceptible functional disturbances appeared at all. In the others, we observed paresis of the distal sections in one or both hind paws, appearing immediately after the operation (in 2 animals) or 2-4 hours later, but toward the morning of the following day there was perceptible lessening. No disturbances of the functions of the pelvic organs occurred in the cats.

The sections were cut in rabbits at four intervals of time after ligature of the aorta: 6 hours after the operation (3 rabbits), 12 hours after (2 rabbits), 24 hours after (4 rabbits) and 36 hours after (3 rabbits). The sections in the cats were cut 24 hours (in four cats) and 36 hours (in 2 cats) after ligaturing the aorta.

In all the animals, 14 caudal intervertebral ganglia were cut away together with the spine: 5 pairs of vertebrae, L_3 - L_7, and 2 pairs of sacral vertebrae (S_1 and S_2). All in all, over 200 ganglia were examined. The greater part of this material was fixed with 96° alcohol, and stained chiefly according to the method of Nissl, and also where necessary, with hematoxylin-eosin. In some cases, the ganglia were impregnated with silver according to Cajal (usually after fixing with alcohol-chloral hydrate-pyridine).

* In addition, four caudal common vertebral arteries were ligatured in a group of rabbits, but the results require further experimental confirmation.

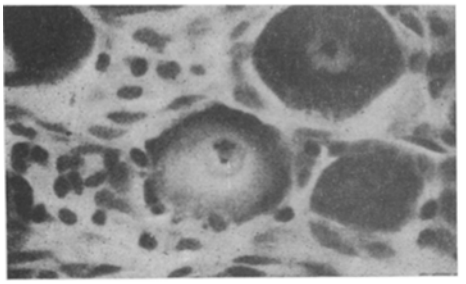

Fig. 1. Spinal ganglion (L7). Acute central chromatolysis, coagulation of Nissl substance at the periphery of the body of the cell. Stained according to Nissl. Enlargment, objective 40, ocular 10, Zeiss.

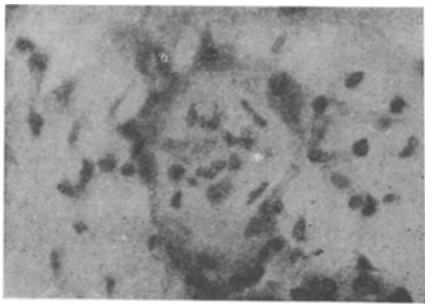

Fig. 2. Leucocytic invasion in body of necrotic nerve cell of spinal ganglion (S_1). Stained according to Nissl. Enlargement, objective 40, ocular 15, Zeiss.

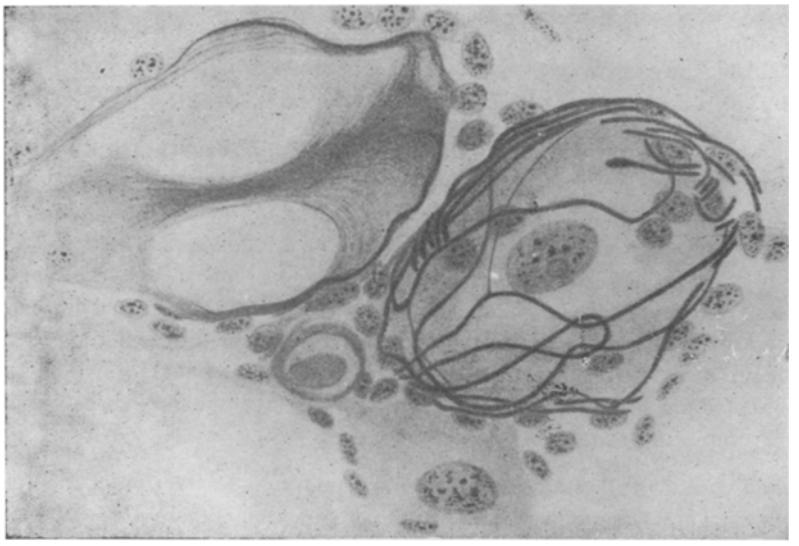

Fig. 3. Pericellular plexus and large vacuoles of nerve cells of the seventh vertebral ganglion. Impregnated according to Kajal. Enlargment, objective 40, ocular 10, MBI - 1. (Sketched by A. Ya.Khabarova).

EXPERIMENTAL RESULTS

On investigation of the spinal ganglia of the rabbits, stained according to Nissl we found already signs of structural changes in the ganglia in the first group of animals, which lived for 6 hours after the operation. They were not yet widely distributed, and appeared in the main in different degrees and in forms of pulverization and disintegration of the Nissl granules, occasionally in some small parts of the body of the cell, more considerably in the sections. In the first case, the cells acquired a "spotted" appearance, in the second, with a more equal chromatolysis, the Nissl substance was maintained around the nucleus in the form of significantly larger than usual granules, lined up in a single row, or, on the contrary, concentrated in the perpiphery of the cells, sometimes running together in a general amorphous mass (Fig. 1). The remainder of the cellular body contained only minute, scarcely perceptible grains of tigroid. However, similar forms in this group of animals were rarely found. The nucleus of the changed nerve cells retained its normal structure, remaining bright and, as a rule, centrally situated. Occasionally, decomposition of the nucleus in some separate formations was seen.

Topographically, the changes described were essentially confined to ganglia of the 6 and 7th vertebral segments.

Already 12 hours after ligaturing the aorta, in the ganglia, completely distinct irreversible changes of the nerve cells were found, but of a different character. In one of the rabbits of this group, they had the appearance of "fusion" (severe cellular disease, Nissl) with signs typical of this form (wrinkled, pycnotic nucleus, bright round nuclear zone, disintegration of the Nissl granules in the body of the cell).

In the second rabbit, the changes had the character of ischemic degeneration: affected nerve cells became transparent formations completely lacking in Nissl substance. These formations, on staining with hematoxylin-eosin, eagerly absorbed the latter, assuming a rosy color.

Similarly, the number of changed cells and their topographic distribution were also completely different. In the first animal, the cells with signs of "fusion" were isolated in the microscopic sections, but were found in all the investigated ganglia without exception, from L_3 to S_2. In the second rabbit, there were many cells with ischemic degeneration, but they were situated only in the ganglia of S_1, and were absent in the other ganglia.

The reaction of the Satellites and connective tissue cells of the capsules were not on a par with the changes described above. These elements revealed a distinct productive reaction less often than one might have expected (well formed residual ganglia were rarely found).

An interesting point was that in the protoplasm of the nerve cells, which showed signs of ischemic degeneration, now and then we found leucocytes (from 3-4 up to 12 in one cell), which had invaded through the capsules, and obviously had taken part in the removal of the products of decomposition from the dead cells (Fig. 2).

With an extension of the post-operative periods (up to 24 and 36 hours), the changes in the ganglia grew sharply, becoming more frequently irreversible, and sometimes embracing the majority or even all the nerve cells in the observed microscopic sections of the individual ganglia. In their character, these changes were similar to those which had occurred with a 12-hour ligature of the aorta, and independent of the duration of life of the animals, and in some rabbits we saw signs of "fusion" and in others, ischemic degeneration. Sometimes even in the same rabbit, the first of these irreversible forms was seen in some ganglia, and in other ganglia, the second. This considerably lessened the gap in the named pathological forms, indicating that both of them can arise under the influence of uniform causes, despite basic differences in characteristic signs. Manifestation of "fusion" in the animals which survived longer was more often accompanied, than in the other rabbits, by vacuolation of the protoplasm of the dying nerve cells.

The Satellites and capsule cells in the ganglia with a continuous affection of the nerve cells were also often subject to degeneration. Even with partial ganglia involvement, these elements occasionally maintained their usual appearance, but sometimes showed different signs of productive reaction.

Upon impregnation with silver, especially in the ganglia containing, apart from being subject to necrosis, only slightly changed nerve cells, we saw more than once signs of excessive growth of the nerve fibers with formation of round cellular plexus (Fig. 3).

Topographically the most profound changes in the rabbits surviving 24 and 36 hours were situated in the ganglia of the two lower vertebrae (6 and 7) and the two higher sacral segments. But in these rabbits, even more distinct was the inequality and lack of uniformity of the affection of the ganglia, noted earlier in the previous group of animals. Thus, in some of these rabbits, in some caudal ganglia, all, or the overwhelming majority of the nerve cells, as already mentioned, were affected, while in the other rabbits of the same group, irreversible changes in the ganglia at similar levels were observed much more seldom.

This discrepancy in affection of the ganglia at a uniform level in different rabbits points, in particular, to the existence of a large number of variants in the anastomoses of the vessels feeding this or that ganglia. As a result, the conditions of blood supply to ganglia of the same segment, with uniform influence, varied in different rabbits, apparently leading to those divergent consequences just mentioned.

The investigation of the spinal ganglia of cats showed that in these animals ligature of the peritoneal aorta does not produce in the ganglia such significant changes as in rabbits. In some cases, both in the vertebral and sacral sections, we found pathological forms akin to ischemic degeneration, and also occasionally signs of "fusion" of the nerve cells, but on each occasion these irreversible manifestations were seen microscopically either in the individual

nerve cells, or small cellular groups. Among the other nerve cells, as in the rabbits, we not infrequently observed disintegration of the Nissl granules, sometimes very marked, with the formation of "spotted" cells, and this curious chromatolysis was accompanied by manifestation of vacuoles in parts of the body of the cell, with disintegration of tigroid. All the same, a considerable part of the nerve cells, independent of the level of distribution of the ganglia, even 48 hours after the operation, did not show fundamental deviations from the normal picture.

The findings cited show that alongside individual singularities of feeding of the spinal ganglia, which appeared distinctly in the experiments on the rabbits, there exist even more marked species changes in their blood supply. Further proof of this is offered by the results of the investigation of the spine, carried out on the rabbits and cats simultaneously with the investigation of the spinal ganglia. In the rabbits, as a rule, we observed severe necrotic changes of the grey matter, considerably less marked in cats, a factor also affecting the physiological state of the animals in the post-operative period. It was clear that in the cats, the vascular connections between the arteries, emerging from the aorta above and below the site of ligature, could in these conditions maintain the blood supply to the caudal part of the spine and the corresponding ganglia at a higher level.

The reaction of the satellites and capsule cells in the series of experiments under consideration was more clearly marked than in the rabbits. We often observed activation of these elements, and sometimes effective pictures of neuronophagia.

LITERATURE CITED

[1] Dolnikov, [illegible] Sovet. Psikhonevrol. 1938, No. 6. pp. 101-102.

[2] Pervushin, V. Yu., Nerve and Vascular Connections of the Sacral Section of Rabbit Spine. Dissertation * (1953).

[3] Pervushin, V. Yu., Vestnik Khirurg. Vol. 75, No. 3, pp. 61-66 (1955).

[4] Pussep, L. M. Nevrol. (Vestnik) Vol. 10., No. 2. pp. 83-146 (1902).

[5] De Buck, D., and Demoor, L., Le Nevraxe (1901) Vol. 2.

[6] Ehrlich and Brieger, Z. Klin. Med. Vol. 7, Suppl. (1884).

* In Russian.