MORPHOLOGY AND PATHOMORPHOLOGY

THE FUNCTIONAL MORPHOLOGY OF THE AFFERENT SYSTEMS OF THE SPLANCHNIC NERVES*

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Because of their particular importance in the innervation of the organs of the abdominal cavity, the splanchnic nerves have in the past attracted the attention of many workers [1, 2, 3, 9, 11]. The participation of the splanchnic nerves in the conduction of afferent impulses from the internal organs during pathological conditions (cholecystitis, intestinal obstruction, inflammation of the uterine adnexa, enteritis) is undoubtedly great.

The functional activity of the afferent systems of the splanchnic nerves is taken into consideration when a number of clinical procedures are carried out: division of the splanchnic nerves in hypertension [8, 10, 15], splanchnic nerve block [5, 14], anesthesia in the course of operations [13].

In 1867, Asp [12], when stimulating the central segment of the divided splanchnic nerve, observed a considerable rise in the arterial pressure. Similar results were obtained by V.I. Rozhanskii [7], who accounted for them by the presence of a considerable number of sensory fibers – processes of the cells of the spinal ganglia – in the composition of the splanchnic nerves. This explanation was subsequently confirmed morphologically [16].

Until recently, no proof has been forthcoming of the presence of afferent fibers of sympathetic origin in the splanchnic nerves, although their existence has been claimed by some workers [1].

The study of these fibers and of their sources of origin was the aim of our present research, which was composed of morphological and physiological experiments.

EXPERIMENTAL METHOD

We carried out two series of investigations.

In the first series, the presence of afferent fibers of sympathetic type and the sources of their origin were determined by means of the method of secondary degeneration.

The technique of the experiment was as follows: the operation of resection of the small intestine and removal of the ganglia of the solar plexus and the gall bladder was performed on 25 cats.

The small intestine was resected from the duodenum to the ileocecal junction under pentothal sodium anesthesia. Not more than 30-40 cm of intestine was resected, and its continuity was subsequently restored by end-to-end anastomosis. The animals were killed after 12-96 hours by the air embolism method.

Neurohistological examination of the splanchnic nerves was carried out by the original Bielschowsky method and by Campos's modification of this method.

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The second series of investigations was performed in 12 cats in order to confirm the presence in the splanchnic nerves of afferent fibers which preserved their function after exclusion of the sensory fibers of spinal origin.

The experimental technique was as follows: the splanchnic nerve was divided below the diaphragm. From 17 to 27 days after operation, the animals were placed in a screened room. The peripheral end of the divided splanchnic nerve was placed on platinum electrodes. The action potentials were recorded by means of a loop oscillograph type MPO-2, with a 4-channel balanced amplifier with symmetrical input. The sensitivity of the apparatus was 5 microvolts/mm deviation of the beam of light; the frequency characteristics of the amplifier remained linear between limits of 3 and 3000 cps (loop IV).

EXPERIMENTAL RESULTS

In the first series of experiments, the phenomenon of secondary degeneration of the afferent sympathetic fibers in the composition of the splanchnic nerves was noted in all cases: varicose changes in the axons, vacuolation of the axoplasm and fragmentation of the axis cylinders (Fig. 1).

After resection of the small intestine, the most intensive changes of the secondary degeneration type were detected, after removal of its middle portion, in the splanchnic nerves on both sides.

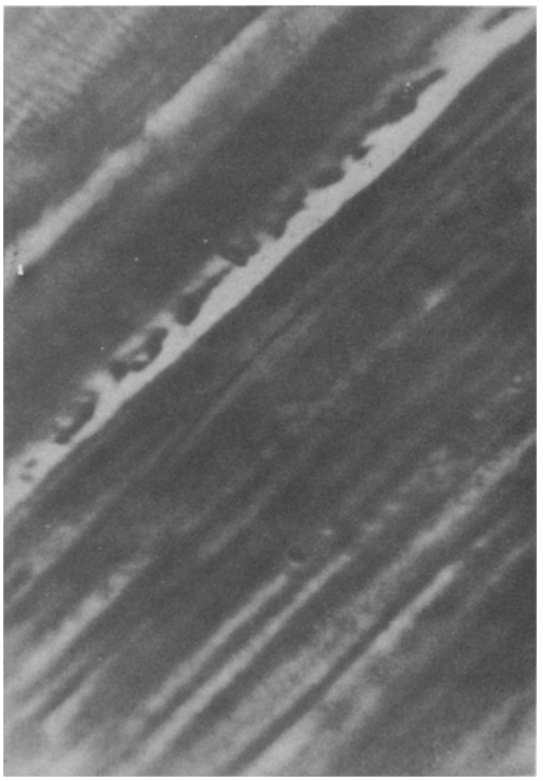

Fig. 1. Secondary degeneration of the afferent fibers in the composition of the splanchnic nerve, 72 hours after resection of the small intestine. Bielschowsky's method. Ocular 5×, objective 90×.

The secondary degeneration observed in the nonmedullated and fine medullated fibers in the composition of the splanchnic nerves after these operations must be regarded as the result of their severance from their trophic centers – the receptor neurones (Dogiel's type II cells [4]) situated in the intramural plexuses of the extirpated organs.

The degeneration of the afferent fibers in the composition of the splanchnic nerves after removal of the ganglia of the solar plexus could be explained in two ways: either they are "transit" fibers, passing through the extirpated semilunar ganglia, or they are processes of Dogiel's type II cells situated within these ganglia. The existence of these cells has been confirmed very recently by V.I. Pilipenko [6].

In the second series of experiments, during registration of the activity of the peripheral end of the splanchnic nerve from 17 to 27 days after division, the following could be observed: the initial background was characterized by asynchronous groups of single and fused impulses. Comparison of these recordings with a graphic representation of the activity of a control nerve demonstrated the considerable difference in their electrophysiological characteristics (Fig. 2). The frequency of the single impulses was 5-12 cps and that of the grouped impulses 60-80 cps, their amplitude being from 10 to 60 microvolts (in the case of the bursts of fused impulses).

Since the appearance of "background" potentials was not associated with any form of outside influence on the animal, it is obvious that these potentials were due to the physiological activity of the corresponding receptors.

At the times mentioned (17-27 days), the peripheral end of the divided splanchnic nerve was investigated by the Campos impregnation method and by Gomori's method for demonstrating the acid phosphomonoesterase activity. These investigations confirmed the presence of intact fibers in the composition of the "long-surviving"

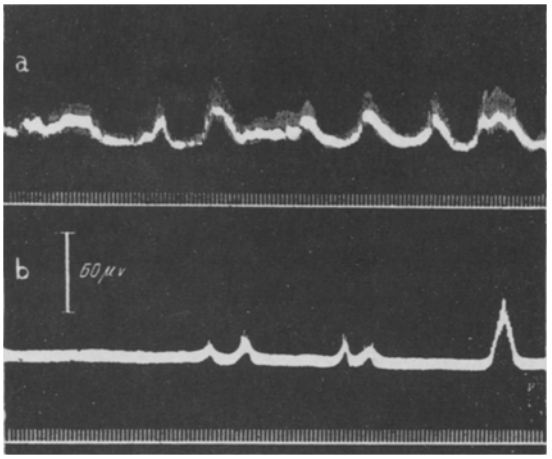

Fig. 2. Electrical activity of the peripheral end of the divided splanchnic nerve. a) Before division of the splanchnic nerve; b) 27 days after division of the nerve.

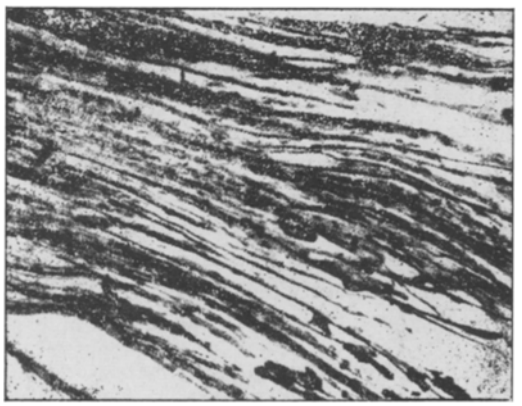

Fig. 3. Intact fibers in the peripheral segment of the splanchnic nerve 24 hours after its division. Bielschowsky–Campos method. Ocular 7×, objective 40×.

segment of the splanchnic nerve, the axons of which preserved a comparatively high degree of enzymic activity. The impregnation method of Campos revealed intact nonmedullated and fine medullated fibers in the composition of the peripheral end of the divided splanchnic nerve (Fig. 3).

The intact fibers described under these experimental conditions evidently did not lose their connection with their trophic center, and further physiological observations confirmed the relationship between the electrical activity of these fibers and the functional state of the corresponding organ.

In animals, selected for the experiment in a fasting condition, single impulses and slow waves of low amplitude were observed; in satiated animals, the number of grouped impulses rose parallel with their amplitude and frequency.

The introduction of a 1:2000 solution of carbachol into the lumen of the bowel and the application of cotton-wool soaked in warm Ringer's solution to the serous membrane of the intestine caused the appearance of large impulses, grouped and fused in character, with an amplitude of up to 60 microvolts.

Application of cotton wool soaked in cold Ringer's solution (T = 8°) to the serous membrane of the intestine led to a fall in the amplitude of the impulses.

Introduction of air and warm Ringer's solution into the cavity of the gall bladder led to the appearance of intensive grouped impulses, which decreased to a minimum 2-4 minutes after a subepineurial novocain block of the peripheral end of the divided splanchnic nerve.

SUMMARY

The morphology, the sources of formation and the functional characteristics of the afferent sympathetic fibers of the splanchnic nerves were studied.

The removal of the gall bladder and of the small intestine, as well as of the semilunar ganglia of the solar plexus was associated with a secondary degeneration of the amyelinated and thin myelinated conductors contained in the splanchnic nerves. This fact shows that they pertain to the neurites of the receptor neurons (II type Dogiel's cells) located in the plexuses within the walls of the corresponding organs.

The electrophysiological and the histochemical study of these neurites was studied after the exclusion of all the spinal afferent fibers of the splanchnic nerves. The preservation of their morphology, function and the enzymatic activity in the peripheral portion of the splanchnic nerve in 21–27 days after its section was demonstrated. Their physiological characteristics are determined by the functional state of the corresponding organ.

LITERATURE CITED

[1] A.S. Gusev, Byull. Éksptl. Biol. i Med., No. 1, 108-113 (1957).*

[2] V.E. Delov, P.A. Kiselev, N.A. Adamovich and O.N. Zamyatina, Problems of the Morphology and Physiology of the Central Nervous System, pp. 31-37, Moscow, 1953 [In Russian].

[3] V.N. Dmitrievskii, Proceedings of a Scientific Conference of the Kazan Postgraduate Medical Institute, pp. 51-53, Kazan, 1955 [In Russian].

[4] A.S. Dogiel, Anat. Anz. 1896, Bd. 11, S.679-687.

[5] V.V. Mosin, Uchen. Zapiski Kazansk. Vet. Inst., 61, 1, 3-110 (1954).*

[6] V.I. Pilipenko, Byull. Éksptl. Biol. i Med., 43, No. 4, 112-116 (1957).*

[7] V.K. Rozhanskii, The Relationship of the Spinal Cord and Sympathetic Ganglia to the Vascular System, Kazan, 1889 [In Russian].

[8] P.L. Sel'tsovskii and N.I. Timofeeva, Klin. Med., No. 2, 39-49 (1950).

[9] F.B. Kheinman, Transactions of the First Belorussian Conference of Anatomists, Histologists, Embryologists and Topographical Anatomists, pp. 336-337, Minsk, 1957 [In Russian].

[10] S.S. Sharimanyan, The Surgical Treatment of Arterial Hypertension. Dissertation, Leningrad, 1937 [In Russian].

[11] M.B. Shtark, Transactions of the First Belorussian Conference of Anatomists, Histologists, Embryologists and Topographical Anatomists, pp. 359-360, Minsk, 1957 [In Russian].

[12] Asp, cited by M. G. Durmish'yan, Effector Mechanisms of Afferent Stimuli, p. 22, Moscow, 1955, [In Russian].

[13] Broun, cited by A.A. Vikhman, Transactions of the Astrakhan Medical Institute, vol. 1, 2, 1932. [In Russian].

[14] Kappis, Beitr. path. Anat., 1919, Bd. 115, S.1617.

[15] Pieri, cited by A.L. Polenov and A.V. Bondarchuk, The Surgery of the Vegetative Nervous System, Leningrad, 1947 [In Russian].

[16] D. Sheehan, Brain, 1922, v.55, p. 493-498.

*See English translation.