THE MORPHOLOGICAL BASIS OF THE SOKOVNIN PHENOMENON

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 56, No. 9, pp. 113-115, September, 1963
Original article submitted April 12, 1963

N. M. Sokovnin [6,7] found evidence for reflex activity in autonomic ganglia under conditions in which connections with the central nervous system had been eliminated. In cats he divided all the preganglionic fibers connecting the inferior mesenteric ganglion with the spinal cord, and he also divided the subsplanchnic* nerve. On stimulating the central end of the divided splanchnic nerve he observed contraction of the urinary bladder, of the sphincter ani, and of the vessels of the lower part of the rectum. He therefore concluded that the inferior mesenteric ganglion is an independent reflex center.

Langley and Anderson [13] have repeated Sokovnin's experiments and obtained the same results, but they explained them differently. Langley maintained that the whole of the autonomic system consists only of effector nerve cells and that it contains no sensory neurones. In the autonomic ganglia there can be a passage of impulses only from a preganglionic nerve fiber to a postganglionic fiber. Langley and Anderson hold that in Sokovnin's experiment there was not a true reflex connection but an axon reflex caused by antidromic impulses originating at the point of stimulation of the subsplanchnic nerve and passing along collaterals of the preganglionic effector fibers to neurones of the inferior mesenteric ganglion. This opinion held sway for a long time. However, despite Langley's authority, results have appeared which do not fit in with the axon-reflex theory [3,5,8-12,14,15].

The phenomenon under discussion has been called the Sokovnin phenomenon. However, despite the large amount of physiological evidence supporting the existence of this phenomenon, until now there has been no morphological basis for it. There has been no demonstration of the afferent portion of the reflex arc concerned; finally the position of the sensory neurones involved in the Sokovnin phenomenon has not been demonstrated either in the inferior mesenteric ganglion or in the wall of the urinary bladder.

The object of the present work has been to discover sensory nerve cells involved in the Sokovnin phenomenon and to determine where they are located.

EXPERIMENTAL METHOD

Two series of experiments were carried out on male cats. In the first set the subsplanchnic nerves were divided 0.5 cm from the inferior mesenteric ganglion. Bielschowsky-Gros and Campos solutions were used 36 and 48 hours after the operation to impregnate the inferior mesenteric ganglia and the central ends of the splanchnic nerves. After 10, 20, and 30 days Nissl's method was used to study the condition of the neurones of the inferior mesenteric ganglion and the neurones of the intramural ganglia of the urinary bladder. In the second set of experiments we removed the sympathetic ganglia from both sides between T_5 and L_4 and between T_{10} and L_3. After 5, 7, 14, 21, 30, and 40 days the inferior mesenteric ganglia were fixed in Carnoy's fluid, the sections were stained in toluidine blue, by Nissl's method, or in chrome-alum gallocyanin by Einarson's method.

EXPERIMENTAL RESULTS

Soon after division of the subsplanchnic nerves we found degenerating fine nerve fibers in silver-impregnated preparations of the central ends of the subsplanchnic nerves, and in the inferior mesenteric ganglia in the direct vicinity of the cell bodies. This result indicated that the subsplanchnic nerves contain nerve fibers proceeding upwards in the direction of the inferior mesenteric ganglion. From these results alone it is difficult to say where the

*Publisher's Note. This term refers to the structure made up of postganglionic sympathetic fibers from the inferior mesenteric ganglion and of the pelvic splanchnic nerves accompanying them.

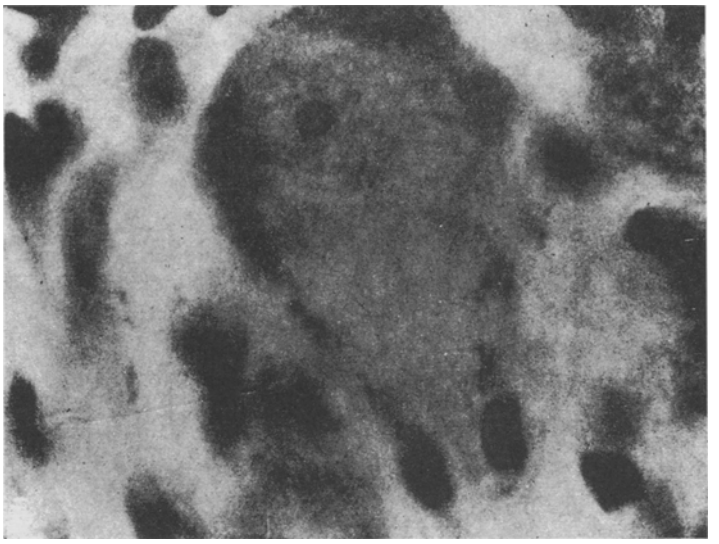

Fig. 1. Retrograde changes shown by a neurone from an intramural ganglion of the urinary bladder 20 hours after division of the subsplanchnic nerves. Micrograph. Toluidine blue. Objective 100 ×, ocular 10 ×.

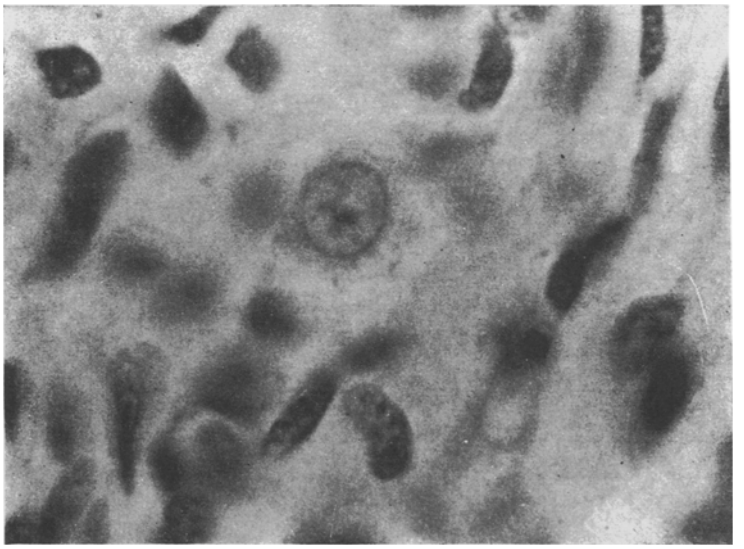

Fig. 2. A neurone showing transneuronal changes; from the inferior mesenteric ganglion, 20 days after division of the subsplanchnic nerves. Micrograph. Toluidine blue. Objective 100 ×, ocular 10 ×.

cell bodies of these neurones are situated, whether they lie along the path of the subsplanchnic nerves or in the wall of the organs of the true pelvis. In Nissl preparations neurones were found in the wall of the bladder which showed retrograde degeneration, chromatolysis, and displacement of the nucleus. These changes were most marked in the large neurones of the intramural ganglia (Fig. 1).

It is known that the retrograde reaction occurs as a result of division of outgrowths of a nerve cell. When dividing the subsplanchnic nerves we evidently destroyed the integrity of the outgrowths of nerve cells of the intramural ganglia of the bladder. By studying the cell changes of neurones of the inferior mesenteric ganglion subsequently, after 10, 20, and 30 days we found in it neurones in a state of marked transneuronal atrophy [4]; the nucleus was

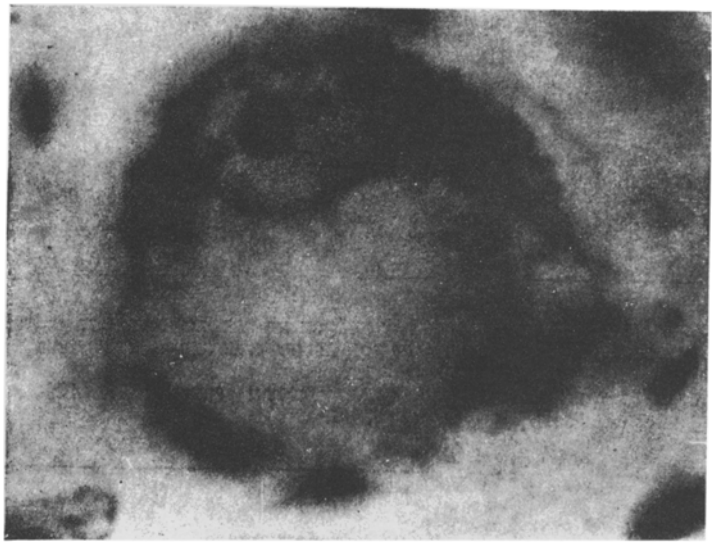

Fig. 3. Retrograde changes from a neurone from the inferior mesenteric ganglion shown 30 days after bilateral removal of the spinal sympathetic ganglia between levels T_{10} - L_3. Micrograph. Immersion object 100 ×, ocular 10 ×.

greatly reduced in size and there was a thin lining of cytoplasm (Fig. 2). Transneuronal strophy is the reaction of a neurone to loss of synaptic connections. In this case transneuronal degeneration was evidently the result of the loss of synaptic connection with neurones of the intramural ganglia of the bladder. These facts indicate that nerve fibers enter the inferior mesenteric ganglia from the intramural ganglia of the bladder.

We consider that neurones of the intramural ganglia of the urinary bladder which react to division of the subsplanchnic nerves by retrograde changes are sensory cells of the type II Dogiel. Degenerating nerve fibers found in the central ends of the subsplanchnic nerves and in the most inferior mesenteric ganglia are neurites of these cells.

Preparations of the inferior mesenteric ganglion studied after the second set of experiments showed retrograde degeneration of neurones in the inferior mesenteric ganglion at all times. These changes were shown by the large neurones of the inferior mesenteric ganglion (Fig. 3).

Control operations for this series of experiments consisted of opening the vertebral canal over the same distance and damaging the meninges of the spinal cord without removing the sympathetic ganglia; they caused no retrograde changes in the neurones of the inferior mesenteric ganglion. This set of experiments was made to determine whether there were any sensory neurones in the inferior mesenteric ganglion itself.

Previously A. A. Zavarzin [2] suggested that the type II Dogiel cells may possible send neurites along the posterior roots into the spinal cord. T. A. Grigor'eva [1] thinks that a sensory neurone of the autonomic system, no matter where it is situated, must necessarily send at any rate collaterals of its neurite into the spinal cord through the posterior root ganglion.

When the spinal ganglia have been removed we have evidently distrubed the integrity of the collateral which was the cause of the retrograde changes of the neurone itself. We consider that neurones of the inferior mesenteric ganglion which undergo retrograde degeneration after removal of these spinal ganglia are sensory neurones. It is quite possible that these neurones together with sensory neurones of the intramural ganglia of the urinary bladder form part of the afferent system of the reflex arc involved in the Sokovnin phenomenon.

SUMMARY

Sensory nerve cells of the type II Dogiel were found; they provide the afferent portion of the reflex arc in the Sokovnin phenomenon. It was shown that the sensory neurones lie in the intramural ganglia of the urinary bladder. They were also present in the inferior mesenteric ganglion.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
