MORPHOLOGY AND PATHOLOGICAL MORPHOLOGY

ON THE PLURISOMITICITY OF THE SOURCES OF INNERVATION OF PERIPHERAL RECEPTOR ENDINGS

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(Received July 25, 1956. Submitted by Active Member of the Academy of Medical Sciences of the USSR, V. N. Chernigovsky)

The problem of the possibility of the plurisomitic innervation of histological structures was first set by Agduhr [12] in 1916. Based on his physiological experiments, he reached the conclusion that it is possible for several motor nerve fibers which originate in different segments of the spinal cord to terminate in the same muscle. Agduhr confirmed by experimental morphological observations his physiological data, proving with respect to the muscles of the anterior extremities and intercostal muscles that it is possible for two nerve fibers originating at different levels of the spinal cord to end at one muscular fiber.

In 1925, B. I. Lavrentyev [8], studying the innervational relationships of the muscles of the posterior extremity of the frog, established the existence of plurisomitic motor innervation of some muscular fibers in the sartorius muscle. Similar facts were proved by V. N. Murat and N. F. Rupasov [10] in 1937, with respect to the fibers of the ocular muscles of the cat. On the fourth day after section of the oculomotor nerve, the authors succeeded in observing two motor end-plates, one of which was completely destroyed while the other looked completely normal, on one of the muscular fibers of the m. rectus oculi lateralis.

The widespread application of the experimental method in studying the afferent innervation of the internal organs has allowed the origins of the sensory fibers of many of them to be established exactly. The undoubted existence of plurisomitic receptor innervation of some of the internal organs was found. The clearest proofs of this phenomenon were obtained by E. M. Krokhina [7] with respect to the afferent innervation of the large intestine and rectum of the cat. She established that the sensory nerve fibers which form the receptor apparatus in the walls of the indicated organs originate in the cells of the spinal ganglion which lie at different levels of the spinal cord (beginning with the upper thoracic segments and ending with the sacral).

Analyzing the results of experimental morphological investigations of the sensory innervation of many internal organs which were obtained by different authors, the undoubted plurisomitic origin of the receptors of this or that organ can be noted. Thus, E. K. Plechkova [11], in studying the innervation of the heart, established the origin of some of the sensory nerve endings of its wall at the vagus nerve, of others at the thoracic intercostal ganglions.

A similar relationship was established by B. A. Dolgo-Saburov [3] for the inferior vena cava and by T. A. Grigoryeva [1] for the aorta. V. F. Lashkov [9], studying the receptors of the lungs, was able to state the connection between the sensory endings of these organs with the spinal ganglions of the cervical, thoracic and lumbar sections of the spinal cord. T. A. Grigoryeva [2], discussing the peculiarities of the sensory innervation of the viscera, indicated directly that the distribution of the sensory nerve fibers to the viscera is characteristically nonsomitic.

Thus, multiple origin of the afferent innervation has been proved for many internal organs at present. The question of the plurisomiticity of the origins of the innervation of individual receptor apparatuses has not been raised until now.

EXPERIMENTAL METHODS

Our experimental morphological investigation was carried out on young, half-grown male dogs. The animals spinal ganglions were removed usually at the levels of the spinal cord where the sensory nerves of the male sex organs originate. As is known, these are the paravertebral ganglions of the lower lumbar and sacral segments. As a rule, separate bilateral extirpation of the ganglions at the indicated levels was carried out, i.e., in some cases only the lumbar ganglions were extirpated, in others only the sacral ones. 72 hours after the operation, the sex organs were removed from the animals for examination fixed in 12% neutral formalin or in A. F. A. fluid and processed according to Bielschowsky-Gross' method.

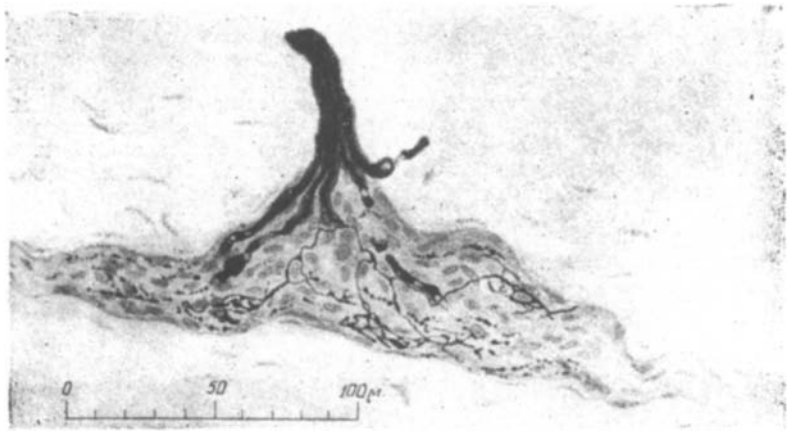

Fig. 1. Receptor in the tunica albuginea of the corpus cavernosa penis of a dog, 72 hours after bilateral extirpation of the five lowest lumbar paravertebral ganglia (processed by the method of Bielschowsky-Gross-Lawrentiew).

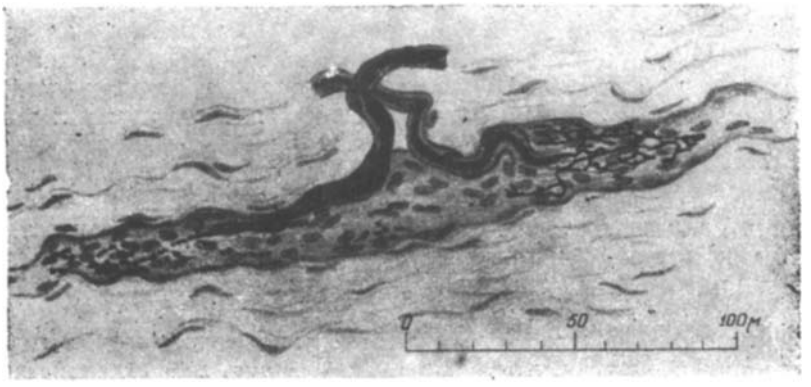

Fig. 2. Sensory ending in the tunica albuginea of the corpus cavernosa penis of a dog, 72 hours after bilateral extirpation of all the sacral paravertebral ganglia.
(Processed by Bielschowsky-Gross method).

We studied the sensory nerve endings which lies in the tunica albuginea of the corpus cavernosa penis. A large number of receptors, differing in morphology, are in this area. Among them, uniquely constructed endings, somewhat resembling tendinous fibers, draw attention. These receptors represent bound nerve endings in the formation of which, in addition to the terminal branches of the nerve fibers, special structures take part, representing the nucleoplasmic component and the membrane which surrounds the ending, together with the bunch of connective tissue fibers which pass through it. The number of sensory nerve fibers which end in this apparatus may vary. Endings formed by only one nerve fiber occur, but more often several nerve fibers participate in the structure of the receptors.

EXPERIMENTAL RESULTS

Studying the experimental material, we found that with the indicated operation, part of the receptors in any portion of the tunica albuginea of the corpus cavernosa were in a state of degeneration, while part preserved all signs of normal structure. This indicated that, in any section of the tunica of the corpus cavernosa, sensory nerve fibers which originate in the lumbar, as well as in the sacral spinal ganglion, end.

Along with the indicated phenomenon, we encountered other facts also. In studying the individual tendinous sensory endings which are formed by several myelinated nerve fibers, we found that not all the fibers entering the receptor, nor their endings, looked the same. The majority of the nerve fibers approaching the sensory apparatus shown in Fig. 1 were in a state of degeneration and only one afferent myelinated fiber remained uninjured. Corresponding to this state of the afferent fibers, the overwhelming majority of the terminal ramifications of the axons within the ending were completely destroyed and looked like dark lumps and grains, not interconnected and lying in chains or singly. Only a comparatively small portion of the receptor's nerve ending apparatus preserved its extremely fine fibrillar structure and a clearly evident connection with the only uninjured nerve fiber. Taking into account that, in this case, bilateral extirpation of the paravertebral ganglions was performed at the level of the five lowest lumbar segments, it can be assumed that the sensory nerve fibers which end in this receptor originate both in the spinal ganglions which were extirpated as well as in the sensory ganglions which lie at other levels of the spinal cord.

In studying the material of the series of experiments in which the spinal ganglions of the sacral region of the spinal column were subjected to bilateral extirpation, a picture similar to the one described above could be observed in some of the tendinous receptors of the tunica albuginea of the corpus cavernosa. In the sensory nerve endings which were formed by some myelinated nerve fibers, part of the latter, together with their end ramifications suffered degeneration, the rest remained uninjured. Fig. 2 gives an impression of the receptor found in this condition. Of the two nerve fibers which participated in the formation of the sensory ending, one is in a state of granular degeneration, and its endings have become disconnected dark lumps; the second fiber kept its normal structure down to the finest final ramifications. Apparently in this case the changed fiber originated in the spinal ganglions of the sacral section of the spinal column, while the intact one, probably, was connected with the paravertebral ganglions of higher segments.

The above data permit the assumption that the axons of several sensory neurons which lie at different levels of the spinal column, can end in one sensory nerve ending.

In other words, these data allow the assumption that the phenomenon of nonsomitic (or plurisomitic) origin of sensory innervation can pertain not only to organs, but also to individual receptor apparatuses of the latter.

However, before finally expressing this assumption, it is necessary to decide whether the above picture did not arise on the basis of the well known phenomenon of unequal stability of the nerve conductors with respect to the action of an injurious agent and whether the unchanged nerve fibers and their terminal ramifications are not so-called "mummified" nerve cells. The following two circumstances contraindicate such a possibility.

In the first place, the investigation of many authors established that "mummification" of nerve fibers usually occurs under definite conditions which can be either the action of a coarse injurious agent (in this case "mummification" takes place either in the area of the nerve directly affected by the agent or in the sections of nerve fiber closest to it), or the sharp disturbance of the blood supply to the tissues surrounding the injured nerve structures [4, 5, 6]. Such circumstances did not occur in the above cases, consequently, there was no reason for the phenomena of "mummification" to develop in large numbers.

In the second place, the frequent repetition of the above picture and the preservation of their normal structure by externally unchanged nerve fibers, down to the finest neurofibrillar ramification in the receptor, could hardly occur in the presence of "mummification" or delayed degeneration of the nerve cells.

And so, if it is assumed that the plurisomitic origin of the innervation of the peripheral receptor apparatuses actually does exist, even if only with respect to certain sensory nerve end apparatuses of the tunica albuginea of corpus cavernosa at present, what can be the physiological significance of this phenomenon?

The impulses which arise on stimulation of a plurisomitic ending enter different sections of the spinal cord simultaneously or almost simultaneously. It is possible that this phenomenon assures the origin here of a wave of stimulation of considerable force, which can play a definite role in the course of these or other reflex reactions.

On the other hand, it can be suggested that the simultaneous entry of impulses into different segments of the spinal cord from a single receptor leads to the development of two (or several) reflex reactions which occur at the same time due to the action of a single stimulus.

SUMMARY

In some receptor terminals of the corpus cavernosa of the penis of dogs, 72 hours after bilaterial extirpation of spinal ganglions on the level of the lumbar or sacral segments of spinal cord a part of conductive nervous fibers and their terminals regenerates markedly and another part remains intact.

These phenomena are observed when lumbar ganglions are extirpated.

The data obtained confirm the fact that in each of the nervous terminals observed the axons of several sensory neurons lying on various levels of spinal cord terminate, e.g., pleurisomiticity of innervation sources of single peripheral receptor apparatus is observed.

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