MORPHOLOGICAL CRITERIA OF AFFERENT SPINAL INNERVATION OF THE VISCERA

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Medullated fibers of large and medium caliber, considered on the basis of experimental morphological data to be dendrites of neurons from the spinal ganglia, were counted in transverse sections through nerves supplying the viscera (heart, lungs, small intestine, liver, kidneys) of man and the dog. The number of viscerosensory fibers in the extramural nerves was small. The degree of development of afferent connections of the spinal cord differs from one organ to another. In the series of organs listed above the heart receives the largest, and the kidneys the smallest,number of sensory fibers.

Dendrites of neurons from spinal sensory ganglia, in their path to the viscera, are known to pass through the lateral sympathetic trunks and their visceral branches [1, 3, 7, 8]. The writers have shown experimentally [4, 5] that the overwhelming majority of spinal viscerosensory fibers are medullated fibers of large and medium caliber.

In the investigation described below, the afferent connections of several organs with the spinal cord were investigated quantitatively.

EXPERIMENTAL METHOD

Material was obtained by a study of 24 series of extramural nerves of the esophagus, heart, lungs, small intestine, kidneys, and liver from human cadavers and dogs. Serial transverse sections through the nerves running to these organs from the para- and prevertebral ganglia were stained by the Weigert – Pal – Favorskii method. In these sections, the myelin sheaths of nerve fibers stood out as dark purple rings of various sizes against the pale background of zones of translucency formed by the nonmedullated fibers. The number of medullated fibers of the various categories was counted on photomicrographs.

The figures illustrating this paper clearly show that all medullated fibers without exception could be counted in each nerve. Because of the purpose of the investigation, only fibers of large (over 7 μ) and medium (from 4 to 7 μ) caliber were counted.

To demonstrate afferent connections between these organs and the spinal cord, and to assess these connections morphologically, 43 experiments were carried out on dogs in which spinal denervation was performed by removal of the spinal ganglia from C_2 to L_5 inclusive. The organs and their nerves were investigated by the Bielschowsky – Gros method.

EXPERIMENTAL RESULTS

Many of the visceral nerves studied in their course from the spinal cord contained dendrites of neurons in the spinal sensory ganglia, consisting of medullated fibers of large and medium caliber. No difference was found between the number of these categories of fibers in different nerves (Fig. 1). The results

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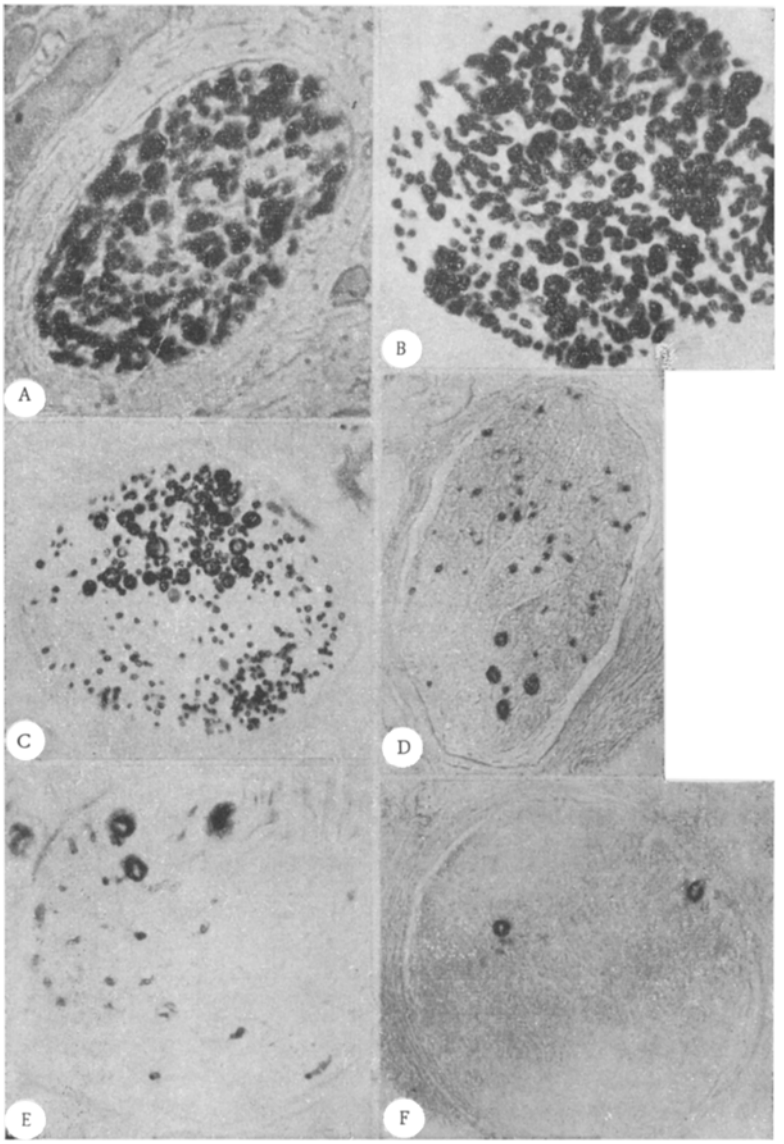

Fig. 1. Internal fiber structure of nerves to the human esophagus (A), lungs (B), heart (C), liver (D), small intestine (E), and kidneys (F). Weigert – Pal. A, B, E, F: 400 ×; C, D: 200 ×.

given in Table 1 reflect the mean number of fibers of each category in each nerve. In each case ten extramural visceral nerves about 0.2 mm in diameter, each containing fibers of the particular type, were investigated. Nerves not containing afferent fibers of these categories were not included in the counting. Such nerves, however, constitute the majority in the renal and hepatic plexuses.

Branches of the lateral sympathetic trunks to the esophagus and bronchi (lungs) contained the largest number of thick and medium-caliber medullated fibers. Somewhat fewer fibers of these categories were present in the cardiac nerves. Nerves of the intestinal, renal, and hepatic plexuses contained only solitary afferent spinal fibers. However, the fibers of these types do not account for all possible connections between the organs and spinal cord. Dogiel [2] observed many years ago that in adults, thin medullated afferent fibers originate from the small neurons of the spinal ganglia. Some such dendrites are certainly visceral in character. A phenomenon of a different order must also be taken into consideration: extramural multiplication of large afferent fibers (Fig. 2). Such fibers may divide dichotomously on their way to the organ. As a result of division, two fibers of smaller caliber are formed, and these separate to enter different nerve trunks of the extramural plexus. If this division is repeated, several daughter fibers,

TABLE 1. Number of Large and Medium-Caliber Medullated Fibers in Various Visceral Nerves

Type of nerve fibers		Esophagus	Lungs	Heart	Liver	Small intestine	Kidneys
Man	Thick (over 7 μ)	10	8	7	2,4	2,1	1,8
Dog		3	3	2	1,8	1,2	1,1
Man	Medium-caliber (from 4 to 7 μ)	19	17	11	3,3	2,4	2,1
Dog		12	6	10	3,2	1,3	1,3

Fig. 2. Extramural division of thick medullated fiber in superior mesenteric plexus near intestinal wall in man. Bielschowsky – Gros, 400 ×.

which may be medullated (of small caliber) or preterminal nonmedullated fibers, are formed. In this way the extramural visceral nerves come to contain afferent spinal fibers differing in their morphology from the original fibers. This phenomenon of extramural multiplication naturally reduces the number of large and medium-caliber medullated fibers in the nerves as they approach the organ (small intestine, heart). These principles apply regularly to man and animals.

Clearly, therefore, the morphology of the afferent spinal fibers is marked by considerable variety: from medullated fibers of all calibers to nonmedullated fibers. The presence of thick and medium-caliber medullated fibers in the visceral nerves is indisputable evidence of connections between the organ and the sensory spinal ganglia. Counting the number of these principal types of fibers in the nerves to an organ is an objective method of assessing the intensity of its afferent innervation. From the basis of this criterion it is clear that all the organs studied differ in the degree of their afferent connections with the spinal cord. The nerves of each organ contain viscerosensory fibers sometimes belonging to very distant spinal segements. The results now described provide a morphological basis for the fact that the total area represented in the cerebral cortex by the higher organs of the sensors and by somatosensory sensation is much greater than the area of representation of the viscera [6]. This investigation shows that the total number of neurons of the spinal ganglia responsible for visceral sensation is small. This feature is evidently associated with the quality of viscerosensory function: impulses from the viscera under normal conditions are not recorded in consciousness. Each viscus, to a certain extent, thus evidently possesses neural coordination mechanisms in which the role of the different spinal component may be minimal or totally absent.

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