

# MORPHOLOGY AND PATHOMORPHOLOGY

## DATA ON THE INNERVATION OF THE MUCOUS MEMBRANE OF THE STOMACH IN MAMMALS AND MAN

F. D. Gilev

From the Department of Histology (Head - Prof. G. A. Nevmyvaka)  
of the Perm Medical Institute

(Received March 30, 1957. Presented by Academician L. A. Orbeli)

Despite the large volume of research devoted to the study of the innervation of the alimentary tract, we still do not have sufficiently complete morphological data on this subject.

In relation to the innervation of the stomach in mammals, the descriptions in the literature deal with mainly the subserous, intermuscular and submucous plexuses and the ganglia contained within them. Contemporary workers have shown that the cells of the first type, discovered by A. S. Dogel', predominate in the ganglia of the stomach, and the cells of the second type are present in that organ in relatively small numbers [2, 4 and others].

There are very few references in the literature to the innervation of the mucous membrane itself in the stomach. In a paper by K. A. Kytmanov [3] there is mention of a plexus in the mucous membrane, and drawings are given of nerve endings on the chief and parietal cells. K. A. Lavrov [5] observed small nerve ramifications among the cells of the gastric glands. A paper by Greving and Berg [6] has appeared in recent years, in which the presence of a nerve plexus containing solitary nerve cells and ganglia is indicated in the muscular coat of the mucous membrane.

### EXPERIMENTAL METHOD

Our experimental material consisted mainly of young dogs, and partly of cats. As our principal method we used staining with methylene blue, by means of injection of the dye into the vascular system after preliminary flushing of the vessels with warm physiological saline. Fixation was with ammonium molybdate solution. The nerves were studied mainly in total preparations, but thick sections were cut from part of the material with a freezing microtome.

### EXPERIMENTAL RESULTS

In total preparations and also in thick sections it could be seen that the mucous membrane of the stomach of dogs and cats was supplied with nerves from the submucosa. Thick bundles of nerve fibers, emerging from the submucous plexus, entered the muscular coat of the mucous membrane, and there ramified. The diverging branches extended along the outer surface of the muscular layer of the mucous membrane, sometimes for quite a long distance, and then turned inwards, perforating the muscular layer and entering the mucous membrane proper (t. propria). Here, these quite thick bundles of nerve fibers ramified and formed a nerve plexus, composed of loops of different sizes, situated immediately beneath the peptic glands. Some idea of the structure of this plexus may be obtained from an examination of Fig. 1.

Along the course of the bundles in the plexus of nerve fibers were seen nerve cells disposed singly. These comparatively large, multipolar cells usually were poorly stained and hence were found with great difficulty. From the body of these cells emerged several processes, which sometimes could be traced for a considerable

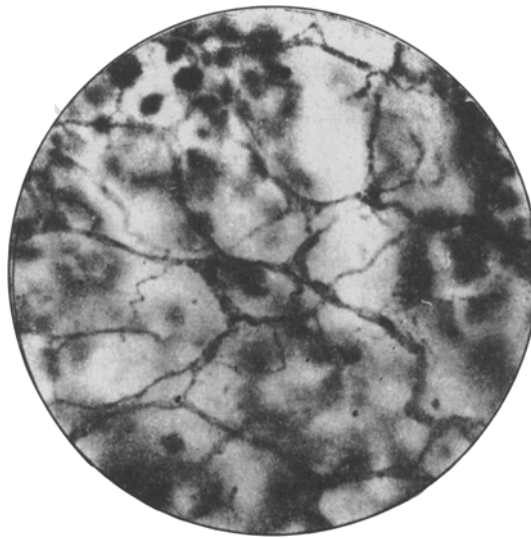


Fig. 1. Portion of a nerve plexus from the mucous membrane of the stomach of a puppy. Total preparation. In preparing this specimen the mucosa was separated from the remaining parts of the stomach wall. Appearance from the outer surface (t. m. m. removed). Microphotograph.



Fig. 2. Ganglia from a nerve plexus in the t. m. m. of the mucous membrane of the human stomach. Total preparation. In preparing this specimen the outer parts of the stomach wall were removed. Microphotograph.

distance. By their morphological character, these cells were most likely to be type two Dogel' cells.

Bundles of nerve fibers, forming yet another plexus in the mucous membrane, left this plexus in the direction of the inner surface; they were situated directly between the gastric pits and consist of bundles of slender fibers. From the bundles of this plexus branched out slender fibers in the direction of the epithelium lining the surface of the stomach and the gastric pits. At the bases of the epithelial cells these fibers divided



Fig. 3. Portion of a nerve plexus from the mucous membrane of the human stomach. Total preparation. Stained with methylene blue. In preparing this specimen the outer layers of the stomach wall were removed. Seen from the outer surface (t. m. removed). Microphotograph.

and terminated either freely or in pin-head thickenings. These endings were mainly situated at the junction of the epithelium with the connective tissue. Some of these fibrils penetrated the epithelium and terminated as expansions on the surface of the epithelial cells.

We thus observed two plexuses in the mucous membrane of the stomach in dogs and cats: one — on the surface of the mucous membrane, at the level of transition of gastric pits into glands, and a second, deeper one — between the base of the gastric glands and the muscular layer of the mucous membrane. From these plexuses and from the bundles of nerve fibers connecting them, were given off slender lateral fibrils, supplied with varicose thickenings. These fibrils formed numerous nerve endings both in the connective tissue and in the epithelium itself. By their situation and morphological structure, the nerve endings could be classified as receptor, responsible for the production of afferent impulses from the mucous membrane of the stomach, although some of them, situated in the immediate vicinity of the glands, were possibly effector in nature, and concerned with the regulation of the secretory function of the gland cells. However we were unable to find any clearly marked morphological differences between them.

We also obtained some information on the innervation of the mucous membrane of the human stomach. The material used for this was areas of human stomach removed at operation. This material was made available to us by Prof. N. M. Stepanov, Head of the Surgical Clinic of the Perm Medical Institute. Specimens were prepared from the peripheral areas of the excised material, i.e. from places where the wall of the organ had preserved a more or less normal structure. We used methylene blue for staining here also. As a preliminary step the mucous membrane was mechanically separated from the remaining portions of the stomach wall. The specimens were stained in the incubator and periodically moistened with a weak solution of methylene blue. After fixing in the ammonium molybdate solution and rinsing, the mucosal layer was stripped from the specimens, after which total surface preparations were obtained from both separated layers, and also preparations in which the mucous membrane remained attached.

In the preparations thus obtained, thick bundles of fibers could be seen penetrating into the mucous membrane from the submucosa. Along their path in the muscular layer of the mucosa these bundles ramified and formed a nerve plexus, situated between the layers of muscles. The loops of the plexus were formed of comparatively thick bundles of nerve fibers and were of different shapes and sizes. Along the course of the bundles and in the ganglionic areas, especially between the internal and middle layers of muscles, nerve cells

were found in the plexus, both solitary and in whole groups; in the latter case they formed true ganglia. One such ganglion is illustrated in Fig. 2. The nerve cells here were of different sizes, and all were multipolar. Their processes could sometimes be traced for a considerable distance.

We saw a similar plexus in the muscular coat of the mucous membrane also in preparations from the stomach of dogs, but there we were unable to detect any ganglia, finding only solitary nerve cells along the course of the bundles of nerve fibers.

Nerve endings were also found in the muscular coat of the mucous membrane of the human stomach. The nerve fibers forming these endings were supplied with numerous varicose thickenings of various shapes. The endings themselves consisted of interlacing, thin nerve branches, somewhat reminiscent of glomeruli in their form. We found no capsule around these glomeruli.

Bundles of nerve fibers penetrating from the submucosa into the mucosa proper (*t. propria*) formed here a plexus which was situated at the level of the base of the gastric glands; the thicker bundles here were distributed mainly in the intervals between the glands and formed here wide loops inside which a network of thinner fibers could be seen. Thanks to this, the base of each gastric gland (sometimes two together) was lightly enveloped in a peculiar type of alveolus formed by the nerve plexus. The edge of this alveolus was formed from loops of thick bundles of the plexus, and its middle part — of a network of finer fibers. One portion of such a plexus is shown in Fig. 3. In this plexus too, along the course of the nerve bundles, nerve cells were seen — singly or in groups of two or three.

Nerve endings were observed here also. They were formed from slender nerve fibers branching from the bundles of the plexus and situated in the connective tissue between the glands. The usual form of the endings was that of a glomerulus, formed by interlacing of a profusely coiled thin nerve fibril. Along the course of the fibril were seen numerous varicose thickenings of various shapes. Some of these glomeruli were greatly elongated, while others were more round in form.

We pointed out above that two nerve plexuses were noted in the *t. propria* of the mucous membrane of the stomach of dogs: one — at the base of the gastric glands, the other — at the level of transition from gastric pits into glands. In the *t. propria* of the human stomach we have so far been able to find only one plexus — at the base of the gastric glands. In the cases which we have examined, the bundles of this plexus in the human stomach were wider and more friable, thanks to which the whole plexus had the character of a comparatively dense network; in dogs the bundles were distributed more sparsely and they were thinner. These differences were sufficiently prominent from a comparison of Fig. 1 and 3 (microphotographs taken with the same magnification).

We have so far been able to examine only a small number of human stomachs (seven cases altogether), whereas in studying the innervation of the stomach in dogs we have dealt with over 300 animals. The fact that the nerve plexus in the mucous membrane of the human stomach at the transition point between gastric pits into glands has not been detected may possibly be explained by the small number of cases studied.

#### SUMMARY

The author stained the nerves with methylene blue and revealed nerve plexuses both in its mucous membrane (where ganglia were also found, especially in man), and in the *t. propria*. In man such plexuses are located at the floor of the glands. There are additional plexuses in cats and dogs — on the level of transition of the gastric fossae into glands. These plexuses have fibers with ramifications which form numerous nerve endings in the connective tissue and at the bases of the epithelial cells.

#### LITERATURE CITED

- [1] A. S. Dogel', *Anat. Anz.* 11, (1896).
- [2] N. G. Kolosov, *Trudy Tatarsk. Nauchno-Issled. Inst. Teor. i Klin. Med.* 2, (1935).
- [3] K. A. Kytmanov, *Nevrol. Vestnik*, 5, 2 (1897).
- [4] B. I. Lavrent'ev, *Morphology of the Autonomic Nervous System. Collected Works*, 1939. [in Russian].
- [5] K. A. Lavrov, *The Terminal Divisions of the Peripheral Nervous System*, 1941. [in Russian].
- [6] R. Greving and G. Berg, *Acta Neuroveget.* 8, 3 (1954).