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# Extracorporeal blood flow pathways in intramural ganglia of the gastrointestinal tract

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**Abstract**
Extra capillary blood flow pathways (EBFP) in the wall of the gastrointestinal tract (GIT) is an integral part of its intraorganic bloodstream. However, their role in the regulation of blood flow in the intramural nerve plexuses (INP) is still not clear.
Objective - morphological analysis of various EBFP variants in intramural nerve plexuses of the gastrointestinal tract and clarification of their functional purpose
Material and methods. Histological preparations of rats' GIT (n = 9) with a microvascular bed impregnated according to Ranvier and supplemented with hematoxylin and eosin were studied at the light-optical level. Results. In the intramural nerve plexuses, numerous EBFP represented by two types of fistulas: arterio-venular anastomoses (AVA) and pre-postcapillary communication (half shunts). Through EBFP constant and adjustable blood flow. Functional purpose of EBFP: 1) shunting of blood flow; 2) venous blood oxygenation; 3) countercurrent gas exchange; 4) blood rheological properties restoration.

**Keywords:** Extra capillary blood flow pathways, gastrointestinal tract, intramural nerve plexus

## Introduction
It is believed that in performing phase functions body should exist arterio-venous anastomoses [1]. However, an analysis of literature data shows that there are still many controversial and unresolved issues requiring detailed and in-depth research. A particular difficulty arises in the interpretation of the results that were obtained with the use of morphological and physiological methods. This is due to the fact that they are often in complete contradiction with each other. There is no unity of views on extra capillary blood flow pathways problem among morphologists as well. As an example, there is recognition by many researchers, the existence of wide arterio- venous anasmosis in various organs [2, 3]. To date, the following terms are found in publications: arterio-venous anasmosis [4], arterial-venous anastomosis [5], and anastomoses type closing arteries [6]. The authors acknowledge the indisputable fact that there are no normal direct communications between arteries and veins and believe that "... such statement opponents should not rely on untested facts and assumptions [7].
Objective - morphological analysis of various extracorporeal blood flow pathways (EBFP) variants in intramural nerve plexuses of the gastrointestinal tract (GIT) and clarification of their functional purpose

## Material and methods.
The work was carried out on outbred sex and age rats (n = 9) received by the Samara Veterinary Clinic Drug LLC (executive director - Ph.D., Dr. V.A. Vankov) for conducting euthanasia. All manipulations with animals were carried out in accordance with the Russian (USSR Ministry of Health Order No. 755 August 12, 19 .., Ministry of Health of the Russian Federation Methodical Guidelines "Deontology of a Medical-Biological Experiment") and European (EU Directive "On the Protection of Animals Used for Experimental and Scientific Purposes "(86/609 CE) ethical standards. 3The sampling of biopsy material from animals was carried out under condemnatory conditions. Animals under anesthesia (Zoletin - 10.0 mg/kg body weight) with a working heart, were treated with mordant, impregnating, reducing and fixing solutions through the left subclavian artery [8]. The preservation of the small intestine microvessels wall functional state is possible only with the impregnation of their walls during lifetime state by silver nitrate and use of a 4% aqueous hydroquinone solution to restore it to the metal. Hydrochemistry was first used by Y.S. Pecker to restore silver in the dentine channels in the pulpitis treatment.

## Results & Discussion
By the time of rats birth, each ganglion of the intermuscular and submucosal nerve plexuses in the small intestine has a formed connective capsule (Fig.1).

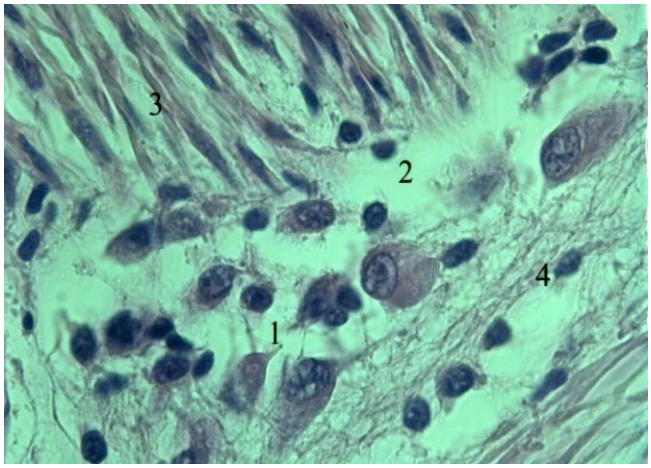


**Fig 1:** The ganglion of intermuscular nerve plexus in the small intestine of a newborn kitten. 1) neuroblasts; 2) the ganglion capsule; 3) a circular layer of the muscular layer; 4) longitudinal layer of the muscular layer. Stained with hematoxylin and eosin. H. 900

It is detected by Bilshovsky-Maresh impregnation in the intermuscular plexus ganglia already in rabbit embryos of 20 days of age. In newborn animals, the submucous nerve plexus is less differentiated than intermuscular plexus. This is due to the fact that by this time the muscular coat of intestinal wall reaches a high degree of differentiation. Namely, intermuscular nerve plexus determines the level of its contractility, whereas the submucosal plexus is the level of its local regulation and spontaneous movements. Much later in the ontogenesis postnatal period, the muscular plate of intestinal wall mucosa is differentiated. Tissue walls of the newborn animals small intestine having specific structures, but they differ significantly from the corresponding tissues of adult animals. In newborn animals, tab intermuscular and submucosal nerve plexus is also already formed. According to the external form and ganglia architecture, they are definitive. But the growth and differentiation of neurocytes processes are far from complete. Most of them are represented by neuroblasts with large eccentrically located nuclei. A part of neuroblasts has one process each, the other part is completely devoid of processes. In addition, a small number of linear elements in the ganglia indicates a low energy supply of neuroblasts and their low impulsive activity. Neuroblasts of the small intestine intermuscular plexus retain normal differentiation properties even in dissociated form, with growth in culture.

Even undifferentiated ganglion neurocytes have weak acetylcholinesterase activity and low values of cytoplasmic nuclear ratios. Obviously, this is due to peculiarities of the nervous ganglia structural organization in the small intestine of newborn animals by the absence of blood microvessels there and the feeding of neuroblasts through interstitial fluid or lymph. The nutrition of intramural nerve plexuses and reptiles is carried out in a similar way - they have it in the lumen of large lymphatic reservoirs. The connective tissue capsule is also detected in nerve plexuses ganglia in the small intestine of mature and old animals (Fig. 2).

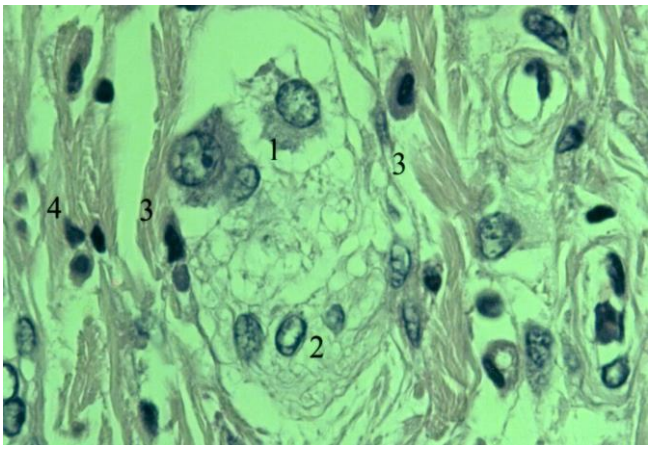


**Fig 2:** The ganglion of submucosal plexus in the small intestine of a semi-matured rat. 1,2) neurocytes; 3) ganglion capsule. Universal impregnation method. H. 900

The basis of the microvascular bed structural organization in the small intestine nerve plexuses is a modular principle. Three of their different specializations were identified: ganglionic, intergang ionic, and stem. An extraneous microvascular bed is formed in the ganglia, whose module is constructed according to the network type with short but wide arterioles and venules (Fig. 3).

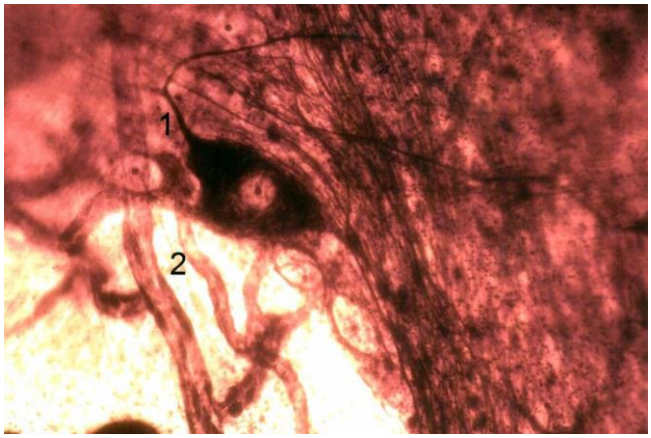


**Fig 3:** The ganglion of submucosal plexus in the small intestine of a semi-matured rat. 1) neurocyte; 2) arthriolum. Universal impregnation method. Magnific. 600

The structural module parameters: arterioles (diameter - 14.0 - 17.0 microns), precapillary arterioles (diameter - 7.0 - 10.0 microns), capillaries (diameter - 5.5-6.1 microns), postcapillary venules ( 15.0-18.0 μm) and venules (diameter 20.0-24.0 μm) indicate its low vascular resistance. Significantly lower than resistance of other tissues vascular structures in the small intestine. This module feature allows it to maintain effective functional blood shunting at various periods of the digestive activity in the small intestine [9]. Each neurocyte in the ganglia has either direct contact with exchange microvessels or is removed from them at a distance of no more than 15.0 - 20.0 μm.

The regulation of blood flow in module microvessels is ensured by smooth muscle sphincters and extracapillary blood flow pathways (Fig. 4).

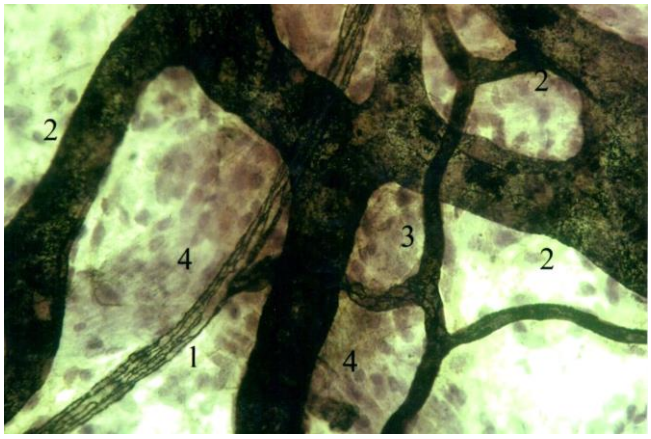


**Fig 4:** The vascular structure of nervous ganglion (4) of submucosal plexus of the sexually mature rat. 1) arteriole; 2) venula; 3) arteriolovenular anastomosis. Impregnation according to Ranvier. Dokraska hematoxylin. Magnific. 400.

A special role in the wall of the small intestine has a submucosa basis. It is like a choroid of its wall, performs a distribution role, directing blood to both mucous, muscular and serous membranes. The main role in this function implement is a performance by extra capillary blood flow paths. They belong to the category of pre-post-capillary half-pads and arteriolar-venular anastomoses and are part of vascular structures of the submucosal nerve plexus and are specialized in transorgan shunt blood flow. Despite organ specificity of intermuscular and submucosal nerve plexuses,

they have a general structure plan. This is in the first, and secondly, the case of morphologically and functionally specialized vascular structures of braditrophore tissues, where not nutritive, but the transient micro vessels function prevails. Shunts localization in the circulatory terminal part suggests that their hemodynamic role is not as great as is commonly believed, especially as mechanisms for redistributing blood. Possessing minimal vascular resistance, they function independently from perfusion pressure fluctuations and thus ensure stability of transorganic blood flow and a constant return of blood to the heart, being one of the circulatory system homeostatic mechanisms.

The microvascular module of interstitial nerve cords is constructed according to the trunk type. In this case, arterioles, venules, postcapillary venules, and capillaries follow in parallel, having a considerable length, but a few transverse anastomoses.

In the module, extra and intra franular micro vessels are interacting. Intraneural capillaries pass in interstitial nerve cords with a diameter of 30.0 to 150.0 microns. Their lumen is filled with red blood cells and this indicates a high capillary hematocrit. The stem microvascular module is formed by an arteriole with a diameter of 25.0 - 35.0 μm, which enters perineural space at the corners.

The arteriole is equipped with an arteriolar smooth muscle sphincter capable of coordinating work of the entire vascular module.

At its entrance, a shunt device is always defined in the form of an arteriolar-venular anastomosis. This allows pre-tomol haemoseparation to be performed, and to send low hematocrit blood to the endoneural capillaries and create conditions for ultrafiltration of blood plasma and formation of perineural liquor. According to Lundborg Y (1975) intraneural microvessels are identical to the capillaries of the central nervous system and are impermeable to most of the substances circulating in the blood [10]. In addition to extracapillary of the blood flow pathways, countercurrent gas exchangers exist in the vascular structures of autonomic nerve plexuses in the small intestine. Their function is performed in parallel by the arterioles and venules, intercapillary arterioles and postcapillary venules, which are located 12.0 - 18.0 μm apart, as close as the capillaries to neurocytes in the ganglia of the intermuscular and submucosal nerves.

**The conclusion.**

Thus, perineurium creates an isolated permanent internal environment for the nerve conductors and provides them with stability even when passing through inflammatory infiltrates and abscesses. The microvascular module of interstitial nerve cords is constructed according to the trunk type. In this case, arterioles, venules, postcapillary venules, and capillaries follow in parallel, having a considerable length, but a few transverse anastomoses.

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