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Elizaveta I Bon *

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Peripheral Autonomic Reactions

Bon E.I *., Maksimovich N.Ye., Olkhovik R.A

Grodno State Medical University, Gorkogo St, Grodno, Republic of Belarus

***Corresponding Author:** Elizaveta I Bon, Candidate of biological science, Assistant professor of pathophysiology department named D. A. Maslakov, Grodno State Medical University; Grodno State Medical University, 80 Gorky St,230009, Grodno, Belarus.

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Abstract

The article presents the results of many years of research. It provides an overview of the world literature on peripheral autonomic reactions, presents our own and literature data proving the existence of true sympathetic reflexes that close in extramural and intramural ganglia, and also proves the receptor function of autonomic ganglia, their two-way connections with the central nervous system. At the same time, it shows the important role of autonomic ganglia in ring and chain reflex reactions of the body, in the formation of previously unknown sympathetic and sympathetic-somatic mechanisms of centripetal connections of internal organs. Based on the data obtained, an attempt is made to re-evaluate the mechanisms of interoceptive reflexes, which are qualitatively different from exteroceptive reflexes, as well as the mechanisms of the adaptive-trophic function of the sympathetic nervous system.

Kew Words: peripheral autonomic reactions; sympathetic nervous system; reflex

Introduction

The article presents the results of many years of research. It provides an overview of the world literature on peripheral autonomic reactions, presents our own and literature data proving the existence of true sympathetic reflexes that close in extramural and intramural ganglia, and also proves the receptor function of autonomic ganglia, their two-way connections with the central nervous system. At the same time, it shows the important role of autonomic ganglia in ring and chain reflex reactions of the body, in the formation of previously unknown sympathetic and sympathetic-somatic mechanisms of centripetal connections of internal organs.

Based on the data obtained, an attempt is made to re-evaluate the mechanisms of interoceptive reflexes, which are qualitatively different from exteroceptive reflexes, as well as the mechanisms of the adaptive-trophic function of the sympathetic nervous system.

It is known that peripheral autonomic ganglia play an exceptionally important role in the regulation of autonomic functions - digestion, blood circulation, excretion, metabolism, etc. This is evidenced by numerous experimental data showing that complete or partial destruction of the central nervous system (CNS), accompanied by the shutdown or sharp disruption of animal functions of animal and human organisms, does not lead to the cessation of autonomic processes. Although the latter are disrupted to some extent, they can ensure life activity for a more or less prolonged period. [23]

In conditions of decentralization of internal organs and vessels, rather complex functional connections and relationships are maintained between them. A striking example illustrating this position are our observations. They showed that dogs in which a large part of the spinal cord has been removed can maintain life activity for a long time (months and years) and even bear and feed viable offspring. [6]

Back in the last century, two hypotheses were put forward that explained the functional interrelations of decentralized organs in different ways: the first hypothesis assessed these connections as true vegetative reflexes, the arc of which closes in the peripheral vegetative ganglia, and the second hypothesis explained them as pre- and postganglionic axon reflexes.[25] Unlike the first hypothesis, which allowed for the existence of special afferent vegetative neurons, the second hypothesis considered the vegetative nervous system as an efferent system, and the vegetative ganglia as intermediate stations of centrifugal influences on peripheral organs and vessels. The existence of special vegetative afferent neurons was denied, believing that internal organs and vessels, like other parts of the body, have a single cerebrospinal (somatic) afferent innervation, which is the processes of afferent neurons of the intervertebral spinal ganglia. The functional connections of decentralized internal organs were assessed as axon reflexes.[5,22]

Despite the fact that special nerve cells (type II cells) were discovered in internal organs and their nerve plexuses, as well as in extramural autonomic ganglia, which were considered sympathetic afferent neurons, that is, the initial elements of the peripheral arc of autonomic reflexes, it so happened historically that the axon reflex hypothesis supplanted the first hypothesis for a long time and until recently was dominant.[4,10] The number of supporters of the first hypothesis, who studied peripheral viscero-visceral reflexes, has noticeably increased. However, they were unable to shake the axon-reflex hypothesis and did not change the opinion of a wide range of physiologists who are still skeptical about the idea of the existence of true vegetative reflexes, as evidenced by the latest reports on the physiology of the nervous system, including the vegetative system, as well as on the physiology of interoceptors. This is explained by the fact that most researchers who studied peripheral viscero-visceral reflexes, as a rule, were only engaged in describing these phenomena and did not pay due attention to their in-depth analysis.[3,14]

It is reasonable to assert that the entire preceding period of studying peripheral vegetative reactions, including viscero-visceral ones, was mainly descriptive. Therefore, the ideas of individual authors about the true-reflex, or axon-reflex, mechanism of these reactions turned out to be largely arbitrary, based on the desire of the experimenter, at best on their comparison with similar phenomena in the cerebrospinal (somatic) nervous system, and not the result of an experimental analysis of these phenomena, direct proof of one or another hypothesis. [7,12] However, at the end of this descriptive period, facts were discovered that excluded the axon-reflex mechanism and provided some grounds for concluding about the existence of true vegetative, in particular sympathetic reflexes. Using the example of the bladder reflex and the intestinal reflex, it can be noted that these reflexes can also be realized after the degeneration of preganglionic axons and that they disappear after lubrication of the corresponding extramural ganglia with a nicotine solution. At the same time, convincing experimental morphological evidence is presented that the axons of the intestinal Dogel type II cells (as sympathetic afferent neurons) terminate on Dogel type I cells (as motor sympathetic neurons) located not only in intramural but also in extramural ganglia and plexuses. In particular, in our laboratory, synaptic connections of type II cells with type I Dogel cells were established in the intramural ganglia and plexuses of the intestine, i.e., the intramural substrate of the peripheral reflex arc was morphologically proven. These physiological and morphological studies began a new, analytical stage of research into peripheral vegetative reflexes, replacing the descriptive stage. [8,18,22]

We arrived at the idea of the existence of special sympathetic afferent neurons as the initial link of true sympathetic reflexes as a result of studies of the mechanisms of interoceptive reflexes of skeletal muscles, in particular as a result of studying the relationship between triggering and corrective interoceptive influences on the motor, skeletal-muscular apparatus, which made it possible to speak of two types of visceral afferent fibers - somatic and sympathetic. The special studies undertaken later finally convinced our team of the existence of peripheral mechanisms of true sympathetic reflexes, which have their own afferent link. This conclusion followed from various experiments, in which the phenomenon of ganglionic mediation during the course of peripheral viscero-visceral reflexes was proven, and temporary switching off of these reflexes was established with the local action of various ganglionic blocking substances on the corresponding vegetative ganglia. Thus, the closure function of the vegetative ganglia was indisputably proven. [15,16,22]

The results obtained became possible due to the fact that we managed to develop a new method for preparing a "peritoneal organ preparation" that allows reliable decentralization of the abdominal organs (without which a flawless study of the mechanisms of peripheral viscero-visceral reflexes is impossible) and compares favorably with Elliott's preparation and various preparations of isolated organ systems. At the same time, this became possible due to the separate (and not the combined, as was most often done before) study of the function of individual ganglia and their role in the implementation of certain peripheral reflexes, which was facilitated by the use of methods of perfusion of individual vegetative ganglia, developed for the first time on the example of the superior cervical sympathetic ganglion, and in relation to the posterior mesenteric sympathetic ganglion. These methods of perfusion of vegetative ganglia turned out to be especially useful for solving the second question concerning the receptor function of vegetative ganglia. [2,20]

After the studies, the position that vegetative ganglia are connected with the central nervous system unilaterally, that is, only centrifugally, was considered indisputable. We came to the conclusion that ganglion receptors, informing the central nervous system about changes occurring in the ganglia, perform the function of controlling the transition of excitation from preganglionics to postganglionics, that is, in essence, we put forward the hypothesis about the receptor function of the autonomic ganglia.[1]

Despite the enormous significance of this assumption and despite the fact that interoception has been widely studied, no attention has been paid to the receptor function of the autonomic ganglia for a long time. We were the first to establish this function. It was shown that the passage of various biologically active substances through the vessels of the posterior mesenteric sympathetic ganglion, which is excluded from the general circulation but has retained its neural connections, is accompanied by a reflex change in blood pressure, respiration, and in some cases, a reflex motor reaction. It was then established that the natural stimulator of ganglion receptors are mediators formed in the ganglion during the implementation of the corresponding interoceptive reflexes. Later, the receptor function of the superior cervical sympathetic ganglion was proven. [12,19]

The above-mentioned, as well as other personal and literary data, led us to the conclusion that the autonomic ganglia are not only intermediate stations of centrifugal influences, but also peripheral centers of true sympathetic reflexes; they are connected with the central nervous system not only centrifugally, but also centripetally, that is, between the autonomic ganglia and the central nervous system, as well as between them and peripheral organs, there are ring mechanisms of reflex relationships; in the autonomic ganglia, the reflex arcs of the autonomic (peripheral) and cerebrospinal (central) reflexes are functionally sequentially united; the above-mentioned two-storey (or multi-storey) functional associations are of great importance both in the central-reflex regulation of the function of the autonomic ganglia and the sympathetic reflexes that close in them, and in the implementation of complex, chain, reflex reactions.[9,11,17] At the same time, the noted data and generalizations formed the basis for the ideas we are developing about the three mechanisms of centripetal connections of internal organs and vessels, namely: somatic, sympathetic and sympathetic-somatic (autonomic-cerebrospinal) mechanisms. Thus, a new idea is being created about the function of the autonomic ganglia and their important role in the activity of the whole organism. The experimental substantiation of this idea is the task of this work.

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