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Данное пособие является английской версией учебника профессора И. В. Гайворонского «Нормальная анатомия человека», который был издан в России 9 раз и одобрен Министерством образования Российской Федерации. Структура пособия соответствует современным стандартам медицинского образования в России и важнейшим европейским стандартам. Английская и латинская терминология приведены в соответствии с Международной анатомической номенклатурой.

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CONTENTS

LIST OF ABBREVIATIONS

Art., art., — articulatio
Artt., artt., — articulationes
For., for. — foramen
Lig., lig. — ligamentum
Ligg., ligg. — ligamenta
M., m. — musculus
Mm., mm. — musculi
N., n. — nervus
Nn., nn. — nervi
R., r. — ramus
Rr., rr. — rami
S., s. — sulcus

PREFACE

The creation of the manual “Central Nervous System” in English meets the requirement of modern Russian medicine and education. Nowadays many English-speaking oversea students study in Medical Universities of Russia. Besides, many Russian school leavers have a good command of the English language so they will be able to use this manual taking into consideration the fact that many Russian specialists in medicine work abroad after graduating from the universities or take part in different international conferences and symposiums.

The English version of the manual is based on the Russian manual by professor I. V. Gayvoronskiy “Normal Human Anatomy” which has been published in Russia 9 times and is approved by the Ministry of education of Russia.

This manual introduces the main principles of Russian Anatomy School such as: detailed study of the general aspects and items of Anatomy including the development of organs and anomalies of the development. If we compare theoretical approaches to Anatomy in Russia and in other countries we`ll see that our approach is based on the system descriptions of organs, i.e. we describe separately Skeletal system, Articulations, Muscular system etc. Moreover, we use Latin terminology while describing the organs and discuss clinicoanatomical and functional problems. As for the manuals in other countries many of them describe Anatomical systems in accordance with the regional and topographical principles.

The structure of our manual meets the requirements of modern standards of medical education in Russia which in their turn correspond to the major European standards. After each chapter we give test questions and clinicoanatomical problems. The English and Latin terminology is given in accordance with International Anatomical Nomenclature.

The authors strongly believe that the manual will allow future doctors to form the morphological foundation for the further study of theoretical and clinical disciplines. We also hope that it will be of great help to Anatomy teachers.

ПРЕДИСЛОВИЕ

Создание учебного пособия «Центральная нервная система» на английском языке является требованием современной системы медицинского образования в России. В настоящее время в медицинских университетах нашей страны обучаются студенты из различных регионов дальнего зарубежья. Кроме того, многие выпускники российских школ хорошо владеют английским языком, поэтому они также смогут пользоваться данным пособием, принимая во внимание, что зачастую русские специалисты в медицине после окончания университета уезжают работать за рубеж или принимают участие в различных международных конференциях и симпозиумах.

Английская версия пособия базируется на русском учебнике профессора И. В. Гайворонского «Нормальная анатомия человека», который был издан в России 9 раз и одобрен Министерством образования Российской Федерации.

Данное пособие познакомит читателей с главными принципами Русской анатомической школы, которые заключаются в подробном изучении общих вопросов, в том числе развития органов и аномалий развития. В России преподавание анатомии ведется с функционально-клинических позиций и основано на описании органов по системам, т.е. отдельно изучается опорно-двигательная система, артросиндесмология, миология и другие системы. Также при описании строения органов акцентируется внимание на латинской терминологии. Что касается зарубежных руководств по анатомии человека, многие из них основываются на регионально-топографическом принципе без использования латинской терминологии.

Структура данного пособия соответствует современным стандартам медицинского образования в России, которые, в свою очередь, соответствуют важнейшим европейским стандартам. После каждой главы мы приводим контрольные вопросы и ситуационные клинические задачи. Английская и латинская терминология приведена в соответствии с Международной анатомической номенклатурой.

Авторы выражают уверенность, что данное пособие позволит будущим докторам сформировать морфологический фундамент для последующего изучения теоретических и клинических дисциплин. Мы также надеемся, что оно принесет определенную пользу и преподавателям анатомии человека.

1. GENERAL DATA OF CENTRAL NERVOUS SYSTEM

The nervous system, *systema nervosum*, is a collection of anatomically and functionally interrelated structures which regulate and coordinate the activity of the body as a single whole, and the interaction of the organism with the external environment. It works as an apparatus which perceives the stimuli, analyze them and provides the body`s response.

The nervous system appeared during evolution as an integrative system, i.e. the system which coordinates the functions of all organs and provides the adaptation of the organism to environmental changes. Unlike the activity of the other integrative systems (cardio-vascular system provides the humoral integration and the endocrine system provides the hormonal integration), the activity of the nervous system is very rapid, aiming and momentary (hundredths of a second pass from the moment of the stimulus appearance to the feeling of the stimulus). Usually, a certain organ reacts to the stimulus, or the group of the organs. When the action of the stimulus ceases, the response momentarily stops.

1.1. Classification of Nervous System

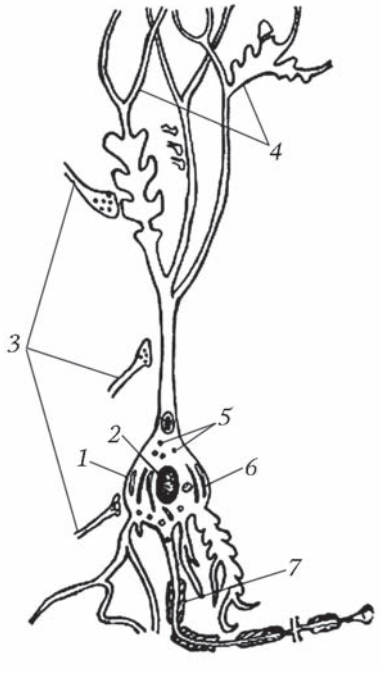

Fig. 1.1. Scheme of the structure of neuron:

1 — cell body; *2* — nucleus; *3* — endings of other neurons; *4* — dendrites; *5* — secretory granules; *6* — neurofibrillar apparatus; *7* — axon

According to the topographical and anatomical principles, the nervous system is divided into central and peripheral. The central nervous system consists of the brain and the spinal cord; the peripheral nervous system comprises all the nervous structures lying outside the brain and the spinal cord. The structures associated with the spinal cord form the spinal part of the peripheral nervous system. Here belong the sensory ganglia of the spinal nerves, the roots of the spinal nerves, the trunks and the branches of the spinal nerves, the plexuses of the spinal nerves, the ganglia of the sympathetic nervous system and nerve endings. The spinal part provides the innervation of the trunk, limbs, partially of the neck and internal organs.

The structures associated with the brain constitute the cranial part of the peripheral nervous system. Here belong the sensory ganglia of the cranial nerves, the cranial nerves, the branches of the cranial nerves, the ganglia of the parasympathetic nervous system and nerve endings. The cranial part provides the innervation of the head, partially of the neck and internal organs. It should be noted that the division of the central nervous system into central and peripheral is arbitrary because these parts are closely interrelated, anatomically and functionally.

According to the function, the nervous system is divided into somatic (animal) and autonomic (vegetative). The somatic nervous system is respon-

sible for the innervation of the *soma* (skin, skeletal muscles). The autonomic nervous system provides the innervation of the internal organs, glands and vessels. In its turn, it comprises the sympathetic and parasympathetic parts.

The central nervous system includes billions of highly specialized cells, the neurons and glial cells; the glial cells provide the activity of the neurons (support, protect and perform the trophic function). The neurons are grouped according to their functions into the corresponding cerebral and spinal centres. These centres constantly receive the impulses from different sensory receptors of skin, muscles, internal organs, organs of vision, hearing, balance, taste and smell. This information is analyzed by the central nervous system in fractions of a second to give an appropriate response. When the central nervous system generates a response, it uses the ability of the brain to store and release the information which was received previously (memory) at a determined moment. The greatest achievement of the nervous system, developed during evolution, is the thinking ability. The thinking activity is the higher nervous activity of the human body; it is performed as a result of analysis and synthesis of the nerve impulses in the higher cerebral centers.

The central nervous system also has an own initiative. It actively influences the vessels, muscles and glands, stimulating their work, and it also effects on the sensory organs, regulating their functioning.

Peripheral nervous system connects the spinal cord and brain with the receptors (sensory apparatuses of the organs) and with the effectors (the apparatuses transmitting the nerve impulses to the effector organs). In the response to the internal or external stimuli, the effector organs give the adaptive reactions of the organism, such as contraction of muscles or discharge of the secretions by the glands.

Somatic nervous system innervates skin, muscles, skeleton, some internal organs (tongue, pharynx, larynx etc.). It communicates the body as an integrated system with the external environment. It accepts the stimuli from outside, analyzes them and provides the response reaction to the external stimuli, controlling the skeletal (striated) muscles.

Autonomic nervous system innervates the internal organs and blood vessels, controls the action of smooth musculature and the work of the glands. It unites the different parts of the body into the integrated system and carries adaptive and trophic functions in the body.

1.2. Neurons

The neuron, or neurocyte, is a structural unit of the nervous system (fig. 1.1).

The neuron consists of a cell body (soma), processes and their endings. There are two types of the processes: dendrites and axon (neuritis).

The cell body is a mass of cytoplasm (neuroplasm) with a large round nucleus. The neurons of the autonomic nervous system may have 2—3 nuclei. The number of nucleoli in the nucleus is 1—3. The increase of the number and size of the nucleoli indicates the increase of the functional activity of the neuron. The nucleus carries the genetic information which determines the properties of the neuron and regulates the synthesis of proteins. The cytoplasm of the neuron contains the organelles of general purpose (mitochondria, ribosomes, endoplasmic reticulum, lysosomes, Golgi complex etc.) and specialized structures (neurofibrils, chromatophilic substance and synaptic vesicles). There are two types of neurofibrils: neurofilaments and neurotubules. In the cell body the neurofilaments form the network of thin white protein filaments, 6—10 nanometers

in diameter. In the neuron`s processes the filaments are arranged longitudinally. They perform a support function, giving a certain form to the cell.

The neurotubules are also formed by the protein filaments having a spiral orientation. The diameter of the tubules is 20–30 nm, the thickness of the wall is 10 nm. The neurotubules transport the substances within the neuron.

The chromatophilic substance (Nissl substance) is the condensation of protein (ribonucleoproteins). This substance is found in the cytoplasm of the cell body and dendrites; it is not observed in the axons.

The synaptic vesicles are situated mainly in the cytoplasm of the axon terminal, but may be located in the neuronal soma. They contain the mediators (acetylcholine, noradrenaline, gamma aminobutyric acid etc.), which provide the chemical transmission of the nerve impulse from one neuron to another, or from the neuron to the effector organ.

Externally, the neuron has a membrane, called cytolemma, which determine the limits of the cell and provides the contact of the cell with surrounding environment. Besides, the cytolemma contains much of protein structures that carry out chemoreceptor function. The cytolemma is able to conduct the nervous excitation (nerve impulse).

There are two types of the neuron processes: dendrites and axon (neuritis); they are the cytoplasmic extensions. The dendrites conduct the nerve impulse only towards the cell body. They start to branch near the cell body, then gradually become thinner and end in the surrounding tissues. The dendrites greatly increase the receptive surface of a neuron. The number of the dendrites varies from 1 to 10. Rarely, the neurons without dendrites are observed. Such cells perceive the impulses by the cell body.

Apart from the dendrites, the neuron always has only one axon (neuritis). This process is always larger, longer and less branched. It has sparse collateral branches just near the terminal. There is a correlation between the size of the cell body and length of the axon: the larger cell body, the longer and larger the axon. The axon conducts the nerve impulse only away from the cell body. Thus, the neuron with its processes is strictly dynamically polarized: the nerve impulse passes towards the cell body via the dendrites and away from it via the axon.

The neurons differ from each other in shape, size, number of processes and function.

According to the shape of the cell body, the neurons are described as: pyramidal, piriform, fusiform, polygonal, oval, stellate, round etc.

According to the size of the cell body, three groups of the neurons are distinguished: small (4—20 mcm); middle (20—60 mcm) and large (60—130 mcm).

According to the number of the processes, the neurons are classified as (fig. 1.2): unipolar, bipolar, pseudounipolar and multipolar. In the human nervous system the bipolar, pseudounipolar and multipolar neurons are observed most commonly.

According to the function, three groups of the neurons are distinguished in the reflex arch:

1) receptor (sensory, afferent), having the sensory nerve endings (receptors), which are able to perceive the stimuli from the internal or external environment;

2) effector (motor, efferent), whose axon terminals have the effectors, which transmit the nerve impulse to the effector organ;

3) association (intermediate), which have the intermediate postion in the reflex arch and transmit the information from the afferent neuron to the efferent one. The complex reflex arches may have several association neurons.

The structure and the function of the neurons are interrelated.

For example, the pseudounipolar neurons are receptor (sensory). They perceive such excitations as pain, temperature changes and tactile stimuli. The bipolar neurons

are the cells of special senses. They perceive the light, olfactory, auditory and vestibular stimuli. The small multipolar neurons are association; middle and large neurons, multipolar and pyramidal, are motor.

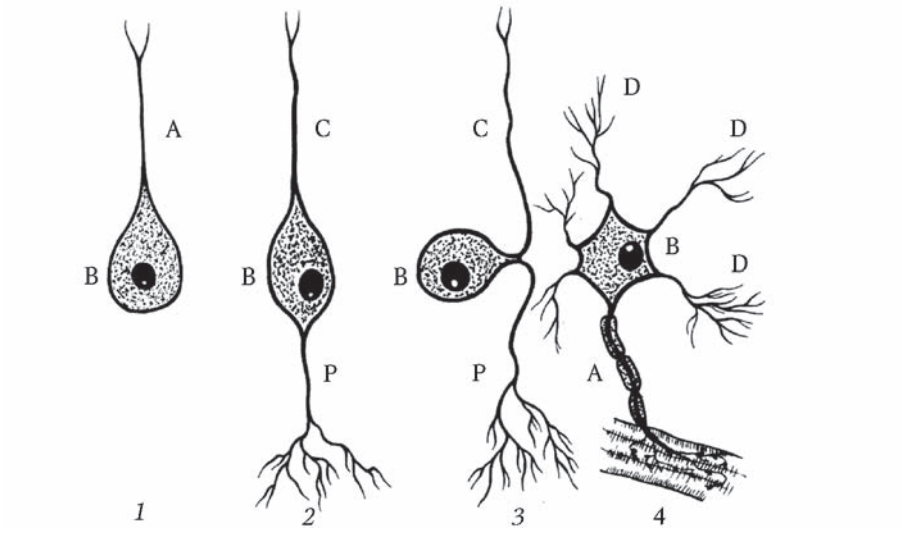

Fig. 1.2. Main types of the neurons:
1 — unipolar neuron; *2* — bipolar neuron; *3* — pseudounipolar; *4* — multipolar neuron; A — axon; B — body; C — central process; D — dendrite; P — peripheral process

It should be noted that the processes of the receptor neurons (bipolar and pseudounipolar) are not called a dendrite or axon but peripheral and central processes respectively. They have such names due to the position of the processes relatively to the central nervous system and to the cell body. The peripheral process passes from the cell body to the periphery, while the central process runs from the cell body to the spinal cord or the brain.

1.3. Nerve Fibres

The nerve fibres are the neuronal processes ensheated by a glial membrane, which conduct the nerve impulses.

The neuronal process situated in the center of the nervous fibre is called the axial cylinder. The axial cylinder is a neuroplasmic extension with contained organelles, surrounded by a membrane called axolemma.

Depending on the presence of the myelin in the glial cell membrane, two types of the nerve fibres are distinguished: myelinated and non-myelinated. In the myelinated fibres the glial cell membrane is thicker (forms $^{1}/_{2}$–$^{2}/_{3}$ of the diameter of the whole nerve fibre); these fibres have white colour due to contained myelin.

The myelinated fibres are divided into three groups according to the diameter: thick (12–20 mcm), middle (6–12 mcm) and thin (1–6 mcm). The nerve fibre narrows at

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CENTRAL NERVOUS SYSTEM
ЦЕНТРАЛЬНАЯ НЕРВНАЯ СИСТЕМА

The manual for medical students

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