ANATOMY OF THE NERVOUS SYSTEM - LECTURES

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Neurology is a specialty that emerged from internal medicine in the mid-19th century, but the roots of knowledge about the nervous system and its diseases go back several thousand years. For centuries, the structure and function of the brain, then its subordinate structures, have been studied. Expanding knowledge about the entire nervous system. At the end of the 19th century, the first departments, clinics and departments teaching neurology and psychiatry began to be established at universities. Since the beginning of the 20th century, most Nobel Prizes in medicine have been awarded for achievements in research on the nervous system. The beginnings of knowledge about the brain can be found in ancient Egypt, but the greatest contribution to understanding the brain and its role was made by ancient Greek doctors.

Hippocates, the father of medicine, can be considered the first outstanding scientist in neurology. (author of the first textbook "Corpus Hippocratinum"). He considered the brain to be the most important organ in human life, responsible for all mental and motor activities.

Galen's views were of great importance for medicine. He gave medicine anatomy based on animal autopsies and claimed that the life force is a fluid that penetrates from the air into the blood and cerebrospinal fluid and in contact with the brain becomes the soul of a person. Galen's achievement was the first description of alcoholic neuropathy and sciatica and the identification of three separate types of sensation: touch, pain and temperature.

15th century Italy - Loenardo da Vincii performed autopsies and sketched elements of the anatomical structure of the human body.

Thomas Willis (1621-1675) is considered the father of neurology. He was the first to publish an atlas of brain anatomy, distinguished the somatic and autonomic nerves from the peripheral nervous system and pointed out the differences between sympathetic and parasympathetic nerves, described the ophthalmic nerve, accessory nerve, innervation of the heart and arteries. He also described the circle of arteries at the base of the skull (circle of Willis) and the vascularization of the brain and spinal cord.

In 1882, the first chair of neurology was established in Paris, headed by Jean Martin Charcot, who dealt with mentally ill women, epileptics, prostitutes and other poor people. He organized sick shows for students and doctors. Among the assistants was a Pole, Józef Franciszek Babiński. Charcot was the first to make a complete clinical and morphological description of multiple sclerosis and described amyotrophic lateral sclerosis.

Józef Franciszek Babiński described the famous symptom of damage to the pyramidal tracts and to this day it is examined in all patients, not only neurological ones. He was nominated for the Nobel Prize for his research on the symptoms of cerebellar damage.

The second school, after the Paris school, was established in London. Charles Bell, a Scottish surgeon, anatomist and physiologist, described the functioning of the nervous system based on his research.

German school - Moritz von Romberg - symptom of falling down after closing the eyes, differentiating spinal ataxia from cerebellar ataxia. He wrote a description of hemifacial atrophy. In 1817, James Parkinson described the disease as paraplegia.

Wrocław became a very famous neurological center thanks to Alois Alzheimer, who described pre-senile brain atrophy in his maid.

In Poland, the first schools were established only at the beginning of the 20th century

1. Krakow neurological school
2. Lviv neurological school
3. Vilnius neurological school
4. School of neurology in Poznań
5. Warsaw neurological school
6. Lodz neurological school

1. DEVELOPMENT AND DIVISION OF THE NERVOUS SYSTEM

1. Basic elements of the nervous system

Neuron–nerve cell - conducts nerve impulses, which are supported by cells called neuroglia

1. Nerve cell body – form the gray matter of the nervous system
2. Two types of tabs:

Dendrites - protoplasmic projections, conduct impulses centripetally to the cell body,

Neurites–axon, conducts impulse from the nerve cell body i.e. centrifugally

We distinguish neurons: afferent - reaching the spinal cord in the dorsal roots (sensory)

efferent – originate from the spinal cord through ventral roots (motor)

Synapse –a place where two or more neurons meet. At synapses, impulses from one cell can be transmitted to another.

Chemical synapses - constitute the majority of synapses in humans and other mammals

Electrical synapses – are bidirectional information transfer

Myelin sheath/ myelin sheath -it is a substance that adheres directly to nerve processes called axons. This sheath serves as an electrical insulator and mechanical support for axons in nerve cells. Depending on the type of system that a given nerve cell creates, different types of glial cells are created:

Oligodendrocytes, appearing in the case of building neurons central nervous system

Schwann cells (lemocytes), found in neurons
forming the peripheral nervous system

The brain is undoubtedly most plastic in its early stages of development. Until recently, it was even believed that only during this period it was plastic at all. Today it is known that, although not as plastic as in youth, the adult brain is still capable of significant adaptations.

Many scientists are trying to understand the causes, mechanisms and functions of newly formed cells, especially those in the hippocampus, where neurogenesis is especially abundant. - one provocative report is that adult rats living in an enriched environment produce 60% more new neurons in the hippocampus area than normal rats.

A second important area of research on brain plasticity has focused on the extent to which experience can lead to reorganization of synaptic connections in the sensory and motor cortex in adults. - e.g. in musicians playing string instruments, the sensory areas of the right hemisphere of the brain are significantly enlarged

There are two main parts of the nervous system:

1. **Somatic**–processes and integrates sensory information from the sense organs, and also controls skeletal muscles. The somatic nervous system consists of:

   a) motor system: pyramidal, extrapyramidal

   b) sensory system: superficial and deep sensation, related to sense organs

2. **Autonomous-**it controls the activity of smooth muscles and the secretion of glands. It consists of parts:

   a) sympathetic

   b) parasympathetic

They work opposite to each other.

The element connecting the somatic and autonomic systems is the limbic system, which influences not only the functions of the motor system, but also the activity of the autonomic system.

Central nervous systemrecords and analyzes stimuli received by specialized peripheral organs - receptors. Stimuli are carried from receptors through peripheral nerve fibers to appropriate centers in the central nervous system. The analysis of incoming stimuli determines the appropriate response of the body to changing conditions in the external and internal environment.

1. Spinal cord - located in the spinal canal in its cervical, thoracic and upper lumbar parts. It has a cylindrical shape, approximately 45 cm long. The spinal cord begins in the extension of the medulla oblongata and ends at the bottom with the conus medullaris.

External structure of the spinal cord

- Ventral surface
- Dorsal surface
- Spinal nerves

Internal structure of the spinal cord

- Gray matter – characteristic H-shape
- Center channel

2. Brain stem – composed of three floors of the central nervous system:

- Midbrain
- Bridge
- Medulla oblongata

It plays a key role in maintaining basic life functions.

The death of the brain stem is equivalent to the death of a person.

Twelve pairs of cranial nerves, the nuclei of which are distributed throughout the brainstem, innervate most of the muscles of the head and neck, transmit sensory information (including taste, hearing, and balance) from receptors in this area, and parasympathetically innervate most of the internal organs.

Numerous pathways pass through the brain stem, connecting the spinal cord with higher levels of the nervous system, and pathways connecting with the cerebellum, through the lower, middle and upper cerebellar peduncles. Moreover, along the entire brain stem there is a reticular formation, a complex structure formed by crossing nerve fibers and neurons and their clusters arranged between them.

3. The medulla oblongata is the lower part of the brainstem and connects the spinal cord with the cerebellum.

In the medulla oblongata there are also nuclei of cranial nerves, responsible, among others, for receiving sensory impressions from the internal organs of the chest and abdominal cavity (via the vagus nerve - X) and taste sensations (facial nerve - VII and glossopharyngeal nerve - IX), as well as for the motor innervation of the tongue muscles (hypoglossal nerve-XII). On the border of the medulla oblongata and the pons lie the vestibular and cochlear nuclei (vestibulocochlear nerve -VIII), receiving signals from balance and hearing receptors in the inner ear.

It contains the nerve centers responsible for reflex functions:

- Respiratory center
- Vasomotor center
- Swallowing center

- Centers responsible for: vomiting, sneezing, coughing, yawning and sweating

4. Pons - part of the brain stem, contains: projection pathways, cranial nerve nuclei V,VI,VII,VIII. Pontine nuclei are responsible for: sleep, wakefulness, hearing, balance, taste, associated eye movements, facial expression, secretion of saliva and tears, and body posture

5. Midbrain - the highest level of the brain stem, located in the tentorial notch. The structures include:

- Brain peduncles
- Midbrain aqueduct
- The cover of the midbrain

The substantia nigra, which has connections with the telencephalic nuclei, plays an important role in regulating the activity of any muscles.

The red nucleus receives information (including from the cerebellum through the superior peduncles) and gives rise to pathways descending to the spinal cord and ascending to the thalamus.

6. Reticular formation of the brainstem - is a network of interconnected neurons scattered throughout the brainstem. Sometimes called the brainstem cortex. It is connected to almost all parts of the central nervous system.

7. Cerebellum – part of the secondary hindbrain. It occupies most of the posterior cranial fossa, located dorsal to the brainstem. It is made of:

- Gray matter, which forms: the cerebellar cortex and the cerebellar nuclei
- The white matter that makes up the core body

8. Diencephalon – located between the telencephalon and midbrain. They include:

- Third ventricle
- Thalamencephalon
- Hypothalamus
- Suprathalamic commissure
- Low hill

9. Telencephalon - divided into the paired telencephalon, also known as the lateral telencephalon, and the unpaired telencephalon, or medial telencephalon.

The structures of the paired telencephalon include:

- The coat consists of: the cerebral cortex, the insula, the hippocampus, and the rhinbrain
- Basal nuclei

- White matter of the hemispheres
- Side chambers

The azygos telencephalon includes:

- Corpus callosum
- Rostral/anterior commissure
- Transparent partition
- Vault and end plate

The skull is a bone box surrounding the brain, nasal cavity, oral cavity and sense organs. It has a protective function in relation to vital organs.

- Cerebellum - the nervous part, the box for the brain
- The skull - the facial part, is used for obtaining and receiving food and breathing
- The sense organs are associated with both parts of the skull

CRANIAL BONES:

- Occipital bone
- Sphenoid bone
- Ethmoid bone
- Interparietal bone
- Parietal bone
- Frontal bone
- Temporal bone

CRANIAL FACIAL BONES

- Jaw bone/maxilla
- Incisor bone
- Nasal bone
- Zygoma
- Lacrimal bone
- Palatine bone
- Wing bone
- Blade
- Nasal turbinates

- Jaw
- Hyoid bone

10. Meninges

The brain and spinal cord are covered by three connective tissue sheaths, the meninges.

The outermost tire is the dura mater, and underneath it is the middle tire, the spider tire. The tire located most inside the skull cavity is the pia mater, which surrounds blood vessels and penetrates deep into the brain. There is cerebrospinal fluid between the pia mater and pia mater.

- Dura mater of the brain and spinal cord
- Arachnoid of the brain and spinal cord - there are subarachnoid cisterns here, which protect the brain, especially during injuries or sudden head movements. They play an important role in subarachnoid hemorrhages and inflammatory processes.
- Soft tire

11. Cerebrospinal fluid

Colorless and transparent liquid. It fills the subarachnoid cavity of the brain and spinal cord. It fulfills many functions: it surrounds the central nervous system and is an important protective element, e.g. during injuries. An extremely important role is the regulation of intracranial pressure. Cerebrospinal fluid is secreted into each ventricle of the brain by the choroid plexuses. The fluid returns to the blood through tiny diverticula of the arachnoid mater called arachnoid granules that protrude into the venous sinuses. The fluid is secreted continuously at a rate of 0.5 ml per minute, i.e. 720 ml per day, its volume is constant and is approximately 150 ml.

The brain, although it constitutes only 2% of body weight, uses as much as 20% of the energy produced by the body. The brain is made of several dozen billion nerve cells, and each of them may have 25,000 connections with other neurons. Over the course of an individual's life, further neural connections may be created, making learning possible. Tasks that require performing new activities and training physical skills and solving theoretical problems promote the creation of new connections and increase intellectual performance.

Furrows on the surface of the brain divide it into 2 hemispheres - right and left, and each of them into 4 lobes: frontal, parietal, temporal and occipital, whose names correspond to the bones of the skull lying above them and protecting them. In each lobe there are clusters of nerve cells that manage the body's activities, e.g. speech, analysis of auditory and tactile stimuli, and learning.

The two most famous and associated with speech**around the cerebral cortex**this:

- **Broca's area**(opercular and triangular part of the inferior frontal gyrus), responsible for generating movements enabling speech production,

- **Wernicke's area**(posterior part of the superior temporal gyrus), including the mechanisms of understanding the meaning of individual words

Damage to structures responsible for speech within**left hemisphere**result in disorders called**aphasias.**Depending on the location of the damage, you may be unable to form words or understand speech.

Peripheral nervous systemit is a link between the central nervous system and the organs of the human body. It receives information from receptors, transmitting it to the central nervous system where it is analyzed and modulated, and then conducts the response generated by the central nervous system to the appropriate effector.

The peripheral nervous system includes:

- Cranial nerves - 12 pairs
- Spinal nerves – 31 pairs
- The autonomic part – the autonomic nervous system

Peripheral autonomic system

Consists:

- Networks of nerve centers
- Centrifugal and centripetal nerve pathways
- Nerves and branches

The autonomic system is closely functionally related to the functioning of the endocrine organs. It ensures homeostasis of the body and creates opportunities for adaptation to constantly changing conditions.

The effectors are smooth muscle, cardiac muscle and glands. It works closely with the somatic system.

There are three levels of structural organization of the autonomic system:

1. Master part - centers that control the system's operation (cortical, hypothalamus and spinal)
2. Sympathetic and parasympathetic parts
3. Autonomous weaves

Sympathetic nervous systemits preganglionic neurons originate from the spinal cord at the thoracic and lumbar levels. A postganglionic neuron terminates in the organ or tissue it supplies.

Parasympathetic nervous system Two neurons participate in the transmission of impulses, and the neurotransmitter in both synapses is acetylcholine.

Functions of the vegetative system:

1. The circulatory system
2. Respiratory system

3. Digestive and urinary system
4. Eye
5. Leather
6. Visceral pain
7. Referred and referred pain

Cranial nerves

These are nerves whose fibers originate or end in appropriate areas of the brain. Their branches are located around the head and neck (with the exception of the vagus nerve, which innervates the chest and abdominal cavity. The cranial nerves are responsible for:

- Reception of sensory impressions (sight, hearing, balance, smell, taste, various types) – sensory nerves
- The work of muscle groups
- Secretory functions of glands

Division of cranial nerves:

1. Due to the type of fibers
2. Due to the nature of the cell columns of the gray matter of the nerve nuclei

Spinal nerves

They arise from the union of two roots: the ventral root and the dorsal root.

There are usually 31 pairs of spinal nerves and they are divided topographically into 5 groups depending on the area of the body:

1. Cervical spinal nerves – 8 pairs
2. Thoracic nerves – 12 pairs
3. Lumbar nerves – 5 pairs
4. Sacral nerves – 5 pairs
5. Coccygeal nerves – usually 1 pair

Each spinal nerve supplies its own segment of the body.

Classic neurotransmitters

1. Acetylcholine
2. Norepinephrine
3. Serotonin

4. Dopamine
5. Glutamate
6. GABA - gamma-aminobutyric acid
7. Neuropeptides

Cerebral vascularization and the blood-brain barrier

The arterial vascularization of the brain and a significant part of the spinal cord comes from two pairs of vessels - internal carotid arteries and vertebral arteries. The internal carotid arteries supply approximately 80% of the blood volume, supplying most of the telencephalon and a significant part of the diencephalon. The vertebral artery system supplies the remaining 20% of blood volume, supplying the brainstem and cerebellum, as well as part of the diencephalon, the spinal cord, and the occipital and temporal lobes.

The brain is characterized by high metabolic activity, but it cannot store oxygen or glucose. Therefore, it requires a stable and abundant blood supply. The brain, which constitutes only 2% of the total body weight, consumes approximately 15% of the heart's stroke volume and nearly 25% of the oxygen used by the body. The total amount of cerebral blood flow is kept constant under normal conditions, but it may vary in specific brain regions in a manner correlated with the activity of individual structures.