Mirzayuldashev Numonjon

# SURGICAL TREATMENT OF BRAIN INJURIES AND DISEASES

## TEXTBOOK ON NEUROSURGERY

**MINISTRY OF HIGHER EDUCATION, SCIENCE AND INNIVATION OF THE REPUBLIC OF UZBEKISTAN**

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The textbook for the first time summarizes the vast experience in the diagnosis and treatment of surgical pathologies of the spine and spinal cord. It describes the detailed tactics and basics of surgical intervention of the spine and spinal cord proposed by domestic and foreign authors. This manual is intended for doctors of surgical profile: neurosurgeons, traumatologists, orthopedists, neuropathologists, as well as teachers and residents of the master's degree program of medical universities.

The textbook was approved at the meeting of the Council of the Andijan State Medical Institute

Secretary of the Council, Associate Professor, N.A. Nasritdinova

## Contents

## List of abbreviations

AVM — arteriovenous malformation
ACTH is an adrenocorticotropic hormone
ICA — internal carotid artery
Ventilator — artificial lung ventilation
CT — computed tomography
MRI magnetic resonance imaging
NF — neurofibromatosis
PNS — peripheral nervous system
SMT — spinal injury
AIDS — acquired immunodeficiency syndrome
DM — dura mater
USE — ultrasound examination
CNS — central nervous system
TBI — traumatic brain injury
GCS — Glasgow Coma Scale
EEG electroencephalography
DrABC (Eng.DangerremoveAirwayBreathingCirculation) — algorithms for emergency assistance

## Chapter 1. Fundamentals of neurosurgical pathology

The most important data on the structure of the nervous system, pathological processes and their diagnosis are described in detail in the course of normal, topographic, pathological anatomy, neurology and pathology. Here we will recall only the main points that are essential from the standpoint of a neurosurgeon.

The nervous system is divided into CNS, PNS and autonomous. The CNS includes the brain and spinal cord, the PNS – nerve roots, ganglia and nerves, including cranial. The autonomous (formerly called autonomic) nervous system is extremely rarely the object of neurosurgeon interventions.

PNS is extremely branched, so it is affected quite often – PNS diseases account for about 50% of all nervous diseases. However, in many cases, these diseases are treated conservatively.

The majority of neurosurgical interventions today are carried out about the pathology of the central nervous system.

The largest organ of the central nervous system is the brain, and accordingly, most often neurosurgeons have to deal with the pathology of the brain. The spinal cord has about 10 times less mass and is affected by the same number of times less often.

The brain consists of large hemispheres connected by the corpus callosum, anterior and posterior commissures, and the cerebellum, the hemispheres of which are connected by the middle section – the cerebellum. The hemispheres of the large brain through the legs of the brain and the cerebellum, the legs of the cerebellum (upper, middle and lower) are connected to the brainstem, which passes into the spinal cord at the level of the large occipital foramen.In the depths of the hemispheres of the large brain there are lateral ventricles connecting through the interventricular openings (Monroe) with the third ventricle. The lateral walls of the III ventricle are the visual jugra. At the bottom of the III ventricle forms an outgrowth – the pituitary funnel, then passes into the water supply of the large brain (sylvii), which connects the III ventricle with the IV. In the walls of the III ventricle there are neurosecretory nuclei that ensure the maintenance of homeostasis, in the bottom of the IV ventricle there are cranial nerve nuclei, including those regulating breathing and cardiac activity. The pituitary gland is located in the cavity of the Turkish saddle, separated from the cranial cavity by a diaphragm – DMS with an opening through which the pituitary stalk passes. Normally, this hole is hermetically sealed, the cavity of the Turkish saddle with the intracranial space is not communicated.

The subarachnoid space is located between the arachnoid (arachnoid) and the soft (pial) membrane fused to the surface of the brain. In the area of the brain convolutions, this space is normally minimally expressed and, with objective studies (MRI, CT), can be traced only in the furrow area. In the area of the base of the skull, the subarachnoid space is wider and is called basal cisterns. Of the basal cisterns, the largest, in the area of the craniovertebral junction, is called the large (cysternamagna). Next, there is an encompassing cistern surrounding the brain stem, and several smaller cisterns – chiasmal, prepontine, side bridge cistern and some others.

The arachnoid shell closely adheres to the inner leaf of the TM and normally the space between them – subdural – contains a minimum amount of liquid.

DM acts as a periosteum for the bones of the skull. Usually it is connected to them rather loosely, but in the area of seams – denser; in most cases it can be detached without damage. DM performs an important protective function, if it is damaged in case of injury, the risk of infectious complications increases significantly.

The brain is supplied with blood from the internal carotid and vertebral arteries, anastomoses between the branches of the external and internal carotid arteries (orbital, meningolacrimal) are of little importance, which increase significantly when the main arteries of the head are affected. On the basis of the brain, the carotid and main arteries through the connecting arteries anastomose the interstitial, forming the arterial circle of the large brain (Willis circle)For the blood supply of the brain, not only the large arteries (middle, anterior, posterior cerebral, upper, anterior and posterior lower cerebellar) are important, but also small vessels extending from the trunks of the anterior and middle cerebral arteries – perforating arteries and small branches extending from the main artery supplying the brain stem.

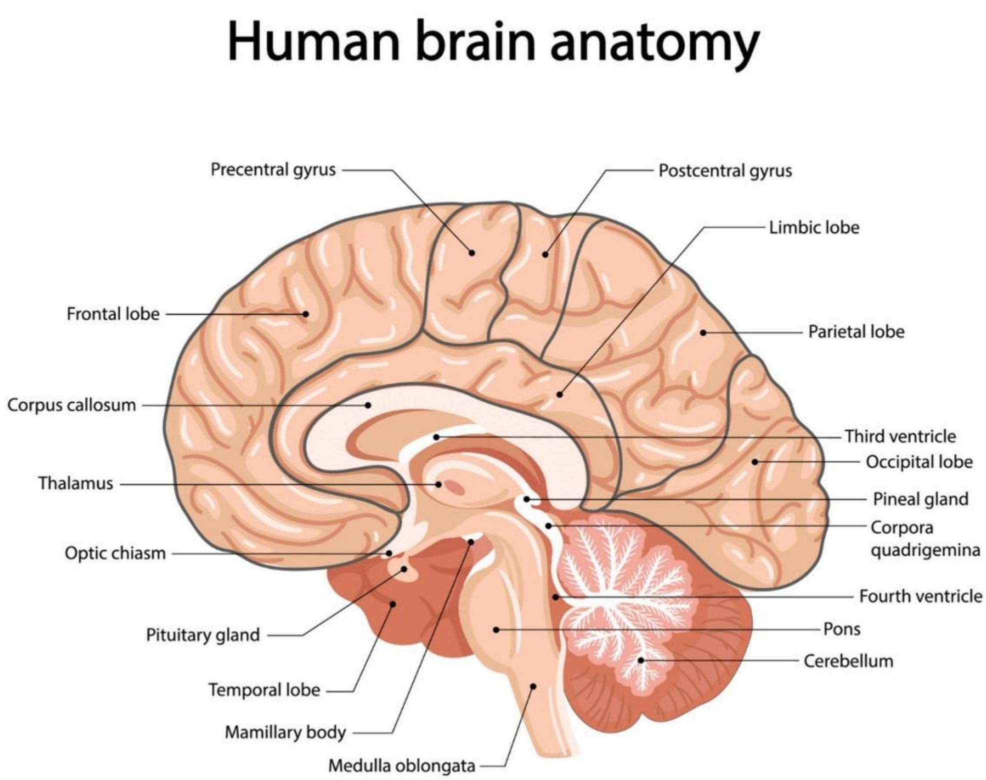
The outflow of blood from the brain is carried out into the superficial shallow veins, which, in turn, flow into the venous sinuses. Venous sinuses merge in the occipital region (sinus drain), from which blood flows through the transverse sinuses into the sigmoid sinuses and then into the jugular veins. In pathology, the pathways of blood outflow from the brain to the veins of the face can be formed.

The spinal cord is supplied with blood by the root arteries that enter it with each root. However, not all radicular arteries have the same diameter, and accordingly their role in the blood supply to the spinal cord is different. Moreover, the diameter of the left and right radicular arteries may differ. The root arteries of the following levels are of primary importance for the blood supply to the spinal cord:

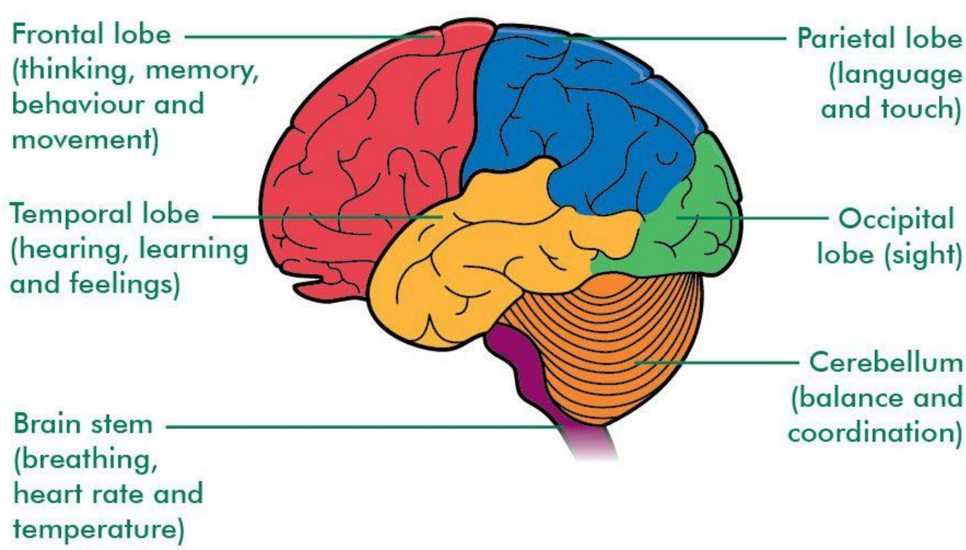
XIII (departs from the vertebral artery), CVI, CVIII, ThIV or THV and the Adamkiewicz arteria, formed from several radicular spinal arteries of the lower thoracic level.The outflow of blood from the spinal cord is carried out into the sheathed venous plexus. Lymphatic capillaries are represented only in the lobes of the spinal roots.

*Functional anatomy of the central nervous system*

There are central (CNS) and peripheral (PNS) nervous systems. The central nervous system includes the brain (large hemispheres of the brain; brain stem, cerebellum) and spinal cord. The peripheral nervous system includes cranial and spinal nerves. In the nervous system, there is also a vegetative (autonomous) nervous system consisting of sympathetic and parasympathetic divisions. The autonomic nervous system is a regulator of the activity of internal organs and systems, providing self–regulation and adaptation of the body to changing environmental conditions and the internal state of a person.




The brain is located in the cranial cavity (cavum cranii). Its shape corresponds to the outlines of the inner surface of the bones of the skull, to which it adheres. So, from the dorsal surface it is convex, and from the ventral it is somewhat flattened and has characteristic irregularities. The absolute and relative mass of the brain in animals is variable and increases due to the complexity of the overall organization of the animal. The brain is divided into the cerebrum (cerebrum), cerebellum (cerebellum) and brainstem (truncus encephali). The brain stem includes the medulla oblongata, the bridge, the middle and intermediate brain. There are also five divisions in the brain: – terminal brain (telencephalon); – intermediate brain (diencephalon); – midbrain (mesencephalon); – posterior brain (metencephalon); – medulla oblongata (myelencephalon). The brain (encephalon) is the highest department of the central nervous system, which controls all processes occurring in the body and provides all higher and lower nervous activity. It develops in connection with the development of three main analyzers (olfactory, visual and equilibrium-auditory).




Large hemispheres and lobes of the brain

The development of the olfactory receptor is accompanied by the formation of the terminal and intermediate parts of the brain; the visual receptor – the middle part of the brain; the statoacoustic receptor – the diamond-shaped part of the brain. The progressive development of the brain is caused by the formation of a large number of insertion neurons, which are structurally designed in the form of nuclei. The specific features of the human brain structure that distinguish it from the brain of highly developed animals are the maximum predominance of the young parts of the central nervous system over the old ones: the brain over the spinal cord, the cloak over the trunk, the new cortex over the old, the surface layers of the cerebral cortex over the deep ones. The ultimate brain.

The terminal brain (telencephalon), or the large brain (cerebrum), is the most massive part of the brain (85-90% of the mass of the entire brain) and occupies most of the cranial cavity. The terminal brain consists of two hemispheres (hemispherium) separated from each other by a deep longitudinal slit (fissura longitudinalis cerebri) and interconnected by three structures – hemispheric commissures: corpus callosum, anterior commissura (commissura anterior) and posterior commissura (commissura posterior). The large hemispheres are separated by a longitudinal slit, in the depth of which lies a plate of white matter consisting of fibers connecting the two hemispheres – the corpus callosum. In the corpus callosum, a trunk (truncus) is distinguished, bending forward to form a knee (genu), passing into the beak (rostrum) of the corpus callosum. The beak continues into the terminal plate (lamina terminalis). The posterior part of the corpus callosum is thickened, called a roller (splenium), which freely hangs over the pineal gland and over the roof plate of the midbrain. The transversely running fibers of the corpus callosum diverge radially in the thickness of each hemisphere and form the radiance of the corpus callosum (radiatio corporis callosi). Under the corpus callosum there is a vault, which is two curved fibrous strands, which are connected to each other in the middle part, and diverge from the front and back, forming pillars and legs of the vault. In front of the pillars of the arch is the front spike. A thin vertical plate of brain tissue is stretched between the anterior part of the corpus callosum and the vault – a transparent septum. In each hemisphere, the most prominent areas are distinguished anteriorly, posteriorly and laterally, called poles: frontal (polus frontalis), occipital (polus occipitalis) and temporal pole (polus temporalis). In each hemisphere, there is a cloak (pallium), an olfactory brain (rhinencephalon), a striatum (corpus striatum), a septum (septum) and a lateral ventricle of the brain. The cloak of each hemisphere is divided into five lobes: frontal (lobus frontalis), parietal (lobus parietalis), occipital (lobus occipitalis), temporal (lobus tempotalis) and hidden lobe, or insula (lobus insularis, insula), located in the depth of the lateral (lateral) furrow. The border between the frontal and parietal lobes is the central (Roland's) furrow, between the parietal and occipital – parietal-occipital. The temporal lobe is separated from the rest by a lateral (Sylvian) furrow. As a rule, the grooves of the III order are not inherited. Frontal lobe. On the upper lateral surface of the hemisphere in the frontal lobe, there is a central furrow (sulcus centralis Rolandi), a precentral furrow (sulcus precentralis) separating the precentral gyrus and two frontal furrows: upper and lower (sulcus frontalis superior et inferior), dividing the rest of the frontal lobe into upper, middle and frontal branches (gyrus frontalis superior, medius et inferior).There are two convolutions on the inner surface of the frontal lobe: a straight line – between the inner edge of the hemisphere and the olfactory furrow, in the depth of which the olfactory bulb and the olfactory tract, as well as the orbital gyrus, are located. Parietal lobe. In the parietal lobe there is a postcentral sulcus (sulcus postcentralis), separating the postcentral gyrus, and an intra-parietal sulcus (sulcus interparietalis), dividing the rest of the parietal lobe into upper and lower parietal lobules (lobules parietalis superior et inferior). The junction of the postcentral furrow and the intertribal furrow is usually called a whorl (vortex), behind which two lobules lie. In the lower lobule, the marginal and angular gyri are distinguished. The supracranial gyrus frames the posterior end of the Sylvian sulcus. The temporal lobe is bounded by the lateral (sylvian) furrow, and the caudal border is drawn according to the same principles as in the parietal lobe. The temporal lobe consists of: the upper temporal sulcus (sulcus temporalis superior), the lower temporal sulcus (sulcus temporalis inferior). There are three horizontal gyri on the outer surface: the upper temporal gyrus (gyrus temporalis superior), the middle temporal gyrus (gyrus temporalis medius), and the lower temporal gyrus (gyrus temporalis inferior). Based on the lobe (basally), the lateral gyrus and the inner (medially) gyrus of the hippocampus are distinguished. The occipital lobe occupies the posterior parts of the hemispheres and is located behind the parietal-occipital sulcus and its conditional continuation on the upper lateral surface of the hemisphere. The furrows and convolutions of the outer surface of the occipital lobe are very variable. There are usually two to four furrows: upper occipital (sulci occipitales superiores) and lateral occipital (sulci occipitales iaterales). Between the upper occipital furrows are the upper occipital gyri (gyri occipitales superiores), and between the lateral furrows are the lateral gyri (gyri occipitales laterales). However, these patterns of topology are often violated, since these furrows belong to the III order and have significant individual variability. In the region of the occipital lobe, transverse occipital furrows and convolutions are observed. The islet (or closed lobule) is located in the depth of the Sylvian furrow. To see the island, you need to push the furrow apart. The islet is closed from above by the lid of the islet (operculum). The tire represents the lower sections of the pre- and post-central gyri of the parietal and frontal lobes and the anterior section of the temporal lobe. If they are removed, the lateral cerebral fossa will open and the convolutions of the islet will become visible. The islet is responsible for taste perception. The cloak of the finite brain includes three sets of structures: the old cloak (archipallium), or the old cortex; ancient cloak (paleopallium), or ancient bark; new cloak (neopallium), or new bark. 4.1.2. Cytoarchitectonics of the brain The cerebral cortex (cortex hemispheria cerebri), pallium, or cloak, a layer of gray matter (1-5 mm) covering the hemispheres of the brain. This part of the brain, developed at the late stages of evolution, plays an extremely important role in the implementation of higher nervous activity, participates in the regulation and coordination of all body functions. In humans, the cortex makes up approximately 44 % of the volume of the entire hemisphere, its surface is on average 1468-1670 cm2. In humans, due to the uneven growth of individual structures of gray matter, the surface of the cortex becomes folded, covered with furrows and convolutions. Furrows and convolutions increase the surface of the cortex without increasing the volume of the skull. The cerebral cortex varies in different areas. This is well known since the time of Vic d'Azyr, a French anatomist who described in 1872 the strips of white matter in the cortex of the occipital lobe of the brain bearing his name. For a long time, the extremely unequal thickness of the gray substance of the cloak has attracted attention. The thickness of the cortex ranges from 4.5 mm (in the anterior central gyrus) to 1.2 mm (in the sulcus calcarinus). In 1874, V.A. Betz discovered giant pyramidal cells (Betz cells) in the cortex of the anterior central gyrus of man and in the motor area of the animal cortex and emphasized the absence of these cells in areas of the cortex, 72 irritation of which by electric current does not cause a motor effect. Cytoarchitectonic study of the cerebral cortex of adults, human embryos and the cerebral cortex of different animals allowed it to be divided into two areas: homogeneous and heterogenetic (according to Brodman), or isocortex and allocortex (according to Focht). The homogeneous cortex (isocrtex) in its development necessarily goes through a phase of a six-layer structure, while the heterogeneous cortex (allocortex) is formed without going through this phase. Phylogenetic studies have shown that the isocortex corresponds to a new cortex – neocortex, appearing in more highly organized animals and humans, while the allocortex corresponds to the old cortex – paleo- and archicortex. In the human brain, the allocortex occupies only 5% of the entire cortex, and 95% belongs to the isocortex. Those areas of the isocortex that retain a six-layer structure in an adult will form a homotypic cortex. The heterotypic cortex is a part of the isocortex that deviated from the six–layer structure in the direction of reducing or increasing the number of layers. In heterotypic regions of the isocortex, the six-layered structure of the cortex is disrupted. There are agranular and granular heterotypes. Agranular heterotype. The agranular regions of the human cortex are completely or almost completely devoid of the outer and inner granular layers. The place of the grain cells was taken by pyramidal cells of different sizes, therefore the agranular region is otherwise called the pyramidized crust. Agranular heterotype characterizes mainly some motor areas of the cortex, especially the anterior central gyrus, where numerous giant Betz cells lie. Granular heterotype. In the area of granular heterotype, the cerebral cortex presents the opposite picture. The pyramidal cells of the third and fifth layers are displaced by densely arranged small cells-grains. Granular heterotype is represented in sensitive areas of the cortex. The structure of the cortex is characterized by orderliness with a horizontal vertical distribution of neurons in layers and columns. The structural and functional unit of the cortex - a module (union, block) – consists of special, pyramidal, stellate and spindle–shaped cells, as well as fibers and vessels and has a diameter of about 100-150 microns. The crust covers the entire surface of the large hemispheres. Its structural elements are nerve cells with processes extending from them – axons and dendrites, as well as neuroglia cells. The bulk of cortical cells consists of three types of elements: pyramidal, fusiform and stellate cells. It is believed that pyramidal and fusiform cells with long axons represent pre-73 essentially efferent systems of the cortex, while stellate cells are predominantly afferent. It is believed that there are 10 times more neuroglia cells in the brain than ganglion (nerve) cells, i.e. about 100-130 billion. The total surface of both hemispheres of the cortex in an adult is from 1450 to 1700 cm2 . The cortex mainly consists of six layers of cells and their processes – nerve fibers. The thickness of the layers varies in different zones of the cortex, it depends on the function of the site, genetic characteristics (Fig. 21). 1. The first layer – the zonal (marginal) layer or molecular (lamina zonalis) – is poor in nerve cells and is formed mainly by a plexus of nerve fibers. 2. The second layer – the outer granular layer (lamina granularis externa) is so called because of the presence in it of densely arranged small cells, 4-8 microns in diameter, having the shape of round, triangular and polygonal grains on microscopic preparations. 3. The third layer – the pyramidal layer (lamina pyramidalis) has a greater thickness than the first two layers. It contains pyramid cells of different sizes. 4. The fourth layer is the inner granular layer (lamina granularis interna), like the second layer, it consists of small cells. This layer may be absent in some areas of the cerebral cortex of an adult organism; for example, it is not present in the motor cortex. 5. The fifth layer is a layer of large pyramids (giant Betz cells, lamina gigantopyramidalis), from the upper part of these cells departs a thick process – dendrite, repeatedly branching in the surface layers of the bark. Another long process – the axon – of large pyramidal cells goes into the white matter and goes to the subcortical nuclei or to the spinal cord. 6. The sixth layer, the polymorphic layer (multiform, lamina multiformis), consists of triangular–shaped cells and spindle-shaped cells. According to the functional feature , the neurons of the cerebral cortex can be divided into three main groups: 1) sensory neurons of the cerebral cortex, the so-called stellate neurons, which are in especially large numbers in the III and IV layers of the sensory areas of the cortex. Axons of the third neurons of specific afferent pathways end there. These cells provide the perception of afferent impulses coming to the cerebral cortex from the nuclei of the visual tubercles; 2) motor (effector) neurons are cells that send impulses to the underlying parts of the brain – to the subcortical nuclei, brain stem and spinal cord. These are large pyramidal neurons, which were first described by 74 V.A. Betz (1874). They are concentrated mainly in the V layer of the motor cortex. Some fusiform cells also take part in the effector function of the cortex; and in Fig. 21. The microscopic structure of the cerebral cortex includes cytoarchitectonic (A, B) and myeloarchitectonic (C) layers: I – zonal (molecular); II – outer granular; III – pyramidal layer (layer of small and medium pyramids); IV – inner granular layer; V – layer of large pyramids (ganglion); VI – layers of polymorphic cells (triangular) 3) contact, or intermediate, neurons are cells that communicate between different neurons of the same or different areas of the cortex. These include small and medium-sized pyramidal and fusiform cells. 75 Myeloarchitectonically, the human cerebral cortex is also divided mainly into six layers corresponding to the specified cellular layers. Myeloarchitectonic layers, even more than cytoarchitectonic layers, break up into sublayers and are extremely variable in various parts of the cortex. In the complex structure of the nerve fibers of the cerebral cortex, there are: horizontal fibers connecting various parts of the cortex, and radial fibers connecting gray and white matter. The above description of the cellular structure of the cortex is somewhat schematic, since there are significant variations in the degree of development of these layers in different areas of the cortex. 4.1.3. Bark fields. Cortical analyzers, according to the peculiarities of cellular composition and structure, the cortex of the large hemispheres is divided into a number of sections called cortical fields. Cytoarchitectonic, myeloarchitectonic and functional fields in the human brain coincide. Anatomist V.A. Betz (1874) for the first time drew attention to the differences in the architectonics of cortical fields and described 11 fields with differences in histological structure. Later, K. Brodman (1909) devoted his research to this issue, who also divided the entire human cerebral cortex according to cytoarchitectonic features into 11 regions (regiones), and regions into fields (ageae), which he described 52; K. Economo (1925) described 190 fields in the cerebral cortex; Focht, using mainly myeloarchitectonics, indicated more than 200 different fields, etc. The simplest cytoarchitectonic Brodman map with its 11 regions enjoys wide international recognition: 1) the postcentral region (regio postcentralis) includes fields 1-3, 43; 2) precentral area (regio praecentralis) has fields 4, 6; 3) frontal area (regio frontalis) with fields 8-12, 44-47;4) insula area (regio insularis) includes fields 13-16; 5) parietal area (regio parietalis) with fields 5, 7, 39, 40; 6) temporal region (regio temporalis) with margins 21-22, 36-38, 41, 42, 52; 7) the occipital region (regio occipitalis) includes fields 17-19; 8) the cingulate region (regio cingularis) has fields 23-25, 31-33; 9) the retrosplenial region (regio retrosplenialis) contains fields 26, 29, 30;10) the hippocampal region (regio hippocampi) has fields 27, 28, 34, 35, 48; 11) the olfactory region (regio olfactoria) includes the field 51, the olfactory tubercle and the periamygdalar region. The evolutionary approach made it possible to create a more detailed, modern classification of the fields of the cerebral cortex, which was proposed by the Brain Institute of the Academy of Medical Sciences (Fig. 22). 76 1. Postcentral region (fields 3/4, 3, 1, 2, 43). 2. Precentral region (fields 4 and 6). 3. Frontal area (fields 8-12, 44-47 and 32). 4. Insular area (fields 13 and 14 and peripaleocortical fields). 5. There are 2 areas in the parietal lobe: the upper parietal (fields 5 and 7) and the lower parietal (fields 39 and 40) areas, which are separated by an inter-parietal furrow. 6. The temporal region occupies 23.5% of the surface of the cortex. It includes the following subdomains: – upper (fields 41, 42, 41/42, 22, 52, 22/38); – middle (fields 21 and 21/38); – basal (20–b, 20–c, 20-1, 20/38 fields); – temporal-parietal-occipital (37–a, 37–b, 37, 37–ab, 37–aa). 7. Occipital region (fields 17, 18 and 19). 8. Limbic region (fields 23, 23/24, 24, 25 and peritectal fields). 9. The ancient cortex (paleocortex) includes the olfactory tubercle, the diagonal region, the transparent septum, the periamygdalar region and the prepiriform region. 10. The old cortex (archicortex) includes the hippocampus, subiculum, dentate fascia and taenia tecta. The cells of the cerebral cortex are less specialized than the cells of the nuclei of subcortical formations. This increases the compensatory capabilities of the cortex, since other neurons can take over the functions of the affected cells. The lack of narrow specialization of cortical neurons creates conditions for the emergence of a wide variety of interneuronal connections, the formation of complex ensembles of neurons to perform various functions. At the same time, despite the well-known nonspecificity of cortical neurons, certain groups of them are anatomically and functionally more closely related to certain specialized departments of the nervous system. The existing morphological and functional ambiguity of the cortical areas allows us to talk about cortical centers of vision, hearing, smell, etc., which have a certain localization. The areas of the cerebral cortex that are approached by ascending pathways from the organs of vision, hearing, smell, taste, pain, temperature and tactile receptors of the skin, from internal organs, are called "cortical analyzer departments". Accordingly, there are visual, auditory, olfactory, gustatory, skin, motor (muscle) analyzers. 77 Fig. 22. Map of cytoarchitectonic fields: a – the outer surface of the cerebral hemisphere; b – the inner surface of the cerebral hemisphere The cerebral cortex is divided into 50-52 fields – these are centers, including the central departments of analyzers, regulating various functions and differing in structure. There are three types of cortical fields. 1. The primary fields (analyzer cores) correspond to the architectonic zones of the cortex, in which the sensory conductor paths (projection zones) end. The cells of this zone have connections with peripheral receptors (IV layer) and muscles (V layer). They are called primary or projection cortical zones due to their direct connection with the peripheral parts of the analyzer. 2. Secondary fields (peripheral parts of the analyzer cores) are located around the primary fields. These include, among others, the II and III layers, in which associative connections with other parts of the cortex predominate. They are called secondary zones, or projection-associative. These zones are indirectly connected to the receptors, and more detailed processing of incoming signals takes place in them. Such a structure is found in the cortex of the occipital lobe, where the visual pathways are projected, in the temporal lobe, where the auditory pathways end, in the postcentral gyrus – cortical department of the sensitive analyzer. Fig. 24. Functional zones of the cerebral cortex: 1 – associative motor zone; 2 – primary motor zone; 3 – primary somatosensory zone; 4 – parietal lobe of the large hemispheres; 5 – associative somatosensory zone; 6 – associative visual zone; 7 – occipital lobe of the large hemispheres; 8 – primary visual zone; 9 –

associative auditory zone; 10 – primary auditory zone; 11 – temporal lobe of the large hemispheres; 12 – olfactory cortex; 13 – gustatory cortex; 14 – prefrontal associative zone; 15 – frontal lobe of the large hemispheres Morphological heterogeneity of primary and secondary zones is accompanied by physiological differences. The excitation of the primary zones of the sensory departments leads to the appearance of elementary sensations. For example, irritation of the primary zone of the occipital lobe causes the appearance of photopsias, and the same irritation of the secondary zones is accompanied by more complex visual phenomena – the subject sees people, animals, distinguishes objects. Therefore, it is assumed that it is in the secondary zones that the operations of recognition (gnosis) and, in part, action (praxis) are carried out. 3. Tertiary or associative fields are located horizontally in the zones of mutual overlap of cortical representations of individual analyzers and occupy more than half of the entire surface of the cortex in humans. First of all, they are located in the temporomandibular-occipital and frontal zones. The tertiary zones enter into extensive connections with cortical analyzers and provide the development of complex integrative reactions, among which meaningful actions (planning and control operations) that require the complex participation of various parts of the brain occupy the first place in humans. The defeat of these zones is accompanied by a violation of gnosis, praxis, speech, purposeful behavior. Primary, secondary and tertiary fields in the cortex of the cerebral hemispheres As part of the cortex are projection (primary and secondary sensory), associative (tertiary multisensory) and integrative (motor, etc.) fields, which is associated with the complex nature of information processing and the formation of a program of purposeful behavior. First, primary, specific information (heat, cold, light, etc.) comes from the receptors to the primary (projection) zones of the cerebral cortex. They perceive only certain qualities of external stimuli (for example, when the retinal receptors are irritated, the cortex of the visual analyzer in the 17 field reproduces sensations in the form of luminous dots). At the same time, there is a connection between specific receptor fields on the periphery and specific areas of the primary zones (for example, sensitivity from the skin of the leg is carried out to the upper parts of the opposite postcentral gyrus). The zone in the cortex is proportional in area to the functional significance of the controlled object: the representation of the hand, lips and tongue in the cortical zone is much greater than the representation of the hip (since the functions of the hip are quite primitive). Secondary, gnostic (from the word "gnosis" – recognition, cognition) cortical zones are located next to the primary zones; they synthesize information received and processed by the primary zones. Here, the binding of receptors to certain cortical areas (somatotopic localization) is no longer observed. Irritation of neurons of secondary fields leads to the appearance of images – visual, sound, etc. Accordingly, failures in the work of secondary zones cause agnosia – disorders of object perception (unrecognition of images of faces, objects, melodies, smells, etc.). Tertiary zones of the cortex are formed due to areas of overlap of secondary zones; they are the most complex in structure and mature late in ontogenesis. The tertiary zones lie along the boundaries of the cortical representations of the cutaneous, visual and auditory analyzers (at the junction of the parietal, occipital and temporal lobes) and synthesize information from various analyzers. Their damage leads to complex forms of spatial perception disorders (orientation on the terrain, agnosia of the right-left sides of the body, etc.). Motor representation Motor (motor) zones of the cortex. The anterior central gyrus (anterior to the Roland sulcus) and the adjacent posterior sections of the first and second frontal gyri make up the motor zone of the cerebral cortex (Fig. 17–19). The core of the motor analyzer is the anterior central gyrus (field 4). A characteristic cytoarchitectonic feature of field 4 is the absence of the IV layer of granular cells and the presence in layer V of giant pyramidal Betz cells, whose long processes reach the intermediate and motor neurons of the spinal cord as part of the pyramidal pathway. This is the speech motor center. When it is affected, articulation is disrupted. In the central parts of the lower frontal gyrus there is a motor field associated with singing. Fig. 25. Projection of the motor sphere in the precentral gyrus of the cerebral cortex [Penfield et al., 1948] Electrical or chemical irritation of field 4 sites causes coordinated contraction of strictly defined muscle groups. Extirpation of some center is accompanied by paralysis of the corresponding segment of the musculature. This paralysis is replaced after a while by weakness and restriction of movement (paresis), since many motor acts can be performed due to non-pyramidal pathways or due to the compensatory activity of the surviving cortical mechanisms. The premotor zone of the cortex. Anterior to the motor zone is the so-called premotor zone of the cortex, occupying fields 6 and 8. This zone is also characterized by the absence of the IV layer, but in the V layer, unlike field 4, there are almost no giant pyramidal cells. The premotor region is closely connected with the subcortical nodes and forms the most important part of the extrapyramidal systems of the cortex, which reach the final motor centers only after switching in the formations lying below the cortex. Field 6 provides, unlike field 4, the implementation of not elementary movements, but complex automated motor complexes. Field 8 is the oculomotor center, the irritation of which leads to a combined deviation of the head and eyes in the opposite direction. Motor and premotor fields have well-developed connections that unite them into a single complex. Afferent impulses reaching the precentral region arrive mainly along the pathways going from the cerebellum, through the red nucleus and thalamus to the cortex. This ensures the circulation of pulses through extrapyramidal cortical systems. Electrical irritation of individual sections of the field 6 causes movements of the head and trunk in the direction opposite to the irritated hemisphere. These movements are coordinated in nature and are accompanied by changes in muscle tone. In response to the irritation of one of the sections of field 6, swallowing movements, sudden changes in breathing and screaming occur. Operative removal of small areas of the premotor zone in humans (during neurosurgical interventions) leads to a violation of motor skills, although subtle hand movements are preserved. Removal of some areas of the premotor zone of the cerebral cortex leads to the emergence of reflexes that are not characteristic of a healthy adult. So, after removing the premotor cortex area, on which the movements of the hand depend, an enhanced grasping reflex occurs: a light tactile touch to the palm causes a strong grasping movement. It resembles the grasping reflex in newborn children in the period preceding the functional maturation of the pyramidal tract. When removing the area where the leg muscles are represented in the motor or premotor cortex, the Babinsky reflex appears in adults. Irritation of different points of field 8 (and field 19 – occipital lobe) is accompanied by arbitrary eye movements (field 19 – fixation of the eye on the object in question). An additional motor area is located on the inner surface of the hemisphere near the sensorimotor representation of the leg. The diameter of this area does not exceed 1-2 cm. Irritation of its various parts shows that in this zone there is a representation of the musculature of all parts of the body. With irritation of the additional motor area, changes in posture are observed, accompanied by bilateral movements of the legs and trunk. Often, when this area is stimulated, various vegetative reactions occur – changes in the width of the pupils, palpitations, etc. It is assumed that the additional zone plays an auxiliary role in controlling the human posture, which is carried out by the motor and premotor areas. The tertiary motor zone of voluntary movements is actually any cortex lying in front of the motor and premotor cortex. This so-called prefrontal region occupies about 25% of the entire cerebral cortex and belongs to the phylogenetically most recent brain formations. Diverse effector and afferent connections provide the decisive role of the prefrontal cortex in the organization of conscious purposeful human activity. Fig. 26. Projection of the sensory sphere in the postcentral gyrus of the cerebral cortex [Penfield et al., 1948] Sensory representation The cortical representation of somatic (skin and articular muscle) and visceral sensitivity is localized in the posterior central gyrus (Brodman fields 1, 2 and 3) and in the cortex of the upper parietal lobe for the entire opposite half of the body. They are arranged in the same order as the motor centers in the anterior central gyrus, namely, the upper third of the posterior central gyrus is occupied by the sensitive centers of the leg, the middle one is the centers of the trunk and arm, the lower third is the centers of the face. This projection is called the sensitive homunculus, or Penfield's little man (Fig. 26). The largest area is occupied by the cortical representation of the receptors of the hand, vocal apparatus and face, the smallest area is the representation of the trunk, thigh and lower leg. Irritation of the somato-sensory zone causes sensations of touch, tingling, numbness, crawling sensation, heat, cold, less often a weak temperature or pain sensation. Pronounced pain sensations are almost never observed. Extirpation of the cortical sensitive center causes a decrease in sensitivity in a certain area of the body, and tactile sensitivity, muscle feeling, discriminatory sensitivity suffer more, and a decrease in pain sensitivity is much weaker. The cortical representation of specially painful sensitivity is attributed to the upper parietal lobule. The upper parietal lobule is considered a secondary zone of skin sensitivity, responsible for complex tactile sensations: for the perception by touch of the shape of objects, their weight, surface. The cortical representation of stereognosis is attributed to the inferior parietal lobule, closely adjacent to the posterior central gyrus. Stereognosis is the ability to recognize objects by groping. The cortical representation of the visual analyzer, the so-called visual zones, are located on the inner surface of the occipital lobes of both hemispheres in the area of the spur furrow and adjacent gyri (fields 17-19). The visual zones are a projection of the retina of the eye. Afferent impulses enter this area from the external cranked bodies, where the third neurons of the visual pathway are located. Irritation of the visual zone in a person leads to a feeling of flashes of light, darkness and different colors. No complex visual hallucinations are observed when this area is irritated. In the primary auditory fields, the perception of high- and low–frequency audio signals is carried out, and in the secondary auditory field (Wernicke field - the auditory center of speech), auditory signals are processed. Bilateral damage to these fields leads to "cortical deafness", i.e. the perception of speech by ear is impaired. Next to the auditory zone is the vestibular zone. The cortical representation of the taste analyzer – according to Penfield, is located in a person in the temporal lobe, near the sylvian and circular furrows, next to the area of the cortex, the irritation of which causes salivation. Or the core of the taste analyzer may be, in particular, in the hook and the parahippocampal gyrus. Afferent impulses enter the taste zone from the lower posterior nucleus of the thalamus. When the taste zone is irritated, various taste (mostly unpleasant) sensations arise. The cortical representation of the olfactory analyzer is located in the phylogenetically ancient part of the cerebral cortex, within the hook and partly in the parahippocampal gyrus. Olfactory sensitivity pathways are the only afferent pathways that do not pass through the nuclei of the visual tubercles. Their first neurons – olfactory cells – are located in the nasal mucosa. The second neurons are located in the olfactory bulb, their processes are the olfactory tract, which reaches the cells of the olfactory analyzer. When the olfactory zone is irritated, various odorous (mostly unpleasant) sensations arise. The destruction of sensory zones in humans usually leads to gross violations of this type of sensitivity or complete loss of function (blindness, deafness, etc.). Violations of the functions of sensory zones in organic pathology (hemorrhage, tumor, injury) in humans are compensated much worse than in animals. The Roland's furrow separating the anterior and posterior central gyri is only a conditional boundary of the motor and sensory zones. Histological studies show that there are a large number of sensitive elements in the motor area; similarly, giant pyramidal cells are found in the sensory area. Given the functional proximity of these two cortical zones, they are often united by the common name of the sensorimotor zone. In addition, the motor and sensory centers do not function in isolation, in isolation from the rest of the brain, but in close connection with the entire central nervous system. 87 The bark only stores sets of "orders" for performing actions, and has no idea about specific performers (muscles). An example is Broca's motor aphasia, which has been known for a long time. With this pathology of the motor centers of the cortex, the ability to speak is lost. Projection-associative zones of the cerebral cortex Projection-associative zones (secondary sensory zones, in contrast to the primary sensory zones discussed above) are nerve cells located in a wide area where impulses come from the same receptors as in the core of the analyzer. These scattered elements make it possible to compensate for the function when the analyzer core is destroyed. In humans, the compensation of functions is less pronounced, probably because the nerve cells of the cortical ends of the analyzers are more concentrated in the sensory zones. Projection-associative zones are located along the edge of the sensory zones and extend 1-5 cm in all directions from them. An important feature of the cells of projection-associative zones is their ability to respond to peripheral stimuli of different receptors. The removal of projection-associative zones does not entail the loss of this type of sensitivity, but the ability to correctly interpret the meaning of the active stimulus is often impaired. The destruction of fields 18 and 19 in humans (according to Brodman), which are the secondary visual zone, never leads to blindness, but the patient loses the ability to evaluate what he has seen. In particular, he does not understand the meaning of words when reading. The destruction of the secondary auditory zone in the temporal cortex often leads to a loss of the ability to understand the meaning of words heard by the patient. These facts indicate that associative zones play an important role in the processes of synthesis and analysis of stimuli in the cerebral cortex. An important feature of projection-associative zones in humans, unlike sensory ones, is that their destruction leads only to a temporary violation of certain functions. In the future, the remaining parts of the cortex take over the functions of the destroyed associative zones and their damage is compensated. Associative zones of the cerebral cortex. Along the horizontal plane in the cortex, tertiary (associative) zones, or zones of overlap of cortical representations of individual analyzers, are distinguished. In the human brain, they occupy a very significant place and are located primarily in the temporal-parietal-occipital and frontal zones. The tertiary zones enter into extensive connections with cortical analyzers and provide the development of complex integrative reactions, among which meaningful actions (planning and control operations) that require the complex participation of various parts of the brain occupy the first place in humans. Functionally, several integrative levels of cortical activity can be distinguished. The first signal system is connected with the activity of individual analyzers and carries out the primary stages of gnosis and praxis (integration of signals coming from the outside world through the conductors of individual analyzers, the formation of responses taking into account the state of the external and internal environment, as well as past experience). The second signal system is a more complex functional level of cortical activity; it combines the systems of various analyzers, making possible a meaningful perception of the surrounding world and a conscious attitude to it. This level of integration is closely related to speech activity – the understanding of speech (speech gnosis) and the use of speech (speech praxis). 90 The highest level of integration is formed in a person during his social development and as a result of the learning process - mastering skills and knowledge. This stage of cortical activity ensures the purposefulness of certain acts, creating conditions for their best implementation. 4.1.4. Basal nuclei and white matter of the cerebral hemispheres Basal ganglia (subcortical nodes). In addition to the cortex, which forms the surface layers of the terminal brain, there are clusters of gray matter in the form of separate nuclei in the depths of each hemisphere (Fig. 27). The basal ganglia lie deep in the white matter of the hemispheres near the lateral ventricles of the brain. They are called basal, or subcortical nuclei (nucl. basales), which traditionally include the striatum (sogris striatum) and the amygdaloid body (corpus amygdaloideum). The striated body, in turn, includes a caudate nucleus (nucl. caudatus), a lenticular nucleus (nucl. lentiformis) and a fence (claustrum). Fig. 27. Basal nuclei The striatum is located under the cortex and on the sections of the brain has the appearance of alternating bands of gray and white matter. It is a group of nuclei, which are the most important motor centers. The nuclei of the striatum coordinate involuntary movements (walking, running, climbing, swimming), regulate muscle tone, unconditioned reflexes (gestures, facial expressions) and autonomic functions. These include caudate, lenticular, almond-shaped kernels and fence. Between the nuclei there are capsules (external, internal) formed by projection paths. A. The caudate nucleus (nucleus caudatus) is located at the bottom of the lateral ventricle, laterally and above the thalamus. It distinguishes the head, body and tail. Small layers of white matter divide the lentil-shaped core into three parts (kernels): the shell (putamen), the lateral and medial pale ball (globus pallidus lateralis et medialis). The medial part of this nucleus is more ancient (paleostriatum) and is called the pale ball (globus pallidus), which is closely related to the olfactory brain. A new striatum (neostriatum) is formed with the development of the sensorimotor centers of the new cortex. The neostriatum includes a caudate nucleus, a shell and a fence. B. The fence (claustrum) in the form of a thin plate of gray matter up to 2 mm thick passes laterally from the outer capsule and outwards from the lentil-shaped core. The amygdala belongs to the old striatum (archistriatum). It is part of the olfactory brain (subcortical centers) and is part of the limbic system. The caudate nucleus and the shell are functionally connected and are designated as the "striatum"; pale globes (pallidum), black substance, red and subthalamic nuclei are also functionally united. All of them are formations of the extrapyramidal (striopallidar) system. The functions of the extrapyramidal system are very important: it implements automated movements, creates "preparedness" for arbitrary movement, regulates muscle tone and increases it at a danger signal (start reflex). The basal nuclei of the hemispheres are separated from each other by layers of white matter, which in this case are called capsules. There are three capsules: internal (capsula interna), external (capsula externa) and extreme (capsula extrema). The white matter of the cerebral hemispheres consists of fibers –

nerve conductors; among them are: • associative fibers that unite different parts of the cortex of one hemisphere; • projection, which connect the cerebral hemispheres with the brain stem and spinal cord; • commissural, which connect the zones of the right and left hemispheres, forming a corpus callosum, a spike arch, front and rear spikes. The corpus callosum provides information exchange between the hemispheres of the brain. Fig. 28. The inner capsule is a dense layer of projected ascending and descending nerve fibers (pathways), has the appearance of an obtuse angle open to the outside. It is located between the head of the caudate nucleus, the visual bug-93 and the pale ball of the lenticular nucleus. The inner capsule consists of the front and rear legs located at an angle (sometimes the legs are designated as hips, and the synonyms of the front and rear legs are the designations upper and lower); the joint area of the legs is designated as the knee (Fig. 28). The anterior pedicle contains descending pathways from the frontal cortex to the bridge of the brain and cerebellum, to the visual hillock. The knee contains a descending cortical-nuclear pathway (part of the pyramidal pathway), which provides conscious control of the motor nuclei of cranial nerves. The anterior 2/3 of the posterior legs are formed by descending fibers of the cortical-spinal pathway (part of the pyramidal pathway), the posterior third are ascending fibers of the deep and superficial sensitivity pathways (thalamo–cortical pathway), ascending pathways of the visual and auditory analyzer (to the occipital and temporal lobes) and descending fibers of the occipital-temporal-bridge cerebellar pathway. The outer capsule is a layer of white substance between the shell of the lentil-shaped core and the fence. The extreme capsule separates the fence from the bark of the island. 4.1.5. Olfactory department of the terminal brain. The concept of the limbic system The olfactory part of the terminal brain (rhinencephalon) is divided into peripheral and central parts. The peripheral part of the olfactory department includes: olfactory bulb (bulbus olfactorius); olfactory tract (tractus olfactorius); olfactory triangle (trigonum olfactorium); medial olfactory gyrus (gyrus olfactorius medialis); lateral olfactory gyrus (gyrus olfactorius lateralis); olfactory region (area parolfactoria); anterior perforated substance (substantia perforata anterior). The arch (fornix) is the conducting system of the olfactory brain (Fig. 29). The arch is a strongly curved weight of white matter, almost all 94 consisting of longitudinal fibers. It distinguishes the body of the vault (corpus fornicis), the leg of the vault (crus fornicis) and the column of the vault (columna fornicis). The main structures of the vault: 1 – the body of the vault (corpus fornicis); 2 – the leg of the arch (crus fornicis); 3 – the column of the arch (columna fornicis); 4 – the fringe of the hippocampus (fimbria hippocampi); 5 – the mastoid body (corpus mamillare) 96 4.1.6. Lateral ventricles of the brain Lateral (lateral) ventricles (ventriculi lateralis) are located inside the hemispheres of the terminal brain. Each ventricle has three horns: anterior (cornu frontale (anterius) ventriculi lateralis), posterior (cornu occipitale (posterius) ventriculi lateralis), lower (cornu temporale (inferius) ventriculi lateralis). The lateral ventricles of the right and left hemispheres are connected to each other and the III ventricle by means of the interventricular (Monroi) orifice (foramen interventriculare Monroi). The anterior horn is a section of the lateral ventricle located rostral to the Monroe orifice. The medial wall of the anterior horn of the lateral ventricle is represented by a transparent septum (septum pellucidum), the lateral and ventral walls are the surface of the caudate nucleus head, and the dorsal wall of the anterior horn is formed by a corpus callosum. Behind the Monroe orifice lies the central part of the lateral ventricle (pars centralis). 7.2. The intermediate brain is located under the corpus callosum and the vault, fusing on the sides with the hemispheres of the large brain.

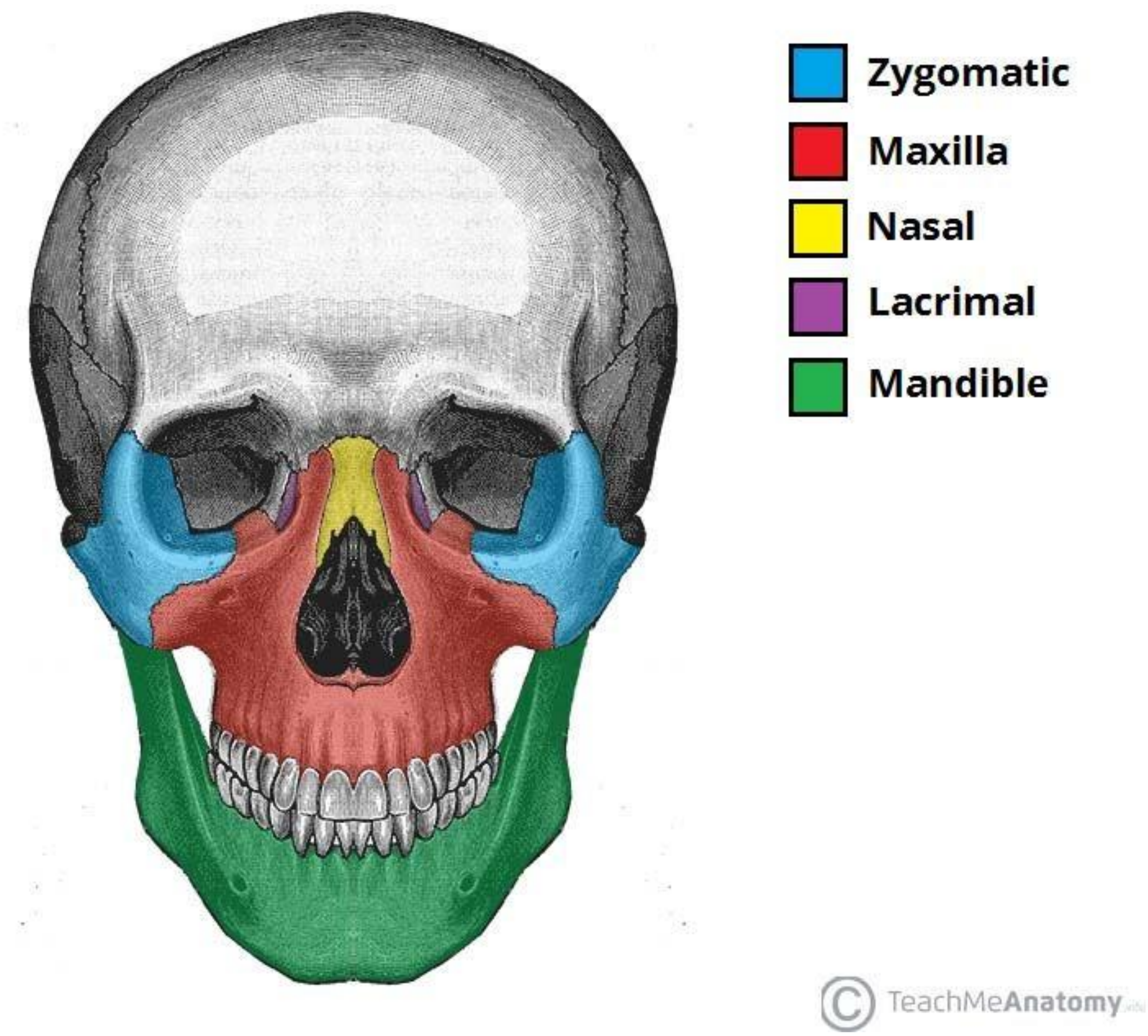
It includes: the thalamus (visual tubercles, thalamus), consisting of the dorsal (thalamus dorsalis) and ventral thalamus (thalamus ventratis), epithalamus (suprahedral region, epithalamus), metathalamus (transhedral region, metathalamus) and hypothalamus (hypothalamus, hypothalamus). The cavity of the intermediate brain is the III ventricle (ventriculus tertius). The supraorbital region of the intermediate brain – the epithalamus includes the triangle of the leash (trigonum habenulae), the leash (habenula), the commissure (spike) of the leashes (commissure habenularum), the pineal body (corpus pineal, epiphysis). Since the nuclei are highly specialized and are clearly expressed in humans as independent hill–shaped structures, anatomists distinguish these nuclei into an independent department of the dorsal thalamus - the trans-mountainous region (metathalamus). The metathalamus includes two pairs of cranial bodies: the lateral cranial body (corpus geniculatum laterale) and the medial cranial body (corpus geniculatum mediate). The lateral cranial body is located to the side of the pillow. It is connected to the upper mound of the roof of the midbrain by means of the handle of the upper mound. In the lateral cranial body, most of the lateral root of the visual tract ends (the other part ends in the pillow), therefore, together with the pillow and the upper mound of the roof of the midbrain, the lateral cranial body is the subcortical center of vision. The medial cranial body lies in front of the handle of the lower mound under the thalamus cushion. It is connected to the lower mound of the roof of the midbrain by means of the handle of the lower mound. In the medial cranial body, the fibers of the nuclei of the lateral (auditory) loop end, therefore, the medial cranial body, together with the lower mound of the roof of the midbrain, is the subcortical center of hearing. The hypothalamus (hypothalamus) is located ventral to the visual hillock and includes the hypothalamus proper and a number of formations located at the base of the brain, participates in the formation of the bottom of the III ventricle. The hypothalamus includes the terminal plate, the intersection of the optic nerves (chiasma opticum), the optic tract (tractus opticus), the gray tubercle (tuber cinereum), the funnel (infundibulum), the pituitary gland (hypophysis) and the mastoid bodies (corpora mamillaria). In the hypothalamic region there are nuclei (supervisory, pericentricular, etc. nucl. hypothalamici), containing large nerve cells capable of secreting a secret (neurosecret) entering the posterior lobe of the pituitary gland, and then into the blood. In the posterior part of the hypothalamus there are nuclei formed by small nerve cells that are connected to the anterior pituitary gland by a special system of blood vessels. The complex of hypothalamic nuclei includes three areas of accumulation of nerve cells: anterior (regio hypothalamica anterior), posterior (regio hypothalamica posterior) 100 and intermediate (regio hypothalamica intermedia).it is transported to the area of the neurohypophysis. There are two lobes in the pituitary gland (in accordance with the development of two different rudiments): the anterior lobe (adenohypophysis) (lobus anterior, adenohypophysis), which makes up 70-80% of the total pituitary mass, and the posterior lobe (neurohypophysis, lobus posterior, neurohypophysis). The third ventricle is located along the midline and is a narrow vertical slit. Its side walls are formed by visual bumps and the subcutaneous region, the anterior – by the pillars of the arch and the anterior spike, the lower – by the formations of the hypothalamus and the posterior – by the legs of the brain and the supraorbital region. The upper wall, the roof of the third ventricle, is the thinnest and consists of a soft (vascular) shell of the brain lined with an epithelial plate (ependyma) from the side of the ventricular cavity. From here, a large number of blood vessels are pressed into the ventricular cavity and a vascular plexus is formed. The brain stem consists of the midbrain, the bridge of the brain, the medulla oblongata (Fig. 30). 102 Fig. 30. Brain stem: 1 – bridge; 2 – pyramids (pyramis medullae oblongatae) and olives of the medulla oblongata; V–XII – cranial nerves 7.3. Midbrain. The concept of the extrapyramidal system of the midbrain extends dorsally from the pineal gland (epiphysis) to the posterior edge of the quadrilateral plate, and ventrally from the mastoid bodies to the anterior edge of the bridge (see Fig. 30). Dorsally, the water supply is limited by the roof of the midbrain, ventrally by the covering of the legs of the brain. The legs of the brain (pedunculi cerebri) – the ventral part of the midbrain, have the appearance of two thick semi-cylindrical white strands that diverge from the edge of the bridge at an angle and sink into the thickness of the hemispheres of the large brain. They contain descending pathways from the cerebral cortex to the anterior horns of the spinal cord, motor nuclei of cranial nerves, cerebellum. The nuclei of the midbrain: the black substance, the nuclei of the III and IV pairs of cranial nerves, the red nucleus, the nuclei of the medial longitudinal bundle. Between the legs of the brain there is an interdigital (tarin's) fossa (fossa interpeduncularis), the bottom of which is the posterior perforated substance (substantia perforata posterior). The posterior perforated substance got its name from the holes left by the vessels entering the brain. Fibers of the oculomotor nerve (III pair of cranial nerves) come out of the caudal part of the interdigital fossa. Skirting the legs of the brain, the fibers of the block nerve (IV pair of cranial nerves) come out from the lateral side. The dorsal part, the roof of the midbrain (tectum mesencephali) is hidden under the posterior end of the corpus callosum and is divided by means of two criss-crossing grooves – longitudinal and transverse – into four mounds arranged in pairs. In the flat groove between the upper tubercles lies the pineal body (epiphysis). The upper two mounds (colliculi superiores) are subcortical centers of vision, both lower ones (colliculi inferiores) are subcortical centers of hearing. A thickening in the form of a roller, representing bundles of fibers, departs from each mound in the lateral direction. This is the handle of the upper (brachium colliculi superioris) and lower mounds (brachium colliculi inferioris). The handles of the mounds are directed to the intermediate brain. On the transverse (frontal) section of the midbrain, four main parts are distinguished: the lamina quadrigemina (lamina quadrigemina), the tire (tegmentum), the black substance (substantia nigra), the base of the brain pedunculi (basis pedunculi cerebri). Below the plate of the quadrilateral are the legs of the brain, which are divided into the dorsal part (the cap) and the ventral part (the base of the leg of the brain). The red core belongs to the extrapyramidal system. The midbrain tire contains the midbrain nuclei and ascending pathways. Laterally and above the red nucleus in the cap of the leg of the brain lies the medial loop. A reticular formation is located between the medial loop and the central gray matter. The reticular formation of the midbrain is a neural fiber network capable of cascading amplification or inhibition of transmitted impulses. Fibers from all ascending and descending paths are directed to it. Forms a descending pathway to the spinal cord (reticulospinal pathway). The base of the brain stem consists entirely of white matter, there are descending conductive pathways, they include cortical-bridge pathways, cortical-nuclear fibers and cortical-spinal pathways. The concept of an extrapyramidal system. Ancient motion control centers are located in the midbrain. These include the upper 105 mounds of the quadrilateral, the red nucleus, the reticular formation of the midbrain and the black substance. 7.4. Rhomboid brain Rhomboid brain (rhombencephalon) as a term is an obsolete common name of the posterior (metencephalon) and oblong (myelencephalon) brain. This term emphasizes the anatomical commonality of the two departments and originated from the name of the bottom of the IV ventricle – the rhomboid 106 fossa. In the posterior brain (metencephalon), the varolian bridge is located ventrally, dorsally – the cerebellum. 4.4.1. Isthmus The isthmus of the rhomboid brain in the process of development forms the boundary between the posterior and middle brain. It develops the upper legs of the cerebellum (pedunculi cerebellares superiores), the upper cerebral sail (velum medullars superius), the tongue of the cerebellum (lingula cerebelli), the bridle of the sail (frenulum veli medullaris superioris) and the triangle of the loop (trigonum lemnisci), which are located on the dorsal side of the isthmus of the brain. On the ventral side, the isthmus of the brain is bounded by the legs of the brain. The triangle of the loop is caused by the course of the auditory fibers of the lateral loop. The nuclei of the lateral loop are located in the depth of the triangle of the loop. 4.4.2. The bridge of the brain is located on the side of its base, lies against the slope and is a wide transverse roller (see Fig. 30). It is located between the middle and medulla oblongata, passes from above into the legs of the brain, its lateral sections form the middle legs of the cerebellum. The ventral surface of the bridge is convex and striated with transverse lines marking the boundaries of fiber bundles. The boundary between the bridge and the middle knife-107 of the cerebellum is the exit point of the roots of the trigeminal nerve (V pair of cranial nerves). It contains fibers of the pyramidal pathway, nuclei of the VI and VII pairs of cranial nerves and conducting pathways. In the anterior (ventral) part of the bridge there are clusters of gray matter – the bridge's own nuclei, in the posterior (dorsal) part of it lie the nuclei of V–VIII pairs of cranial nerves. These nerves exit at the base of the brain to the side of the bridge and behind it at the border with the cerebellum and the medulla oblongata. This system of longitudinal and transverse fibers (a system of conducting pathways) connects the cerebral cortex and the cerebellum through the reticular formation (through the middle cerebellar legs). It has two hemispheres and the middle part is a worm. The gray medulla forms the cerebellar cortex (cortex cerebelli) and is located on the periphery, and the white one is located in the center and has the form of a branched formation, for which it is called the tree of life – arbor vitae. The surface of the cerebellum 108 is covered with a layer of gray matter (cerebellar cortex) and forms narrow convolutions separated by furrows. The archicerebellum is separated from the neocerebellum by a deep prepyramidal furrow (fissura secunda). Table 2 Lobules of the worm and hemispheres of the cerebellum, included in the lobes of the cerebellar worm Hemisphere of the cerebellum Upper lobe of the cerebellum (lobus superior) Tongue (lingula) Tongue frenulum (vinculum lingulae) Central lobule (lobulus centralis) Wing of the central lobule (ala lobuli centralis) Mound (montriculus): tip (oilmen) slope (declive) Quadrangular lobules (lobuli quadrangularis): front part (pars anterior) back part (pars posterior) Posterior lobe of the cerebellum (lobus posterior) Leaf worm (folium vermis) Upper semilunar lobules (lobuli semilunaris superiores) Lower semilunar lobules (lobuli semilunaris inferiores) Worm tubercle (tuber vermis) Thin lobule (lobulus gracilis) The lower lobe of the cerebellum (lobus inferior) Pyramid (pyramis) Double-bellied lobule (lobulus biventer) Hub (uvula) Amygdala (tonsilla) Nodule (nodulus) The patch (flocculus) 109 Fig. 31. Figure 31 shows a diagram of the division of the main divisions of the cerebellum of primates and humans according to the new nomenclature. The cerebellum connects to neighboring parts of the brain using three pairs of legs (pedunculi cerebelli). The lower (posterior) legs of the cerebellum (pedunculi cerebellares inferiores) connect it to the medulla oblongata (Fig. 32). Thus, through the middle legs of the cerebellum, the cerebral cortex controls its activity. The central part of the cerebellum consists of white matter, which contains clusters of gray matter – the nuclei of the cerebellum. The cerebellum is connected to the brainstem by three pairs of legs: the upper ones connect it to the midbrain, the middle ones to the bridge and the lower ones to the medulla oblongata. Bundles of fibers connecting the cerebellum to various parts of the brain and spinal cord pass through them. In the thickness of the white matter of the cerebellum there are several clusters of gray matter – paired nuclei of the cerebellum (nuclei cerebellaris) (Fig. 33). In the pathology of the cerebellum, the following are observed: atony – weakening of muscle tone; ataxia – impaired coordination of movements; astasia – inability to stand still, the body continuously swings in different directions; asthenia – significant loss of strength, rapid fatigue during movements. In addition to the regulation of motor functions, the cerebellum affects the autonomic nervous system. The cerebellum is the roof of the fourth cerebral ventricle (see Fig. 32). The rhomboid fossa is bounded by the upper and lower legs of the cerebellum; at its bottom lie the nuclei of cranial nerves (from V to XII pairs). 113 4.4.4. Medulla oblongata The anterior (ventral) surface of the medulla oblongata is located on the slope of the skull to the level of the large occipital foramen. On the anterior (ventral) surface of the medulla oblongata, the anterior median fissure runs along the midline, which is a continuation of the same-named fissure of the spinal cord. On both sides of the anterior median fissure, there are two narrow oblong rollers (pyramids – pyramis medullae oblongatae) – these are centrifugal descending pathways (the main pyramidal pathway, tractus pyramidalis) that connect the brain with the spinal cord. When crossing to the other side, a pyramid intersection (decussatio pyramium) is formed, and here the XII pair of cranial nerves comes out. On the sides of each pyramid of the medulla oblongata is a rounded elevation – an olive (oliva), which is separated from the pyramid by an anterolateral furrow. The roots of the sublingual nerve (XII pair) come out of this furrow. The composition of the olive includes the olive kernel (nucleus olivaris). The olive kernel participates in the coordination and coordination of skeletal muscle movements. The gray medulla of the medulla oblongata consists of a cluster of nerve cells that form nuclei and a reticular formation. There are many sensitive (sensory) and motor (motor) nuclei on its ventral surface. Sensory nuclei occupy a lateral position, and motor nuclei occupy a medial position. In the anterolateral sections (inside the olives) are the right and left lower olive kernels. The medulla oblongata contains vital reflex centers, namely, cardiovascular activity, respiration, digestion (swallowing, sucking, chewing, salivation, separation of digestive juices), vomiting, blinking, lacrimation. The medulla oblongata plays an important role in the regulation of muscle tone, receiving impulses from the organs of hearing and balance. Many cranial nerves come out of it (V–XII). The upper edges of the rhomboid fossa are formed by the upper legs of the cerebellum converging to the quadrilateral of the midbrain. Its lower edges are formed by the lower cerebellar legs. The fibers conducting impulses of taste sensitivity end on the cells of this nucleus. The nucleus of a single pathway is projected laterally to the border furrow throughout the dorsal parts of the medulla oblongata from the level of the cerebral stripes up to the first cervical segment of the spinal cord.

## Chapter 2. Traumatic brain injury. Penetrating and non-penetrating damage

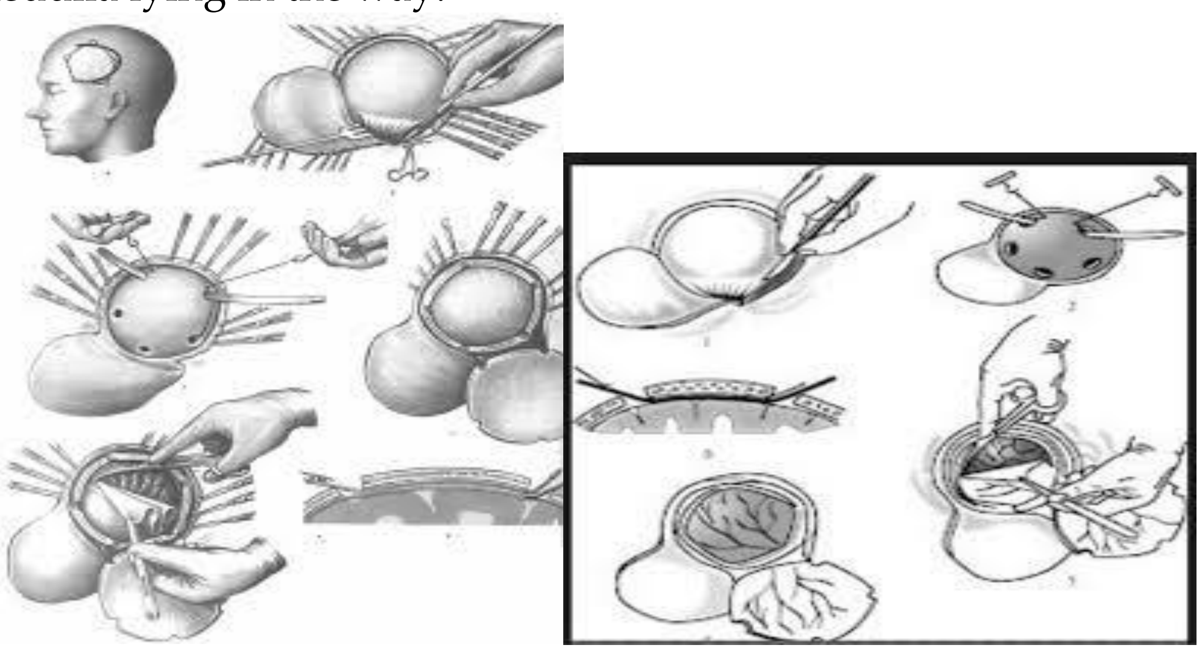
Damage to the meninges occurs with traumatic brain injury, there may be penetrating and non-penetrating wounds. With non-penetrating wounds, the dura mater remains intact with damage to soft tissues (periosteum, aponeurosis, skin) separately or together with the bones of the skull. The wound of the soft tissues of the head without damage to the bones of the skull proceeds without complications after the surgical primary treatment of the wound with suturing. If the bones are damaged, complications are possible – osteomyelitis, hematoma.

During the initial treatment of the wound, skull fragments are removed, stitches are applied. With penetrating wounds (open head wounds), there is a violation of the integrity of the dura mater, the most superficial shell of the brain. Penetrating wounds can be caused by fast-moving projectiles or slow-moving objects like knives, as well as bone fragments from a skull fracture that shift towards the brain. A through wound to the head is a type of penetrating wound in which a traumatic object passes through the head and leaves an exit wound. Head injuries caused by penetrating wounds are severe conditions and can lead to permanent disability or death. Although penetrating wounds have a greater risk of infection, in some aspects they are similar to such closed craniocerebral injuries as brain contusion and intracranial hemorrhage.

As with closed head wounds, intracranial pressure increases due to brain edema or bleeding, compression of the soft tissues of the brain is possible. Most deaths from penetrating wounds are caused by damage to blood vessels, intracranial hematomas and ischemia. With penetrating wounds, the brain injury is mostly local, that is, the brain is damaged in a limited area. While blunt force trauma to the head does not have the risk of shock due to hemorrhage, penetrating head injuries do.



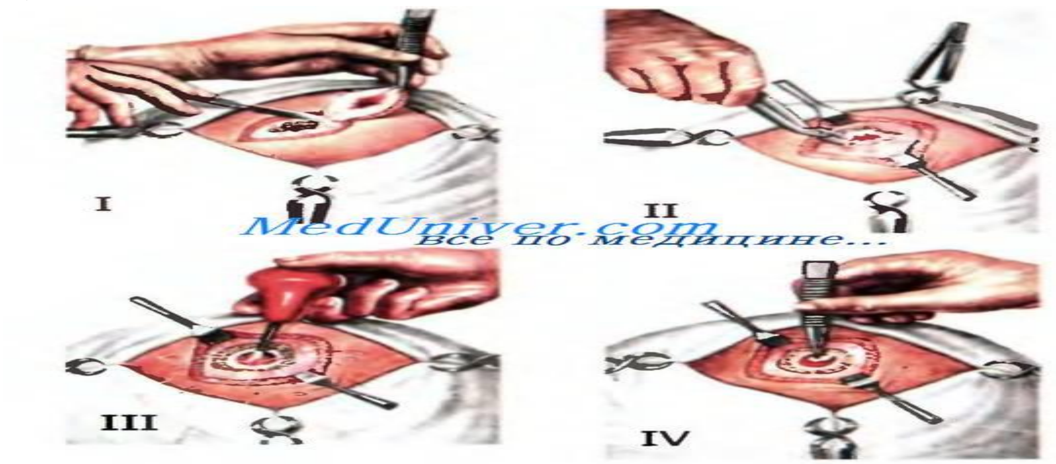

The basic principles of surgical interventions on the skull and its contents. During operations on the brain, when choosing surgical approaches, the following circumstances should be taken into account: firstly, it is impossible to open the cranial box along the midline where the sagittal sinus passes, as well as along the projections of the location of other large sinuses; secondly, it is impossible to create accesses in which the incision would pass through the medulla, with the exception of accesses for opening brain abscesses and removing foreign bodies. thirdly, after opening the skull cavity and performing the operation, provide for the closure of the trepanation hole with a viable bone plate. The choice of a place for the formation of a trepanation hole is dictated by the localization of the pathological process and the features of the anatomical structure of the cranium and its contents. In neurosurgery, it is almost impossible to perform surgical accesses along the nearest path: this is prevented by the danger of damage to either the venous sinuses or functionally important areas of the medulla lying in the way.



Operations in the brain region of the head

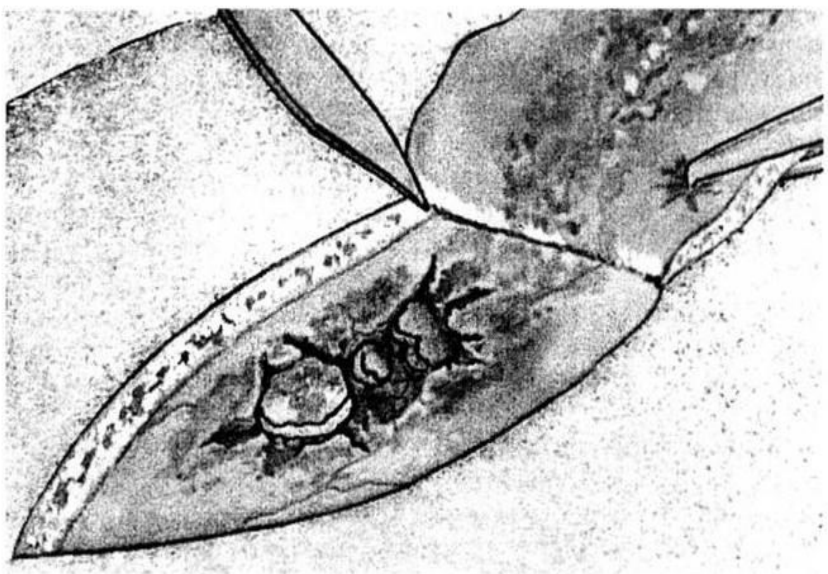
Most often, the temporal region is chosen for access to the base of the brain and temporal lobes; for access to the posterior cranial fossa, the large occipital foramen (foramen occipitale magnum) is chosen, increasing it by expanding to the occipital tubercles. Less often they resort to trepanations in the frontal and parietal bones, since tumors are mostly localized at the base of the brain and in the ventricles of the brain. In case of brain injuries, the skull is trepanned in places of injuries and hematomas. With penetrating wounds of the skull, surgical accesses are carried out along the course of the wound canal, as the surgeon solves the problems of removing damaged tissues and foreign bodies along the course of the wound canal and stopping bleeding. The difficulties of accessing the brain can be judged by the current state of pituitary surgery. To remove the pituitary gland, many different surgical approaches were recommended, and in each of them surgeons tried to find a shorter way to it, to injure the brain matter less and to perform the operation under the control of the eye. It is very difficult to access the pituitary gland located in the pit of the Turkish saddle, although there is a very close way for this: through the nasal opening with the destruction of the sinus sphenoidalis plate, where the pituitary bed is separated from the sinus of the main bone by a thin bone plate. Various approaches have been proposed to the pituitary gland: through the nose (transnasal), through the temporal region, from where it is possible to approach the base of the brain by pushing and lifting the temporal lobe of the brain hemisphere. Attempts were made to remove the pituitary gland in a rather complicated and dangerous way – through the corpus callosum, which was approached through a trepanation hole in the frontal or parietal bone (Brunner, Brunner). Temporal access has an undoubted advantage in that it allows you to remove a pituitary tumor under the control of the eye, and not blindly, as it is done transnasally. Meanwhile, the famous Soviet neurosurgeon A.I. Arutyunov (1972) considers transnasal access to pituitary tumors to be the most anatomically and technically justified method. The main surgical access for brain surgery is trepanation. Trepanation is distinguished by two types: according to Wagner–Wolf – simultaneous cutting out of a horseshoe-shaped flap containing all layers of the cranial integument (skin, aponeurosis, periosteum and bone) in a single complex and connected to the maternal soil by a narrow dermomuscular-periosteal pedicle. Trepanation is carried out by an arcuate incision of soft tissues to the bone, and after that the bone plate is opened along the soft tissue incision line. As a result, a skin-bone flap is formed in the form of a valve held on the skin-musculoskeletal- 47 periosteal pedicle. By pulling the specified valve with hooks, the dura mater is exposed. As a rule, when cutting out a skin-aponeurotic flap, it is guided by the fact that its base is located at the place of passage of blood vessels feeding the integuments of the skull. So, for example, during trepanation in the temporal region, an arcuate incision passes along the edge of the scales of the temporal bone, the base of the flap is the skin, temporal muscle and aponeurosis, through the vessels of which the blood supply to the flap is carried out. The disadvantage of the simultaneous method of cutting out the flap according to Wagner–Wolfe (W. Wagner–J.R. Wolfe) is that it is necessary to significantly narrow the size of the skin-aponeurotic leg of the flap in order to cross the bone plate at the base. This reduces the viability of the flap due to a violation of the blood supply. To eliminate these shortcomings, Olivecrona proposed the separate cutting out of the skin-aponeurotic and bone-periosteal flaps on independent legs that do not coincide with each other. First, a skin-aponeurotic flap is cut out according to the above method on a wide base, it is peeled off, and after that a bone-periosteal flap with a narrower leg is cut out, which does not coincide with the base of the skin-aponeurotic flap. If there is a muscle (for example, temporal) attached to the bone in the trepanation area, it does not separate from the bone, it is part of the bone-bone-muscle flap, strengthening its feeding leg. The technique of skull trepanation by Olivecron makes it possible to make a wider hole in the skull and eliminates the dangers of infringement of the soft tissues of the flap, which can be observed when many layers of soft tissues are bent together with the bone plate. This technique almost eliminates postoperative liquorrhea due to the fact that the incision lines do not match. The methods of bone-plastic trepanation of the skull described above are used as the main types of accesses during operations in the cranial cavity. However, trepanation is often used to reduce increased intracranial pressure in tumors and other diseases when it is not possible to eliminate the underlying disease. Such trepanation is called decompressive, i.e. the goal is to reduce intracranial pressure by creating additional space for bulging of the medulla under the flap of the soft integuments of the skull.

The technique of decompressive trepanation differs from bone-plastic trepanation in that in these cases the bone plate is removed and after surgery the defect of the cranial box remains covered only by a skin-aponeurotic flap. Decompressive trepanation is performed either over the site of the nearest projection of the lesion, or in the temporal region, if the lesion is removed from the periphery of the cerebral hemispheres. The skin-aponeurotic flap is cut out by a horseshoe-shaped incision and peeled downwards, then the temporal muscle is dissected along its fibers with a linear incision. The muscle is stretched with hooks and this exposes the bone plate on an area with a diameter of 5-6 cm . A bone plate is drilled with a cutter and, expanding this hole, the exposed portion of the temporal bone is gradually bitten off. After that, the dura mater is dissected with a cruciform incision, stitches are applied to the temporal muscle and the skin wound is sewn up. In the soft bed formed in this way, the brain protrudes (prolapse), which reduces the risk of increased intracranial pressure. To prevent acute prolapse of the brain into the trepanation hole and its possible infringement, a lumbar puncture is made beforehand and 30-40 ml of cerebrospinal fluid is released. As mentioned earlier, with open injuries of the skull, access to its cavity is carried out mainly through the wound, i.e. by removing the damaged edges of the bone plate. There is no other way out. And in these cases, a very difficult question arises before the doctor about closing the defects of the cranium in order to prevent the development of cerebral hernias or prolapse of adjacent parts of the brain. Previously, bone grafting was used (mostly unsuccessfully) to close skull defects. In the sixties, alloplasty with the help of polymethylmethacrylate and polyvinyl plates was widely used. A fibrous capsule develops around the implant, which holds the plate. Alloplasty is successful in closing a skull defect of up to 5x6 cm and no more. Otherwise, the approach in the occipital region to the posterior cranial fossa is determined. Subtentorial tumors of the cerebellum, the bridge-cerebellar angle, the IV ventricle, and the brainstem occupy a prominent place among brain tumors: they account for 35-40% of brain tumors in adults and up to 70% of brain tumors in children. Therefore, the development of surgical approaches to tumors located in the posterior cranial fossa is of great interest. The peculiarities of surgery in the posterior cranial fossa are that there are no conditions for creating a skin-bone flap, as with trepanations in the temporal or frontal region, and in addition, the proximity of the medulla oblongata does not allow any pressure to be produced, which is dangerous for human life. Previously completed trepanations of the occipital bone, as a rule, ended in death. At the beginning of the XX century, the American surgeon Cushing (Gushing), and then in Russia A.L. Polenov developed access to the posterior cranial fossa with the removal of the posterior edge of the foramen magnum and the Atlas arch (I cervical vertebra). For this purpose, at the level of the external occipital protuberance (inion), an arcuate incision is made parallel to the edge of the foramen occipitale magnum to the mastoid processes; a vertical incision is added to it strictly along the midline, starting from the occipital protuberance and ending with the spinous process of the V cervical vertebra. 2 cm below the lin. The nuchae superior intersects the cervical aponeurosis and occipital muscles. At the same time, A. and v. occipitales are bandaged and N. occipitalis is resected. The soft tissues of the entire lower surface of the occipital bone are separated. With pliers, the posterior arch of the I cervical vertebra is removed and the membrana atlantooccipitalis is opened. After that, several holes on the occipital bone are applied with a hand cutter and through them the lower part of the occipital bone is bitten together with the posterior edge of the large occipital opening. Then the dura mater is opened and a large cistern and hemispheres of the cerebellum are opened. After removal of the tumor, the dura mater and soft tissues are sutured.




Primary surgical treatment of skull wounds.

A few words about the surgical treatment of epilepsy. There are no effective methods of treating this disease, although neurosurgeons are trying to treat epilepsy. Thus, the Canadian neurosurgeon Penfield proposed lobotomy – an operation consisting in removing to a depth of 1 cm an area of up to 20 cm2 of the cortex and white matter of the brain in the area of pathological bioelectric activity of the brain. The operation is dangerous, but in some cases it gives positive results in the treatment of gene epilepsy. Other neurosurgeons offer suction of a part of the cerebral cortex using a vacuum device. In general, all these operations require further experimental study.



Closure of a tissue defect.

Wounds of the cranial vault can be non-penetrating (without damage to the dura mater) and penetrating (with damage to the dura mater). The rules for performing primary processing are as follows. Economical excision of soft tissues, taking into account the topographic and anatomical features of the area: the skin, along with fiber and aponeurosis, is excised, retreating 3-5 mm from the edges of the wound, the wound is given an oval shape. The following techniques are used to stop bleeding from soft tissues: 1) finger pressing of the skin against the bone along its incision; 2) applying clamps to the bleeding vessels with the seizure of aponeurosis, followed by ligation or electrocoagulation; 3) stitching of soft tissues around the wound together with the vessels (the Heydenhain method); 4) metal brackets (clips); 5) electrocoagulation.

Economical excision of the damaged periosteum and removal of bone fragments and foreign bodies unrelated to the periosteum. The edges of the bone defect are leveled with Luer wire cutters. The outer plate is bitten off so that all the fragments of the inner plate can be removed. To stop bleeding from the diploetic veins of the bone , the following methods are used: 1) rubbing wax paste into the edges of the bone; 2) crushing the bone with Luer wire cutters, pressing the outer and inner plates to each other to destroy the beams of the diploetic layer. Processing of the dura mater: 1) with non-penetrating wounds and the absence of shell tension (pulsates well) it is not opened; 2) if a subdural hematoma is seen through a tense, weakly pulsating dura mater, it is sucked through a needle; 3) if blood clots are not removed in this way, or with penetrating wounds, the dura mater is dissected crosswise or radially to access the brain wound; the edges of the damaged shell are excised very sparingly. With wounds of the shell or during the removal of bone fragments, if the fragment covered the wound of the sinus, bleeding from the sinus of the dura mater may occur, which is stopped in the following ways: 1) suturing of small wounds; 2) plastering of the sinus wall defect with a flap from the outer sheet of the dura mater or an autograft from the wide fascia of the thigh; 3) with large ruptures – tamponade of the sinus with a muscle fragment or gauze turunds, which are extracted after seven days; 4) ligation of the sinus (with a complete rupture); this method is dangerous, as it leads to the development of cerebral edema, venous encephalopathy and death of the victim due to a violation of intracranial hemocirculation. Brain wound treatment. Removal of the destroyed brain tissue and superficially located bone fragments is carried out by carefully washing off detritus with a stream of warm saline solution. An increase in intracranial pressure contributes to the better removal of the contents of the wound canal. For this purpose, the patient, operated under local anesthesia, is offered to strain, cough. The victim's jugular veins are squeezed in an unconscious state. To stop bleeding from the cerebral vessels, the following methods are used: 1) electrocoagulation; 2) filling the wound canal of the brain with a mixture of fibrinogen and thrombin.

The wound of the dura mater is sutured with thin silk ligatures, the bones are connected with sutures conducted through a tendon helmet and periosteum, with thin silk or threads of polymer material; the edges of the skin wound are connected with silk nodular sutures. Trepanation of the skull. There are two types of cranial trepanation: osteoplastic, which is an operative access to the cranial cavity and is performed in two ways (single–flap – according to Wagner–Wolf and two-flap - according to Olivecron) and decompression (decompressive, resection), which is a palliative operation, including operative access and operative reception. Indications: abscess, hematoma, brain tumor. Stages of two-flap bone-plastic trepanation of the skull: 1) formation of a skin-aponeurotic flap; 2) processing of the periosteum (dissection and displacement in order to form a "track" for applying milling holes and sawing bone); 3) drilling of milling holes, sawing bone bridges between them and folding the bone-periosteal flap with the preservation of the feeding leg; 4) arcuate dissection of the dura mater and performing the necessary manipulation on the brain; 5) suturing of the dura mater, closure of the skull defect by placing the flap in its original position and suturing. Advantages in comparison with single-flap cranial trepanation are the possibility of a wide opening of the cranial cavity by sawing out a bone-periosteal flap of any size and eliminating the danger of infringement of the soft tissues of the flap. The "gold standard" of craniotomy. The "gold standard" of craniotomy is currently a free bone flap formed by a craniotome from one (if possible) milling hole. Advantages:

• Reducing the risk of postoperative epidural hematoma formation.

• The bone flap does not interfere with the work around the wound (since it is removed from the wound during the main stage of the operation).

• Less traumatic surgery due to the implementation of subcostal dissection (rather than dissection between aponeurosis and periosteum).

• Versatility of application of this technique.

Decompression trepanation of the skull is a palliative operation. It is produced with an increase in intracranial pressure in cases of inoperable brain tumors, with progressive edema developing as a result of trauma. The purpose of the operation is to create a defect in the bones of the skull and dura mater in a certain area of the arch. In the bed formed in this way, the brain protrudes, which reduces the increase in intracranial pressure. A trepanation window is applied over the lesion. Currently, the operation is performed mainly in the temporal region according to Cushing. Operation stages: 1) a horseshoe–shaped incision of the skin and subcutaneous tissue with the base facing down to the level of the zygomatic arch - respectively, the line of attachment of the temporal muscle; 2) dissection of temporal aponeurosis, interaponeurotic fatty tissue and temporal muscle in the vertical direction to the periosteum; 3) dissection and separation of the periosteum with an area of 6 cm2; 4) the imposition of a milling hole on bone with its subsequent expansion with pliers to form a 6x6 cm defect; 5) opening of the dura mater with a cruciform incision and additional radial incisions; 6) layer-by-layer suturing of the surgical incision with the exception of the dura mater, which is sutured. Trepanation of the mastoid process (antrotomia, mastoidotomia). Indications: purulent mastoiditis. Technic: 1) incision of soft tissues to the bone 5-6 cm long in parallel with the attachment of the auricle and posteriorly by 1 cm; 2) detachment of the periosteum from the bone by a rasp; 3) removal of the outer wall of the mastoid process within the triangle with a chisel with a hammer; 4) removal of the affected part of the spongy layer, destruction of partitions between individual cells, removal pus; 5) drainage of the bone wound with a gauze strip. Complications arise when the boundaries of the trepanation triangle of the Shipo are not observed, as a result of which it is possible to damage: at the top – the contents of the middle cranial fossa; in front – the facial nerve; behind – the sigmoid venous sinus. Plastic skull defects (cranioplasty). Measures to close the bone defect are carried out using various methods of auto-, homo- and alloplasty of the skull bones. Autoplasty according to Polenov – autoplasty with a bone flap on the leg. Kutner autoplasty is an autoplasty using a free external bone plate with a periosteum. The Dobrotvorsky method is the replacement of a bone defect using a patient's rib.

*Vascular lesions of the meninges*

Vascular lesions of the meninges of various etiologies are manifested by hemorrhages. The volume of intracerebral hemorrhages varies: from microscopically small (petechial) to massive hematomas. A significant volume of hematomas is achieved with severe damage to brain tissue, more often as a result of primary vascular rupture, but they can also be of secondary, arrosive origin, due to progressive necrosis of the brain substance and the vascular wall, Incomplete rupture of the vessel wall leads to the formation of a traumatic aneurysm.

Extracerebral intracranial hematomas in relation to the membranes of the brain can be located subdural, epidural and subarachnoid. Epidural hematomas are an accumulation of blood clots between the outer surface of the dura mater and the bones of the skull; they have the appearance of a layer up to 2.5—3 cm thick. The volume of blood spilled can be different: from 30 ml to 200 ml or more. Epidural hematomas are localized, as a rule, on the side of the application of traumatic force, according to the place of fracture of the skull bones. On the anti-shock side, they rarely develop. More often, epidural hematomas are located in the parietal-temporal region, where they reach the largest volume. The source of bleeding here is the trunk or branches of the middle sheathed artery. Rarer localizations include: the frontal-temporal and parietal-occipital regions, as well as the anterior and posterior cranial fossa, in which the source of bleeding are diploetic veins, veins of emissaries, sinuses of the dura mater. Often epidural hematomas are combined with subdural ones, forming a two-chamber episubdural hematoma (in 15.5%).

Subdural hematomas are the accumulation of blood or its clots between the arachnoid membrane and the inner surface of the dura mater; they are much more common than epidural ones. Unlike the latter, they spread over vast territories, covering not only the convexital, but also the basal surface of the brain. The volume of these hematomas is from up to 200 ml or more. Subdural hemorrhages of small volume (30-40 ml) should not be underestimated, since they are a constant irritant affecting the brain and causing a number of new vascular pathological reactions, edema phenomena, which in some cases leads to the appearance of brain compression syndrome. The source of subdural bleeding is damaged superficial cortical and pial vessels, vessels of the inner leaf of the dura mater and veins passing in the subdural space. When the brain is bruised, subdural hemorrhages develop both on the side of the impact application and on the opposite side, often being bilateral. It should be emphasized that intracranial hematomas (epi- and subdural) are often combined with brain contusion of varying severity, which allowed V.M. Ugryumov to amend the clinical classification of closed skull and brain trauma and call the third form not "brain compression", but "brain contusion with compression". Classical forms of compression of the brain without simultaneous bruising are rarely observed. Subarachnoid hemorrhages are the accumulation of blood in the cerebrospinal fluid channels and cells of the subarachnoid space. In case of brain injury, they occur in all cases, have a different distribution pattern from limited to diffuse, depending on the degree of damage to the brain surface. Massive subarachnoid hemorrhages, located deep in the furrows and in the cisterns of the brain, may look like limited hematomas. Massive subarachnoid hemorrhage is often combined with ventricular hemorrhage. In such cases, it is more correct to talk about subarachnoid-ventricular hemorrhage. Thrombosis of the dura mater sinuses can be the result of trauma, compression of the sinus by a tumor, dural malformation or septic lesion. Thrombosis can develop spontaneously in patients with leukemia, coagulopathy, systemic connective tissue lesions. The spectrum of clinical manifestations of sinus thrombosis varies from asymptomatic course to severe neurological dysfunction and death. General clinical manifestations are associated with intracranial hypertension syndrome: congestive changes in the fundus, headache, convulsive seizures, focal neurological prolapses. A specific pattern is characterized by thrombosis of the cavernous sinus. There is marked non-pulsating exophthalmos, conjunctival edema and chemosis, venous hyperemia, pronounced venous congestion on the fundus. Diagnosis of sinus thrombosis is difficult. Computed tomography may reveal signs of venous cerebral infarction, intracerebral hemorrhage. With thrombosis of the sagittal sinus in the fusion area, a symptom is detected (a zone of reduced density of a triangular shape in the lumen of the sinus, surrounded by a contrasting edge). The method of choice is considered magnetic resonance imaging of the brain with MRFLEBOGRAPHY. For the final determination of the localization and extent of thrombosis, cerebral angiography and phlebography are used. The natural course of thrombosis of the sinuses of the dura mater is not exactly known. Mortality in acute thrombosis ranges from 10 to 50%, but the frequency of asymptomatic thrombosis is not taken into account. The course and outcome of the disease may be influenced by factors such as the age of patients, the extent of thrombosis, the presence of cortical vein lesions. The outcome of the disease depends on the rate of recanalization of the obliterated sinus or the formation of venous collaterals. The significant variability of these indicators makes it difficult to systematically analyze the results of treatment. Drug treatment of sinus thrombosis is limited in its capabilities and is mainly reduced to the treatment of consequences in the form of venous infarcts with mass-effect phenomena. Intracranial hypertension and dislocation syndrome are being treated. Systemic heparinization prevents the progression of thrombosis, but does not contribute to thrombus lysis. The use of systemic fibrinolysis in combination with heparinization has demonstrated favorable results for recanalization of the thrombosed sinus, but is associated with a significant risk of hemorrhagic complications. Cases of open surgical thrombectomy have been described, but this method has not received any significant spread. Of the "active" methods of correction, selective catheterization of the affected sinus and local fibrinolysis with bolus injection of urokinase and subsequent systemic therapy are most widely used. The microcatheter remains in the sinus for several days until the restoration of its patency is achieved. Therapy of septic sinus thrombosis necessarily includes systemic and regional rational antibacterial therapy. Regional infusion of antibacterial drugs is carried out through a catheter installed at the bifurcation level of the common carotid artery by catheterization of the superficial temporal or thyroid arteries.

### *The concept of stereotactic operations.*

Indications: destruction of a deep intracerebral tumor, pituitary adenoma, shutdown of an intracranial aneurysm, removal of a deep-seated foreign body, emptying of an intracerebral hematoma or abscess. The stereotactic method involves a combination of techniques and calculations that ensure the precise insertion of an instrument (cannula, electrode, etc.) into a predetermined, deeply located structure of the brain. For its implementation, a stereotactic apparatus, a stereotactic atlas of the brain and data from X-ray examination of brain structures with a well-established spatial localization of intracerebral landmarks are needed. The principle of operation of stereotactic devices is based on the comparison of the coordinate systems of the brain and the device. The preparatory stage begins with a radiopaque examination of the brain, including ventriculography. Then the skull is X-rayed in two projections with rigid fixation of the patient's head. Based on the results of the X-ray examination, intracerebral landmarks are determined, which are compared with the data of the stereotactic atlas. The spatial localization of the subcortical structure is compared with the coordinate system of the stereotactic apparatus, and the calculated data obtained are transferred to the guiding devices of the apparatus. After that, according to the specified scheme, an electrode or a cryogenic cannula is inserted into the calculation zone, depending on the task of the operation. Ligation of the middle sheathed artery. Indications: closed and open injuries of the skull, accompanied by injury to the trunk and branches of the artery with the formation of an extradural hematoma. The operation consists in trepanation of the corresponding part of the skull. In case of unclear localization, the main trunk of a. meningeae mediae is exposed. Operation technique: 1) a horseshoe-shaped incision of the skin in the temporal region with the flap separating from the base downwards; 2) cutting out the bone-periosteal-muscular flap (according to the general rules) and throwing it down; 3) ligation with a needle or clipping of the damaged vessel above and below the injury site; 4) examination of the dura mater (when it is wounded, a subdural hematoma is removed with a jet of saline solution); 5) laying the flaps in place and layer-by-layer suturing.

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In such cases, it is more correct to talk about subarachnoid-ventricular hemorrhage. Thrombosis of the dura mater sinuses can be the result of trauma, compression of the sinus by a tumor, dural malformation or septic lesion. Thrombosis can develop spontaneously in patients with leukemia, coagulopathy, systemic connective tissue lesions. The spectrum of clinical manifestations of sinus thrombosis varies from asymptomatic course to severe neurological dysfunction and death. General clinical manifestations are associated with intracranial hypertension syndrome: congestive changes in the fundus, headache, convulsive seizures, focal neurological prolapses. A specific pattern is characterized by thrombosis of the cavernous sinus. There is marked non-pulsating exophthalmos, conjunctival edema and chemosis, venous hyperemia, pronounced venous congestion on the fundus. Diagnosis of sinus thrombosis is difficult. Computed tomography may reveal signs of venous cerebral infarction, intracerebral hemorrhage. With thrombosis of the sagittal sinus in the fusion area, a symptom is detected (a zone of reduced density of a triangular shape in the lumen of the sinus, surrounded by a contrasting edge). The method of choice is considered magnetic resonance imaging of the brain with MRFLEBOGRAPHY. For the final determination of the localization and extent of thrombosis, cerebral angiography and phlebography are used. The natural course of thrombosis of the sinuses of the dura mater is not exactly known. Mortality in acute thrombosis ranges from 10 to 50%, but the frequency of asymptomatic thrombosis is not taken into account. The course and outcome of the disease may be influenced by factors such as the age of patients, the extent of thrombosis, the presence of cortical vein lesions. The outcome of the disease depends on the rate of recanalization of the obliterated sinus or the formation of venous collaterals. The significant variability of these indicators makes it difficult to systematically analyze the results of treatment. Drug treatment of sinus thrombosis is limited in its capabilities and is mainly reduced to the treatment of consequences in the form of venous infarcts with mass-effect phenomena. Intracranial hypertension and dislocation syndrome are being treated. Systemic heparinization prevents the progression of thrombosis, but does not contribute to thrombus lysis. The use of systemic fibrinolysis in combination with heparinization has demonstrated favorable results for recanalization of the thrombosed sinus, but is associated with a significant risk of hemorrhagic complications. Cases of open surgical thrombectomy have been described, but this method has not received any significant spread. Of the "active" methods of correction, selective catheterization of the affected sinus and local fibrinolysis with bolus injection of urokinase and subsequent systemic therapy are most widely used. The microcatheter remains in the sinus for several days until the restoration of its patency is achieved. Therapy of septic sinus thrombosis necessarily includes systemic and regional rational antibacterial therapy. Regional infusion of antibacterial drugs is carried out through a catheter installed at the bifurcation level of the common carotid artery by catheterization of the superficial temporal or thyroid arteries.

## Chapter 3. Functionally significant areas of the brain

Functionally significant areas of the brain conditionally include those whose defeat leads to disability of the patient. First of all, these are structures that provide movement, speech and vision.

### *Localization of functionally significant brain areas*

Speech: motor – Broca's area (the posterior part of the lower frontal gyrus of the dominant hemisphere – left in right–handed and right – in left-handed); sensory - Wernicke's area (the posterior parts of the upper temporal gyrus and adjacent posterior parts of the parietal lobe of the dominant hemisphere).

Movements: anterior central gyrus, sometimes with adjacent areas of the frontal and parietal lobes. The external reference point is 4-5 cm away from the coronary suture.

Vision: the cortex of the occipital lobe in the area of the spur furrow, as well as the pathways in the depths of the hemispheres. With a unilateral lesion, defects in the visual fields of both eyes occur from the side opposite to the focus, up to the complete loss of the opposite halves of the visual fields (homonymous contralateral hemianopia).

Central vision does not suffer because it has a bilateral representation. Cortical blindness develops only with bilateral inflammation.

A significant influence on the manifestation of brain lesions is exerted by the closed nature of the cranial cavity and the spinal canal. Changes in the volume ratios in this space are described by the "Monroe–Kelly hypothesis".

After the closure of the cranial sutures and fontanelles, the cavity of the skull and spinal canal, the "craniospinal space", becomes frigid. Its entire volume is filled: 1) brain and spinal cord; 2) cerebrospinal (cerebrospinal) fluid; 3) blood (in the lumen of the vessels). An increase in the volume of one of the components or the appearance of an additional volume (tumors, hematomas, abscesses, etc.) is compensated to a certain extent by a decrease in other volumes (primarily liquor spaces), and when the compensation reserves are depleted, it leads to an increase in intracranial pressure (intracranial hypertension).Intracranial pressure in an adult lying down is normally 10-15 mmHg.

This parameter is very important, because only in normal indicators of intracranial pressure adequate blood supply to the brain is provided – the flow of 70-80 ml of blood through 100 g of brain matter per minute. With an increase in intracranial pressure, perfusion pressure (which is the difference between the mean arterial 1 and intracranial) decreases and the blood supply to the brain worsens. Normally, the perfusion pressure should exceed 50 mmHg.

Especially dangerous is the combination of an increase in intracranial pressure with a decrease in arterial pressure, which can occur in TBI, In addition to the volume ratios described by the Monroe–Kelly hypothesis, the ratio of production and resorption of cerebrospinal fluid plays an important role in regulating intracranial pressure. Normally, the weight produced in the vascular plexuses of the ventricles and in the cerebrospinal fluid is absorbed by the membranes of the brain at a rate of approximately 0.35 ml / min. With an increase in intracranial pressure, the rate of resorption of cerebrospinal fluid increases, which compensates for intracranial hypertension within certain limits.

1 Mean blood pressure = 2/3 diastolic + 1/3 systolic (in mmHg).

## *Brain dislocations*

From the point of view of hydrodynamics, the craniospinal space is divided into 3 sections: supratentorial (located above the cerebellum and partially divided by the sickle of the large brain), subtentorial (between the cerebellum and the large occipital foramen) and spinal. Normally, the cerebrospinal fluid freely circulates through all these departments and the pressure in them (in the supine position) is the same, i.e. the pressure of the cerebrospinal fluid in the lumbar spine is equal to the intracranial pressure measured during lumbar puncture.

The volumetric pathological process exerts pressure on the adjacent parts of the brain and causes their displacement. This leads to the displacement of part of the cerebrospinal fluid from the corresponding part of the craniospinal space – first near, then away from the focus. By exaggerating the pathological volume, the compensation reserves are depleted and local hypertension leads to a displacement of the brain beyond the corresponding part of the craniospinal space into neighboring ones, where the pressure is not yet increased and the liquor spaces are free.Since anatomical formations (sickle-shaped process, cerebellar namet, edges of the large occipital foramen) prevent uneven displacement of the brain, its departments located near the edges of these formations (cingulate gyrus, medial temporal lobe, parts of the cerebellum) are mainly located. In the displaced parts of the brain, due to stretching, inflection of the veins, swelling increases, and a strangulation furrow forms in the area of the edge of the anatomical structure under which the brain is displaced. This, in turn, increases the swelling. At the same time, the displaced parts of the brain complicate the circulation of the cerebrospinal fluid at this level, which leads to a further increase in intracranial pressure, an increase in edema and dislocation of the brain. Given that events in the dislocation of the brain develop rapidly, according to the principle of a "vicious circle", the operativeness of diagnostic and therapeutic measures is of exceptional importance.

There are only a few variants of brain dislocation with a characteristic symptom complex for each.With unilateral volumetric processes of supratentorial localization, it is possible to shift the cingulate gyrus under the lower extremity of the cingulate process. This displacement is called transverse. This displacement usually does not manifest itself clinically, as it leads to impaired circulation of the cerebrospinal fluid. However, in some cases, it is possible to develop a brain infarction in the basin of the anterior cerebral artery or its branches, pressed by the dislocated cingulate gyrus to the edge of the sickle-shaped process.

The most frequent option of clinical significance is the dislocation of the brain into the opening of the cerebellar namet – "tentorialneuklinenie". There are 2 main types of such insertion – central (axial) and lateral (hippocampal), which are usually combined to some extent.

The central wedge develops more often with long–term processes, primarily with tumors of the frontal, parietal or occipital localization.

With the central insertion, the diencephalic structures shift into the opening of the cerebellar namet, which initially leads to the appearance of diencephalic symptoms. Usually, this symptom appears against the background of increased headache, which is often accompanied by nausea and vomiting. There is a decrease in the level of consciousness due to superficial or deep deafening, lability of the pulse, breathing rhythm, hyperemia, greasiness of the skin or, conversely, their icing. Due to stretching of the pituitary stalk, diabetes insipidus may develop. This stage of dislocation is called diencephalic and, with adequate treatment, is reversible.

As the dislocation increases, symptoms of compression of the four–holm plate appear - restriction of arbitrary and reflex gaze upward, up to its complete absence, narrowing of the pupils. As the dislocation increases, visual disturbances progress, up to complete immobility of the eyeballs (internuclear ophthalmoplegia), there are breathing disorders of the Cheyne–Stokes type, turning into persistent tachypnea. Consciousness is lost, the reaction to pain persists.

A bilateral Babinsky symptom is revealed. This stage is called the medullary stage and is characterized by a less favorable prognosis.With further progression of dislocation, the lower head stage develops, due to the displacement of the tonsils of the cerebellum into the large occipital foramen with compression of the medulla oblongata.

In addition to the compression of the stem structures, the circulation of the vestibule stops at the level of the large occipital foramen, which further aggravates intracranial hypertension. A deep coma develops, tachypnea turns into "automatic" breathing (regular, 20-30 minutes), pupil dilation increases, deep and pathological reflexes disappear. The prognosis is unfavorable.

The final (terminal) stage of dislocation is the medullary stage – compression of the upper neck of the spinal cord by roughly displaced tonsils of the cerebellum. At the same time, terminal (atonic) coma develops with extreme mydriasis and areflexia (3 points on the SHG).The prognosis is hopeless, neurosurgical treatment is not indicated.

Lateral (temporal, hippocampal) insertion usually develops with rapidly increasing intracranial volumetric processes, primarily with hematomas, massive bruises, less often with tumors or abscesses of the temporal region. With this type of insertion, there is a displacement of the medial parts of the temporal lobe — the hippocampal hook, the hippocampal gyrus – into the excision of the cerebellum with compression of the oculomotor nerve passing here and then directly to the midbrain. In addition to these structures, there is a compression of the Sylvian aqueduct, which leads to an aggravation of intracranial hypertension.

Accordingly, the first symptom of lateral insertion is a violation of the function of the oculomotor nerve, manifested by hydriasis (pupil dilation). In 85% of cases, the pupil dilates on the side of the lesion, but in the remaining 15% of observations, the opposite pupil dilates – due to the pressure of the displaced middle brain of the opposite oculomotor nerve in the edge

clippings of the cerebellum namet. This stage is called oculomotor and is divided into early and late. At an early stage, anisocoria with moderate pupil dilation, a contralateral symptom of Babinsky and nystagmus from the opposite side of anisocoria are detected; consciousness is preserved, there are no violations of movements and sensitivity. This stage of temporal insertion can take several hours and is reversible under the condition of timely diagnosis and treatment.

At a late stage, the pupil expands as much as possible, weakness appears in the opposite extremities, but homolateral hemiparesis can also form similarly to anisocori due to the pressing of the opposite leg of the brain to the edge of the cerebellar notch. The prognosis in this case, provided adequate treatment, is quite favorable.

If emergency measures have not been taken, soon the other pupil dilates, the level of consciousness quickly decreases to the level of copulation and coma, respiratory disorders appear – the midbrain stage of dislocation is formed, and then events develop as with a central connection.

A rare variant of tentorial wedging is the dislocation of the upper parts of the cerebellum into the opening of the cerebellum namet — the so—called upper wedging, which occurs when the volumetric process is localized in the cranial fossa. It is characterized by a combination of signs of lesion of posterior cranial fossa formations with symptoms of central occlusion (see above) and insertion at the level of the large occipital opening (see below). In acute situations, there is an extremely unfavorable type of brain dislocation that requires emergency measures. It can also occur with a number of chronic processes, for example, with the anomaly of the Dendi–Walker – atresia of the holes of the Mazhandi and Lushka; in these cases, provided timely diagnosis and treatment, the prognosis is better.

The insertion of the cerebellar tonsils into the large occipital foramen is possible in the advanced stage of central dislocation and in this situation is characterized by a poor prognosis (see above). A more favorable variant of such wedging occurs with slow–developing volumetric processes localized in the posterior cranial fossa In this case, the displacement of the tonsils of the cerebellum downwards (sometimes to the level of II-III cervical vertebrae) develops gradually, and there is no complete blockade of cerebrospinal fluid dynamics. At the same time, the clinical picture is dominated by pain in the cervical-occipital region, sometimes violent, tonic tension of the cervical paravertebral muscles, often with the formation of a forced position of the head (pain is relieved when the head is tilted to the side or backward). When changing the position of the head, especially when tilting it forward, episodes of acute increase in intracranial pressure may occur, manifested by Bruns syndrome – a sharp headache with vomiting, dizziness, a feeling of approaching loss of consciousness, sometimes with a fall. When the head returns to its original relaxed position, the cerebrospinal fluid is restored and the indicated symptoms quickly disappear.

In the later stages of insertion, swallowing disorders are joined, respiratory and cardiac disorders occur.

# Chapter 4. Fundamentals of neurosurgical technique

Neurosurgery as one of the surgical specialties is inseparable from surgery in general, from which it stood out at the turn of the XIX–XX centuries. Naturally, our science uses the general principles of modern surgery. It is clear that instruments, materials and hands should be sterile, scalpel — sharp, and anesthesia — adequate.

However, the specificity of the object of neurosurgery — the nervous system makes neurosurgery very peculiar, to a certain extent — a unique surgical discipline.

As already mentioned, the complexity of the structure of the nervous system, the high density of the location of functionally important elements place the highest demands on the accuracy of manipulations. Often the pathological process is directly attached to vital formations or even they are involved in it, and manipulations in this zone require exceptional accuracy and enormous responsibility.


Operating microscope

Microsurgical instruments

For the success of modern neurosurgical surgery, the use of ordinary surgical instruments and suture materials, instruments for skull trepanation, sufficient training and experience of the operating team, are required:

•• adequate anesthesia with complete immobilization of the patient and relaxation of the brain;

••rigid fixation of the patient's head to the operating table, eliminating even minimal displacement of the brain relative to both the instruments in the surgeon's hands and the spatulas fixing the brain;

•• adequate illumination of the wound;

•• wound irrigation – washing it with a saline solution from special irrigators or from available devices (syringe, pear), which allows you to clearly identify the source of bleeding;

•• vacuum aspirator – suction with an adjustable amount of vacuum, with

replaceable nozzles with a diameter of several millimeters to 1 mm;

• • optical magnification of the manipulation area with sufficient depth of penetration, which is achieved by using an operating microscope (or

in certain cases, an endoscope). Modern surgical microscopes have a number of special features: they are easily moved in the right direction by the surgeon's hand or with the help of special devices (a joystick fixed in the surgeon's mouth, etc.).


Bipolar Coagulation Tweezers

Using the buttons on the handle, control panel or pedal, you can change the magnification ratio, depth of field, the degree of illumination of the operating field, there are systems for autofocus sharpness;

• • special surgical instruments that allow manipulation in the depth of the wound in conditions of optical magnification — bayonet tweezers,

scissors, dissectors, needle holders, thread holders, etc.;

•• special tools and materials for stopping bleeding —electro coagulator with a set of monopolar and bipolar coagulation

instruments, including bayonet coagulation tweezers, means for physical hemostasis — quilted jackets, surgical wax, gelatin or collagen hemostatic sponge, means for combined — chemical and physical — hemostasis — preparations of cellulose, means for biological hemostasis — fibrinthrombin or other adhesive compositions.

Additional eyepieces are used for the assistant's participation in the operation.

The microscope has a built-in TV camera that transmits the image to the screen in the operating room, which allows the operating nurse and assistants to monitor the progress of the operation; the ability to broadcast the image at a distance allows you to organize the educational process without increasing the air contamination in the operating room.

To ensure sterility, the movable part of the microscope is usually placed in a special sterile plastic bag, which does not limit the possibility of performing the necessary manipulations of the microscope, to perform some stages of operations (and sometimes the entire operation, for example, on the vessels of the neck), a binocular magnifier with an increase of 2-6 times is used; a binocular magnifier is often combined with a device for wound illumination.

In special cases, other instruments are also required, used only in neurosurgery or adapted to its needs:

•• ultrasonic aspirator — an instrument whose tip vibrates with an ultrasonic frequency and destroys the tissues it touches, while detritus is absorbed into the central channel of the aspirator and removed outside the wound; used in basic neuro-oncology;

• • an endoscope is a device with an optical channel or, more often today, a stelecamera and instrumental channels, inserted through a small hole or used as an auxiliary during a routine neurosurgical operation (Fig. 4.5);

Neuronavigation system

Neurosurgical endoscope

•• surgical laser – provides evaporation of pathological tissue with minimal impact on the surrounding structures; today it is used very rarely, since its use requires a lot of time and is associated with a certain risk;

•• devices for neuronavigation – complex computer devices that provide comparison of intraoperative measurements of the position of the instrument (equipped with appropriate markers on the handle) with preoperative CT and/or MRI, allow you to plan surgical access and orient yourself more confidently in the wound;

•• stereotactic navigation is a device that provides, based on computer calculations, the introduction of a working tool (biopsy cannula, electrode, etc.) strictly into a given area of the brain.

Finally, in certain situations, they can be applied:

• intraoperative echolocation

of pathological formations (two- and three-dimensional)


Intraoperative ultrasonography for brain tumors

• intraoperative dopplerography, including determination of volumetric blood flow through the cerebral vessels;

• intraoperative CT and/or MRI ("open" devices are used to ensure the sterility of the surgical field);

• intraoperative fluorescence — the glow of tumor tissue in a certain spectrum after intravenous or intravenous photosensitizers; the technique has not yet been widely distributed, its effectiveness is being clarified;

• endovasal (intravascular) methods — conducting a catheter into the area of vascular pathology and eliminating it by special methods — the introduction of microspirals provoking thrombosis in pathological vascular formation, special thrombosing

compositions, discharged cylinders, etc. Most of these methods are used in specialized clinics.

# Chapter 5. Stages of neurosurgical intervention

## *Patient preparation.*

In planned situations, with regular stools, the intestines are not additionally cleaned. With irregular stools in the evening before the operation, an effective laxative or cleansing enema is prescribed. For cyclisms, a salt solution is used — isotonic or hypertonic. Hypotonic solution or just water can lead to hyperhydration and increased intracranial pressure. From the night they are not allowed to eat, 4-5 hours before the operation — and drink. Sedative medications are prescribed (usually benzodiazepines). Anticonvulsant medications are not canceled if the operation is performed in the second place, the next dose is taken in the morning with a small amount of water.

In emergency cases, they are limited to the administration of a high dose of H2 blockers (ranitidine or famotidine) intravenously.

## *Anesthesia.*

In most neurosurgical interventions, combined general anesthesia is used, including tracheal intubation and artificial lung ventilation (ventilator). Anesthesia should ensure complete immobility of the patient and, if possible, a decrease in intracranial pressure.

The brain is practically devoid of pain receptors, they are only present in the walls of the main vessels. However, the soft tissues of the head, periosteum and DMS contain pain receptors. Therefore, analgesic protection should be maximum precisely at the initial and final stages of neurosurgical intervention. A reduction in the use of anesthetics (and, accordingly, a reduction in side effects) can be achieved when a neurosurgeon uses methods of locoregional anesthesia or at least anesthesia of the incision area of soft tissues. To preserve the local anesthetic effect during this intervention, it is advisable to use long—acting local anesthetics -

bupivacaine, naropine, etc. In order to potentiate the analgesic effect, the addition of epinephrine solution to the anesthetic was previously widely used, today this method is used only in the absence of modern long-acting anesthetics.

The optimal means for anesthesia in neurosurgery are drugs that reduce intracranial pressure (barbiturates, propofol, benzodiazepines) or do not affect it (opiates). However, some drugs that moderately increase intracranial pressure further reduce the energy needs of the brain and, accordingly, are also widely used. These include halothane, enflurane, isoflurane, sevoflurane and some others.

Ventilator parameters are also essential. Moderate hyperventilation (maintaining PaCO2 within 35-36 mmHg)promotes relaxation of the brain and is routinely used during neurosurgical interventions. Intensive hyperventilation (PaCO2 below 30 mmHg) causes a decrease in intracranial pressure for 10-15 minutes, after which, due to an increase in vascular spasm, the positive effect of hyperventilation disappears and ischemic lesions of brain tissue may develop.

Hypoosmolar drugs (5% dextrose solution, Ringer's solution) are not included in the infusion therapy scheme, since they contribute to the accumulation of water in the brain tissue and its edema. I use isotonic (saline sodium chloride solution) or hypertonic crystalloid and colloidal solutions. When the arm is stressed (before opening it, to minimize brain injury), a bolus infusion of 20-25% mannitol solution is performed.

In some cases, the anesthesia scheme changes due to the wishes of the neurosurgeon.

If it is necessary to register the bioelectric activity of the cortex (primarily in epilepsy surgery), long—acting barbiturates and benzodiazepines are excluded from the drugs for anesthesia.

If necessary, studies of evoked potentials or electrodiagnostics of peripheral nerve conduction use short-acting muscle relaxants that cease their effect by the time of the study.

Finally, if intraoperative identification of speech zones is necessary, the patient is awakened during the operation (preservation of analgesia); at the same time, the patient's level of consciousness ensures the implementation of instructions and neuropsychological tests. At the final, painful, stages of the operation, the level of narcosis deepens.

Some minimally invasive interventions (for example, stereotactic biopsy, drainage of chronic subdural hematoma) can be performed under local anesthesia, if necessary, potentiated intravenous sedation.

In extreme situations, the simplest neurosurgical interventions (for example, ventricular puncture, cranial trepanation with removal of intracranial hematoma) can be performed under local anesthesia using any local anesthetic, for example, 0.5–0.25% novocaine solution. The necessary stages of such anesthesia:

•• infiltration anesthesia of the skin with the formation of a "lemon peel";

•• infiltration anesthesia of subcutaneous and subaponeurotic cells (in this case, anesthesia of the periosteum is usually achieved; in case of pain of the latter, the anesthetic is additionally administered subcostally);

•• the bone is usually small or painless, does not require anesthesia;

•• DM can be painful and give shock reactions; it is possible to anesthetize by injecting an anesthetic solution between the cysts (using a thin needle, subcutaneous or insulin, 25–29G); an alternative is to apply an anesthetic (for example, 10% lidocaine solution) to the surface of the DM with an exposure of 4-5 min.

Locoregional anesthesia. Local anesthesia can be supplemented with conduction.At the same time, a more concentrated solution of the anesthetic (for example, a 2% solution of novocaine) is injected into the area of the sensitive nerves innervating the scalp — frontal, temporal, large occipital (Fig. 4.10). Due to the variability of the localization of these nerves, conduction anesthesia is rarely effective and should always be supplemented with local anesthesia.

Shaving the head. The use of modern antiseptics makes shaving the entire head unnecessary. Moreover, shaving on the eve of surgery significantly increases the level of infection of the scalp pathogen and increases the risk of infectious complications. Therefore, with the availability of modern means, it is sufficient to ensure that the head is washed (with antiseptic or even simple shampoo) in the evening before the operation. In the operating room, the hair is shaved (or disassembled to the sides) along the incision line and the area of the operation and the remaining hair are treated with modern antiseptics (alcohols with octenidine hydrochloride, etc.). If the skin in the area of the incision line is shaved (1-1.5 cm apart), it can be sealed with a transparent surgical film before the incision (after treatment). In the absence of modern antiseptics and emergency situations, the head is shaved directly on the operating table and treated with available disinfectants.

Blood-saving technologies. Recall that approximately 20% of the minute volume of blood flows through the brain, which is about 1.5% of the body weight. Therefore, the fight against bleeding is an urgent issue of neurosurgery. Anesthesiological support of neurosurgical surgery provides for catheterization of 2 peripheral and 1 central or 4-5 peripheral veins. In potentially dangerous situations, in addition to 1-2 peripheral ones, 2 central veins are catheterized with multi-pass catheters.

At the risk of blood loss, the radial (or other) artery is usually catheterized and blood pressure is monitored directly.

In addition to thorough stopping of bleeding, special methods are also used at all stages of the operation and advanced replenishment of blood loss.

•• Hypervolemic hemodilution — the introduction of an excessive amount of colloidal and crystalloid solutions into the vascular bed before incision of the skin. This leads to the deposition of shaped blood elements in reserve spaces, and dilute blood is lost in the wound first of all. The use of the method requires a high qualification, since it can lead to overload of the small circle of blood circulation and edema of the lungs (and brain).

••Isovolemic hemodilution. The method consists in taking blood into a container with a preservative (a standard bag for blood preparation)with simultaneous replenishment with colloids and crystalloids.Usually, blood is taken using a catheter installed in the radiation artery (which is subsequently connected to a pressure sensor) after anesthesia, at the stage of positioning the patient's head and processing the surgical field. The volume of blood taken is from 800 to 1500 ml, the volume of replenishment is the same amount of colloids and twice as many crystalloids. During the operation, blood loss is compensated by colloids and crystalloids, at the end of the operation, the patient's stored blood is returned. In case of excessive infusion (blood loss turned out to be less than the calculated one), excess fluid is removed from the body using diuretics (usually furosemide intravenously).

••Hardware reinfusion of blood is usually combined with isovolemic hemodilution. All the blood pouring into the wound is collected by a pump into a special tank, and at the very beginning of the pump tube, the blood is mixed with the heparin solution automatically supplied there. To complete the collection of blood, the edges of the wound are glued with a special film, to which a film reservoir is also glued from below, from which the spilled blood is sucked out in a timely manner, before the formation of clots, with massive blood loss, by a second suction. The blood that has entered the reservoir of the device is filtered from clots, separated from destroyed erythrocytes, repeatedly washed from free hemoglobin, filtered through single filters that filter out tumor cells and leukocytes, and returned to the patient's bloodstream. To correct the coagulation system, it is necessary to use plasma preparations (donor or patient's plasma stored earlier). The method allows in most cases with blood loss up to 10,000 ml to do without infusion of donor erythrocyte mass.

Perioperative antibiotic prophylaxis. In most clinics, a broad-spectrum antibiotic is administered at the stage of introductory anesthesia (or earlier, but in any case before the skin is cut). The choice of an antibiotic is determined by the sensitivity spectrum of the hospital flora, cephalosporin of the 1st-3rd generation or amoxicillin or ticarcillin potentiated with clavulanate are more often used (see Chapter 7). Perioperative antibiotic prophylaxis usually lasts for a day after the final closure of the wound (the actual operation or removal of drains).

Fight against hypothermia. In modern conditions, the air temperature in the operating room is set to be the most comfortable for the surgical team, usually it is 20-22 ° C. To prevent the patient from cooling down, a special blanket is used, into which air is injected at a given temperature, or another warming device. In addition, all infusion solutions are heated to 36-37 ° C before administration (crystalloid solutions are stored in thermal cabinets with a set temperature based on daily demand).

Operating table. A modern neurosurgical table should provide: the possibility of changing the patient's position during surgery for a better view of the wound, as well as performing the operation in any (from lying to sitting) position of the patient;

the possibility of installing a system of rigid fixation of the patient's head (see below). The table used in spinal neurosurgery should allow for intraoperative X-ray examination.

Rigid head fixation system

it is a brace with three spikes, which, after giving anesthesia, are inserted into the outer bone plate with a overdosed effort (no incisions are made and no stitches are applied, the point defect of the skin heals independently without a bandage). The system is attached to the operating table, the patient's head is given an optimal position, all the nodes of the system are securely fixed. After that, the patient's head can only move together with the head end of the operating table.

Device for rigid fixation of the head

Location of the operating team. With intracranial intervention, the optimal location of the surgeon is right at the head patient, the assistant is on the right and the operating nurse is on the left. The operating microscope is located behind and to the right of the surgeon, surgical devices — coagulator, ultrasonic aspirator, etc. to the left of the patient, an anesthesiological team with equipment — to the right of the patient.

With other options for the location of the built-in equipment of the surgical team, the placement of the surgical team may be different, so that the operating nurse has the opportunity to control the surgeon's hands and the operating field (directly and on the monitor screen). These options for the location of the operating team reduce the opportunity for assistants to actively participate in the operation.

Spinal operations are performed in the position of the patient on his stomach or on his side. The first position is more convenient for operating surgeons, but there is increased bleeding due to increased pressure in the peridural veins (to reduce compression of the contents of the abdominal cavity, special rollers are placed under the wings of the iliac bones; there are operating tables for operations in the abdominal position, equipped with special devices). In addition, there is a need to use a special gel headrest or a rigid fixation of the head. The surgeon is located on one side, the assistant is on the other side of the patient, the operating nurse is on the side of the surgeon or above the patient's head, the anesthesiological team is at the patient's head, behind

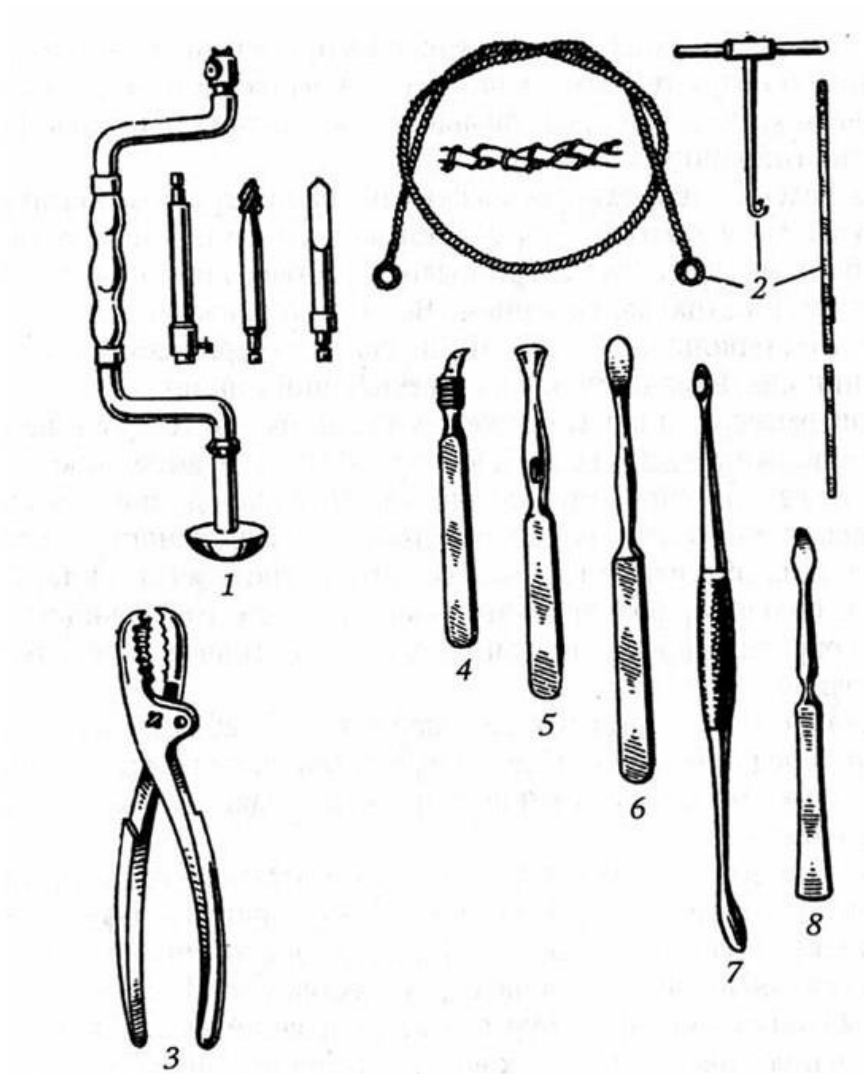
the operating nurse, or on the side, opposite the surgeon. When the patient is placed on his side, bleeding decreases and there is no need for special devices for fixing the head, but this position is less convenient for surgeons and for intraoperative X-ray diagnostics.With this position of the patient, the assistant is usually located on the left, the operating nurse is to the right of the surgeon, the anesthesiological team is opposite or at the patient's head.

Tools

Tools for working in soft tissues are ordinary (scalpel, needle holder, surgical tweezers). In connection with the yawning of the vascular scalp after the incision, special clips are used that compress the skin during surgery (Fig. 4.16). An alternative to clips are more traumatic curved clips applied to the osteoarthritis.

Hemostasis on the skin can also be carried out with the help of bipolar coagulation of each bleeding vessel (requires a lot of time).

When manipulations are performed deeper than the surface layers of the skin, a monopolar coagulator-an electric knife can be used (the buttons on the wrist of the tool or foot pedals allow you to use the cutting or coagulation mode separately). Skeletonization of the skull bones is performed using a straight or curved raspator.




Tools for skull trepanation

Trepanation tools

The main tool, without which no intracranial intervention is possible, is a trepan — a mechanical (gyro) with Jigley saws, pneumatic or electric. Spinal intervention also often requires permanent or temporary removal of the bone structures forming the anterior or posterior parts of the spinal canal.

The rotifer has replaceable working nozzles — cutters. First, a spear—shaped cutter is used, then a conical one. The skull trepanation technique is described in detail below.

A Jigley wire saw with a conductor is used to connect milling holes.

With a bone spoon (Volkman), the remains of the inner bone plate are removed from the bottom of the milling hole.

Dahlgren's pliers are bone pliers that ensure the formation of a narrow path in the bone. They are used when it is not possible to safely hold a conductor with a Jigsaw saw under the bone (in the case of a DM with an internal bone plate).

Bone cutters come in different shapes and sizes. They are used to remove the affected bone (with osteomyelitis, tumor invasion), as well as if for some reason a resection trepanation of the skull is performed (see below) or laminectomy - removal of the posterior parts of the vertebra.

Currently, special pneumatic or electric tools with replaceable rotating (at speeds up to 100,000 rpm or more) nozzles are more often used for cranial trepanation and manipulations on the bone structures of the spine. In pneumatic systems, sterile nitrogen is usually used, a special eyeliner is required.Electrical systems do not need compressed gas supply and there are 2 types — with a separate motor connected to the working part of the tool by a flexible drive, and with a motor integrated into the tool. The former are characterized by a low speed of rotation of the milling cutter and unreliability of the flexible drive. The latter can be high—speed, lightweight and compact; their disadvantage is the heating of the tool handle during prolonged operation.

The spherical cutters used for trepanation are sharpened so that the very end of the cutter does not injure the tissue, bone cutting is carried out when the tool axis deviates from 90 °.

The safest ones are automatic trepans, usually electric, in which the milling cutter automatically stops when passing the inner bone plate.After forming a hole in the bone, a craniotome is inserted into it, the working part of which is a "foot" that peels off from the inner bone plate during the movement of the DMS, and a thin rotating cutter that creates a cut in the bone immediately with a thickness of.

Pneumatic and electric tools are used not only for trepanation, but also for the removal of pathologically altered bone tissue, for the formation of holes for fixing structures, etc.

Diamond-coated cutters are used for bone resection near cranial nerves and large vessels.

The instruments for opening DMS are a thin scalpel with a straight blade, with which the shell is cut, a long and thin surgical forceps ("dural"), with which the shell is lifted from the brain, and bent surgical scissors ("dural"), with which the DMS is dissected.

Tools for working on the structures of the brain and spinal cord:

••spatulas, which are automatically held in the position set by the surgeon using a system of retractors, which, in turn, are fixed to the rigid fixation system of the head in the absence of retractors, the spatulas are held by an assistant;

•• coagulation tweezers of various shapes and thicknesses;

•• vacuum aspirator with tips of various diameters and shapes;

•• surgical and anatomical tweezers that facilitate micro-preparation;

•• sharp and blunt dissectors — dissectors used to separate adhesions and divert certain structures to the side;

••microsurgical scissors of various shapes;

•• finished tweezers that allow you to hold or remove
the pathological tissue;

•• tumor pliers are instruments of the conchotome type, of various sizes and shapes, allowing fragmentation of dense pathological tissue;

•• clip holders used to apply a metal clip to the neck of an arterial aneurysm or to a bleeding vessel.

The figures show that almost all instruments have a bayonet handle; this allows manipulation in the depth of a narrow wound, without obstructing the field of view in an operating microscope.

In addition to instruments, specific surgical materials are used in neurosurgery:

•• surgical wax is a mixture of purified beeswax with paraffin and glycerin; it is used for mechanical hemostasis during trepanation — they cover up bone channels with bleeding vessels; excess wax slows down the consolidation of the bone;

•• quilted jackets — strips of compressed cotton wool or synthetic fabric 1-2 mm thick, used to protect the brain, in particular when using a vacuum aspirator, as well as for mechanical hemostasis; the dimensions of quilted jackets can vary from a few millimeters to 3-4 × 10-15 cm. In order not to leave the quilted jacket lying, each of them is stitched with a dark (usually black) double thread about 15 cm long and can be equipped with a longitudinal strip, usually blue;

•• hemostatic sponge is a dry elastic plate made of foamed medical gelatin or collagen, which can have different thickness and size; sticking to the tissue under compression conditions with a padded jacket for 1-2 minutes, provides a stop of parenchymal bleeding; resolves a few weeks after surgery;

• • oxycellulose preparations in the form of cotton wool or gauze; they provide both chemical and mechanical hemostasis, usually allowing for venous and moderate arterial bleeding; when applying the oxycellulose preparation to the bleeding area, they also use temporary compression with an instrument (thicket respirator) through a padded jacket; they dissolve by the 2-3 month after surgery;

• •fibrin-thrombin and other biological adhesive compositions; used for effective hemostasis, including damage to the walls of the main vessels, as well as for sealing seams — both vascular and plastic closure of the skull base defects.Finally, there are many more surgical materials that are used only in specific situations, for example, for the closure of DM defects, skull, stabilization of the vertebral segment, intravascular surgery, etc. These materials and devices will be described in the relevant sections.

To close the wound, the same tools are used as in the initial stages of neurosurgical intervention. For the purpose of fixation of allogenic materials and bones, non-absorbable threads or titanium wire are used; otherwise, the choice of suture materials is determined by the preferences of the surgeon and the capabilities of the clinic. If it is necessary to drain the wound, active drainage is usually removed through the counterpoint.

## *Skull trepanation technique*

Skin incision

The shape of the skin incision should ensure the possibility of performing the planned trepanation in full, i.e., allow exposing the surface of the skull over the entire area of the trepanation window. Additional skin incisions are always unfavorable from the point of view of both wound healing and cosmetology. When planning an incision, one should always take into account the blood supply to the scalp and the cosmetic consequences, as well as the course of the facial nerve fibers.

The main types of skin incision. Optimal in terms of ease of closure and wound healing is a linear (or slightly curved) incision, which is used within the scalp. The hair in the incision area is shaved (in this case, transverse risks can be applied to the skin, which helps to accurately match the edges of the skin when sewing) or disassembled to the sides of the incision (then an intradermal suture is applied at the end of the operation). To minimize the cosmetic defect, you can use a tortuous incision, so that the scar will not be noticeable with wet hair.

Retrosigmoid linear skin incision

A linear incision is more often used for trepanation of the posterior cranial fossa. Such an incision made vertically along the median line is called median, and the one made 2-3 cm medial to the mastoid process is paramedian (retrosigmoid).

Hemicraniotomic incision. This is the most common incision in neurotraumatology and other areas of neurosurgery in the posterior-

the parietal-temporal region, also called "traumatic" and "hemicraniotomic". According to the indications, in accordance with the required size of the trepanation window, the incision can be shortened or lengthened; if necessary, it allows for trepanation of almost the entire half of the skull.The incision begins at the level of the upper edge of the tragus, several millimeters anteriorly from the auricle, continues 5-10 mm above the ear horizontally (if necessary, to the occipital region), then goes arched up to the midline and straight ahead to the border of the hair growth zone (or to the coronary suture). The reverse sequence of the incision is also possible.When separating soft tissues from the bone, it is necessary to cut off the fascia of the temporal muscle and shift it anteriorly together with the skin flap (this allows you to preserve the fibers of the facial nerve soldered to the fascia, innervating the forehead muscles).

Zuter cut. In the original — a linear incision of the skin "from ear to ear" in the area of the coronary suture. Today it is called a Zoeter-type incision and is performed somewhat tortuously, 1 cm behind the front edge of the hair growth zone, repeating its shape.It provides wide access to the anterior parts of the skull, including the base, with minimal cosmetic defect and, in addition, makes it possible to take large flaps of the periosteum for plastic purposes.

Semicircular incisions — single or double-sided are used for trepanation in different areas.To access the structures of the base of the skull, special incisions of complex shape are sometimes used.Finally, some previously common incisions are not used today due to inconvenience and injury. These outdated incisions include, first of all, the horseshoe-shaped one, previously recommended for TBI. Such an incision should not be used.

Skin incision technique. The incision line is marked with a marker, after antiseptic treatment, soft tissues are infiltrated with a solution of a local anesthetic (with some anesthesia schemes). Draw with a marker or superficially scratch the transverse risks with a needle. After the final disinfection and drying of the skin and surrounding hair, the incision line is delimited with surgical underwear, which is fixed to the skin with a sticky film or hemmed.The assistant presses the skin with his fingertips on both sides of the incision line. The surgeon cuts the skin vertically to the bone or the underlying muscle and, holding the scalpel like a writing pen, dissects the skin into all layers for 6-7 cm. An alternative is to dissect the upper layers of the skin to a depth of 3-4 mm with a scalpel, and to the rest with an electric knife (or, if desired, with a laser, ultrasound or radiofrequency scalpel). At the same time, the assistant, without weakening the compression, stretches the edges of the skin to the sides. If the edges of the wound now diverge, then the aponeurosis (tendon helmet) is incompletely dissected.

After dilution of the wound edges, either skin clips are applied to them (in a row), or curved clamps are applied to the aponeurosis through 1-1.5 cm, or as the pressure of the assistant's fingers weakens, point hemostasis is performed using bipolar coagulation.Wet wipes can then be applied to the edges of the skin, cauterization — with a 3% solution of hydrogen peroxide.

The technique of separating the skin flap. If trepanation is performed in the frontal or parietal region, outside the muscle attachment zone, the periosteum can be dissected simultaneously with the skin incision (or after), separated with a rasp from the outer bone plate and moved together with the skin flap. In the case when the periosteum is supposed to be used for the plastic closure of the TM defect, it is preferable to first separate the skin flap, azathem — periosteal. The skin flap is stitched at the base and fixed with a turunda to the surgical underwear.

### *Principles of trepanation window formation*

As already mentioned, the size of trepanation should ensure a calm, non-traumatic performance of the intracranial stage of the operation. Although some operations are performed by experienced surgeons with minimal access (keyhole surgery, key hole surgery), sufficiently wide trepanations are preferred, especially in neurotraumatology — naturally, within reason. In other words, in case of doubt, it is always necessary to perform a trepanation of a large size, and immediately, so as not to expand it during the operation.

The optimal technique of skull trepanation is bone—plastic surgery, while, as a rule, the bone flap is skeletonized, completely sawn off and removed during the intracranial stage of the operation.Depriving the bone of blood supply sources practically does not affect healing and does not increase the risk of infectious complications.Even with fractures of the skull, all more or less large bone fragments, including those devoid of connection with the periosteum, should be fixed to each other and to the edges of the bone defect at the end of the operation.

In the case of severe edema of the brain with its bulging out into the trepanation window, the bone flap is not put in place. Be sure to hermetically sew a flap of the periosteum or other tissue into the incision of the DMS and close the wound. In this case, the bone flap is wrapped in sterile linen, then in a sterile plastic bag and placed in a low—temperature cabinet (with a temperature of at least -18 ° C), where it is stored until the operation of closing the bone defect.In rare cases, for special indications (for example, with a tumor or inflammatory lesion of the bone), resection trepanation of the skull is performed. However, even then it is required to close the bone defect —simultaneously or after a certain period after the first operation.

### *Bone flap formation technique*

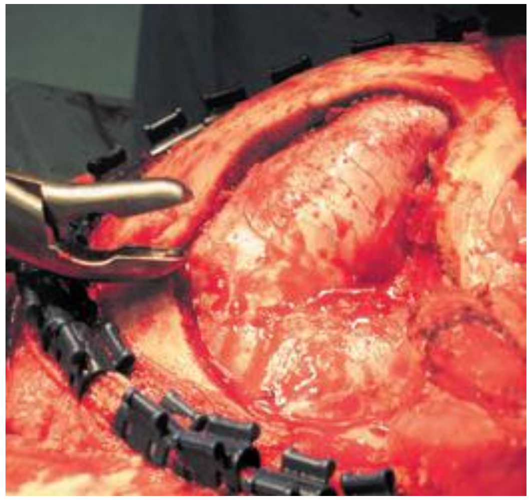
A. Using a gyrator and saw jigs.First, a spear-shaped milling cutter is used, which, when rotated by moderate pressure, forms a conical notch in the skull bone.The end of the spear-shaped cutter should reach the inner bone plate and create a defect of several millimeters in it; this moment is determined by the characteristic vibration of the tool. Manipulations should be very careful, because the "sinking" of the cutter into the skull cavity can have irreparable consequences. Therefore, you should stop, examine the hole (after draining it with a tampon or vacuum aspirator), perhaps examine its bottom with a Volkman spoon. Bone chips are collected (used for laying in the hole at the end of the operation). When a small defect of the inner bone plate is clearly visible, it is replaced with a cylindrical one and the formation of the milling hole is completed. The holes can be formed sequentially, changing the cutters each time, or first use a spear—shaped cutter everywhere and then a cylindrical one. The distance between the milling holes is not should exceed 7 cm, optimal — 5-6 cm.When bleeding from the bone, surgical wax is used, from which the fingers form a plate according to the size of the milling hole and completely close it. Before using a cylindrical cutter, wax is not removed, it does not interfere with manipulations and, by smearing into the bone (Haversov) channels, reduces bleeding.If it is necessary to perform trepanation over the upper sagittal or transverse sinus, it is most safe to apply a free-the pharyngeal openings on the sides of the sinus, at a distance of 3 cm from each other, followed by the separation of the upper wall of the sinus from the bone by a dissector. An experienced surgeon can apply holes directly above the sinus.In case of accidental "failure" of the rotary cutter into the cavity of the skull — do not panic, this usually does not entail catastrophic consequences-consequences. It is necessary to complete trepanation (or, in case of massive bleeding, quickly perform resection trepanation), assess the nature of the damage and take the necessary measures (stop the bleeding, remove the hematoma, etc.).After applying all the milling holes, they are connected by sawing. To do this, the remnants of the inner bone plate are removed with a Volkman spoon and the outer leaf of the DM is separated from the inner bone plate at the edges of the hole with the blunt side of the spoon.

Then, a guide for the Jigsaw saw is inserted with a thickening at the end down to the DM, and a small, about 1 mm, protrusion up to the bone. The conductor is introduced slowly, with resistance moving it a few millimeters to the sides. With proper conduction of the conductor, a slight vibration is felt from the passage of the upper protrusion along the inner bone plate. If the end of the conductor appeared in the adjacent milling hole, it is lifted with a Volkmann spoon and taken out.Occasionally, when conducting a conductor, there is a perforation of its end. This happens more often in the suture area, where the DMS are rougher soldered with an internal bone plate. The greater the age of the patient, the more pronounced the fusion of DM with the inner bone plate and, accordingly, the risk of damage to the shell. When the DM is perforated, there is a feeling of "sinking", the conductor moves easily, without characteristic resistance. If the perforation occurred near the milling hole, a door appears in it.

The very fact of DM perforation is not a disaster. In this case, it is necessary to carefully remove the conductor and insert it through another milling hole in the opposite direction. If this fails without repeated damage to the DM, after the connection by sawing through the remaining milling holes, you can try to conduct the conductor not from the neighboring one, but from another hole, after which you can move it along the existing bone to the side, into the desired milling hole. If the conductor fails, an additional milling hole is applied between the existing ones or Dahlgren wire cutters are used.After carrying out the saw from hole to hole, the Jigs are removed from the conductor, in no case removing the latter — it protects it from damage by the saw. The saw is fixed with handles for the holes at the ends or, more conveniently, with clips near the ends and cuts are made for the entire length of the saw.During the last bone cutting, the assistant or the operating nurse must hold the bone flap (otherwise it may fall to the floor).In case of bleeding from the bone, in addition to the milling holes, the entire length of the cut is tamponed with surgical wax.

The general rule: first, a jigsaw saw should be carried out and the milling holes should be connected in the most "safe" places, outside the projection of the DM sinuses or outside the course of the middle sheathed artery. If there is bleeding, with this sequence of actions, it will take less time to complete trepanation and final hemostasis.

B. Using an automatic electric trepan.The electric trepan is a combined milling cutter that allows you to immediately form a hole of the desired shape and diameter. The trepan is located perpendicular to the surface of the skull and is switched on by the pedal (or automatically when pressed). When the bone passes through the entire thickness, the trepan stops automatically, which minimizes the risk of damage to the DM.In the presence of a craniotome, it is enough to apply 1 or 2 milling holes, then the DMS are separated from their edges with a dissector or a Volkman spoon and a craniotome is inserted — a "foot" with a rotating thin cutter, peeling the shell from the bone. A craniotome forms a cut of the desired shape. Bone filings tampon bone channels and, accordingly, blood vessels, which reduces bleeding.



Technique of resection trepanation of the skull

If trepanation extends beyond the sinuses of the DMS, 2 holes are laid over the sinus — at the anterior and posterior edges of the bone flap, carefully separate the DMS (which is the upper wall of the corresponding sinus) from the bone and only after that the propyl is carried out.When using a craniotome, the propyl turns out to be wider, than when using a jigsaw saw. This requires more careful fixation of the bone flap at the end of the operation.As already mentioned, resection trepanation is rarely used today. However, in military field conditions, the surgeon may encounter the absence of not only a craniotome, but also saw Jigs. A milling hole is applied and gradually widened with the help of cutters to the desired size.DM autopsy is performed under optical magnification (using an operating microscope or a magnifying glass).Initially, the DMS are cut with a thin straight scalpel, holding it flat, almost parallel to the surface of the shell. When dissecting both sheets of DM, liquor is released. Then the edge of the shell at the incision site is lifted with tweezers and the incision is continued with curved "dural" scissors, lifting the shell of the brain with them. With swelling and tension of the brain, which happens in the first turn of a TBI, a narrow spatula is inserted along the incision line under the DM, protecting the brain from injury with scissors.

Closing of the DM section. At the end of each operation, the DM incision must be hermetically sealed. The suture technique — nodular or continuous — is determined by the surgeon's preference. The optimal suture material is a 4/0–5/0 thread, absorbable or monofilament non-absorbable.

All defects of DM must also be hermetically sealed. This also applies to cases of brain edema, when it is not possible to sew up DMS. To close the defects, a free periosteal flap taken in the trepanation area or in the neighborhood is most often used.If necessary, other local tissues are used — fascia of the temporal muscle, aponeurosis. Finally, in the absence of local tissues, it is possible to use subcutaneous adipose tissue of the anterior abdominal wall or a wide fascia of the thigh, in extreme cases — synthetic DMS.The same threads (4/0–5/0) are used to fix the graft, non—absorbable suture materials are used for fixing synthetic grafts.

Small defects of the shell can be covered with local fabrics, fixed adhesive compositions.

Fixation of the bone flap. In most cases, at the end of the operation, the bone flap is placed in place. Usually, for strong fixation, small holes, at least 3, are drilled in the edges of the flap and the surrounding bone, and the bone flap is fixed with strong non-absorbable threads. Instead of threads, you can use titanium or tantalum wire, the ends of which are twisted, shortened and loaded into the bone cut.The holes in the bone flap and the edge of the bone should be completely symmetrical, including in direction and depth: only in this case the edges of the bone flap will coincide with the surface of the skull (otherwise a difference of 1-2-3 mm is possible).Holes in the bone are drilled with high—speed cutters, in the absence of such - with thin drills fixed in the rotation.

In children, holes in the edges of the bone can be formed with a pointed clamp (used in general surgery to fix surgical underwear to the skin) or sometimes with a suture needle.To fix the bone flap, special devices can be used that simultaneously close the milling holes and fix the bone flap (see Fig. 4.17, b). Closing of the cut holes is especially important if trepanation is performed in an area not covered by hair. In the absence of this system, the milling holes are closed with bone chips (which are collected when they are applied with a twist) or artificial material (polymethylmethacrylate, titanium, etc.).

After resection trepanation, in the absence of contraindications (infectious process, brain edema), the bone defect can be closed with a fast—hardening plastic - polymethylmethacrylate or titanium mesh.

By pulling the specified valve with hooks, the dura mater is exposed. As a rule, when cutting out a skin-aponeurotic flap, it is guided by the fact that its base is located at the place of passage of the blood vessels feeding the integuments of the skull. So, for example, during trepanation in the temporal region, an arcuate incision passes along the edge of the scales of the temporal bone, the base of the flap is the skin, temporal muscle and aponeurosis, through the vessels of which the blood supply of the flap is carried out. The disadvantage of the simultaneous method of cutting out a flap according to Wagner–Wolf (W.Wagner–J.R. Wolfe) is that it is necessary to significantly narrow the size of the cutaneous-aponeurotic leg of the flap in order to cross the bone plate at the base. This reduces the viability of the flap due to a violation of the blood supply. To eliminate these shortcomings, Olivecrona proposed the separate cutting out of the skin-aponeurotic and bone-periosteal flaps on independent legs that do not coincide with each other.

Closure of soft tissues. Soft tissues are sewn in layers with nodular seams. The number of layers depends on the anatomical area and can range from 2 (in the frontal, parietal areas) to 5-6 in the occipital area. The choice of threads is determined by the wishes of the surgeon and the capabilities of the clinic. In most cases, there is no fundamental difference between absorbable and non-absorbable suture materials. In diseases that violate reparative processes (for example, diabetes, radiation sickness, mustard gas poisoning, etc.), non—absorbable threads are preferred, in infected wounds - absorbable.It is not necessary to strive to restore the integrity of the periosteum. Layering nodal sutures should be applied to the muscles and fascia, if they have been dissected. At the same time, threads 2/0–3/0 are used.One row of nodal inverted sutures with 3/0 threads is applied to the inner layers of the skin, which provides a comparison of the edges of the skin. If non-absorbable threads are used, the seam should pass no closer than 3-4 mm from the surface of the skin, if absorbable in 2-3 mm. A continuous wound-traumatic suture with threads from 2/0 to 5/0 can be applied to the edges of the skin (3/0 is more often used). It is possible to apply an intradermal suture with a non-absorbable monofilament2/0-3/0 on "buttons" or a absorbable unpainted thread3/0-4/0. Nodular skin sutures are cosmetically less advantageous, the exception is the Donati suture.From the outside, the seam is closed with a non-sticky, moisture-permeable cloth (there are many variants of such napkins). In their absence, it is possible to lubricate the seam with sterile vaseline or sterile antibacterial ointment on a mineral basis and apply a gauze napkin.

Drainage of the wound. After trepanation of the skull of a small size and in the absence of diffuse bleeding of tissues, the wound is not drained.This also applies to contaminated wounds during TBI.In the case of trepanation of a large size under the skin, it is advisable to put a tubular drainage, which is removed through the contraperture and hermetically connected to a sterile receiving tank. It is advisable to apply a provision seam to the drainage outlet area, which is tied after drainage removal.

Bandage. There are several headbands (Hippocrates cap, Pirogov, etc.). All of them are uncomfortable, do not allow the patient to lie on his side due to nodes in the temporal region. It is optimal to apply several rounds of bandage on top of sterile napkins and fix them with a tubular elastic bandage.

Postoperative management of patients

In each case, the treatment program is determined individually depending on the nature of the neurosurgical pathology, the severity of the patient's condition, concomitant diseases, etc.As for the direct care of the wound, the dressing is done on the 1st day after the operation, removed (if it was installed) active drainage, tie a provision seam. Antibiotic prophylaxis is continued for a day after the wound is closed. In the absence of local complications, the bandage can be removed on the 2nd-3rd day. In this case, the wound is not treated with antiseptics, film-forming protective compounds can be used. The seams are usually removed for 7 days. The head is allowed to be washed on the 8th day.

## Chapter 6. Traumatic brain injury. Penetrating and non-penetrating damage

Damage to the meninges occurs with traumatic brain injury, there may be penetrating and non-penetrating wounds. With non-penetrating wounds, the dura mater remains intact with damage to soft tissues (periosteum, aponeurosis, skin) separately or together with the bones of the skull. The wound of the soft tissues of the head without damage to the bones of the skull proceeds without complications after the surgical primary treatment of the wound with suturing. If the bones are damaged, complications are possible – osteomyelitis, hematoma. 45 During the initial treatment of the wound, skull fragments are removed, stitches are applied. With penetrating wounds (open head wounds), there is a violation of the integrity of the dura mater, the most superficial shell of the brain. Penetrating wounds can be caused by fast-moving projectiles or slow-moving objects like knives, as well as bone fragments from a skull fracture that shift towards the brain. A through wound to the head is a type of penetrating wound in which a traumatic object passes through the head and leaves an exit wound. Head injuries caused by penetrating wounds are severe conditions and can lead to permanent disability or death. Although penetrating wounds have a greater risk of infection, in some aspects they are similar to such closed craniocerebral injuries as brain contusion and intracranial hemorrhage. As with closed head wounds, intracranial pressure increases due to brain edema or bleeding, compression of the soft tissues of the brain is possible. Most deaths from penetrating wounds are caused by damage to blood vessels, intracranial hematomas and ischemia. With penetrating wounds, the brain injury is mostly local, that is, the brain is damaged in a limited area. While blunt force trauma to the head does not have the risk of shock due to hemorrhage, penetrating head injuries do.

## *Operations in the brain region of the head*

The basic principles of surgical interventions on the skull and its contents. During operations on the brain, when choosing surgical approaches, the following circumstances should be taken into account: firstly, it is impossible to open the cranial box along the midline where the sagittal sinus passes, as well as along the projections of the location of other large sinuses; secondly, it is impossible to create accesses in which the incision would pass through the medulla, with the exception of accesses for opening brain abscesses and removing foreign bodies. thirdly, after opening the skull cavity and performing the operation, provide for the closure of the trepanation hole with a viable bone plate. The choice of a place for the formation of a trepanation hole is dictated by the localization of the pathological process and the features of the anatomical structure of the cranium and its contents. In neurosurgery, it is almost impossible to perform surgical accesses along the nearest path: this is prevented by the danger of damage to either the venous sinuses or functionally important areas of the medulla lying in the way. Most often, the temporal region is chosen for access to the base of the brain and temporal lobes; for access to the posterior cranial fossa, the large occipital foramen (foramen occipitale magnum) is chosen, increasing it by expanding to the occipital tubercles. Less often they resort to trepanations in the frontal and parietal bones, since tumors are mostly localized at the base of the brain and in the ventricles of the brain. In case of brain injuries, the skull is trepanned in places of injuries and hematomas. With penetrating wounds of the skull, surgical accesses are carried out along the course of the wound canal, as the surgeon solves the problems of removing damaged tissues and foreign bodies along the course of the wound canal and stopping bleeding. The difficulties of accessing the brain can be judged by the current state of pituitary surgery. To remove the pituitary gland, many different surgical approaches were recommended, and in each of them surgeons tried to find a shorter way to it, to injure the brain matter less and to perform the operation under the control of the eye. It is very difficult to access the pituitary gland located in the pit of the Turkish saddle, although there is a very close way for this: through the nasal opening with the destruction of the sinus sphenoidalis plate, where the pituitary bed is separated from the sinus of the main bone by a thin bone plate. Various approaches have been proposed to the pituitary gland: through the nose (transnasal), through the temporal region, from where it is possible to approach the base of the brain by pushing and lifting the temporal lobe of the brain hemisphere. Attempts were made to remove the pituitary gland in a rather complicated and dangerous way – through the corpus callosum, which was approached through a trepanation hole in the frontal or parietal bone (Brunner, Brunner). Temporal access has an undoubted advantage in that it allows you to remove a pituitary tumor under the control of the eye, and not blindly, as it is done transnasally. Meanwhile, the famous Soviet neurosurgeon A.I. Arutyunov (1972) considers transnasal access to pituitary tumors to be the most anatomically and technically justified method. The main surgical access for brain surgery is trepanation. Trepanation is distinguished by two types: according to Wagner–Wolf – simultaneous cutting out of a horseshoe-shaped flap containing all layers of the cranial integument (skin, aponeurosis, periosteum and bone) in a single complex and connected to the maternal soil by a narrow dermomuscular-periosteal pedicle. Trepanation is carried out by an arcuate incision of soft tissues to the bone, and after that the bone plate is opened along the line of the soft tissue incision. As a result, a skin-bone flap is formed in the form of a valve that is held on the skin-muscle- 47 periosteal pedicle.

Decompression trepanation of the skull is a palliative operation. It is produced with an increase in intracranial pressure in cases of inoperable brain tumors, with progressive edema developing as a result of trauma. The purpose of the operation is to create a defect in the bones of the skull and dura mater in a certain area of the arch. In the bed formed in this way, the brain protrudes, which reduces the increase in intracranial pressure. A trepanation window is applied over the lesion. Currently, the operation is performed mainly in the temporal region according to Cushing. Operation stages: 1) a horseshoe–shaped incision of the skin and subcutaneous tissue with the base facing down to the level of the zygomatic arch - respectively, the line of attachment of the temporal muscle; 2) dissection of temporal aponeurosis, interaponeurotic fatty tissue and temporal muscle in the vertical direction to the periosteum; 3) dissection and separation of the periosteum with an area of 6 cm2; 4) the imposition of a milling hole on bone with its subsequent expansion with pliers to form a 6x6 cm defect; 5) opening of the dura mater with a cruciform incision and additional radial incisions; 6) layer-by-layer suturing of the surgical incision with the exception of the dura mater, which is sutured. Trepanation of the mastoid process (antrotomia, mastoidotomia). Indications: purulent mastoiditis. Technic: 1) incision of soft tissues to the bone 5-6 cm long in parallel with the attachment of the auricle and posteriorly by 1 cm; 2) detachment of the periosteum from the bone by a rasp; 3) removal of the outer wall of the mastoid process within the triangle with a chisel with a hammer; 4) removal of the affected part of the spongy layer, destruction of partitions between individual cells, removal pus; 5) drainage of the bone wound with a gauze strip. Complications arise when the boundaries of the trepanation triangle of the Shipo are not observed, as a result of which it is possible to damage: at the top – the contents of the middle cranial fossa; in front – the facial nerve; behind – the sigmoid venous sinus. Plastic skull defects (cranioplasty). Measures to close the bone defect are carried out using various methods of auto-, homo- and alloplasty of the skull bones. Autoplasty according to Polenov – autoplasty with a bone flap on the leg. Kutner autoplasty is an autoplasty using a free external bone plate with a periosteum. The Dobrotvorsky method is the replacement of a bone defect using a patient's rib.

By pulling the specified valve with hooks, the dura mater is exposed. As a rule, when cutting out a skin-aponeurotic flap, it is guided by the fact that its base is located at the place of passage of the blood vessels feeding the integuments of the skull. So, for example, during trepanation in the temporal region, an arcuate incision passes along the edge of the scales of the temporal bone, the base of the flap is the skin, temporal muscle and aponeurosis, through the vessels of which the blood supply of the flap is carried out. The disadvantage of the simultaneous method of cutting out a flap according to Wagner–Wolf (W.Wagner–J.R. Wolfe) is that it is necessary to significantly narrow the size of the cutaneous-aponeurotic leg of the flap in order to cross the bone plate at the base. This reduces the viability of the flap due to a violation of the blood supply. To eliminate these shortcomings, Olivecrona proposed the separate cutting out of the skin-aponeurotic and bone-periosteal flaps on independent legs that do not coincide with each other. First, a skin-aponeurotic flap is cut out according to the above method on a wide base, it is peeled off, and after that a bone-periosteal flap with a narrower leg is cut out, which does not coincide with the base of the skin-aponeurotic flap. If there is a muscle (for example, temporal) attached to the bone in the trepanation area, it does not separate from the bone, it is part of the bone-bone-muscle flap, strengthening its feeding leg. The technique of skull trepanation by Olivecron makes it possible to make a wider hole in the skull and eliminates the dangers of infringement of the soft tissues of the flap, which can be observed when many layers of soft tissues are bent together with the bone plate. This technique almost eliminates postoperative liquorrhea due to the fact that the incision lines do not match. The methods of bone-plastic trepanation of the skull described above are used as the main types of accesses during operations in the cranial cavity. However, trepanation is often used to reduce increased intracranial pressure in tumors and other diseases when it is not possible to eliminate the underlying disease. Such trepanation is called decompressive, i.e. the goal is to reduce intracranial pressure by creating additional space for bulging of the medulla under the flap of the soft integuments of the skull. The technique of decompressive trepanation differs from bone-plastic trepanation in that in these cases the bone plate is removed and after surgery the defect of the cranial box remains covered only by a skin-aponeurotic flap. Decompressive trepanation is performed either over the site of the nearest projection of the lesion, or in the temporal region, if the lesion is removed from the periphery of the cerebral hemispheres. The skin-aponeurotic flap is cut out by a horseshoe-shaped incision and peeled off from the bottom, then the temporal muscle is dissected by a linear incision along the course of its fibers. The muscle is stretched with hooks and this exposes the bone plate on an area with a diameter of 5-6 cm . A bone plate is drilled with a cutter and, expanding this hole, the exposed portion of the temporal bone is gradually bitten off. After that, the dura mater is dissected with a cruciform incision, stitches are applied to the temporal muscle and the skin wound is sewn up. In the soft bed formed in this way, the brain protrudes (prolapse), which reduces the risk of increased intracranial pressure. To prevent acute prolapse of the brain into the trepanation hole and its possible infringement, a lumbar puncture is made beforehand and 30-40 ml of cerebrospinal fluid is released. As mentioned earlier, with open injuries of the skull, access to its cavity is carried out mainly through the wound, i.e. by removing the damaged edges of the bone plate. There is no other way out. And in these cases, a very difficult question arises before the doctor about closing the defects of the cranial box in order to prevent the development of cerebral hernias or prolapse of adjacent parts of the brain. Previously, bone grafting was used (mostly unsuccessfully) to close skull defects. In the sixties, alloplasty with the help of polymethylmethacrylate and polyvinyl plates was widely used. A fibrous capsule develops around the implant, which holds the plate. Alloplasty is successful in closing a skull defect of up to 5x6 cm and no more. Otherwise, the approach in the occipital region to the posterior cranial fossa is determined. Subtentorial tumors of the cerebellum, the bridge-cerebellar angle, the IV ventricle, and the brainstem occupy a prominent place among brain tumors: they account for 35-40% of brain tumors in adults and up to 70% of brain tumors in children. Therefore, the development of surgical approaches to tumors located in the posterior cranial fossa is of great interest. The peculiarities of surgery in the posterior cranial fossa are that there are no conditions for creating a skin-bone flap, as with trepanations in the temporal or frontal region, and in addition, the proximity of the medulla oblongata does not allow any pressure to be produced, which is dangerous for human life. Previously completed trepanations of the occipital bone, as a rule, ended in death. At the beginning of the XX century, the American surgeon Cushing (Gushing), and then in Russia A.L. Polenov developed access to the posterior cranial fossa with the removal of the posterior edge of the foramen magnum and the Atlas arch (I cervical vertebra). For this purpose, at the level of the external occipital protuberance (inion), an arcuate incision is made parallel to the edge of the foramen occipitale magnum to the mastoid processes; a vertical incision is added to it strictly along the midline, starting from the occipital protuberance and ending with the spinous process of the V cervical vertebra. 2 cm below the lin. The nuchae superior intersect the cervical aponeurosis and occipital muscles. At the same time, A. and v. occipitales are bandaged and N. occipitalis is resected. The soft tissues of the entire lower surface of the occipital bone are separated. With pliers, the posterior arch of the I cervical vertebra is removed and the membrana atlantooccipitalis is opened. After that, several holes on the occipital bone are applied with a hand cutter and through them the lower part of the occipital bone is bitten together with the posterior edge of the large occipital opening. Then the dura mater is opened and a large cistern and hemispheres of the cerebellum are opened. After removal of the tumor, the dura mater and soft tissues are sutured. A few words about the surgical treatment of epilepsy. There are no effective methods of treating this disease, although neurosurgeons are trying to treat epilepsy. Thus, the Canadian neurosurgeon Penfield proposed lobotomy – an operation consisting in removing to a depth of 1 cm an area of up to 20 cm2 of the cortex and white matter of the brain in the area of pathological bioelectric activity of the brain. The operation is dangerous, but in some cases it gives positive results in the treatment of gene epilepsy. Other neurosurgeons offer suction of a part of the cerebral cortex using a vacuum device. In general, all these operations require further experimental study.

### *Primary surgical treatment of skull wounds.*

Wounds of the cranial vault can be non-penetrating (without damage to the dura mater) and penetrating (with damage to the dura mater). The rules for performing primary processing are as follows. Economical excision of soft tissues, taking into account the topographic and anatomical features of the area: the skin, along with fiber and aponeurosis, is excised, retreating 3-5 mm from the edges of the wound, the wound is given an oval shape. The following techniques are used to stop bleeding from soft tissues:

1) finger pressing of the skin against the bone along its incision;

2) applying clamps to the bleeding vessels with the capture of aponeurosis, followed by ligation or electrocoagulation;

3) stitching of soft tissues around the wound together with the vessels (the Heydenhain method);

4) metal brackets (clips);

5) electrocoagulation.

Economical excision of the damaged periosteum and removal of bone fragments and foreign bodies unrelated to the periosteum. The edges of the bone defect are leveled with Luer wire cutters. The outer plate is bitten off so that all the fragments of the inner plate can be removed. To stop bleeding from the diploetic veins of the bone , the following methods are used:

1) rubbing wax paste into the edges of the bone;

2) crushing the bone with Luer cutters, pressing the outer and inner plates to each other to destroy the beams of the diploetic layer.

Processing of the dura mater:

1) with non-penetrating wounds and the absence of shell tension (pulsates well) it is not opened;

2) if a subdural hematoma is seen through a tense, weakly pulsating dura mater, it is sucked through a needle;

3) if blood clots are not removed in this way, or with penetrating wounds, the dura mater is dissected crosswise or radially to access the brain wound; the edges of the damaged shell are excised very sparingly.

With wounds of the shell or during the removal of bone fragments, if the fragment covered the wound of the sinus, bleeding from the sinus of the dura mater may occur, which is stopped in the following ways:

1) suturing of small wounds;

2) plastering of the sinus wall defect with a flap from the outer sheet of the dura mater or an autograft from the wide fascia of the thigh;

3) with large ruptures, sinus tamponade with a muscle fragment or gauze turunds, which are extracted after seven days;

4) ligation of the sinus (with a complete rupture); this method is dangerous, as it leads to the development of cerebral edema, venous encephalopathy and death of the victim due to a violation of intracranial hemocirculation.

Brain wound treatment. Removal of the destroyed brain tissue and superficially located bone fragments is carried out by carefully washing off detritus with a stream of warm saline solution. An increase in intracranial pressure contributes to the better removal of the contents of the wound canal. For this purpose, the patient, operated under local anesthesia, is offered to strain, cough. The victim's jugular veins are squeezed in an unconscious state. To stop bleeding from the cerebral vessels, the following methods are used: 1) electrocoagulation; 2) filling the wound canal of the brain with a mixture of fibrinogen and thrombin.

Soft tissues are sewn in layers with nodular seams. The number of layers depends on the anatomical area and can range from 2 (in the frontal, parietal areas) to 5-6 in the occipital area. The choice of threads is determined by the wishes of the surgeon and the capabilities of the clinic. In most cases, there is no fundamental difference between absorbable and non-absorbable suture materials. In diseases that violate reparative processes (for example, diabetes, radiation sickness, mustard gas poisoning, etc.), non—absorbable threads are preferred, in infected wounds - absorbable.It is not necessary to strive to restore the integrity of the periosteum. Layering nodal sutures should be applied to the muscles and fascia, if they have been dissected. At the same time, threads 2/0–3/0 are used.One row of nodal inverted sutures with 3/0 threads is applied to the inner layers of the skin, which provides a comparison of the edges of the skin. If non-absorbable threads are used, the seam should pass no closer than 3-4 mm from the surface of the skin, if absorbable in 2-3 mm. A continuous wound-traumatic suture with threads from 2/0 to 5/0 can be applied to the edges of the skin (3/0 is more often used). It is possible to apply an intradermal suture with a non-absorbable monofilament2/0-3/0 on "buttons" or a absorbable unpainted thread3/0-4/0. Nodular skin sutures are cosmetically less advantageous, the exception is the Donati suture.

### *Closure of a tissue defect.*

The wound of the dura mater is sutured with thin silk ligatures, the bones are connected with sutures conducted through a tendon helmet and periosteum, with thin silk or threads of polymer material; the edges of the skin wound are connected with silk nodular sutures. Trepanation of the skull. There are two types of cranial trepanation: bone–plastic, which is an operative access to the cranial cavity and is performed in two ways (one–flap – according to Wagner-Wolf and two-flap - according to Olivecron) and decompression (decompressive, resection), which is a palliative operation, including operative access and operative reception. Indications: abscess, hematoma, brain tumor. Stages of two-flap bone-plastic trepanation of the skull: 1) formation of a skin-aponeurotic flap; 2) processing of the periosteum (dissection and displacement in order to form a "track" for applying milling holes and sawing bone); 3) drilling of milling holes, sawing bone bridges between them and folding the bone-periosteal flap with the preservation of the feeding leg; 4) arcuate dissection of the dura mater and performing the necessary manipulation on the brain; 5) suturing of the dura mater, closure of the skull defect by placing the flap in its original position and suturing. Advantages in comparison with single-flap cranial trepanation are the possibility of a wide opening of the cranial cavity by sawing out a bone-periosteal flap of any size and eliminating the danger of infringement of the soft tissues of the flap. The "gold standard" of craniotomy. The "gold standard" of craniotomy is currently a free bone flap formed by a craniotome from one (if possible) milling hole. Advantages:

• Reducing the risk of postoperative epidural hematoma formation.

• The bone flap does not interfere with the work around the wound (since it is removed from the wound during the main stage of the operation).

• Less traumatic surgery due to the implementation of subcostal dissection (rather than dissection between aponeurosis and periosteum).

• Versatility of application of this technique.

Decompression trepanation of the skull is a palliative operation. It is produced with an increase in intracranial pressure in cases of inoperable brain tumors, with progressive edema developing as a result of trauma. The purpose of the operation is to create a defect in the bones of the skull and dura mater in a certain area of the arch. In the bed formed in this way, the brain protrudes, which reduces the increase in intracranial pressure. A trepanation window is applied over the lesion. Currently, the operation is performed mainly in the temporal region according to Cushing. Operation stages: 1) a horseshoe–shaped incision of the skin and subcutaneous tissue with the base facing down to the level of the zygomatic arch - respectively, the line of attachment of the temporal muscle; 2) dissection of temporal aponeurosis, interaponeurotic fatty tissue and temporal muscle in the vertical direction to the periosteum; 3) dissection and separation of the periosteum with an area of 6 cm2; 4) the imposition of a milling hole on bone with its subsequent expansion with pliers to form a 6x6 cm defect; 5) opening of the dura mater with a cruciform incision and additional radial incisions; 6) layer-by-layer suturing of the surgical incision with the exception of the dura mater, which is sutured. Trepanation of the mastoid process (antrotomia, mastoidotomia). Indications: purulent mastoiditis. Technic: 1) incision of soft tissues to the bone 5-6 cm long in parallel with the attachment of the auricle and posteriorly by 1 cm; 2) detachment of the periosteum from the bone by a rasp; 3) removal of the outer wall of the mastoid process within the triangle with a chisel with a hammer; 4) removal of the affected part of the spongy layer, destruction of partitions between individual cells, removal pus; 5) drainage of the bone wound with a gauze strip. Complications arise when the boundaries of the trepanation triangle of the Shipo are not observed, as a result of which it is possible to damage: at the top – the contents of the middle cranial fossa; in front – the facial nerve; behind – the sigmoid venous sinus. Plastic skull defects (cranioplasty). Measures to close the bone defect are carried out using various methods of auto-, homo- and alloplasty of the skull bones. Autoplasty according to Polenov – autoplasty with a bone flap on the leg. Kutner autoplasty is an autoplasty using a free external bone plate with a periosteum. The Dobrotvorsky method is the replacement of a bone defect using a patient's rib.

### *The concept of stereotactic operations.*

Indications: destruction of a deep intracerebral tumor, pituitary adenoma, shutdown of an intracranial aneurysm, removal of a deep-seated foreign body, emptying of an intracerebral hematoma or abscess. The stereotactic method involves a combination of techniques and calculations that ensure the precise insertion of an instrument (cannula, electrode, etc.) into a predetermined, deeply located structure of the brain. For its implementation, a stereotactic apparatus, a stereotactic atlas of the brain and data from X-ray examination of brain structures with a well-established spatial localization of intracerebral landmarks are needed. The principle of operation of stereotactic devices is based on the comparison of the coordinate systems of the brain and the device. The preparatory stage begins with a radiopaque examination of the brain, including ventriculography. Then the skull is X-rayed in two projections with rigid fixation of the patient's head. Based on the results of the X-ray examination, intracerebral landmarks are determined, which are compared with the data of the stereotactic atlas. The spatial localization of the subcortical structure is compared with the coordinate system of the stereotactic apparatus, and the calculated data obtained are transferred to the guiding devices of the apparatus. After that, according to the specified scheme, an electrode or a cryogenic cannula is inserted into the calculation zone, depending on the task of the operation. Ligation of the middle sheathed artery. Indications: closed and open injuries of the skull, accompanied by injury to the trunk and branches of the artery with the formation of an extradural hematoma. The operation consists in trepanation of the corresponding part of the skull. In case of unclear localization, the main trunk of a. meningeae mediae is exposed. Operation technique: 1) a horseshoe-shaped incision of the skin in the temporal region with the flap separating from the base downwards; 2) cutting out the bone-periosteal-muscular flap (according to the general rules) and throwing it down; 3) ligation with a needle or clipping of the damaged vessel above and below the injury site; 4) examination of the dura mater (when it is wounded, a subdural hematoma is removed with a jet of saline solution); 5) laying the flaps in place and layer-by-layer suturing.

### *Vascular lesions of the meninges*

Vascular lesions of the meninges of various etiologies are manifested by hemorrhages. The volume of intracerebral hemorrhages varies: from microscopically small (petechial) to massive hematomas. A significant volume of hematomas is achieved with severe damage to brain tissue, more often as a result of primary vascular rupture, but they can also be of secondary, arrosive origin, due to progressive necrosis of the brain substance and the vascular wall, Incomplete rupture of the vessel wall leads to the formation of a traumatic aneurysm.

Thrombosis of the dura mater sinuses can be the result of trauma, compression of the sinus by a tumor, dural malformation or septic lesion. Thrombosis can develop spontaneously in patients with leukemia, coagulopathy, systemic connective tissue lesions. The spectrum of clinical manifestations of sinus thrombosis varies from asymptomatic course to severe neurological dysfunction and death. General clinical manifestations are associated with intracranial hypertension syndrome: congestive changes in the fundus, headache, convulsive seizures, focal neurological prolapses. A specific pattern is characterized by thrombosis of the cavernous sinus. There is marked non-pulsating exophthalmos, conjunctival edema and chemosis, venous hyperemia, pronounced venous congestion on the fundus. Diagnosis of sinus thrombosis is difficult. Computed tomography may reveal signs of venous cerebral infarction, intracerebral hemorrhage. With thrombosis of the sagittal sinus in the fusion area, a symptom is detected (a zone of reduced density of a triangular shape in the lumen of the sinus, surrounded by a contrasting edging). The method of choice is considered magnetic resonance imaging of the brain with MRFLEBOGRAPHY. For the final determination of the localization and extent of thrombosis, cerebral angiography and phlebography are used. The natural course of thrombosis of the sinuses of the dura mater is not exactly known. Mortality in acute thrombosis ranges from 10 to 50%, but the frequency of asymptomatic thrombosis is not taken into account. The course and outcome of the disease may be influenced by factors such as the age of patients, the extent of thrombosis, the presence of cortical vein lesions. The outcome of the disease depends on the rate of recanalization of the obliterated sinus or the formation of venous collaterals. The significant variability of these indicators makes it difficult to systematically analyze the results of treatment. The medical treatment of sinus thrombosis is limited in its capabilities and mainly boils down to the treatment of consequences in the form of venous infarcts with mass-effect phenomena. Intracranial hypertension and dislocation syndrome are being treated. Systemic heparinization prevents the progression of thrombosis, but does not contribute to thrombus lysis. The use of systemic fibrinolysis in combination with heparinization has demonstrated favorable results in recanalization of the thrombosed sinus, but is associated with a significant risk of hemorrhagic complications. Cases of open surgical thrombectomy have been described, but this method has not received any significant spread. Of the "active" methods of correction, selective catheterization of the affected sinus and local fibrinolysis with bolus injection of urokinase and subsequent systemic therapy are most widely used. The microcatheter remains in the sinus for several days until the restoration of its patency is achieved. Therapy of septic sinus thrombosis necessarily includes systemic and regional rational antibacterial therapy. Regional infusion of antibacterial drugs is carried out through a catheter installed at the bifurcation level of the common carotid artery by catheterization of the superficial temporal or thyroid arteries.

Extracerebral intracranial hematomas in relation to the membranes of the brain can be located subdural, epidural and subarachnoid. Epidural hematomas are an accumulation of blood clots between the outer surface of the dura mater and the bones of the skull; they look like a layer up to 2.5—3 cm thick. The volume of blood spilled can be different: from 30 ml to 200 ml or more. Epidural hematomas are localized, as a rule, on the side of the application of traumatic force, according to the place of fracture of the skull bones. On the anti-shock side, they rarely develop. More often, epidural hematomas are located in the parietal-temporal region, where they reach the largest volume. The source of bleeding here is the trunk or branches of the middle sheathed artery. Rarer localizations include: the frontal-temporal and parietal-occipital regions, as well as the anterior and posterior cranial pits, in which the source of bleeding are diploetic veins, veins of emissaries, sinuses of the dura mater. Often epidural hematomas are combined with subdural ones, forming a two-chamber episubdural hematoma (in 15.5%).

Subdural hematomas are the accumulation of blood or its clots between the arachnoid membrane and the inner surface of the dura mater; they are much more common than epidural ones. Unlike the latter, they spread over vast territories, covering not only the convexital, but also the basal surface of the brain. The volume of these hematomas is from up to 200 ml or more. Subdural hemorrhages of small volume (30-40 ml) should not be underestimated, since they are a constant irritant affecting the brain and causing a number of new vascular pathological reactions, edema phenomena, which in some cases leads to the appearance of brain compression syndrome. The source of subdural bleeding is damaged superficial cortical and pial vessels, vessels of the inner leaf of the dura mater and veins passing in the subdural space. When the brain is bruised, subdural hemorrhages develop both on the side of the impact application and on the opposite side, often being bilateral. It should be emphasized that intracranial hematomas (epi- and subdural) are often combined with brain contusion of varying severity, which allowed V.M. Ugryumov to amend the clinical classification of closed skull and brain trauma and call the third form not "brain compression", but "brain contusion with compression". Classical forms of compression of the brain without simultaneous bruising are rarely observed. Subarachnoid hemorrhages are the accumulation of blood in the cerebrospinal fluid channels and cells of the subarachnoid space. In case of brain injury, they occur in all cases, have a different distribution pattern from limited to diffuse, depending on the degree of damage to the brain surface. Massive subarachnoid hemorrhages, located deep in the furrows and in the cisterns of the brain, may look like limited hematomas. Massive subarachnoid hemorrhage is often combined with ventricular hemorrhage. In such cases, it is more correct to talk about subarachnoid-ventricular hemorrhage. Thrombosis of the dura mater sinuses can be the result of trauma, compression of the sinus by a tumor, dural malformation or septic lesion. Thrombosis can develop spontaneously in patients with leukemia, coagulopathy, systemic connective tissue lesions. The spectrum of clinical manifestations of sinus thrombosis varies from asymptomatic course to severe neurological dysfunction and death. General clinical manifestations are associated with intracranial hypertension syndrome: congestive changes in the fundus, headache, convulsive seizures, focal neurological prolapses. A specific pattern is characterized by thrombosis of the cavernous sinus. There is marked non-pulsating exophthalmos, conjunctival edema and chemosis, venous hyperemia, pronounced venous congestion on the fundus. Diagnosis of sinus thrombosis is difficult. Computed tomography may reveal signs of venous cerebral infarction, intracerebral hemorrhage. With thrombosis of the sagittal sinus in the fusion area, a symptom is detected (a zone of reduced density of a triangular shape in the lumen of the sinus, surrounded by a contrasting edging). The method of choice is considered magnetic resonance imaging of the brain with MRFLEBOGRAPHY. For the final determination of the localization and extent of thrombosis, cerebral angiography and phlebography are used. The natural course of thrombosis of the sinuses of the dura mater is not exactly known. Mortality in acute thrombosis ranges from 10 to 50%, but the frequency of asymptomatic thrombosis is not taken into account. The course and outcome of the disease may be influenced by factors such as the age of patients, the extent of thrombosis, the presence of cortical vein lesions. Intracranial hypertension and dislocation syndrome are being treated. Systemic heparinization prevents the progression of thrombosis, but does not contribute to thrombus lysis. The use of systemic fibrinolysis in combination with heparinization has demonstrated favorable results in recanalization of the thrombosed sinus, but is associated with a significant risk of hemorrhagic complications. Cases of open surgical thrombectomy have been described, but this method has not received any significant spread. Of the "active" methods of correction, selective catheterization of the affected sinus and local fibrinolysis with bolus injection of urokinase and subsequent systemic therapy are most widely used. The microcatheter remains in the sinus for several days until the restoration of its patency is achieved. Therapy of septic sinus thrombosis necessarily includes systemic and regional rational antibacterial therapy. Regional infusion of antibacterial drugs is carried out through a catheter installed at the bifurcation level of the common carotid artery by catheterization of the superficial temporal or thyroid arteries.

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## TEXTBOOK ON NEUROSURGERY

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