**Epidemiology of brain tumors**

- About 40,000 people are diagnosed with a brain tumor each year in the United States.
- Gliomas account for more than 70% of all brain tumors.
- Caucasians have a higher incidence than African or Asian populations.
- Fewer than 3% of glioblastoma patients are still alive at 5 years after diagnosis, older age being the most significant and consistent prognostic factor of poorer outcome.
- Brain and spinal cord tumors in children are the second most common form of childhood cancer, with about 1,500 children developing these tumors each year.
- Almost 10,000 Americans are diagnosed each year with a spinal cord tumor.

**WHO classification of the tumors of the CNS**

For each tumor there are the WHO official name, the ICD-10 code (with Arabic numeral, where 0 indicates "benign" tumor, 3 malignant tumor and 1 borderline tumor), and with Roman numeral the WHO Grade (a parameter connected with the "aggressiveness" of the tumor).

1. **Astrocytic tumours**
   - 1.1. Aastrocytomas (ICD-10 D421, WHO grade I)
   - 1.1.1. Diffuse astrocytoma (ICD-10 D421, WHO grade I)
   - 1.1.2. Anaplastic astrocytoma (ICD-10 D421, WHO grade II)
   - 1.1.3. Glioblastoma (ICD-10 D421, WHO grade IV)
   - 1.1.4. Primary melanocytic lesions (ICD-10 D421, WHO grade II)
   - 1.1.5. Gliomatosis cerebri (ICD-10 D421, WHO grade II)
   - 1.1.6. Gliosarcoma (ICD-10 D421, WHO grade III)

2. **Tumours of cranial and paraspinal nerves**

3. **Tumours of the meninges**
   - 3.1. Tumours of meningeal cells
   - 3.2. Mesenchymal tumours
   - 3.3. Primary melanocytic lesions
   - 3.4. Other neoplasms related to the meninges

4. **Tumors of the haematopoietic system**

5. **Germ cell tumours**

6. **Tumours of the sellar region**

7. **Metastatic Tumours**
The concept of grading of the tumors of the central nervous system, agreeing for such the regulation of the "progressiveness" of these neoplasias (from benign and localized tumors to malignant and infiltrating tumors), dates back to 1926 and was introduced by P. Bailey and H. Cushing, in the elaboration of what turned out the first systematic classification of gliomas. In the following, the grading systems present in the current literature are introduced. Then, thru a table, the more relevant are compared.

**Kernohan grading**
The Kernohan grading system defines progressive malignancy of astrocytomas as follows:
- Grade 1: tumors are benign astrocytomas.
- Grade 2: tumors are low-grade astrocytomas.
- Grade 3: tumors are anaplastic astrocytomas.
- Grade 4: tumors are glioblastomas.

**St Anne-Mayo grading**
The St Anne-Mayo grading system also is used to grade astrocytomas; however, this system uses four morphologic criteria to assign a grade:
- a) nuclear atypia
- b) mitosis
- c) endothelial proliferation ('piled-up' endothelial cells. NOT hypervascularity
- d) necrosis

The St. Anne-Mayo grade has four categories of tumors:
- Grade 1: tumors do not meet any of the criteria.
- Grade 2: tumors meet one criterion, usually nuclear atypia.
- Grade 3: tumors meet two criteria, usually nuclear atypia and mitosis.
- Grade 4: tumors meet three or four of the criteria

**WHO grading**
The World Health Organization (WHO) grading system is contained in the volume *Histological Typing of Tumours of the Central Nervous System*, whose first edition dates back to 1979, the second to 1993 and last one to 2007. The WHO grade has four categories of tumors:
- Grade I: tumors are slow-growing, nonmalignant, and associated with long-term survival.
- Grade II: tumors are relatively slow-growing but sometimes recur as higher grade tumors. They can be nonmalignant or malignant.
- Grade III: tumors are malignant and often recur as higher grade tumors.
- Grade IV: tumors reproduce rapidly and are very aggressive malignant tumors.

From the histological point of view the WHO system is based on the same criteria as the St Anne-Mayo system.

### Comparison of the grading systems

<table>
<thead>
<tr>
<th>Tumor Type</th>
<th>WHO grade</th>
<th>Kernohan grade</th>
<th>St Anne-Mayo grade</th>
<th>St Anne-Mayo criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilocytic astrocytoma</td>
<td>I</td>
<td>-</td>
<td>1</td>
<td>0 criterion</td>
</tr>
<tr>
<td>Diffuse astrocytoma</td>
<td>II</td>
<td>1</td>
<td>2</td>
<td>1 criterion (a)</td>
</tr>
<tr>
<td>Anaplastic astrocytoma</td>
<td>III</td>
<td>2</td>
<td>3</td>
<td>2 criteria (a+b)</td>
</tr>
<tr>
<td>Glioblastoma</td>
<td>IV</td>
<td>3/4</td>
<td>4</td>
<td>3-4 criteria (a+b+c)</td>
</tr>
</tbody>
</table>

**ICD-O scale**
The first edition of the *International Classification of Diseases* (ICD) dates back to 1893, the current review (ICD-O) dates 1994. In 1976 the World Health Organization (WHO) publishes the first edition of the *International Classification of Diseases for Oncology* (ICD-O), now at the third edition (ICD-O-3, 2003). In this last edition, the Arabic numeral after the character "/" indicates the "behavior" of the neoplasia, with the following meaning:
- /0 benign neoplasia
- /1 uncertain neoplasia (benign or malignant)
- /2 neoplasia in situ
- /3 primary infiltrative malignant neoplasia
- /6 secondary malignant neoplasia
- /9 malignant neoplasia, uncertain if primitive or secondary

A brain tumor composed of benign cells, but located in a vital area (as the brain is), can be considered to be life-threatening — although the tumor and its cells would not be classified as malignant.
Symptoms and Signs

The clinical manifestations of a brain tumor may range from a virtually asymptomatic state to a constellation of symptoms and signs that is specific for a particular type and location of lesion.

What are the symptoms of a brain tumor?
The symptoms are related to an increase in pressure in the brain. The symptoms include:
- Headache
- Vomiting (usually in the morning)
- Nausea
- Personality changes
- Irritability
- Drowsiness
- Depression
- Incontinence
- Decreased cardiac and respiratory function and, eventually, coma if not treated

What are the symptoms of a brain tumor?
The symptoms relate to the increased intracranial pressure (ICP) and may include:
- Increased intracranial pressure (ICP)
- Seizures
- Endocrine problems (diabetes and/or hormone regulation)
- Visual changes or double vision
- Headaches
- Paralysis of nerves/muscles of the face, or half of the body
- Respiratory changes
- Clumsy, uncoordinated walk
- Hearing loss
- Personality changes

What are the symptoms of a brain tumor?
The symptoms of brain tumors in the cerebrum (front of brain) may include:
- Increased intracranial pressure (ICP)
- Seizures
- Visual changes
- Slurred speech
- Paralysis or weakness on half of the body or face
- Drowsiness and/or confusion
- Personality changes/impairment of judgment
- Short-term memory loss
- Gait disturbances
- Communication problems

What are the symptoms of a brain tumor?
The symptoms of brain tumors in the cerebellum (back of brain) may include:
- Increased intracranial pressure (ICP)
- Vomiting (usually occurs in the morning without nausea)
- Headache
- Uncoordinated muscle movements
- Problems walking (ataxia)

How is a brain tumor diagnosed?
- Neurological examination
- Computed tomography scan (CT scan)
- Magnetic resonance imaging (MRI)
- X-ray
- Arteriogram (Angiogram)
- Myelogram
- Spinal tap (Lumbar puncture)
- Positron emission tomography (PET)
- Magnetic resonance spectroscopy (MRS)
- Biopsy of tumor
In a craniotomy, the skin over a part of the skull is cut and pulled back. Small holes are drilled into the skull, and a special saw is used to cut the bone between the holes. The bone is removed, and a tumor or other defect is visualized and repaired. The bone is then replaced and the skin closed.
Common Primary and Metastatic Spinal Cord Tumors

<table>
<thead>
<tr>
<th>Primary Tumors</th>
<th>Metastatic Tumors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extramedullary (89%)</td>
<td>Breast (22%)</td>
</tr>
<tr>
<td>Neurofibroma (29%)</td>
<td>Lung (15%)</td>
</tr>
<tr>
<td>Meningioma (25%)</td>
<td>Prostate (10%)</td>
</tr>
<tr>
<td>Sarcoma (12%)</td>
<td>Lymphoma (10%)</td>
</tr>
<tr>
<td>Other (10–15%)</td>
<td>Sarcoma (9%)</td>
</tr>
<tr>
<td>Dermoid</td>
<td>Kidney (7%)</td>
</tr>
<tr>
<td>Epidermoid</td>
<td>Gastrointestinal tract (5%)</td>
</tr>
<tr>
<td>Intramedullary (11%)</td>
<td>Melanoma (4%)</td>
</tr>
<tr>
<td>Ependymoma (55%)</td>
<td>Unknown primary (4%)</td>
</tr>
<tr>
<td>Astrocytoma (31%)</td>
<td>Head and neck (3%)</td>
</tr>
<tr>
<td>Vascular tumors (4%)</td>
<td></td>
</tr>
<tr>
<td>Other (5–10%)</td>
<td></td>
</tr>
<tr>
<td>Mixed glioma</td>
<td></td>
</tr>
<tr>
<td>Oligodendroglioma</td>
<td></td>
</tr>
</tbody>
</table>

Craniography makes it possible to identify a number of X-ray symptoms: 1) Changes in bones caused by increased intracranial pressure (depending on the developmental stage of the process and the patient’s age): the deepening of “finger” depressions, thinning of the bones of the skull, widening of the sutures (in infants); osteoporosis of back of the sella turcica and of sphenoid wing, strengthening vascular pattern, expanding diploic channels, deepening pits pacchionian granulations; 2) Focal signs (corresponding to the tumor site): calcification, osteosclerosis, hyperostosis, local thinning, osteoporosis, atrophy, osteolysis, destruction, increasing the local vascular pattern; 3) Indirect symptoms (due to mass effect of a growing tumor): dislocation - the pineal gland, choroid plexus, falx of the brain, brain vessels.

Computed tomography (CT) based on detected changes in optical density makes it possible to diagnose tumors, to determine the topography of the process, the size of the tumor, detect calcifications, cystic components, the zone of necrosis, verify the fact of spontaneous hemorrhage in the parenchyma of the tumor and adjacent brain structures, an idea hisotstructure of the tumor, differentiate tumor tissue from edema of the brain substance. The additional (indirect) diagnostic CT signs of tumor mass effect are: the shift of median structures of the brain, the sickle of the brain, choroid plexus, ventricles and aqueduct of the brain, the deformation of subarachnoid space and cisterns of the brain, and compression in a limited area of lateral, III and IV ventricles, presence of hydrocephalus, local destructive changes in the bones of the skull.

Magnetic resonance imaging (MRI) is substantially complementary to the results of CT with respect to the location and spread of tumors to determine topographic and anatomical features of its growth, the nature and extent of tumor involvement in the process of adjacent brain structures. MRI is superior to CT in the diagnosis of tumors did not accumulate the contrast agent (eg, low-grade gliomas). In the diagnosis of calcifications, bone-destructive changes, delineation of the tumor and perifocal edema MRI features are limited. Addition to the standard MRI neurooncology used functional MRI (preoperative mapping of areas of the brain), MR angiography (study of the great vessels of the brain, determination of the degree of vascularization of the tumor) MR spectroscopy (the study of regional metabolism) MR thermography (check the temperature gradient during the thermal degradation of the tumor).

Positron emission tomography (PET) allows non-invasively investigate the biological properties of the local tumor and the substance of the brain, to map functionally important areas, timely detection of recurrent tumor growth, tumor differentiation grade.

Single photon emission computed tomography (SPECT) is carried out with the introduction of radiopharmaceuticals (99mTc pertechnetet, 99mTcGMPAO, 99mTcMIBI). SPECT can identify and localize the tumor, to get an idea of the degree of malignancy and vascularity, diagnose multifocal neoplastic lesions of the brain to carry out dynamic monitoring in the postoperative period.

Angiography (carotid, vertebral, selective) is carried out to visualize cerebral vessels, to clarify their relationship topografanatomicheskih with the tumor, determine the degree of vascularization and to identify sources of blood supply to tumors.

Survival prognosis

<table>
<thead>
<tr>
<th>Histology</th>
<th>Treatments</th>
<th>Time to tumor recurrence</th>
<th>Median survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBM (IV)</td>
<td>Srgy/RT/CT</td>
<td>6 months</td>
<td>11 month</td>
</tr>
<tr>
<td>AA (III)</td>
<td>Srgy/RT/CT</td>
<td>18 months</td>
<td>3 years</td>
</tr>
<tr>
<td>Astrocyt II</td>
<td>Srgy/RT</td>
<td>3 years</td>
<td>6 years</td>
</tr>
<tr>
<td>Astrocyt I</td>
<td>Srgy/RT</td>
<td>8 years</td>
<td>10 years</td>
</tr>
<tr>
<td>Lung met</td>
<td>Surgery/RT</td>
<td>12 wks</td>
<td></td>
</tr>
<tr>
<td>Breast met</td>
<td>Surgery/RT</td>
<td>25 wks</td>
<td></td>
</tr>
<tr>
<td>Colon met</td>
<td>Surgery/RT</td>
<td>48 wks</td>
<td></td>
</tr>
<tr>
<td>Melanoma</td>
<td>Surgery/RT</td>
<td>26 wks</td>
<td></td>
</tr>
<tr>
<td>Renal met</td>
<td>Surgery/RT</td>
<td>8 wks</td>
<td></td>
</tr>
</tbody>
</table>
Lymphoma of the right temporo-parietal region
28-year-old woman with frequent focal epileptic fits affecting the left arm but no deficit

Glioblastoma (GBM) (GIV)

Metastasis

Oligodendroglioma

Giant meningioma

Giant meningioma
Midle 1/3 of the falx
CT-angiography
Inoperable low-grade astrocytoma (histologically verified) 'Butterfly glioma'. Glioblastoma multiforme of corpus callosum spreading into both frontal lobes.

Glioblastoma

MR-tractography

MRT tractography

Glioblastoma

CT + contrast

Autopsy

Navigation system

Intraoperation USI

Stereotaxis

Autopsy

Intraoperation USI
Microscope

Endoscopic assistance

Cryotom

Stereotactic tumor-cryotomy controlled computed tomography intraoperative electrophysiological monitoring

Glioblastoma

Biopsy and cryotomy
1. Meningioma
2. Osteoma

CT

T1W COR
T1W+GD
FLAIR
T2W

Muscle separation

Osteom skeletization

Resection

Dura mater after bone removal
Meningioma removal

Histological samples

Tumor removal

S100 (+)
After operation

Angiograms (meningioma) ECA basin

After embolisation

Tumor mass

Intracerebral tumor (ICA basin)

After embolisation
There are several types of devices for stereotactic radiosurgery: Gamma Knife, LINAC, XKnife, SynergyS, Trilogy, CyberKnife, Novalis, and Syclotron. The principle of operation is the same for all machines, and they differ in energy sources and methods of targeting radiation to the target. So for example a linear accelerator LINAC, which basically uses X-rays and electromagnetic waves of energy all the way allowing to reach 46 MeV. During the procedure, the treatment unit rotates around the patient, providing accurate radiation, focusing on the tumor? The phone Gamma Knife uses 201 radioactive cobalt source and electromagnetic wave, with the ability to achieve the maximum energy of up to 1.25 MeV.
12.11.2013

First «Leksell GammaKnife» (1968)

Proton emitter

Linear accelerator
Varian “CLINAC 600 C”

Linear accelerator
Novalis

CyberKnife

Results

Показать видеоролик

Показать видеоролик

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THANK YOU!!!