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MODERN NEUROIMAGING CRITERIA FOR DIAGNOSIS AND PREOPERATIVE PLANNING IN INTRACRANIAL MENINGIOMAS

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Abstract.
Background. Intracranial meningiomas are the most common non-glial primary brain tumors and demonstrate wide variability in localization, morphology, and clinical presentation. Accurate preoperative differentiation between extra- and intra-axial lesions and assessment of their relationship with neurovascular structures are essential for surgical planning.
Objective. To evaluate the diagnostic value of computed tomography (CT) and magnetic resonance imaging (MRI) in identifying neuroimaging features of intracranial meningiomas and their role in surgical decision-making.
Materials and Methods. Thirty patients with intracranial meningiomas of various locations underwent preoperative CT and MRI with contrast enhancement. Tumor localization, size, imaging characteristics, peritumoral edema, bone involvement, mass effect, midline shift, and vascular supply were analyzed.
Results. CT was particularly useful for detecting hyperdense tumors, calcifications, and bone changes, while MRI provided superior visualization of tumor-brain interfaces, venous sinus involvement, and cranial nerve relationships. Contrast-enhanced MRI significantly improved delineation of tumor boundaries and assessment of surgical complexity.
Conclusion. Combined use of CT, MRI, and MR angiography enables comprehensive preoperative evaluation of intracranial meningiomas and facilitates optimal surgical strategy selection.
Key words: meningioma; neuroimaging; computed tomography; magnetic resonance imaging; MR angiography; surgical planning.

СОВРЕМЕННЫЕ НЕЙРОВИЗУАЛИЗАЦИОННЫЕ КРИТЕРИИ ДИАГНОСТИКИ И ПРЕДОПЕРАЦИОННОГО ПЛАНИРОВАНИЯ ПРИ ВНУТРИЧЕРЕПНЫХ МЕНИНГИОМАХ

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Аннотация.
Актуальность. Внутричерепные менингиомы являются наиболее распространёнными опухолями неглиального происхождения и характеризуются разнообразием локализации, морфологии и клинического течения. Точная дооперационная дифференциация экстра- и интрацеребральных новообразований, а также оценка их взаимоотношений с сосудистыми и функционально значимыми структурами головного мозга имеют ключевое значение для выбора хирургической тактики.
Цель исследования. Оценить диагностическую значимость компьютерной томографии и магнитно-резонансной томографии в выявлении нейровизуализационных признаков внутричерепных менингиом и их роли в планировании хирургического лечения.

Материалы и методы. Обследованы 30 пациентов с внутричерепными менингиомами различной локализации, которым выполнены КТ и МРТ головного мозга с контрастным усилением. Анализировались локализация опухоли, размеры, плотностные и сигнальные характеристики, выраженность перифокального отёка, состояние костных структур, степень компрессии и дислокации срединных структур, а также источники кровоснабжения.
Результаты. КТ позволила эффективно выявлять гиперденсные менингиомы, кальцификаты и изменения костей черепа, тогда как МРТ превосходила КТ в оценке взаимоотношений опухоли с веществом мозга, венозными синусами и черепными нервами. Контрастное усиление существенно повышало точность диагностики и определение истинных границ опухоли.
Заключение. Комплексное применение КТ, МРТ и МР-ангиографии обеспечивает оптимальную предоперационную оценку внутричерепных менингиом и способствует выбору наиболее безопасной и радикальной хирургической тактики.
Ключевые слова: менингиома; нейровизуализация; компьютерная томография; магнитно-резонансная томография; МР-ангиография; хирургическое планирование.

INTRAKRANIAL MENINGIOMALARDA DIAGNOSTIKA VA OPERATSIYAGACHA REJALASHTIRISHDA ZAMONAVIY NEYROVIZUALIZATSIYA MEZONLARI

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Annotatsiya.
Dolzarbligi. Intrakranial meningiomalar glial bo'lmagan miya o'smalari orasida eng ko'p uchraydi va joylashuvi hamda klinik kechishi jihatidan xilma-xildir. Operatsiyagacha o'smalarning miya tuzilmalari va tomirlar bilan o'zaro munosabatini aniqlash jarrohlik taktikasini tanlashda muhim ahamiyatga ega.
Tadqiqot maqsadi. Kompyuter tomografiyasi va magnit-rezonans tomografiyaning intrakranial meningiomalarni aniqlashdagi diagnostik ahamiyatini va jarrohlik rejalashtirishdagi rolini baholash.
Materiallar va usullar. Turli lokalizatsiyadagi intrakranial meningiomasi bo'lgan 30 bemorda kontrastli KT va MRT o'tkazildi. O'smaning joylashuvi, hajmi, tasviriy xususiyatlari, perifokal shish, suyak o'zgarishlari va qon bilan ta'minlanishi tahlil qilindi.
Natijalar. KT suyak o'zgarishlari va kalsifikatsiyalarni aniqlashda samarali bo'lsa, MRT o'smaning miya va venoz sinuslar bilan munosabatini baholashda ustunlik ko'rsatdi.
Xulosa. KT, MRT va MRT-angiografiyaning kompleks qo'llanilishi intrakranial meningiomalarni aniq baholash va xavfsiz jarrohlik taktikasini tanlash imkonini beradi.
Kalit so'zlar: meningioma; neyrovizualizatsiya; kompyuter tomografiya; magnit-rezonans tomografiya; MRT-angiografiya; jarrohlik rejalashtirish

Introduction. Meningioma is a tumor of the meninges, extracerebral, originating from the dura mater, less commonly from the pia mater, and rarely from the choroid plexus of the cerebral ventricles or arising ectopically in the bones of the skull [1,7]. According to various authors, meningiomas account for 13 to 27% of all primary brain tumors, being the most common intracranial neoplasms among tumors of non-glial origin [8]. These tumors usually grow slowly, sometimes for many years, asymptomatically. Meningiomas are most often detected in middle-aged and elderly people, but are occasionally detected in children [9]. Advances in modern neurosurgery and the widespread introduction of microsurgical principles have resulted in a clear trend toward a reduction in complications and postoperative mortality. However, the problem of meningioma recurrence, reaching 75 to 100% in anaplastic meningiomas (G-III), remains a pressing issue [4]. This is not only a medical and social issue, but also an economic one, requiring ever-increasing expenditures on rehabilitation and social needs. Furthermore, when diagnosing an intracranial space-occupying lesion, CT and MRI analysis require a clear answer to a very important question: is the detected neoplasm extra- or intracerebral? This forms the basis for developing treatment tactics and planning a surgical approach. Therefore, continuous improvement of diagnostic methods and treatment tactics for patients with intracranial meningiomas is essential.

Purpose of the study. The aim of this work is to study the neuroimaging signs of intracranial meningiomas, to determine the value of one or another research method for the subsequent determination of surgical tactics and treatment.

Materials and methods.A total of 30 patients with meningioma of the brain in various locations were examined preoperatively using CT and MRI with contrast enhancement. All patients met the following selection criteria: 1. The diagnosis of meningioma was verified during subsequent surgical treatment. 2. The surgery was performed at JSC "Russian Scientific Center for Nursing" for the first time. Patients were admitted for examination with various neurological symptoms; no asymptomatic course was recorded in the study group at the time of diagnosis. The age of the patients ranged from 25 to 65 years, the average age was 45 years. The majority of them were people of working age (from 30 to 60 years) - 23 cases (76.6%), which emphasizes the high social significance of the problem. Among the patients, there were 20 women and 10 men, according to the percentage ratio (Diagram No. 1). All patients were divided into 4 groups depending on the initial tumor growth. (Table No. 1)

Tumor localization	Women, n (%)	Men, n (%)
Convexital meningiomas	2 (10%)	1 (10%)
Parasagittal meningiomas	7 (35%)	5 (50%)
Meningiomas of the wings of the sphenoid bone	6 (30%)	2 (20%)
Posterior cranial fossa (PCF) meningiomas	5 (25%)	2 (20%)
Total	**20 (100%)**	**10 (100%)**

Neuroimaging was performed on all patients using CT and/or MRI. The examinations were performed using a SIEMENS MAG-NETOM Symphony 1.5 Tesla magnetic resonance imaging system and a SIEMENS SOMATOM Emotion 6-slice computed tomography system.

CT and MRI methods were used to determine the following parameters: – localization of the tumor matrix;

– tumor size;

– changes in signal density and characteristics of contrast agent accumulation;

– tumor spread;

– the presence of cysts, petrifications, and hemorrhages in the tumor stroma;

– the effect of volumetric impact in the form of compression and dislocation of the ventricular system and midline structures;

– changes in the bone adjacent to the tumor matrix;

- peritumoral edema;

– signs of tumor infiltration of brain tissue;

– sources of blood supply to the tumor.

Research results and their discussion. Computed tomography was performed on 12 patients, including 7 women and 5 men. According to a number of authors [2,3], the sensitivity of computed tomography in detecting intracranial meningiomas is 96–98%, and the specificity is 93–97%. Approximately 4–5% of meningiomas remain unrecognized, with their predominant localization in the posterior cranial fossa, at the bottom of the anterior and middle cranial fossae, with low-density and flat tumors. We performed computed tomography of the brain according to the standard in projection at an angle of 150 to the orbitomeatal line. The optimal thickness of the examined layer is 2.5 mm. For a general examination of the brain, 7–10 slices are sufficient, for a targeted study of the structures of the posterior cranial fossa 4–6 slices. Most meningiomas on computed tomography are characterized by a zone of increased density up to 40–50 HU, i.e. are hyperdense (Fig. 1). They are clearly delimited from the perifocal zone. In our observation, a hyperdense tumor structure was observed in 8 (66.6%) patients. In most patients, meningiomas are well visualized on native CT. However, there is evidence that in 2-4% of patients, intracranial meningiomas are not visible [10, 11]. To detect them and differentiate them from other tumors, it is necessary to conduct a CT examination after intravenous administration of a radiocontrast agent, which tends to accumulate in the pathological zone. We used the contrast-enhanced CT method in 4 (33.3%) patients with meningiomas that had hypodense and isodense structures that hampered visualization. This allowed us to establish the clarity and true size of meningiomas, and also improved the visualization of tumors located near the bones of the base of the skull. After the introduction of contrast enhancement, the density of the meningioma typically increased to 60-90 HN units (Fig. 2). Magnetic resonance imaging serves as an important, and sometimes very significant, complement to computed tomography, especially in the diagnosis of tumors localized at the base of the skull bones. The use of high-intensity magnetic fields has demonstrated the high effectiveness of MRI in determining the degree of vascularization of meningiomas, the state of arterial vessels, invasion of venous sinuses, visualizing tumor contours, and assessing spread [12]. Factors such as the severity of the surgery, its outcome, the degree of postoperative neurological deficit, the degree of radicality, and therefore the percentage of meningioma recurrence, are largely determined by the location of the tumor - its proximity to functionally significant parts of the brain and the relationship with the anatomical - vessels and nerves, therefore, without diminishing the advantages of CT, we recognize that our experience in the integrated use of CT and MRI in the diagnosis of intracranial space-occupying lesions has shown that MRI with a magnetic field strength of 1.5 Tesla is a more effective method than computed tomography in determining the above characteristics of an extracerebral pathological focus.The majority of meningiomas on T1WI are isointense or hypointense compared to the cerebral cortex, and on T2WI they are either hypointense or moderately hyperintense [13]. We conducted an MRI examination of 22 patients, 13 of whom were women and 9 were men. 89% of patients in this study had parasagittal meningiomas and meningiomas of the posterior cranial fossa (Fig. 3). One of the characteristic signs of meningiomas on MRI is the clear visualization of anatomical structures located between the tumor and the brain. These include slit-like cerebrospinal fluid spaces, fragments of the dura mater, and vessels of the pia mater. The cerebrospinal fluid space slit is recognized by some authors as one of the important characteristics of the tumor, and its presence or absence is used to judge the aggressiveness of growth and the degree of malignancy of the meningioma. In our study, we observed the presence of a gap in 17 patients (77.2%), which is consistent with the literature data, but did not find a direct correlation between its presence and a specific histological type of tumor. Native MRI does not always clearly visualize a number of pathological processes, such as small convexitally located meningiomas, metastases without perifocal edema, etc. [5]. With intravenous contrast enhancement using paramagnetic substances, almost all meningiomas are characterized by pronounced homogeneous accumulation of the contrast agent. This phenomenon is due to the absence of the blood-brain barrier in the capillaries of meningiomas, typical of cerebral capillaries. We used this technique in 8 patients (Fig. 4). After contrast enhancement, a significantly pronounced increase in the MR signal from the tumor is determined after 1 minute. As noted above, after contrast, meningiomas are homogeneous on MRI. Their heterogeneity on MRI after enhancement may be due to the presence of calcifications, small cysts, and vessels. Marked enhancement of tumor visualization after contrast allows for a more precise definition of the topographic and anatomical relationships between the tumor and surrounding intracranial structures [6]. Today, new technologies allow for such an informative study as magnetic resonance angiography (MRA). The method is based on sensitivity to fluid movement and does not require the administration of a contrast agent. When diagnosing, primarily parasagittal meningiomas, it is often necessary to differentiate between tumor invasion of the venous sinus and its compression. Localized slowing of blood flow in the superior sagittal sinus can be incorrectly interpreted as a sign of meningioma invasion. In our study, we applied this technique to 3 patients with parasagittal meningioma (Fig. 5). Tumor invasion of the venous sinus was observed in 2 cases as a complete disappearance of the zone of typical signal loss from the blood flowing through it due to penetration of the soft tissue tumor component into it.Occlusion of the sagittal and transverse sinuses is best identified on coronal MRI scans, while occlusion of the cavernous sinus is best identified on coronal and axial MRI scans (Fig. 6). In addition to vessel displacement according to the location of meningiomas, MRI can also identify their blood supply sources. Given the limited analytical value of our own data, but anticipating the importance of this issue, we would like to provide only a general table of the most common feeding arteries depending on the predominant location of the meningioma. (Table 2)

Table No. 2. The most common sources of blood supply to meningiomas (Konovalov A.N., Kornienko V.N., Pronin I.N. 1997)

Tumor localization	The most common feeding artery
Convexital meningiomas	Middle meningeal artery; artery of falx (branch of the ophthalmic artery)
Meningiomas of the olfactory fossa	Branches of the ophthalmic artery
Meningiomas of the sphenoid wing	Middle meningeal artery
Meningiomas of the tentorium and cerebellopontine angle	Tentorial arteries from the meningohypophyseal trunk (artery of Bernasconi–Casinari)
Meningiomas of the foramen magnum and clivus	Anterior meningeal artery of the clivus (branch of the vertebral artery); dorsal meningeal artery from the meningohypophyseal trunk

Conclusion. Intracranial meningiomas are a diverse group of extracerebral tumors whose diagnosis and treatment require a differentiated approach depending on their location, size, growth pattern, and relationship to surrounding neurovascular structures. Modern neuroimaging techniques, such as CT, MRI, and MRA, allow preoperative prediction of the extent of tumor resection, the severity of the surgery, and its outcome.

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