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ПРИМЕНЕНИЕ РАЗЛИЧНЫХ МЕТОДОВ НЕЙРОНАВИГАЦИИ В ХИРУРГИИ ОПУХОЛЕЙ ГОЛОВНОГО МОЗГА И ПРЕИМУЩЕСТВА УЛЬТРАЗВУКОВОЙ НАВИГАЦИИ

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АННОТАЦИЯ

Рассмотрев все методы нейронавигации в интраоперационных условиях при лечении опухолей головного мозга в историческом аспекте и на современном этапе. Описаны возможности каркасных и бескаркасных стереотаксических систем, интраоперационной МРТ и КТ, интраоперационной ультрасонографии. Выделены достоинства и недостатки каждого метода нейронавигации. При интраоперационной нейросонографии ценную информацию в реальном времени можно получить благодаря правильной ориентации и мгновенной корреляции сонограмм с привычными предоперационными МРТ-изображениями, и этот метод является наиболее доступным простым, но ценным методом нейронавигации. Благодаря этим качествам метод может стать альтернативой более дорогим и сложным стереотаксическим, интраоперационным МРТ- и КТ-методам нейронавигации.

Ключевые слова: интраоперационная нейросонография, продолженный рост опухоли, диагностические признаки, хирургическое лечение.

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APPLICATION OF DIFFERENT NEURONAVIGATION METHODS IN BRAIN TUMOR SURGERY AND THE ADVANTAGE OF ULTRASOUND NAVIGATION

ANNOTATION

Having considered all methods of neuronavigation in intraoperative conditions in the treatment of brain tumors in the historical aspect and at the present stage. The possibilities of stereotactic frame and frameless systems, intraoperative MRI and CT, and intraoperative ultrasonography are described. The advantages and disadvantages of each neuronavigation method are highlighted. With intraoperative neurosonography, valuable real-time information can be obtained through proper orientation and instantaneous correlation between sonograms and familiar preoperative MRI images and this method is the most accessible simple yet valuable method of neuronavigation. Due to these qualities, the method can become an alternative to more expensive and complex stereotactic, intraoperative MRI and CT methods of neuronavigation.

Keywords: intraoperative neurosonography, recurrent glioma, diagnostic signs, surgical treatment.

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Республика ихтисослаштирилган нейрохирургия илмий амалий тиббиёт маркази

МИЯ ЎСМАЛАРИ ЖАРРОҲЛИГИДА НЕЙРОНАВИГАЦИЯНИНГ ТУРЛИ УСУЛЛАРИДАН ФОЙДАЛАНИШ ВА УЛТРАТОВУШ НАВИГАЦИЯСИНИНГ АФЗАЛЛИКЛАРИ

АННОТАЦИЯ

Мия ўсмаларини тарихий жиҳатдан ва ҳозирги босқичда даволашда интраоператив шароитда нейронавигациянинг барча усулларини кўриб чиқиш. Рамка ва рамкасиз стереотактик тизимлар, интраоператив МРИ ва КТ, интраоператив ултратовуш текшируви имкониятлари тасвирланган. Нейронавигациянинг ҳар бир усулининг афзалликлари ва камчиликлари таъкидланган. Интраоператив нейросонография ёрдамида сонограммаларнинг операциядан олдинги одатий МРТ тасвирлари билан тўғри йўналиши ва тезкор корреляцияси туфайли Реал вақтда қимматли маълумотларни олиш мумкин ва бу усул нейронавигациянинг енг оддий, аммо мухум усули ҳисобланади. Ушбу фазилатлар туфайли усул қимматроқ ва мураккаб стереотактик, интраоператив МРИ ва КТ нейронавигация усулларига муқобил бўлиши мумкин.

Калит сўзлар: операция ичи нейросонографияси, ўсманинг қайталаниши, диагностик белгилар, жарроҳлик усули билан даволаш.

Statistical studies conducted in economically developed countries during the last decades have revealed a tendency towards a steady increase in brain neoplasms. The incidence of primary benign and malignant brain tumors is currently 10.9-16.7 cases per 100,000 population [6, 13, 14, 20]. According to GLOBOCAN statistics of the International Agency for Research on Cancer, malignant brain tumors

account for 189 thousand new cases and 142 thousand deaths annually [32]. In European countries, the incidence of metastatic brain lesions has increased from 8.3 to 54.6 per 100,000 population over the last 10 years. In the structure of neuro-oncologic interventions, they account for up to 40% of all neuro-oncologic surgeries [15, 16].

Despite the successes achieved in neurosurgery, radiation diagnostics and radiation therapy in recent years, the results of treatment of patients remain unsatisfactory with regard to the real impact on overall survival and quality of life. Early postoperative lethality (up to 14 days) in gliomas is 17.3%, in meningiomas 9.6% [3]. Cerebral metastases often cause early death of patients, being the cause of death in at least 25% of cases [7].

Currently, due to the introduction of microsurgical techniques, fiber optics, neuronavigation systems into practice, based on rich topographic and anatomical knowledge of their growth patterns has provided a new impetus for surgical treatment of brain tumors [22, 30, 31]. The main problem arising in the surgical treatment of brain tumors is the need to avoid intraoperative damage to the most significant functional areas of the cortex and conductive pathways of the brain and at the same time to perform the most complete resection of tumor tissue [26, 31]. The well-known postulate about access to an intracerebral tumor through the functionally insignificant cortical areas requires rethinking. It was formulated even before the introduction of microneurosurgery and, moreover, modern methods of neuroimaging and navigation. In the absence of a navigation system, access to the tumor was planned on the basis of the coordinate system available on tomograms, calculation of the tumor depth, its distance from the midline, bony protrusions, ventricles, and other anatomical landmarks. In those times, the surgeon always faced a dilemma: how to combine the radicality of the operation and achieve a good functional outcome, especially when the tumor was located near functionally significant areas [9]. Unreasonably long wound channel, insufficient visualization of the tumor reduced the radicality of the intervention and could, in turn, provoke the development of neurological deficit.

The trend toward minimal invasion and high precision, along with improvements in microsurgical techniques, has led to widespread adoption of navigation technology.

Neuronavigation is the use of various technologies to perform precision target localization during surgery in a real patient. In fact, a synonym for the word "neuronavigation" is "stereotaxis". "Stereotactic" in Greek means "moving in space". Stereotactic surgery (or stereotaxis) is a minimally invasive method of surgical intervention, when access to the target point inside the body ortissue thickness of any organ is performed using a spatial scheme according to pre-calculated coordinates on a three- dimensional Cartesian coordinate system [18].

The first stereotactic frame for intracranial navigation ("encephalometer") was created in 1889 by Prof. D.N.Zernov, who proposed to use a three-dimensional polar coordinate system to determine the spatial position of the studied structures of the human brain [5].

The stereotaxis method in neurosurgery was first realized in 1908 by neurosurgeon Sir Victor Horsley and engineer Robert X.Clarke [26]. Clarke [26]. They also introduced the term "stereotactic" for their creation. Between 1947 and 1949, American neurosurgeons Ernst Spiegel and Henry Wycis developed the first stereotactic system for human brain surgery [38]. The uniqueness of this system was the use of anatomical landmarks inside the human brain. Spiegel and Wycis also developed the first stereotactic atlas of the human brain.

Previous static visualization systems have been enhanced by modern navigational imaging systems, which can be divided into two groups.

Frame systems use for calculations the rigid attachment of the patient's head and all intracranial structures to a guide frame to which the surgical instrument is attached - these are devices for classical stereotactic neurosurgery.

Frameless systems use spatialization of the patient not within the confines of the frame, but in a slightly wider area of space around the operating table. They are able to track the movements of the instrument in the surgeon's hands and tell the surgeon where he or she is in real time.

The term "frameless stereotaxis" came into regular surgical practice from American neurosurgical clinics about seven years ago. The term was first used by neurosurgeon David Roberts from Dartmouth-Hitchcock Medical Center (USA) in 1986. Along with this term, the name computer-assisted neurosurgery (computer-assisted neuronavigation) is often used recently [24, 39].

One of the most perfect navigation system "Stealth" is recognized by Sofamor Danek, the inventor of modern technology "optical tracking" [25]. [16, 25]. Under certain conditions, it allows performing all classical stereotactic manipulations with great comfort for the surgeon. In addition, it is used in skull base surgery to control the radicality of resection and orientation in case of widespread tumors.

Despite their high accuracy, within millimeters of measurement, each of these systems has its downsides [22]. Surgeons are faced with some discrepancies between the coordinates stored in the navigation system information preoperatively and what is actually seen in the surgical field after removal of tumor or cerebrospinal fluid, resulting in relaxation of previously compressed tissues and displacement of the brain. Other limiting factors are cerebral edema and hemorrhage [28].

Modern technologies such as intraoperative MRI and ultrasonography also play an important role in neurosurgical operating rooms. Intraoperative MRI allows repeated imaging in patients while the craniotomy is open, giving the opportunity to resect any residual tumor. Intraoperative magnetic resonance image simulation can be used to upgrade the information, updating it in "real time" in neuronavigation systems [19,22,30,31], thus minimizing the brain displacement factor that confuses the surgeon [29,30].

At the same time, the indications for the use of neuronavigation and intraoperative visualization systems are still not clearly defined, and the authors' opinions on this matter are often contradictory. In recent years, the medical literature has been actively discussing the advantages and disadvantages of various intraoperative visualization methods in relation to improving the radicality of neoplasm removal.

Intraoperative imaging technology driven by the need for accurate real-time neuronavigation continues to evolve [21,35,39]. Although second-generation neuronavigation systems based on intraoperative MRI with infrared guidance and staining-capturing operating microscope are considered to be the accepted methods to achieve this goal, they are only used in highly specialized centers, are expensive, and require special infrastructure [40]. Therefore, further development and implementation of more affordable methods remains relevant.

An effective imaging adjunct in neurosurgery is intraoperative sonography. Imaging resolution, as well as probe size and design, has improved significantly since M. H. Reid first used sonography for neurosurgical navigation in 1978 [34]. The recent introduction of navigation-assisted three-dimensional sonography has solved the orientation problem previously experienced with two-dimensional sonography in neurosurgery [40].

The advantages of ultrasound navigation are simplicity and relatively low cost [8,28]. Intraoperative ultrasonography is a fast and efficient method for localization and characterization of brain masses, which provides an accurate anatomical picture and reduces the risk of damage to the surrounding brain parenchyma [21,33]. Precision navigation, to solve the most difficult problems in cranial resection. Visualization and compensation of brain displacement, performing the safest possible resection and detecting residual tumor. The method allows to reduce the traumatic nature of open surgical intervention, optimize its planning and execution, reduce the risk of impact on important anatomical and functional structures.

Intraoperative sonography allows good visualization of volumetric brain masses, as well as assessment of their size, structure, relationship with surrounding anatomical structures, large vessels, blood flow in the tumor vessels, as well as the ventricular system and brain parenchyma [2,4]. Intraoperative ultrasound navigation provides effective intraoperative guidance, which is especially important when removing gliomas localized in functionally significant brain areas [10,17]. With the help of intraoperative sonography in the "real time" mode, it is possible to assess the degree of radicality of volumetric neoplasm removal and, depending on the obtained data, to continue the removal of pathologic tissue or to finish the operation. Intraoperative sonography

data are quite accurate, which is confirmed by postoperative contrast-enhanced MRI [6, 27].

The use of neuronavigation allows to significantly reduce the invasiveness of surgical treatment, increase its radicality and optimize surgical access to deeply located volumetric masses with minimal traumatization of functionally significant areas of the brain substance; significantly improve the quality of life and shorten the rehabilitation period [1, 11, 12].

Thus, the complex application of various methods of neuronavigation makes it possible to optimize surgical access, reduce surgical trauma to the brain, reduce the time of surgical intervention and increase its radicality. Intraoperative ultrasound is a generally available and valuable assisting method, the advantages of which include the possibility of maximum removal of pathological formation with surgically permitted radicalism and monitoring the state of intact brain tissue in the course of surgical intervention with assessment of its radicality. Simplicity, insignificant time consumption for the study, availability of this hardware in our region make this method an alternative to expensive stereotactic and navigation and, therefore, it can be recommended for wider application in neurosurgical practice. The use of the latest technologies, adequate radicalism favorably affect the results of surgical treatment and postoperative quality of life of patients.

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