# MODERN MULTIMODAL APPROACHES TO THE DIAGNOSIS AND TREATMENT OF PRIMARY BRAIN TUMORS

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**Abstract:** Primary brain tumors represent a heterogeneous group of neoplasms with high clinical and social significance. Neuroepithelial tumors, particularly glial neoplasms, account for the majority of intracranial tumors and are characterized by aggressive biological behavior, high recurrence rates, and limited long-term survival despite advances in therapy. Modern diagnostic strategies rely heavily on neuroimaging modalities, primarily magnetic resonance imaging and computed tomography, with increasing interest in hybrid techniques combining MRI and positron emission tomography. Contemporary treatment paradigms are based on multimodal approaches integrating microsurgical resection, radiotherapy, chemotherapy, and emerging immunotherapeutic strategies. Radiotherapy remains a cornerstone of treatment for malignant central nervous system tumors, with fractionated regimens demonstrating optimal tumor control while minimizing neurocognitive toxicity. Advances in stereotactic radiosurgery and neuronavigation have significantly improved treatment precision and outcomes. Nevertheless, prognosis for high-grade gliomas remains poor, underscoring the need for personalized therapeutic strategies and further research into innovative treatment modalities.

**Keywords:** brain tumors, gliomas, radiotherapy, multimodal treatment, stereotactic radiosurgery

# СОВРЕМЕННЫЕ МУЛЬТИМОДАЛЬНЫЕ ПОДХОДЫ К ДИАГНОСТИКЕ И ЛЕЧЕНИЮ ПЕРВИЧНЫХ ОПУХОЛЕЙ ГОЛОВНОГО МОЗГА

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**Аннотация:** Первичные опухоли головного мозга представляют собой гетерогенную группу новообразований, обладающих высокой клинической и социальной значимостью. Наибольший удельный вес среди них занимают нейроэпителиальные опухоли, в частности глиальные новообразования, характеризующиеся агрессивным течением, высокой частотой рецидивов и ограниченной продолжительностью выживаемости пациентов. Современные диагностические подходы базируются преимущественно на методах нейровизуализации — магнитно-резонансной и компьютерной томографии, с возрастающим интересом к гибридным методам, включающим ПЭТ с аминокислотными метками. Современная терапия опухолей ЦНС основана на мультимодальном подходе, включающем нейрохирургическое вмешательство, лучевую терапию, химиотерапию и инновационные методы иммунотерапии. Лучевая терапия остается ключевым методом лечения злокачественных опухолей головного мозга, обеспечивая оптимальный контроль роста опухоли при рациональном фракционировании дозы. Развитие стереотаксической радиохирургии и нейронавигации значительно повысило точность и эффективность лечения. Тем не менее прогноз при высокозлокачественных глиомах остается неблагоприятным, что диктует необходимость дальнейшего совершенствования персонализированных терапевтических стратегий.

**Ключевые слова:** опухоли головного мозга, глиомы, лучевая терапия, мультимодальное лечение, стереотаксическая радиохирургия

## BIRLAMCHI MIYA O‘SMALARINI TASHXISLASH VA DAVOLASHDA ZAMONAVIY MULTIMODAL YONDASHUVLAR

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**Annotatsiya:** Birlamchi miya o‘smalari klinik va ijtimoiy jihatdan muhim bo‘lgan geterogen kasalliklar guruhini tashkil etadi. Ushbu o‘smalar orasida neyroepitelial, ayniqsa glial o‘smalar yetakchi o‘rinni egallaydi va ular agressiv biologik xususiyatlari, yuqori qaytalanish darajasi hamda cheklangan uzoq muddatli yashash ko‘rsatkichlari bilan tavsiflanadi. Zamonaviy diagnostika asosan magnit-rezonans tomografiya va kompyuter tomografiyasiga asoslanadi, shu bilan birga MRI va pozitron-emission tomografiyani birlashtirgan gibrid usullarga qiziqish ortib bormoqda. Markaziy asab tizimi o‘smalarini davolashda multimodal yondashuv qo‘llanilib, unga neyroxirurgik rezeksiya, nur terapiyasi, kimyoterapiya va immunoterapevtik usullar kiradi. Nur terapiyasi malign miya o‘smalarini davolashda asosiy usul bo‘lib qolmoqda va dozaning ilmiy asoslangan fraksiyalanishi o‘sma nazoratini ta’minlab, nojo‘ya ta’sirlarni kamaytiradi. Stereotaktik radiokhirurgiya va neyronavigatsiyaning rivojlanishi davolash aniqligi va samaradorligini sezilarli darajada oshirdi. Shunga qaramay, yuqori darajali glial o‘smalarda prognoz hanuz noqulay bo‘lib, yangi va individuallashtirilgan davolash strategiyalarini ishlab chiqish zaruratini ko‘rsatadi.

**Kalit so‘zlar:** miya o‘smalari, gliomalar, nur terapiyasi, multimodal davolash, stereotaktik radiokhirurgiya

### INTRODUCTION

Currently, there are over 150 different types of brain tumors, of which neuroepithelial neoplasms are of greatest clinical interest, accounting for approximately 60% of all tumors in this region. Specifically, glial tumors, which are the most common subtype, encompass a variety of forms, including astrocytic, oligodendroglial, mixed gliomas, ependymomas, and unspecified neuroepithelial tumors. Each of these forms has its own characteristic morphological features and displays common malignant characteristics, including nuclear atypia, the presence of mitoses, and necrosis. However, the exact causes of these tumors remain unclear, and no clear link has been established with environmental factors or patient lifestyle. A recent study published in The Lancet Oncology drew attention to a potential link between radiation exposure during childhood computed tomography (CT) scans and the risk of developing brain tumors later in life [5, p. 1054].

A study of 658,000 children found that the risk of developing brain tumors was higher in those who had CT scans at an early age. Modern imaging techniques, such as CT and MRI, have become essential tools in diagnosing brain tumors, despite the varying approaches to their use. It is important to note that methods combining MRI and positron emission tomography (PET) with labeled amino acids demonstrate greater efficacy; however, further implementation of this technique in clinical practice is required.

However, physicians still rely heavily on radiological methods such as CT and MRI when assessing the dynamics of a patient's condition with high-grade gliomas, while clinical parameters of the patient's condition play a less significant role [2, p. 77]. The increase in the number of

primary brain tumors expected in the next 20 years underscores the urgent need to optimize approaches to the treatment of this group of diseases. Forecasts of a 10% increase in new cases and a 5% increase in mortality reflected not only the medical but also the social significance of the problem, indicating that this disease requires an active search for innovative and more effective treatment strategies.

**MAIN PART**

Local and international clinical guidelines, structured by the degree of evidence, determine the methodology for the diagnosis and treatment of oncological diseases. Regular updates of existing protocols do not solve the problem of personalizing therapeutic approaches to patients with specific features of the disease. Modern medicine requires an expanded analysis of innovative treatment methods, Significantly improving the quality of life of patients with timely and individualized therapy. Radiation therapy has demonstrated significant results in oncology practice. Clinical studies confirm a significant increase in five-year survival rates among patients with low-grade gliomas after radiotherapy treatment. Statistics indicate a 33% increase in survival, with an overall long-term survival rate exceeding 90%.

Modern cancer treatment protocols invariably include radiotherapy as a fundamental therapeutic modality. The range of therapeutic methods for treating brain tumors encompasses classic surgical interventions, systemic chemotherapy, advanced developments in the field of immunological antitumor response, and high-precision radiation surgery. Experimental developments in local hyperthermia and photodynamic therapy for tumors demonstrate limited effectiveness according to current clinical trials.

Modern approaches to treating central nervous system tumors involve the integrated use of various therapeutic methods. Neurosurgery, initially considered the only effective treatment for CNS tumors, allows for the complete removal of the tumor. Advances in medicine have significantly expanded surgical treatment options, but surgery alone often does not guarantee lasting remission. Progress in neurosurgery has been marked by the introduction of high-precision neuronavigation combined with 5-aminolevulinic acid fluorescence mapping, which has dramatically improved the success of surgical interventions.

Neurosurgeons now have the ability to visualize peripheral tumor zones in extreme detail, which is particularly important during the resection of difficult-to-reach malignant brain tumors. The use of cry destruction has expanded the range of surgical treatments for glial tumors, previously considered inoperable, demonstrating a significant improvement in prognosis even for aggressively growing tumors. Statistical studies demonstrate the limited effectiveness of combined treatments, including surgery, radiation therapy, and chemotherapy. An analysis of glioblastoma patient survival data shows a median survival of 15-18 months after a multimodal treatment approach.

Postoperative chemotherapy, as well as therapy for relapses, plays a crucial role in the fight against the disease. Clinical trial results demonstrate a significant increase in patient survival rates, along with a significant slowdown in the progression of the pathological process contributing to maintaining an acceptable standard of living for patients.

Current research demonstrates that radiation therapy is becoming increasingly effective in the treatment of primary brain tumors, particularly due to improved approaches to dose selection and irradiation regimens. Initially, radiation therapy was used as an adjunct to surgery, but recent randomized trials highlight that the addition of adjuvant radiotherapy significantly increases median survival—by a factor of two, demonstrating the important role of this method in the

systemic treatment of central nervous system tumors. Nevertheless, even given the successful results of combination therapy, radiotherapy remains the primary method for treating malignant CNS tumors.

This method enables targeting tumor cells with varying degrees of resistance by implementing variable focal doses and irradiation regimens. For example, research conducted by the School of Life Sciences and Health Medicine at the University of Rosario identified a wide range of radiation doses, from 29 to 200 Gy, in which changes in cognitive processes were studied at different exposure levels. This allows for research on the effects of radiation on brain function, but the results are currently only experimental and cannot be used for clinical practice. Recent scientific research has established optimal radiation therapy parameters for the treatment of central nervous system tumors, where the total dose varies between 50-60 Gy.

A large-scale study by Dutch specialists conducted in 2021 revealed a significant decline in cognitive abilities in patients with low-grade gliomas when a single radiation dose exceeded 2 Gy, with memory functions being most significantly affected [1, p. 181].

A radiobiologically based treatment method involves a total dose of 60 Gy with a single irradiation of 2 Gy over a six-week period. Multiple radiation therapy parameters determine the success of the treatment process, including the frequency of sessions, the duration of the therapeutic course, the patient's clinical status, and age. The effectiveness of the standard protocol varies among different patient groups, demonstrating reduced efficacy in the elderly and patients with severe neurological manifestations of the disease.

Tumor growth control with minimal side effects is achieved through a scientifically proven approach to radiation dose fractionation. Stereotactic radiosurgical techniques offer the ability to maximize healthy tissue sparing through highly precise focusing of the radiation beam. Frameless and invasive gamma- and X-ray-based systems provide irradiation precision down to one millimeter.allowing the administration of large doses of four to twenty-five gray in one to five procedures with a sharp gradient distribution. Standard stereotactic therapy regimens include three to seven sessions with single doses of five to eight gray in parallel with the use of dexamethasone. The best results are achieved in the treatment of cerebral metastases, although the risk of radionecrotic complications in patients with brain tumors remains significant [2, p. 2018].

Thus, modern methods of treating brain tumors are continuously evolving, including advanced surgical interventions, innovative chemotherapeutic protocols, and high-precision radiology. Medical science is actively expanding diagnostic tools and therapeutic options in the treatment of tumors of the central nervous system, introducing revolutionary approaches and methodologies.

**CONCLUSION**

Primary brain tumors, particularly glial neoplasms, remain a major challenge in neuro-oncology due to their aggressive behavior and poor prognosis. Current evidence supports a multimodal treatment approach combining maximal safe surgical resection, radiotherapy, and chemotherapy as the standard of care. Advances in neuronavigation, fluorescence-guided surgery, and stereotactic radiotherapy have improved treatment precision and local tumor control. Radiotherapy continues to play a central role, with optimized dose fractionation helping to balance tumor control and preservation of cognitive function.

Further progress depends on personalized treatment strategies and the integration of molecular and targeted therapies to improve patient outcomes and quality of life.

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