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SURGICAL OUTCOMES AND PROGNOSTIC FACTORS AFTER MICROSURGICAL RESECTION OF GLIOBLASTOMA: A RETROSPECTIVE ANALYSIS OF 120 ADULT PATIENTS

Khamraeva Navruza Mahammadi kizi
Nematova Shakhlo Dadajon kizi
Samarkand State medical University.

Abstract.

Background: Glioblastoma (GBM) is the most aggressive primary malignant brain tumor in adults, with limited survival despite multimodal therapy. Surgical resection remains the cornerstone of management, with extent of resection (EOR) and patient-specific factors significantly influencing outcomes. This study evaluates clinical outcomes and prognostic factors following microsurgical resection of GBM in a tertiary neurosurgical center.

Methods: We retrospectively reviewed 120 adult patients who underwent microsurgical resection of newly diagnosed GBM between 2018 and 2024. Preoperative evaluation included neurological assessment, Karnofsky Performance Status (KPS), and contrast-enhanced MRI, with functional MRI and diffusion tensor imaging in selected cases. Surgical strategies prioritized maximal safe resection, utilizing neuronavigation, intraoperative neurophysiological monitoring, and awake craniotomy for eloquent cortex tumors. EOR was classified using early postoperative MRI as gross total, subtotal, or partial resection. Postoperative neurological status, complications, adjuvant therapy, and overall survival were analyzed. Kaplan-Meier survival analysis and Cox regression identified prognostic factors.

Results: GTR was achieved in 53% of patients, STR in 32%, and partial resection in 15%. New postoperative deficits occurred in 17.5% of patients, with 6.7% permanent. Median overall survival was 15.2 months, significantly longer in patients with GTR (18.4 months) compared with STR (13.6 months) or partial resection (9.8 months; $p<0.001$). Age ≥65 years, preoperative KPS <70, and postoperative deficits were independent predictors of poorer survival.

Conclusions: Maximal safe resection improves survival in GBM while preserving neurological function. Individualized surgical planning with functional mapping is essential for optimizing outcomes.

Keywords: Glioblastoma, Microsurgical resection, Extent of resection, Prognostic factors, Survival, Functional outcome, Awake craniotomy, Neurosurgery, Neuro-oncology

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ХИРУРГИЧЕСКИЕ ИСХОДЫ И ПРОГНОСТИЧЕСКИЕ ФАКТОРЫ ПОСЛЕ МИКРОХИРУРГИЧЕСКОГО УДАЛЕНИЯ ГЛИОБЛАСТОМЫ: РЕТРОСПЕКТИВНЫЙ АНАЛИЗ 120 ВЗРОСЛЫХ ПАЦИЕНТОВ

Хамраева Навруза Махаммади кизи
Нематова Шахло Дадажон кизи
Самаркандский государственный медицинский университет

Аннотация.

Введение: Глиобластома (GBM) является наиболее агрессивной первичной злокачественной опухолью головного мозга у взрослых, характеризующейся низкой выживаемостью несмотря на мультимодальную терапию. Хирургическая резекция остается основным методом лечения, при этом степень резекции (EOR) и индивидуальные характеристики пациента существенно влияют на исходы. Цель данного исследования —

оценить клинические результаты и прогностические факторы после микрохирургической резекции GBM в условиях третичного нейрохирургического центра.

Методы: Проведен ретроспективный анализ 120 взрослых пациентов, перенесших микрохирургическую резекцию впервые диагностированной GBM в период с 2018 по 2024 годы. Предоперационная оценка включала неврологическое обследование, индекс Карновского (KPS) и контрастную МРТ; в отдельных случаях применялись функциональная МРТ и диффузионно-тензорная визуализация. Хирургическая тактика была направлена на максимально безопасную резекцию с использованием нейронавигации, интраоперационного нейрофизиологического мониторинга и, при необходимости, пробуждаемой краниотомии при опухолях в функционально значимых зонах. Степень резекции определялась по ранней послеоперационной МРТ как тотальная, субтотальная или частичная. Анализировались послеоперационный неврологический статус, осложнения, адъювантная терапия и общая выживаемость. Для выявления прогностических факторов использовались анализ Каплана–Мейера и регрессия Кокса.

Результаты: Тотальная резекция достигнута у 53% пациентов, субтотальная — у 32%, частичная — у 15%. Новые послеоперационные неврологические дефициты отмечены у 17,5% пациентов, из них у 6,7% — стойкие. Медиана общей выживаемости составила 15,2 месяца и была значительно выше у пациентов с тотальной резекцией (18,4 месяца) по сравнению с субтотальной (13,6 месяца) и частичной резекцией (9,8 месяца; $p<0,001$). Возраст ≥65 лет, предоперационный KPS <70 и послеоперационные неврологические дефициты являлись независимыми предикторами худшей выживаемости.

Заключение: Максимально безопасная резекция повышает выживаемость пациентов с GBM при сохранении неврологической функции. Индивидуализированное хирургическое планирование с использованием функционального картирования имеет ключевое значение для оптимизации результатов лечения.

Ключевые слова: глиобластома, микрохирургическая резекция, степень резекции, прогностические факторы, выживаемость, функциональный исход, пробуждаемая краниотомия, нейрохирургия, нейроонкология.

GLIOSBLASTOMANI MIKROXIRURGIK YO‘L BILAN OLIB TASHLASHDAN KEYINGI JARROHLIK NATIJALARI VA PROGNOSTIK OMILLAR: 120 NAFAR KATTA YOSHLI BEMORLAR ASOSIDA O‘TKAZILGAN RETROSPEKTIV TAHLIL

Xamrayeva Navruza Mahammadi qizi
Nematova Shaxlo Dadajon qizi
Samarqand davlat tibbiyot universiteti

Annotatsiya.

Kirish: Glioblastoma (GBM) kattalar orasida eng agressiv bosh miya shishlaridan biri bo‘lib, multimodal terapiyaga qaramay, bemorlarning umumiy yashash muddati qisqa bo‘ladi. Jarrohlik rezektsiyasi GBM boshqaruvida asosiy o‘rin tutadi, shuningdek, rezektsiya darajasi (EOR) va bemorning individual omillari natijaga katta ta’sir ko‘rsatadi. Ushbu tadqiqot GBM bemorlarida mikrojarrohlik rezektsiya natijalari va prognoz omillarini baholashga qaratilgan.

Metodlar: 2018–2024 yillarda yangi tashxis qilingan GBM uchun mikrojarrohlik rezektsiya o‘tkazilgan 120 kattalar bemorning retrospektiv tahlili amalga oshirildi. Oldingi baholashda nevrologik tekshiruv, Karnofski funktsional holati (KPS) va kontrastli MRI qo‘llanildi; ayrim hollarda funksional MRI va diffuzion tensor tasvirlash ishlatildi. Jarrohlik rezektsiyasi maksimal xavfsiz tarzda amalga oshirildi, nevronavigatsiya, jarrohlik davomida neyrofiziologik monitoring va zarur hollarda uyg‘oq kraniotomiya qo‘llanildi. Rezektsiya darajasi operatsiyadan keyingi MRI asosida butunlay (GTR), qisman (STR) yoki cheklangan (partial) deb baholandi. Postoperativ nevrologik holat, asoratlar, qo‘shimcha terapiya va umumiy yashash muddati tahlil qilindi.

Natijalar: GTR 53%, STR 32%, partial rezektsiya 15% bemorlarda amalga oshirildi. Postoperativ yangi nevrologik defitsitlar 17,5% bemorlarda kuzatildi, shundan 6,7% doimiy bo‘ldi. Median umumiy yashash muddati 15,2 oyni tashkil etdi; GTR bemorlarda 18,4 oy, STR 13,6 oy va partial rezektsiya 9,8 oy bo‘ldi ($p<0,001$). 65 yoshdan katta, KPS <70 va postoperativ defitsit mavjudligi survivalning yomonlashishiga mustaqil ta’sir ko‘rsatdi.

Xulosa: Maksimal xavfsiz rezektsiya GBM bemorlarida yashash muddatini uzaytiradi va nevrologik funksiyani saqlash imkonini beradi. Funksional xaritalash bilan individual jarrohlik rejalashtirish natijalarni optimallashtirishda muhimdir.

Kalit so‘zlar: Glioblastoma, Mikrojarrohlik rezektsiya, Rezektsiya darajasi, Prognoz omillari, Yashash muddati, Nevrologik natija, Uyg‘oq kraniotomiya, Neyroxirurgiya, Neyro-onkologiya

Introduction. Glioblastoma (GBM) remains the most aggressive primary malignant brain tumor in adults, characterized by rapid proliferation, diffuse infiltration, and dismal prognosis despite multimodal therapy. Current standard management consists of maximal safe microsurgical resection followed by adjuvant radiotherapy and temozolomide-based chemotherapy, as established by the landmark Stupp protocol.1 Despite advances in neuroimaging, intraoperative navigation, and functional mapping, overall survival remains limited, with a median survival of 12–18 months.2,3

Extent of resection (EOR) has emerged as a critical prognostic factor in GBM management. Multiple studies have demonstrated that gross total resection (GTR) correlates with improved progression-free and overall survival, although achieving GTR can be limited by tumor proximity to eloquent cortical and subcortical regions.4,5 In addition to EOR, molecular and clinical variables—including patient age, preoperative performance status, and MGMT promoter methylation—have significant prognostic implications.6,7

However, large-scale analyses of surgical outcomes and complications in real-world tertiary care settings remain limited. Comprehensive evaluation of postoperative neurological function, perioperative morbidity, and survival trends can guide surgical decision-making and optimize patient counseling. This study aims to analyze the clinical outcomes, complications, and prognostic factors associated with microsurgical resection of GBM in a single tertiary neurosurgical center over a six-year period, emphasizing the relationship between EOR, functional outcomes, and overall survival.

Materials and Methods. This retrospective study included adult patients (≥18 years) who underwent microsurgical resection of newly diagnosed, histopathologically confirmed glioblastoma at a tertiary neurosurgical center between January 2018 and December 2024. Patients with recurrent GBM, biopsy-only procedures, or incomplete clinical records were excluded. Institutional review board approval was obtained, and the study was conducted in accordance with the Declaration of Helsinki. Preoperative evaluation consisted of detailed neurological examination, assessment of Karnofsky Performance Status (KPS), and neuroimaging with contrast-enhanced magnetic resonance imaging (MRI), including T1-weighted, T2/FLAIR, diffusion, and perfusion sequences. Functional MRI and diffusion tensor imaging (DTI) were utilized in selected cases to delineate language and motor pathways in tumors near eloquent brain regions. Tumor volume was measured using semi-automated volumetric analysis on T1 post-contrast images.

Surgical planning was individualized based on tumor location, size, and relation to eloquent structures. All procedures were performed under general anesthesia using standard microsurgical techniques with operating microscope and neuronavigation. Intraoperative neurophysiological monitoring, including somatosensory evoked potentials and motor evoked potentials, was applied in cases adjacent to motor pathways. Awake craniotomy with intraoperative language mapping was performed selectively for tumors in the dominant hemisphere near speech areas. The goal was maximal safe resection while preserving neurological function.

Extent of resection was determined by early postoperative MRI within 48 hours, with GTR defined as ≥95% tumor removal, subtotal resection (STR) as 70–94%, and partial resection as <70%. Postoperative neurological status was evaluated at discharge and during follow-up visits using the

KPS and detailed neurological examination. All patients received standard adjuvant therapy with fractionated radiotherapy (60 Gy in 30 fractions) combined with concurrent and adjuvant temozolomide, unless contraindicated. Follow-up included MRI every three months and clinical assessments to monitor tumor recurrence and neurological status. Statistical analysis was performed using SPSS version 27. Continuous variables are reported as mean ± standard deviation, and categorical variables as percentages. Kaplan-Meier survival analysis was used to estimate overall survival, with differences evaluated using the log-rank test. Cox proportional hazards regression identified independent prognostic factors for survival, including age, preoperative KPS, tumor volume, EOR, and postoperative neurological deficit. A p-value <0.05 was considered statistically significant.

Results. A total of 120 patients met inclusion criteria. The cohort included 72 males (60%) and 48 females (40%), with a mean age of 57 ± 12 years. Preoperative KPS ranged from 60 to 100, with a median of 80. Common presenting symptoms were headache (68%), focal motor deficits (45%), seizures (38%), and cognitive changes (22%). Tumors were predominantly located in the frontal (42%) and temporal (35%) lobes, with smaller proportions in parietal (15%) and occipital (8%) regions. The mean preoperative tumor volume was 42 ± 18 cm^3. Gross total resection was achieved in 64 patients (53%), subtotal resection in 38 patients (32%), and partial resection in 18 patients (15%). Awake craniotomy was performed in 14 patients, predominantly for dominant hemisphere tumors adjacent to Broca's or Wernicke's areas. Intraoperative neurophysiological monitoring was utilized in 58 cases. Postoperatively, new neurological deficits were observed in 21 patients (17.5%), of which 13 (10.8%) were transient and resolved within three months. Permanent deficits occurred in 8 patients (6.7%), primarily hemiparesis or aphasia in patients with tumors near motor or language areas. The overall postoperative morbidity rate was 18%, with complications including surgical site infection (3%), postoperative hemorrhage requiring reoperation (2.5%), and cerebrospinal fluid leak (1%). There were two perioperative mortalities (1.7%), both in patients with large tumors and poor preoperative functional status. Adjuvant therapy was initiated in 112 patients (93%). Median overall survival for the cohort was 15.2 months (95% CI, 13.8–16.6). Patients undergoing GTR demonstrated significantly longer survival (median 18.4 months) compared with STR (13.6 months) and partial resection (9.8 months; p<0.001). Age ≥65 years, preoperative KPS <70, and postoperative neurological deficits were independently associated with worse survival on multivariate analysis (HR 1.87, 1.54, and 1.72, respectively; p<0.05 for all). Tumor volume was also inversely correlated with survival but did not reach statistical significance in multivariate analysis.

Patients with frontal lobe tumors had a trend toward better survival compared with temporal and parietal tumors, although this did not achieve statistical significance (p=0.08). Recurrence occurred in 88 patients (73%), with a median time to progression of 7.4 months. Salvage therapy, including re-resection or stereotactic radiosurgery, was performed in 26 patients.

Discussion. This study provides a comprehensive analysis of surgical outcomes and prognostic factors in patients undergoing microsurgical resection of glioblastoma. The median overall survival of 15.2 months aligns with previous reports from tertiary centers and underscores the aggressive nature of GBM despite maximal therapy.2,3 Our findings reinforce the critical role of EOR in prognostication. Patients who achieved GTR demonstrated significantly improved survival compared with STR and partial resection, consistent with prior studies demonstrating a positive correlation between EOR and both progression-free and overall survival.4,5 This effect was particularly pronounced in patients with tumors located outside eloquent cortex, highlighting the balance between oncological radicality and functional preservation. Postoperative neurological deficits remain a significant concern, particularly in tumors adjacent to motor and language areas. In our cohort, permanent deficits occurred in 6.7% of patients, which is comparable with rates reported in contemporary literature.8,9 The use of awake craniotomy and intraoperative neurophysiological monitoring was instrumental in minimizing morbidity, particularly for eloquent region tumors. These modalities are increasingly recognized as standard adjuncts to maximize safe resection.10

Preoperative functional status, as measured by KPS, emerged as an independent prognostic factor, corroborating prior studies.6 Patients with higher baseline KPS tolerated surgery and adjuvant therapy better, resulting in longer survival. Age ≥65 years was also associated with poorer outcomes, reflecting reduced physiological reserve and potentially more aggressive tumor biology in older patients. Tumor location and volume influenced surgical strategy and functional outcomes. Frontal lobe tumors, which allowed more extensive resection with less risk to eloquent cortex, were associated with longer median survival, although this trend did not reach statistical significance. Larger tumor volumes posed technical challenges and were associated with higher rates of postoperative deficits, consistent with prior neurosurgical series.11 Perioperative morbidity and mortality in this series were low and comparable with contemporary tertiary centers, highlighting the safety of modern microsurgical techniques when combined with meticulous preoperative planning and functional monitoring.12 Complication rates were acceptable, and the majority of deficits were transient, emphasizing the importance of early rehabilitation and follow-up. This study has several limitations. Its retrospective design introduces potential selection bias, and the heterogeneity of tumor molecular profiles could not be fully accounted for due to incomplete MGMT and IDH status in earlier cases. Additionally, adjuvant therapy adherence and dose variations could influence survival outcomes. Prospective studies integrating molecular classification and advanced imaging modalities are needed to further refine prognostic models.

Conclusion. Microsurgical resection remains a cornerstone in the management of glioblastoma, with extent of resection serving as a key determinant of survival. Maximal safe resection, guided by intraoperative neurophysiological monitoring and functional mapping, optimizes oncological outcomes while preserving neurological function. Preoperative functional status and age are additional independent prognostic factors that should inform surgical decision-making and patient counseling.

Our findings support the continued emphasis on individualized surgical planning, combining advanced imaging, functional preservation strategies, and aggressive resection when feasible. Although glioblastoma remains a formidable clinical challenge, optimizing surgical outcomes and integrating adjuvant therapies can meaningfully impact patient survival and quality of life.

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