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Original Article

The Effect of After-Hours Resection on the Outcomes in Patients with High-Grade Gliomas

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ABSTRACT: ***Objective:*** The "weekend effect" is the finding that patients presenting for medical care outside of regular working hours tend to have worse outcomes. There is a paucity of literature in the neuro-oncology space exploring this effect. We investigated the extent of resection and complication rates in patients undergoing after-hours high-grade glioma resection. ***Methods:*** A retrospective review was conducted on patients with high-grade glioma requiring emergent surgery between January 1, 2021, and March 31, 2023. After hours was defined as surgical resection on the weekend and/or evening (>50% of surgical time between 1630 and 0659). These patients were matched to patients undergoing resection during regular working hours. Groups were compared on the basis of the extent of resection, postoperative complications and 6-month mortality rate. ***Results:*** A total of 38 patients were included in this study (19 after hours, 19 regular hours). There was no significant difference in age, sex, tumor grade and tumor size between the two groups (all $p > 0.05$). There was no significant difference in the extent of resection between the groups ($p = 0.7442$). There was no significant difference in the rate of intraoperative complications, postoperative complications, reoperation and death at 6 months between the groups (all $p > 0.05$). Estimated blood loss was significantly higher in the regular hours group ($p = 0.0278$). There was no significant difference in the total operative time ($p = 0.0643$) and length of stay ($p = 0.0601$). ***Conclusions:*** After-hours high-grade glioma surgery has similar outcomes to regular-hours surgery for lesions not requiring specialized functional mapping.

RÉSUMÉ : Les effets de la résection chirurgicale effectuée après des heures normales de travail sur l'évolution de l'état de santé de patients atteints de gliomes de haut grade. ***Objectif :*** On constate, quand il est question de l'« effet week-end », que les patients qui se présentent pour obtenir des soins médicaux en dehors des heures normales de travail tendent à voir leur état de santé évoluer moins favorablement. Dans le domaine de la neuro-oncologie, la littérature explorant cet effet demeure peu abondante. À ce sujet, nous nous sommes penchés sur l'étendue des interventions de résection et sur les taux de complication chez des patients ayant subi une résection de gliome de haut grade en dehors des heures normales de travail. ***Méthodes :*** Nous avons mené une étude rétrospective sur des patients atteints de gliome de haut grade nécessitant une chirurgie émergente, et ce, entre le 1er janvier 2021 et le 31 mars 2023. Une chirurgie en dehors des heures normales de travail a été définie comme une résection survenant le week-end et/ou le soir (> 50 % du temps chirurgical entre 16 h 30 et 6 h 59). Ces patients ont été jumelés à d'autres patients ayant subi une résection pendant des heures normales de travail. Ces groupes de patients ont été ensuite comparés sur la base de l'étendue de la résection, des complications postopératoires et du taux de mortalité au bout de 6 mois. ***Résultats :*** Au total, 38 patients ont été inclus dans cette étude (19 après les heures normales de travail ; 19 pendant les heures normales). Aucune différence notable entre les deux groupes n'est apparue en ce qui concerne l'âge, le sexe, le grade des tumeurs et leur taille (tous les $p > 0,05$). Il n'y a pas eu non plus de différence significative dans l'étendue de la résection entre les groupes ($p = 0,7442$). Plus encore, aucune différence significative n'a émergé entre les deux groupes en ce qui concerne le taux de complications peropératoires, de complications postopératoires, de ré-opération et de décès au bout de 6 mois (tous les $p > 0,05$). La perte de sang estimée était significativement plus élevée dans le groupe des « heures normales » ($p = 0,0278$). Enfin, nous n'avons pas relevé de différence notable dans le temps opératoire total ($p = 0,0643$) et la durée du séjour ($p = 0,0601$). ***Conclusions :*** Dans le cas de lésions ne nécessitant pas de cartographie fonctionnelle spécialisée, la chirurgie des gliomes de haut grade en dehors des heures normales de travail sous-tend une évolution de l'état des patients similaire à celle de la chirurgie effectuée pendant des heures normales de travail.

Keywords: Glioma; malignant; resection; neuro-oncology; after-hours

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Introduction

High-grade gliomas (HGG) are malignant central nervous system (CNS) tumors that present with rapid progression and portend a poor prognosis. They are divided into grade 3 and grade 4 tumors based on histological and genetic findings. They compose 25% of all CNS tumors seen in adults. The standard of care for HGG is maximal safe resection followed by radiation therapy with

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concomitant and adjuvant chemotherapy.[1] Multiple studies have demonstrated a clear benefit of near total and gross total resection compared with subtotal or partial resection.[2,3]

While most patients with gliomas undergo surgery during regular workday hours, occasionally, the surgery may occur after hours in an emergency setting. This could be due to operating room constraints, acute neurological worsening in the patient requiring rapid intervention or other logistical reasons. The significant importance of the extent of resection for these lesions, along with certain challenges of performing an operation after hours, raises questions with regard to the efficacy.[2–6]

There is ample literature that suggests there are increased rates of morbidity and mortality in patients presenting in the evening or the weekend, a term coined as the "weekend effect," which has become evident in other surgical specialties such as spine surgery, vascular surgery, transplant surgery and general surgery.[7–10] The evidence in cranial neurosurgery is conflicting, with some studies supporting this effect[4–6] while others refuting it.[11,12] A study from Texas Children's Hospital investigated the effect of weekend and after-hours surgery on the morbidity and mortality rates in pediatric neurosurgery.[5] They found that pediatric patients undergoing weekday after hours or weekend surgery were more likely to experience complications. Contrarily, a study from the University Hospital of Cologne in Germany examined the impact of the weekend effect on outcomes after clipping of ruptured intracranial aneurysms.[11] They found that overnight clipping was not independently associated with poor outcomes. In neurosurgery, factors such as surgeon fatigue, operating room staffing and reduced availability of neurosurgery residents/staff during on-call hours may be contributors to the "weekend effect."[5,13–16]

There is limited research on the impact of this effect on neurosurgical patients undergoing resection for HGG. The primary objective of this study is to evaluate the effect of surgical timing on the outcomes for patients with HGG undergoing resection, with a focus on safety and efficacy.

Methods

We undertook a retrospective review of the neurosurgical database at Vancouver General Hospital. A total of 103 patients presented urgently and underwent surgery for HGG between January 1, 2021, and March 31, 2023. A comprehensive review of clinical records and surgical reports was performed, and patients were categorized into two groups according to the timing of management of their lesion. Group A underwent operative intervention after hours, while Group B underwent operative intervention during regular operating room working hours. The inclusion criteria for Group A were as follows: (1) after hours, (2) emergent presentation and (3) craniotomy for tumor resection. Craniotomies for biopsy only were excluded. For patients in each category, we analyzed the tumor characteristics, clinical presentation, treatment results and complication profile. The following variables were evaluated: the extent of resection, operative time, estimated blood loss, length of stay, intraoperative complications, postoperative complications, reoperation within 30 days, postoperative Eastern Cooperative Oncology Group (ECOG) performance status and 6-month mortality rates.

Surgical timing was characterized according to the standard booking requirements at the institution at which the study was undertaken. After hours (Group A) was defined as >50% of the surgical time between 1630 h and 0659 h or surgery conducted on the weekend. Regular hours (Group B) was defined as Monday through Friday with ≥50% surgical time between 0700 h and 1629 h. Operative room timing from the surgical reports was used to classify skin-to-skin time.

Table 1. Baseline patient and tumor characteristics

	Group A ($n = 19$)	Group B ($n = 19$)	p-value
Male (%)	16 (84.2)	14 (73.7)	0.426
Mean age, years (SD)	57.7 (13.6)	60.2 (10.0)	0.535
Presenting Karnofsky performance status, mean	81.5	77.9	0.578
Glasgow coma scale ≤ 8 on presentation (%)	1 (5.3)	2 (10.5)	0.547
Neurological deficits on presentation (%)	11 (57.9)	12 (63.2)	0.740
Neuro-oncology trained surgeon (%)	9 (47.4)	6 (31.6)	0.319
WHO grade			1.0
Grade IV (%)	18 (94.7)	18 (94.7)	
Grade III (%)	1 (5.3)	1 (5.3)	
1D tumor size, cm (SD)	4.55 (1.57)	4.85 (1.35)	0.524
3D tumor size, cm^3 (SD)	36.5 (28.2)	48.6 (39.4)	0.352
Eloquent tumor location (%)	10 (52.6)	9 (47.4)	0.746
Recurrent (%)	2 (10.5)	2 (10.5)	1.0

Baseline characteristics were collected for all patients. This included age, sex, presenting neurological status (Karnofsky performance status [KPS], neurological deficits), tumor grade, tumor size, tumor volume, tumor location and recurrence status. The tumor volume was approximated by the formula (CC × TR × AP/2), where craniocaudal (CC), transverse (TR) and anteroposterior (AP) dimensions were analyzed.[17] Eloquent tumor location was defined as including the following areas: sensorimotor cortex, internal capsule, basal ganglia, language centers, visual pathways, corpus callosum, thalamus, brainstem, deep cerebellar nuclei and cerebellar peduncles.[17,18]

Patients in Group A were matched to Group B (matched pairs). Patients were first isolated based on procedure type, tumor grade and recurrence status. Patients were then grouped based on age and tumor size, and statistical analysis was performed to ensure there were no differences between them for discrete variables ($p < 0.05$).

The use of surgical adjuncts was recorded for all procedures. Surgical adjuncts included neuronavigation, 5-aminolevulinic acid (5-ALA), intraoperative neurophysiological monitoring and intraoperative ultrasound. Our center does not have access to intraoperative MRI. Additionally, cases completed by staff surgeons with training in neurosurgical oncology were recorded.

The extent of resection was divided into three groups: gross total resection (GTR), near total resection (NTR) and partial resection (PR), based on postoperative imaging evaluated by a neuro-radiologist and confirmed by the senior neurosurgeon (SM). GTR was defined as no enhancing residual lesion on postoperative CT scan or MRI. NTR was defined as residual limited to resection margins (residual volume < 5%), while PR was defined as significant residual (residual volume ≥ 5%).

Complications were determined via detailed chart review and separated into intraoperative and postoperative periods.

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Table 2. Comparison of surgical adjunct usage

	Group A ($n = 19$)	Group B ($n = 19$)	*p*-value
Procedures with surgical adjunct (%)	16 (84.2)	13 (68.4)	0.252
Multiple adjuncts used (%)	3 (15.8)	5 (26.3)	0.426
(a) Neuronavigation (%)	16 (84.2)	13 (68.4)	
(b) 5-Aminolevulinic acid (%)	2 (10.5)	4 (21.1)	
(c) Neurophysiological monitoring (%)	0 (0)	2 (10.5)	
(d) Intraoperative ultrasound (%)	1 (5.3)	0 (0)	

Table 4. Comparison of outcomes in after-hours group and the regular-hours group (numerical variables)

	Group A ($n = 19$)	Group B ($n = 19$)	*p*-value
Estimated blood loss, mean mL (SD)	123.7 (69.5)	205.3 (112.9)	0.0278
Operative time, mean min (SD)	136.9 (29.9)	174.3 (72.7)	0.0643
Length of stay, median days (SD)	5 (11.0)	3 (2.0)	0.0601
Eastern Cooperative Oncology Group (ECOG) score, median (SD)	1 (1.0)	1 (0.7)	0.3953

Table 3. Comparison of outcomes in after-hours group and the regular-hours group (categorical variables)

	Group A ($n = 19$)	Group B ($n = 19$)	*p*-value
Gross total resection (%)	5 (26.3)	2 (10.5)	0.2093
Gross total/near total resection (%)	9 (47.4)	8 (42.1)	0.7442
Intraoperative complications (%)	0 (0)	0 (0)	1.0
Postoperative complications (%)	4 (21.1)	4 (21.1)	1.0
a) New neurological deficit (%)	3 (15.8)	1 (5.3)	
b) Seizures (%)	0 (0)	2 (10.5)	
c) Deep vein thrombosis (%)	1 (5.3)	0 (0)	
d) Death (%)	0 (0)	1 (5.3)	
Reoperation in 30 days (%)	0 (0)	1 (5.3)	0.3109
Death within 6 months (%)	2 (10.5)	3 (15.8)	0.6315

Intraoperative complications were defined as vascular injury, the requirement for postoperative mechanical ventilation, intraoperative seizures and the surgeon's decision to abort the operation due to safety concerns. Postoperative complications included infection, wound dehiscence, postoperative hemorrhage, new neurological deficits, seizures, venous thrombosis, pulmonary embolism, myocardial infarction, stroke and death during admission. Length of stay was defined as time from surgery to day of discharge from hospital. The ECOG performance status was determined at the standard 6-week follow-up visit with oncology.

Patients were stratified into the regular-hours and after-hours groups based on their surgical time. Numerical variables were expressed as mean or median and standard deviation and tested for Gaussian distribution using the Shapiro–Wilk test. Groups were compared using two-tailed unpaired Student's *t*-test (Gaussian distribution) or Mann–Whitney *U* test (non-Gaussian distribution). Categorical variables were expressed as percentages and analyzed using the Chi-square test. Significance was set to $p < 0.05$.

Results

A total of 19 patients met our inclusion criteria for Group A and were matched to 19 patients in Group B. There were 10 patients who underwent evening procedures (1630 h–0659 h on Monday to Friday), 7 patients who underwent weekend procedures and 2 patients who underwent surgery on a weekend evening (1630 h–0659 h on the weekend). Two patients in Group A underwent a procedure that began prior to 1630 h. There was no significant difference in baseline patient characteristics (84.2% patients vs. 73.7% male patients; $p = 0.426$, mean age 57.7 vs. 60.2 years; $p = 0.535$), neurological status on presentation (mean presenting KPS 81.5 vs. 77.9; $p = 0.578$, frequency of neurological deficits 57.9% vs. 63.2%; $p = 0.740$), maximal tumor size (4.55 vs. 4.85 cm;
$p = 0.524$), tumor volume (36.5 vs. 48.6 cm[3]; $p = 0.352$) or frequency of eloquent tumor location (52.6% vs. 47.4%; $p = 0.746$) in Group A vs. Group B, respectively (Table 1). There was no difference in the number of cases completed by an oncology fellowship-trained neurosurgeon between the two groups (47.4% vs. 31.6%; $p = 0.319$) (Table 1). There was also no significant difference in the frequency of surgical adjunct use in Group A versus B (84.3% vs. 68.4%; $p = 0.252$) (Table 2). Group B utilized intraoperative monitoring in two patients (10.6%), while there was no use of intraoperative monitoring in Group A.

There was no significant difference in the rate of GTR between Group A and Group B (26.3% vs. 10.5%; $p = 0.2093$). There were no intraoperative complications in either group and no difference in the frequency of postoperative complications between the two groups (21.1% vs. 21.1%; $p = 1.0$). The death rate within 6 months was 10.5% and 15.8% in Group A and Group B, respectively ($p = 0.6315$). These outcomes are listed in Table 3.

Estimated blood loss (milliliters) was lower in Group A (123.7 vs. 205.3 mL; $p = 0.0278$). The operative time (minutes) trended toward being lower in Group A (136.9 vs. 174.3 min; $p = 0.0643$). Additionally, the length of stay trended toward being longer in Group A (5 vs. 3 days; $p = 0.0601$). There was no significant difference in ECOG score at 6-week follow-up between the two groups (1 vs. 1; $p = 0.395$) (Table 4).

Discussion

To our knowledge, this is the first study investigating outcomes in patients undergoing craniotomy for resection of HGG after hours. Our study supplements other investigations on this topic in neurosurgery, specifically, the landmark study by Desai et al. on after-hours pediatric neurosurgical procedures demonstrating increased risk of complications[5], as well as investigations into after-hours aneurysm clipping with similar findings.[11]

There are several factors that may theoretically lead to worse outcomes for after-hours procedures. Surgeon-specific factors include general mood, cognitive fatigue and sleep deprivation[13,14] although prior work has demonstrated sleep deprivation has little impact on surgeon performance.[15,20] After-hours procedures are

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more likely to involve nursing staff who are not trained or extensively familiar with complex neurosurgical procedures. At our institution specifically, surgical staff for procedures performed on weekends or after hours belong to the general work schedule and may or may not have specialty training in neurosurgical oncology. Furthermore, as with any institution, there are fewer residents and staff neurosurgeons present after hours to assist in technically challenging cases. Although these factors exist, they do not appear to significantly influence outcomes for patients undergoing after-hours glioma surgery.

We did not demonstrate that after-hours surgery was associated with increased morbidity or mortality in our cohort, nor was there a difference in the extent of resection between the two groups. Neurosurgeon surgical expertise and protocol-driven standard of care may override the potential impact of other negative factors related to staffing as discussed above.

The overall complication rate in this study (21.1%) was comparable to rates reported in previously published studies focusing on HGG resections with no significant difference between the two cohorts.[21,22] Lastly, there was no difference in 30-day reoperation rate, 6-month mortality or functional outcomes between the two groups.

Interestingly, after-hours procedures had lower blood loss than those done during regular hours without a statistically significant difference in surgical time. This could be due to reduced learner involvement as neurosurgeons may be less likely to have senior surgical trainees assisting them at our institution.[23] Additionally, complex resections are deferred to electively scheduled slates, such as those requiring awake language mapping, neurostimulation or other adjuncts such as 5-ALA. Length of stay was longer in after-hours patients, but this did not reach statistical significance and is likely reflective of the overall neurological and medical status of these patients that necessitated urgent surgical intervention.

Limitations

The present study was a retrospective review of the outcomes in a moderate-sized cohort of patients in a single institution with a culture that favors daytime surgery, limiting its generalizability. The availability of surgical staff and access to resources, such as daytime operating room availability and call coverage, introduced a degree of selection bias. Furthermore, recent institutional disruptions such as the COVID-19 pandemic and transition from paper to electronic charting systems limited the data range for our study in attempts to minimize confounding factors.

Tumors within eloquent regions were not all of equal complexity as certain eloquent regions (e.g., motor cortex) require more conservative approaches than others (e.g., sensory cortex, corpus callosum). There are inherent institutional variations in philosophy and approaches to lesions near eloquent brain tissue, where the extent of resection may be guided by individual tolerance for the specific neurological deficits.

Furthermore, considering the impact of extensive resources needed for functional intraoperative monitoring or awake surgeries, these complex cases were performed during regular hours, highlighting that the sample size would be limited in capturing differences in these populations.

Conclusions

HGG patients often have a poor prognosis; thus; achieving maximally safe resection and avoiding complications is key. We demonstrate in our study that patients undergoing craniotomy and tumor resection after hours do not have increased morbidity or mortality, nor is there a meaningful impact on the extent of resection or complication rates. This is likely due to strict adherence to established surgical plans and standardized perioperative care. This study provides additional insight into the consideration of surgical timing in the management of patients undergoing surgical intervention for HGG.

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Author contributions. KD: data collection, data analysis and interpretation, statistical analysis, drafting article, revising article, reviewing final version.

MR: conception and design, data analysis and interpretation, statistical analysis, revising article, reviewing final version.

MF: conception and design, data analysis and interpretation, statistical analysis, revising article, reviewing final version.

SM: study supervision, conception and design, data analysis and interpretation, statistical analysis, revising article, reviewing final version.

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