



Same-day discharge after brain tumor resection: a prospective pilot study

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Abstract

Purpose Outpatient brain surgery has many advantages for the psychological and physical wellbeing of patients, as well as reduced costs to the health care system. Compared with inpatient admissions, same day discharges reduce patient exposure to nosocomial infection, thromboembolic complications, and medical error. We aim to establish a prospectively collected quality outcomes database to examine the outcomes of patients that undergo brain tumor resection and are discharged home the same day as surgery.

Methods We have established a prospectively collected quality outcomes database to examine the outcomes of all patients that underwent brain tumor resection by a single neurosurgeon (R.J.K) at our institution from August 2020 to August 2021 and were discharged home the same day as surgery.

Results Over the one-year period this study was conducted, 37 of 334 patients met inclusion criteria for the outpatient protocol. Thirty-two patients were discharged on the same day as surgery. Five patients (14%) were considered eligible for outpatient surgery but were ultimately admitted to the hospital postoperatively and were discharged after an overnight observation. No postoperative complications were noted at two-week postoperative follow-up.

Conclusion In select patients undergoing brain tumor surgery, same day discharge should be considered. Establishing a multidisciplinary team of physicians, nurses, radiologists, and physical therapists is critical to achieving this aim. Physicians should have a low threshold to admit a patient with concerning exam findings, complications, or complicated past medical history. Once discharged, open communication with the patient and their family is critical to detect complications that should trigger rehospitalization and intervention.

Keywords Brain tumor · Neuro-oncology · Neurosurgical outcomes · Outpatient craniotomy · Same-day discharge

Introduction

Cranial neurosurgery confers psychological stress due to the perceived invasiveness of the procedures, as well as the stress of being in the hospital rather than at home on one's preferred surroundings [1]. Hospitalization also confers risks such as hospital acquired infections, medical errors, and deep tissue injuries such as pressure ulcerations. Because of the risks associated with long postsurgical inpatient hospitalizations, some neurosurgeons have challenged the standard

practice of admitting all postoperative patients for at least one-night following craniotomy for observation in order to attempt to progressively reduce the time patients must spend inpatient without sacrificing safety.

Previous retrospective studies on same-day discharge have shown this practice to be safe, effective, and beneficial for certain patients [2–6]. These findings, led by the University of Toronto, assert that outpatient craniotomy is safe in neuro-oncology patients who had supra-tentorial tumors resected or biopsied. Following a similar approach, we conducted the first prospective study in the United States to establish a quality outcomes database examining the outcomes of patients that undergo brain tumor surgery and are discharged home the same day as surgery. We posit that, with proper patient selection, same-day discharge is safe and can improve patient flow through our neurosurgical service

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due to more effective allocation of postoperative inpatient resources. Here, we report the results of a pilot study prospectively evaluating outpatient brain tumor resection in a series of 37 selected patients treated over one year at our institution.

Methods

Study population

The University of Miami institutional review board approved the present study (protocol #20201078). A prospective quality intervention study including patients who underwent outpatient surgery for brain tumors by a single neurosurgeon (R.J.K) at the University of Miami from August 2020 to August 2021 was performed. Complete demographic, anatomic, and clinical data were collected prospectively for each patient from their inpatient admission, clinic follow-up, and any readmission records. Hospital readmissions were classified as very early (1–3 days after the surgery) and early (4–30 days after the surgery). The electronic medical records, operative notes, radiographic films, and final pathology reports were also reviewed. This study was adherent to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) criteria.

Inclusion criteria for outpatient surgery

We considered eligible for outpatient surgery all patients between 16 and 85 years of age, with an American Society of Anesthesiologists (ASA Score) physical status classification system ≤ 4 and a Karnofsky Performance Score ≥ 70 , who were undergoing craniotomy for suspected supratentorial brain tumor at the University of Miami Hospital. Additional inclusion criteria included tumors with a maximum diameter of 4 cm, surgeries with predicted blood loss of less than 300 ml, and a predicted maximum surgery length of less than 3 h. Both surgeries under general endotracheal anesthesia and awake surgeries utilizing monitored anesthesia care were considered eligible. All eligible patients were reviewed by the attending neurosurgeon to determine if a patient was expected to be ready for safe discharge home the same day as surgery (Fig. 1). Attending neurosurgeons remained able to modify their decision at any moment and admit the patient if it was considered necessary by clinical judgement. Patients must give informed consent to be included in the study. This study was conducted in accordance with IRB requirements with the intention of collecting prospective data for this pilot study.

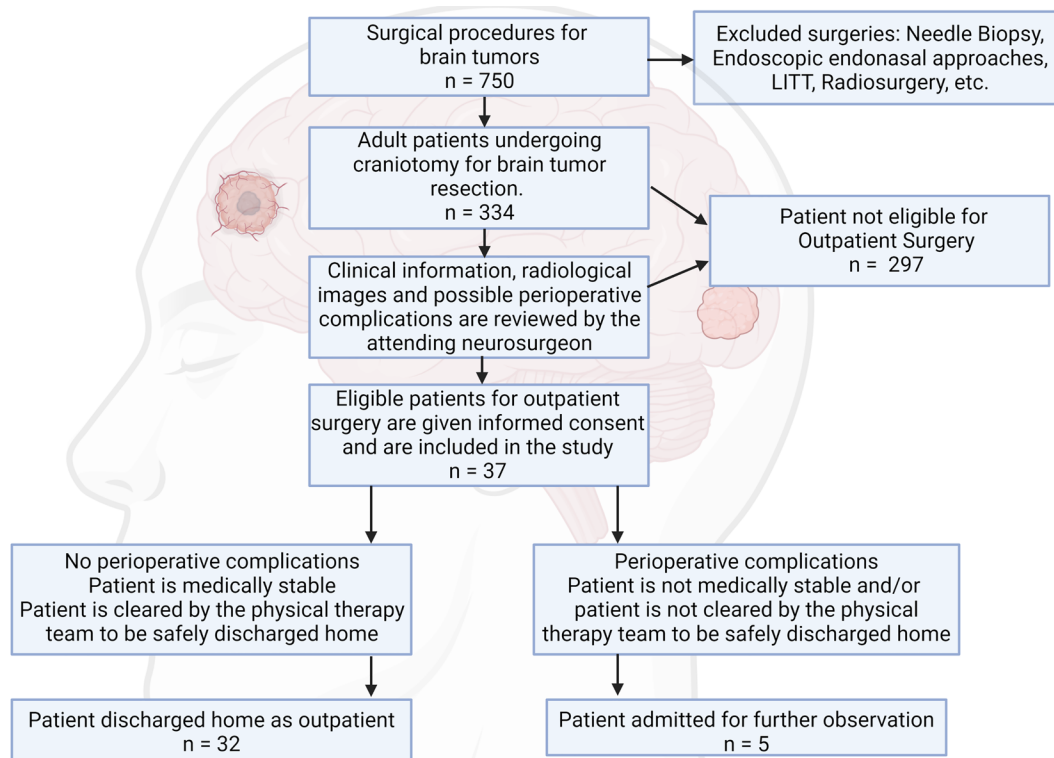


Fig. 1 Outpatient surgery protocol and patients included from August 2020 to August 2021

Exclusion criteria

Individuals with lesions carrying a higher risk of surgical morbidity as infratentorial or intraventricular tumors were not included in the outpatient protocol. Also, patients with a Body Mass Index (BMI) of more than 35 kg/m², limited home support, pituitary or skull base tumors, or requiring CSF diversion were not considered eligible for outpatient surgery. Surgeries were planned to start prior to 8:30 AM in order to qualify for same-day discharge.

Admission and pre-op clearance

Patients were admitted the evening before surgery to get pre-op clearance and a contrast-enhanced fiducial MRI.

Postoperative monitoring

After surgery, patients who underwent tumor resection were observed for 3 h in the Post-anesthesia Care Unit (PACU), followed by a contrast-enhanced MRI. Once the MRI was acquired, the patient was monitored in the NeuroICU for an additional 3 h. In all patients, the minimum observation period was 6 h after surgery.

Discharge and follow-up

Patients were deemed safe for discharge when they were hemodynamically stable, had been cleared by physical and occupational therapy, had completed postoperative imaging without any concerning neurosurgical findings, and had passed a complete neurological assessment. To be medically clear for discharge, patients had to be afebrile, have no issue with their surgical incision, and adequate pain-management had to be obtained. The goal of physical and occupational therapy was to ensure patients were able to eat, drink, and walk without assistance prior to discharge.

The attending neurosurgeon determined if a patient was safe to discharge home on the same day as surgery, or if the patient would be admitted to the hospital. If there was any concern about the patient’s medical status, or if the physical therapy team did not clear the patient for safe discharge home, the patient was admitted to the hospital. All patients voluntarily consented for this study and the priority of the team was to ensure each patient felt safe and secure with the discharge plan. As such, if a patient were to feel more secure leaving after overnight inpatient-monitoring, this decision would be reached collaboratively putting the patient’s well-being first. Patients were seen two weeks postoperatively in outpatient clinic for routine follow-up (Fig. 2).

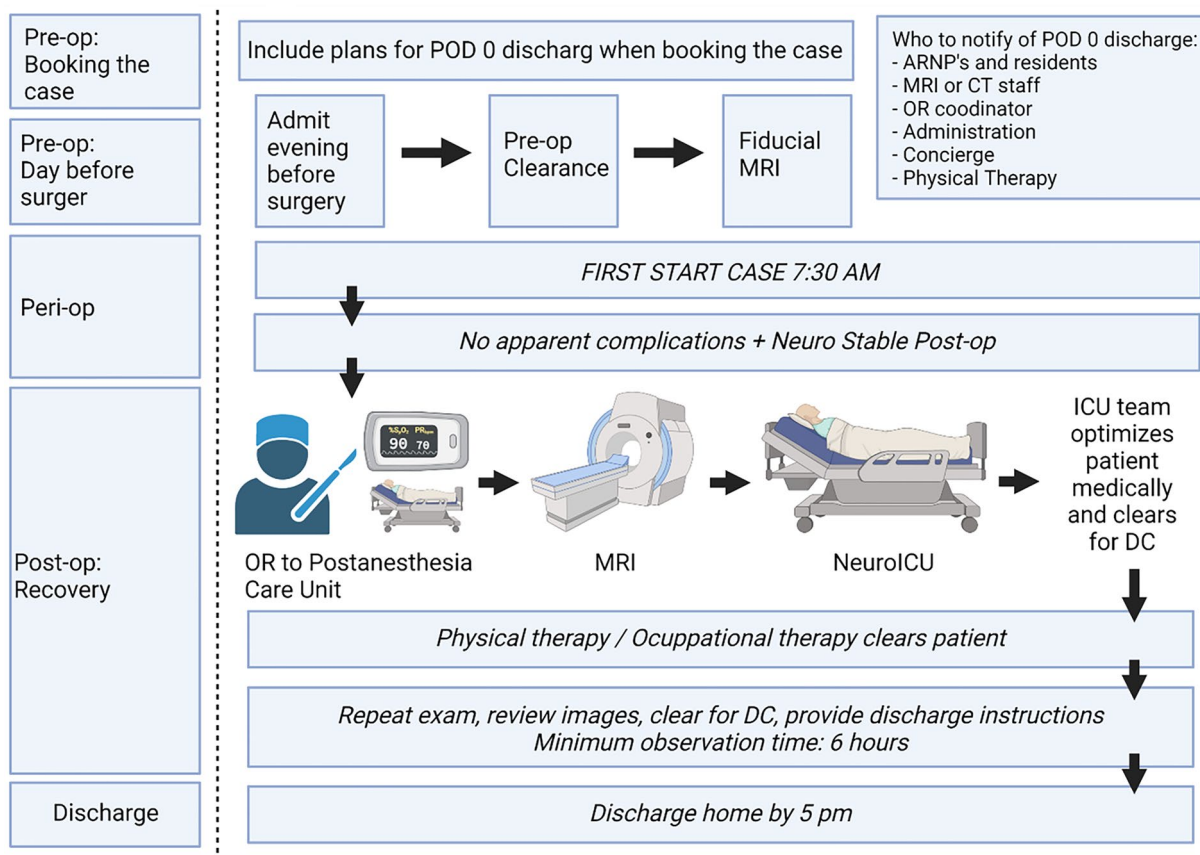


Fig. 2 Flow Chart describing outpatient management in brain tumor resection and brain tumor biopsy

Statistical analysis

All statistical analysis was performed with IBM SPSS v26.0 (IBM, Armonk, NY) at an alpha value of 0.05. A qualitative and quantitative comparison between discharged and admitted patients was performed. Ordinal variables were compared using a Mann–Whitney U test with two-sided and one-sided comparisons and exact significance values corrected for ties reported. Nominal variables were compared using a Fisher Exact Test. Lastly, continuous variables were compared using independent samples t-test. Figures were created with Biorender.com.

Results

Thirty-seven consecutive brain tumor patients who had surgical interventions over a one year period between August of 2020 and August of 2021 were included in this study (Table 1). The median patient-age was 52 years with 32% (12/37) of patients being male and 68% (25/37) being female. Frontal-lobe lesions accounted for 49% (18/37) of the surgeries, 27% (10/37) located in the temporal region, 14% (5/37) in the parietal region, 5% (2/37) in the occipital region, and multiple locations in 5% (2/37). Additionally, 70% (26/37) of tumors were primary lesions whereas 30% (11/37) tumors exhibited pathology indicative of metastatic disease. All tumors operated on in this study were supratentorial lesions and all operations were performed without complications. Anesthesia was administered as part of an awake procedure in seven patients (19%), with the rest receiving standard general anesthesia (81%). The average BMI across all patients was 25.80 kg/m² (17.4–32.24), while ASA score was 1 in one patient (3%), 2 in fifteen patients (41%), 3 in twenty-one (56%). Lastly, the median tumor volume resected across the thirty-seven patient cohort was 3.48 mL, with a mean tumor volume of 4.58 mL (0.033–23.65) (Fig. 3).

Of the 37 patients who were included in the study, 32 (86%) patients were discharged on the same day of surgery (Table 2). Five of the thirty-seven (14%) of the patients who underwent open tumor resection were not deemed to be eligible for same day discharge. One of the patients remained in the hospital an additional night due to lack of social support. The remaining four patients had to be admitted for heightened postoperative monitoring. All four patients admitted were successfully discharged 24 h after the surgery. The rationale behind further inpatient monitoring in these cases was because one patient with known epilepsy had presented with a generalized seizure prior to surgery, one patient with post-operative headache, unsteadiness in another patient, and severe postoperative abdominal discomfort in the last.

Table 1 Characteristics of the patients included

Variable	No. (%)
<i>Total no. of patients</i>	37 (100%)
Female	25 (68%)
Male	12 (32%)
<i>Median age in years, range</i>	
All patients	52, 18–81
Female	53, 21–81
Male	49, 18–75
Diabetes	3 (8%)
<i>Tumor location</i>	
Frontal	18 (49%)
Temporal	10 (27%)
Parietal	5 (14%)
Occipital	2 (5%)
Multiple	2 (5%)
<i>Diagnosis</i>	
Meningioma	14 (38%)
Metastatic disease	11 (30%)
Cavernoma	2 (5%)
Glioblastoma	1 (3%)
Osteoblastoma	1 (3%)
Langerhans Cell Histiocytosis	1 (3%)
Benign Hemangioma	1 (3%)
Inflammatory Process	1 (3%)
SMART	1 (3%)
Radiation necrosis	1 (3%)
Grade III Glioma	1 (3%)
Lipoma	1 (3%)
Cortical Dysplasia	1 (3%)
<i>Anesthesia</i>	
General	30 (81%)
Awake	7 (19%)
<i>BMI in kg/m²</i>	
Median	24.82
Range	17.4–32.24
<i>ASA Score</i>	
1	1 (3%)
2	15 (41%)
3	21 (56%)
<i>Karnofsky Performance Score</i>	
Median	90
Range	70–100
<i>Resected tumor volume in mL</i>	
Mean	4.58
Median	3.48
Range	.033–23.65

Very early hospital readmissions (1–3 days after the surgery) were not seen in any of the patients. Early readmissions (4–30 days after the surgery) occurred in 4 patients.

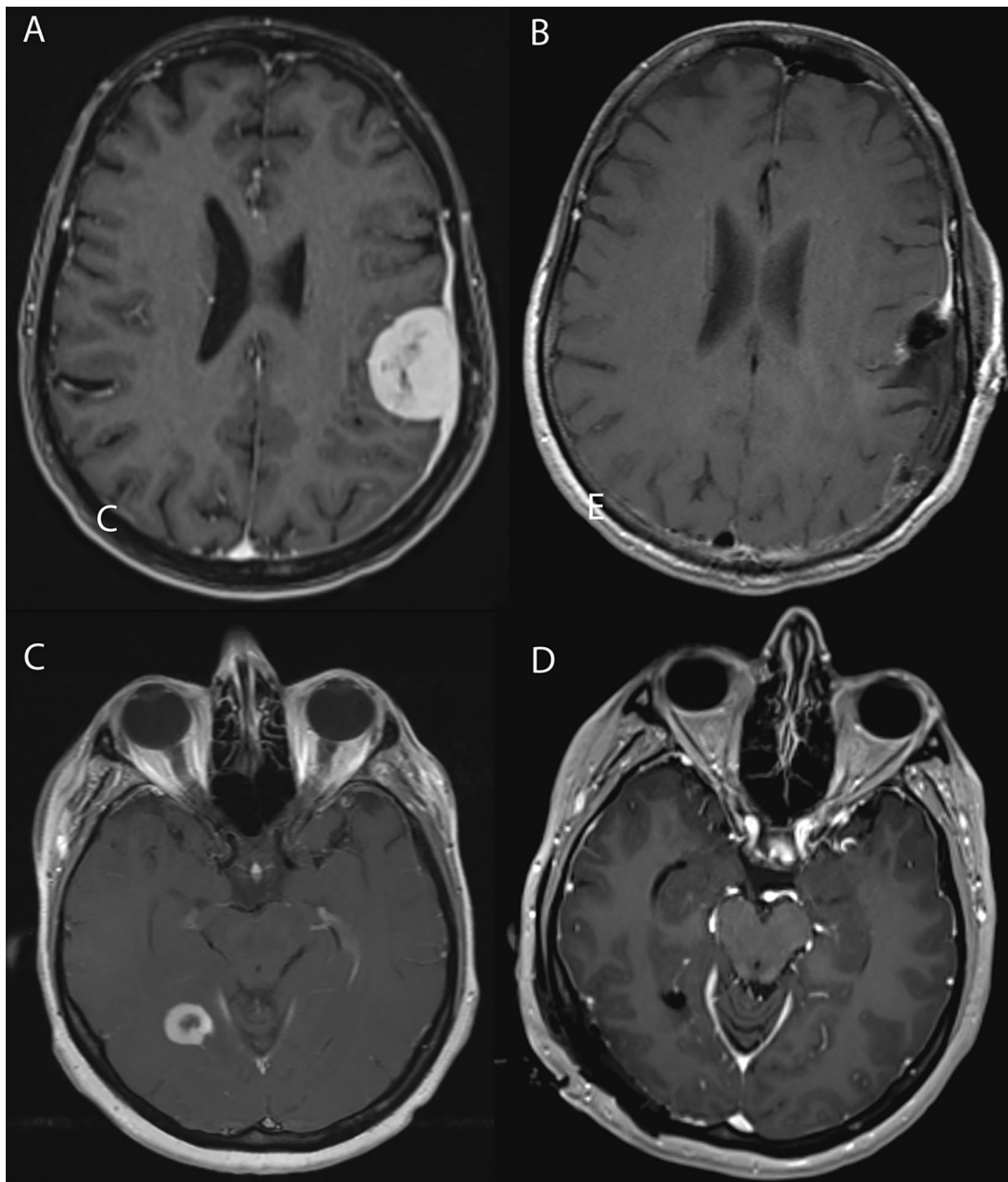


Fig. 3 Pre-operative and post-operative images of patients who underwent surgical resection of a brain tumor. The first patient (**A**, **B**) is a 73 year old female who underwent gross total resection of a WHO Grade 1 meningioma, measuring $3 \times 3.4 \times 3.4$ cm. The second patient (**C**, **D**) is a 45 y.o. female with a history of breast cancer pre-

senting with a solitary metastasis, completing her adjuvant treatment with chemotherapy and stereotactic radiosurgery after gross total resection. The patients were medically stable and were discharged home after being cleared using our protocol (Fig. 2)

The cause of the readmission was related to the perioperative course in one patient, as he presented with hypotension nine days after surgery and was diagnosed with acute adrenal insufficiency. For the other three patients, the cause of the readmission was not related to the surgery. One readmission was due to seizures in another patient who was epileptic prior to surgery. Another was due to abdominal pain and constipation. The final readmission was due to back pain in

the setting of spinal metastases. All patients readmitted were discharged successfully after adequate care.

Analysis of quantitative variables

A comparison of quantitative variables of age, body-mass index (BMI), and pre-operative KPS and ASA between patients discharged on the same day versus patients later admitted postoperatively was performed. Age was the only

Table 2 Outcomes after surgery

	No. (%)
Discharged as outpatient	32(86%)
Discharged on postoperative day 1	5 (14%)
Hospital readmissions (1–30 days postop.)	
Immediate (1–3 days postop.)	1 (0%)
Early (4–30 days postop.)	4 (100%)

variable that was statistically significantly different between patients discharged on POD0 and patients later admitted. Patients that were discharged on the same day were significantly younger than patients later admitted (50.2 vs. 66.2 yo, $p=0.042$). There was no significant difference in BMI or preoperative KPS and ASA between same-day discharge and later admission ($p=0.643$, $p=0.111$, $p=0.259$).

Analysis of qualitative variables

On Fisher Exact Test, emergency room (ER) visit and consultation was trended towards an association with increased rates of hospital admission ($p=0.080$). Forty percent of patients with ER visit were later admitted whereas only two percent of patients that were discharged on POD0 had a prior ER visit. There was no significant association on Fisher Exact Test between same day discharge and gender, history of diabetes or sleep apnea, type of intraoperative anesthesia, or incidence of post-operative neurologic or systemic complications ($p>0.05$). Summary statistics may be reviewed in Table 3.

Discussion

We previously published our institutional experience with discharging patients on postoperative day one (POD1) after craniotomy for brain tumors [7]. We compared complication and readmission rates between patients discharged on POD1 and those with longer stays, as well as predictive factors of successful POD1 discharge. Of patients with > 1 day of hospital stay, 4.4% experienced a deep-vein thrombosis (DVT) or pulmonary embolism (PE) and 2.7% experienced urinary tract infection (UTI). In contrast, patients discharged on POD1 experienced no DVTs, PEs, or UTIs and had significantly lower 30-day rates of readmission to the hospital. Patients discharged on POD1 had significantly better scores on both the Karnofsky performance scale and the modified Rankin scale ($P<0.0001$ for both). Multivariate regression analysis revealed several patient, tumor, and operative factors which were independent predictors of successful discharge on POD1. These factors included: lower modified frailty index score, male sex, right sided tumors, supratentorial tumors, smaller tumor diameter, and awake surgery.

Conversely, patients with tumors located in the posterior fossa, the use of general endotracheal anesthesia, and cerebrospinal fluid drain placement were associated with longer inpatient stays.

Given our consistent positive patient-experience with POD1 discharge, we aimed to extend this opportunity to same-day-discharge (POD0) and prospectively confirm its feasibility in our brain tumor population. Outpatient craniotomy has not been shown to increase morbidity in patients who received either monitored or general anesthesia for their operations [6, 8, 9]. Although spending a night in the hospital before the procedure is contrary to the concept of ambulatory surgery, there is data showing that patients who are admitted on the same day as surgery have a higher stress level (measured by preoperative heart rate and skin conductance), compared to patients admitted the evening prior [10]. Having additional time available before surgery for preparation at a slower pace may have a calming effect on patients [10]. Patients discharged on POD0 have reported high levels of satisfaction, as avoiding an overnight stay in the hospital may lessen some of the psychological stress accompanying brain tumor resection [11]. Outpatient tumor resection may be beneficial on three fronts: optimizing bed-usage for patients who need more aggressive surveillance, decreasing hospital-related complications, thus preventing avoidable postoperative readmissions and driving down costs, and reducing potential cancellations due to a paucity of available beds. Additionally, high-volume surgical centers with same-day imaging capabilities may particularly benefit from implementing same-day discharge at their institutions when there are limited ICU beds available during SARS-CoV-2 or influenza surges.

Whereas same-day discharge for neuro-endovascular treatment of unruptured aneurysms and both minimally invasive cervical and lumbar spinal surgery is commonplace in modern practice, adopting regular outpatient brain surgery has been met with more resistance and apprehension [12–15]. Other surgical procedures across multiple disciplines, which historically admitted patients after the operation, have also found that same-day discharge is a safe and viable option [16, 17]. Regarding awake craniotomy, surgeons have been able to greatly reduce complications by avoiding eloquent regions with intra-operative stimulation under local, less aggressive sedation [18, 19]. General anesthesia does not preclude the possibility of same-day discharge and patients should be considered on a case-by-case basis [6].

Safe outpatient brain surgery is heavily dependent on appropriate patient selection. Between August 2020 and August 2021, the senior author (R.J.K.) performed 334 craniotomies for brain tumors. From that population, only 37 patients were eligible for outpatient management, showing

Table 3 Summary statistics for patient cohort

Variable	Discharged ($\mu \pm$ S.D.)	Admitted ($\mu \pm$ S.D.)	P-value
Age	50.2 \pm 16.3	66.2 \pm 9.9	.042
Variable	Discharged n (%)	Admitted n (%)	P-value
<i>Gender</i>			
Female	22 (68.8)	3 (60)	1.000
Male	10 (31.2)	2 (40)	
<i>Diabetes</i>			
No	30 (93.8)	4 (80)	.362
Yes	2 (6.2)	1 (20)	
<i>Anesthesia</i>			
Awake	7 (21.9)	0 (0)	.560
General	25 (78.1)	5 (100)	
<i>Sleep apnea</i>			
No	30 (93.8)	4 (80)	.362
Yes	2 (6.2)	1 (20)	
<i>ER visit</i>			
No	30 (93.8)	3 (60)	.080
Yes	2 (6.2)	2 (40)	
<i>Neurologic complications</i>			
No	32 (100)	5 (100)	–
Yes	0 (0)	0 (0)	
<i>Systemic complications</i>			
No	31 (96.9)	5 (100)	1.000
Yes	1 (3.1)	0 (0)	
Variable	Discharged (mean rank)	Admitted (mean rank)	P-value
KPS	20	12.4	.111
ASA	18.3	23.4	.259

that even in a high-volume brain tumor practice nearly 90% of the patients still need to be admitted to the hospital.

In our series, 86% (32/37) of the patients were successfully discharged on POD0 with a 30-day surgery-related readmission of 3% (1/37) and no complications. In their series, the University of Toronto published similar results, ranging between 86–94% of successful discharge rate, with 5–11% of complications [2, 3, 6, 20, 21].

Although complications are rare, they tend to present within hours of the operation rather than days. For example, intracranial neurosurgical procedures have been shown to typically elicit postoperative hematoma within 6 h of surgery [22]. In a recent study of 200 consecutive elective craniotomy patients, 4 h of postoperative monitoring in the PACU was found to be a sufficient amount of time before safely moving the patient to a neurosurgical step-down unit [23].

Outpatient brain surgery in select cases is not only safe, but also can increase patient quality of life. Reducing length of hospital stay after resection enables patients to get back to

their homes and families, allowing them to return to a sense of normalcy more quickly. Patient's perception of their individual healing processes heavily depends on "being cared for, being comfortable, and experiencing something familiar or like home," which may be part of the reason why outpatient brain surgery has very positive feedback and high levels of satisfaction [11, 24]. Oftentimes, patients are confronted with psychological and physical stress associated not only with their neuro-oncological pathology, but also due to the financial burden that often accompanies highly specialized surgical interventions.

The fear of legal repercussions after rare complications secondary to early discharge both in the United States and around the world may be one factor deterring cranial surgeons from more openly adopting outpatient craniotomy in their practices as they threaten to undo the financial benefits that incentivize same-day discharge on an institutional level [25]. This emphasizes the critical role attending neurosurgeons play in selecting appropriate patients for which they believe same-day discharge will increase patient outcome

and quality of care. On the contrary, the increase in cost-effectiveness and limitation of resource expenditures may actually directly enable neurosurgical care previously not possible in underserved parts of the world [26]. Given sufficient resources, transportation, and access to appropriate medication, certain areas of the developing world may entertain surgical intervention for eligible candidates which they may not previously have been able to operate on given cost and resource restraints. This being said, physicians in the United States and other countries should have a low threshold to admit a patient with concerning exam findings, complications, or complicated past medical history.

Limitations

We identified age as a variable positively associated with later hospital admission. Patients who visited the ER for consultation trended towards a greater likelihood of postoperative admission but this was not statistically significant. In regards to these findings, our study was of only moderate sample size and may have been underpowered to identify other significant associations should they exist. Ultimately, we believe the data garnered from this preliminary proof-of-principle study warrants further investigation in larger, prospective cohort trials.

Conclusions

With appropriate selection and postoperative monitoring, same day discharge can be considered a safe and feasible option for certain craniotomy cases. Outpatient brain surgery has been shown to be a safe and effective method for postoperative management while optimizing flow through the neurosurgical service by allocating resources to where they are most needed. Establishment of clear protocols for patient selection and patient education is central to the success of same-day discharge for brain tumor resection. We hope that our experience and prospective database enables other institutions to explore the feasibility of offering outpatient brain surgery for their neuro-oncology patients.

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Data availability No data sets were generated or analyzed during the current study.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethical approval This study was performed in line with the principles of the Declaration of Helsinki. IRB approval was granted by the Ethics Committee of University of Miami (protocol #20201078).

Consent to participate Informed consent was obtained from all individual participants included in the study.

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