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Predictors and Impact of Postoperative 30-Day Readmission in Glioblastoma

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BACKGROUND: Postoperative 30-day readmissions have been shown to negatively affect survival and other important outcomes in patients with glioblastoma (GBM).
OBJECTIVE: To further investigate patient readmission risk factors of primary and recurrent patients with GBM.
METHODS: The authors retrospectively reviewed records of 418 adult patients undergoing 575 craniotomies for histologically confirmed GBM at an academic medical center. Patient demographics, comorbidities, and clinical characteristics were collected and compared by patient readmission status using chi-square and Mann–Whitney U testing. Multivariable logistic regression was performed to identify risk factors that predicted 30-day readmissions.
RESULTS: The cohort included 69 (12%) 30-day readmissions after 575 operations. Readmitted patients experienced significantly lower median overall survival (11.3 vs 16.4 months, $P = .014$), had a lower mean Karnofsky Performance Scale score (66.9 vs 74.2, $P = .005$), and had a longer initial length of stay (6.1 vs 5.3 days, $P = .007$) relative to their nonreadmitted counterparts. Readmitted patients experienced more postoperative deep vein thromboses or pulmonary embolisms (12% vs 4%, $P = .006$), new motor deficits (29% vs 14%, $P = .002$), and nonhome discharges (39% vs 22%, $P = .005$) relative to their nonreadmitted counterparts. Multivariable analysis demonstrated increased odds of 30-day readmission with each 10-point decrease in Karnofsky Performance Scale score (odds ratio [OR] 1.32, $P = .002$), each single-point increase in 5-factor modified frailty index (OR 1.51, $P = .016$), and initial presentation with cognitive deficits (OR 2.11, $P = .013$).
CONCLUSION: Preoperatively available clinical characteristics strongly predicted 30-day readmissions in patients undergoing surgery for GBM. Opportunities may exist to optimize preoperative and postoperative management of at-risk patients with GBM, with downstream improvements in clinical outcomes.

KEY WORDS: Brain tumor, Care quality, Glioblastoma, Readmission, Value

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The Agency for Healthcare Research and Quality estimates that individual readmissions cost $14 400 on average and, in 2011, were associated with $41.2 billion in healthcare costs.[1] In 2012, the Centers for Medicare and Medicaid Services initiated the Hospital Readmissions Reduction Program (HRRP), to promote higher care quality through increased transparency of hospital readmission statistics, along with reimbursement penalties for medical centers with high readmission rates.[2] Subsequent increases in these penalties have incentivized healthcare systems to identify and appropriately manage patients at greatest risk of early readmission to reduce overall patient and hospital financial burden.[2]

The prediction and impact of unplanned hospital readmissions have been investigated in nonoperative cohorts[3-5] as well as in the surgical

ABBREVIATIONS: DVTs/PEs, deep vein thrombosis/pulmonary embolisms; **ED,** emergency department; **EMR,** electronic medical record; **HR,** hazard ratio; **HRRP,** Hospital Readmissions Reduction Program; **IDH1,** isocitrate-dehydrogenase-1; **KPS,** Karnofsky Performance Scale; **LOS,** length of stay; **mFI-5,** 5-factor modified frailty index; **MGMT,** O(6)-methylguanine-DNA-methyltransferase; **SAR,** subacute rehabilitation; **OS,** overall survival; **QI,** quality improvement.

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oncology literature.[6-8] However, there is a relative paucity of literature on readmissions in neuro-oncology, including in glioblastoma (GBM), the most common primary malignant brain tumor.[9-12] To the best of our knowledge and of the available literature related to GBM, one study has considered recurrent (ie, progressive) GBM[13] and one[10] has been largely confined to Medicare-linked databases.[9,11] Although requirements for Medicare vary, most Medicare patients are older than 65 years[14]; these databases may therefore not adequately capture a large proportion of patients with GBM, given that the median age of those afflicted is approximately 56 years at diagnosis.[15]

Identification and risk stratification of patients with GBM at risk of readmission have the potential to improve care quality, minimize financial burden, and potentially affect downstream survival. Upfront identification of high-risk patients opens the door for early involvement of extended care teams in discharge disposition planning and mobilization of necessary social support systems. To address this unmet need, our study aimed to describe predictors of early readmission after GBM resection, including patients with recurrent/progressive disease, and elucidate the impact of early readmission on overall survival (OS).

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METHODS

Patient Selection

Patients undergoing resection of primary or recurrent GBM between July 01, 2009, and September 30, 2019, were identified through an institutional database created with institutional review board approval and without requiring patient consent. Senior neuropathologists determined tumor pathology and grade according to current World Health Organization classification systems.[16] Adult (18 years or older) patients with a histopathologically confirmed diagnosis of World Health Organization Grade IV glioblastoma were included. Patients who underwent biopsy only were excluded.

Recorded Variables

We manually reviewed physician and other provider notes for all included patients through the electronic medical record (EMR) from both within our institution and sister institutions throughout our state by using the Chesapeake Regional Information System for our Patients.[17] Preoperative data on patient comorbidities (**Supplement**, http://links.lww.com/NEU/D227) and functional status were used to generate a 5-factor modified frailty index (mFI-5) score.[18] Discharge disposition was defined as home or nonhome.[19] Stupp et al[19] protocol completion, representing the standard of care after primary surgery consisting of postoperative temozolomide and radiation therapy, was also recorded. Readmission was defined as any unplanned readmission within 30 days of postoperative discharge and classified as preventable or nonpreventable, as defined by prior literature in the field.[10,20]

Statistical Analysis

Statistical analyses were conducted using SAS 9.4 (SAS Institute). P values <0.05 were considered statistically significant (**Supplement**, http://links.lww.com/NEU/D227). The Kaplan-Meier method was used to analyze survival, and a multivariable Cox proportional hazards model was used to determine covariate associations with risk of death. Multivariable logistic regression modeling for unplanned readmission was also used (**Supplement**, http://links.lww.com/NEU/D227).

Reporting Guidelines

Strengthening the Reporting of Observational Studies in Epidemiology guidelines were used for this study.

RESULTS

Patient Characteristics

Our cohort included 418 patients undergoing 575 craniotomies for GBM. Overall, the cohort was majority Caucasian (81%) and male (85%). The mean preoperative age, Karnofsky Performance Scale (KPS) score, and mFI-5 score were 59.4 ± 12.9 years, 73.3 ± 16.3, and 0.59 ± 0.80, respectively. Most patients had private health insurance (208, 50%), whereas 172 (41%) had Medicare, 15 (4%) had Medicaid, 12 (3%) were uninsured, and 11 (3%) were self-pay. The mean and median length of stay (LOS) was 5.5 and 3 days, respectively. Patients with nonhome discharge were older relative to their home discharge counterparts (65.2 vs 58.2 years, $P < .001$). A total of 69 (12.0%) cases were readmitted within 30 days, with a median time to readmission totaling 14.33 days. The median OS was 15.4 months. The overall rate of O(6)-methylguanine-DNA-methyltransferase (MGMT) methylation was 17% and isocitrate-dehydrogenase-1 (IDH1) mutation was 7%. MGMT and IDH1 mutation status were known in 233 (56%) patients.

Comparative Analyses

The mean preoperative age, KPS score, and mFI-5 score for readmitted vs nonreadmitted patients were 56.2 ± 12.8 vs 60 ± 12.9 years ($P = .009$), 66.9 ± 16.4 vs 74.2 ± 16.1 ($P = .005$), and 0.77 ± 0.92 vs 0.57 ± 0.78 ($P = .093$), respectively (Table 1). There were no significant differences in readmission status by tumor location, race, sex, or insurance status ($P = .364$, $P = .359$, $P = .114$, and $P = .364$, respectively.) Repeat resection was not associated with a higher rate of 30-day readmission relative to primary resection ($P = .616$). Readmitted patients experienced a similar rate of gross total resections (26% vs 35%, $P = .259$) relative to nonreadmitted patients.

Preoperatively, readmitted patients were more likely to have demonstrated upfront cognitive (32% vs 21%, $P = .004$) or motor (42% vs 31%, $P = .006$) deficits relative to nonreadmitted counterparts. Postoperatively, readmitted patients experienced more deep vein thrombosis/pulmonary embolisms (DVTs/PEs) (12% vs 4%, $P = .006$) and more new motor deficits (29% vs 14%, $P = .002$) before discharge (after surgery) relative to nonreadmitted patients. Readmitted patients also experienced longer mean predischarge hospital LOS (after surgery) (6.1 vs 5.3 days, $P = .007$) and more frequent nonhome discharges (39% vs 22%, $P = .005$) relative to nonreadmitted patients. Of all discharge

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TABLE 1. Patients With and Without 30-Day Readmissions—All Surgeries

Characteristic	30-day readmission category		*P* value
	Yes, n = 63	No, n = 355	
Demographics			
Age in years at surgery, mean ± SD	56.2 ± 12.8	60 ± 12.9	**.0090**
Male	48 (76)	306 (86)	.1141
Race			.3589
White/Caucasian	50 (79)	290 (82)	
African American	5 (8)	26 (7)	
Asian or other	8 (13)	39 (11)	
Total resections			.1332
1	39 (62)	263 (74)	
2	23 (37)	69 (19)	
3	1 (1)	16 (5)	
≥4	0	7 (2)	
(+) *MGMT* methylation	8 (13)	64 (18)	.3943
IDH1 mutation	2 (3)	26 (7)	.3271
Case characteristics	n = 69	n = 506	
Surgery order			.6163
1st	48 (70)	371 (73)	
2nd	18 (26)	95 (19)	
3rd	3 (4)	28 (6)	
≥4th	0 (0)	12 (2)	
Admitted through ED	6 (9)	67 (13)	.3404
KPS score, mean ± SD	66.9 ± 16.4	74.2 ± 16.1	**.0050**
mFI-5, mean ± SD	0.77 ± 0.92	0.57 ± 0.78	.0926
Cognitive deficit at presentation	22 (32)	104 (21)	**.0036**
Motor deficit at presentation	29 (42)	155 (31)	**.0058**
Seizure at presentation	22 (32)	122 (24)	.1650
Headache at presentation	19 (28)	157 (31)	.5483
Op characteristics			
GTR at surgery	18 (26)	178 (35)	.2587
Received carmustine wafers	8 (12)	52 (10)	.7192
Postoperative characteristics			
LOS, mean ± SD	6.1 ± 5.8	5.3 ± 6.7	**.0074**
Intracranial hematoma	2 (3)	5 (0.9)	.1941
DVT/PE	8 (12)	20 (4)	**.0058**
Seizure	6 (9)	23 (5)	.1407
New motor deficit	20 (29)	71 (14)	**.0015**
Palliative care consultation	4 (6)	24 (5)	.6588
Nonhome disposition	27 (39)	114 (22)	**.0051**

DVT/PE, deep vein thrombosis/pulmonary embolism; ED, emergency department; GTR, gross total resection; IDH1, isocitrate-dehydrogenase-1; KPS, Karnofsky Performance Scale; LOS, length of stay; mFI-5, 5-factor modified frailty index.
Unless otherwise indicated, values are expressed as the number (%). Boldface type indicates statistical significance.

dispositions (**Supplement**, http://links.lww.com/NEU/D227), patients discharged to subacute rehabilitation (SAR) had a significantly higher readmission rate (21% vs 9.7%, P = .003) compared with all other dispositions (Table 2). Stupp protocol completion rates were similar between readmitted and nonreadmitted patients (36 [68%] vs 210 [59%], P = .824).

Readmision Effect on Overall Survival

Patients who experienced a 30-day readmission had significantly lower median OS compared with nonreadmitted patients (11.3 vs 16.4 months, P = .014) (Figure) despite similar survival rates at 30 days (95.2% vs 97.4%, P = .413). In a Cox proportional hazards model for death adjusting for age, mFI-5 score, KPS score, extent of tumor resection, and total number of surgeries, 30-day readmission status was associated with an increased risk of death (hazard ratio [HR]: 1.961, P < .0001). Similarly, older age (HR: 1.020, P < .0001), lower KPS score (HR: 1.161, P < .0001), and subtotal resection relative to gross total resection (HR: 1.803, P < .0001) were also associated with an increased risk of death (Table 3). By contrast, the

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TABLE 2. Cases of 30-Day Readmission by Discharge Disposition After Resection

Postresection discharge disposition	KPS score, mean ± SD[a]	30-day readmission category, no. (%)[b]		*P* value
		Yes	No	
Home	76.7 ± 15	42 (10)	392 (90)	.1680
Inpatient rehabilitation	75.2 ± 14	1 (14)	6 (86)	.8523
Subacute rehabilitation facility	63.4 ± 16	25 (21)	96 (79)	**.0034**
Skilled nursing facility	54.0 ± 18	1 (20)	4 (80)	.5820
Hospice	50.0 ± 15	0 (0)	8 (100)	.2963

KPS, Karnofsky Performance Scale.
[a]KPS score differences were statistically significant at $P < .0001$.
[b]Sixty-nine cases were readmitted within 30 days, and 506 were not.
Boldface type indicates statistical significance.

increasing number of total surgeries (HR: 0.873, $P = .0211$) was associated with a decreased risk of death.

Readmission Predictors

Our multivariable logistic regression model adjusted for age, KPS score, mFI-5 score, cognitive deficit at presentation, postoperative DVTs/PEs occurring before discharge, new postoperative motor deficits, and nonhome discharge disposition demonstrated that each 10-point decline in KPS score (OR: 1.322, $P = .002$), each 1-point increase in mFI-5 score (OR: 1.506, $P = .016$), and preoperative cognitive deficits (OR: 2.11, $P = .013$) were independently associated with an increased risk of 30-day readmission. New postoperative motor deficits and DVTs/PEs were significant predictors of readmission on bivariate analysis but not on multivariable analysis ($P = .060$ and $P = .084$, respectively). Interestingly, older age was associated with a decreased risk of readmission (OR: 0.960, $P = .0004$) (Table 4). This model was well-calibrated (Hosmer-Lemeshow test, $P = .926$), performed well on area under the curve analysis (c-statistics 0.717), and on cross-validation (mean 5-fold c-statistic = 0.710). There was no collinearity (variance inflation factors range 1.03-1.33).

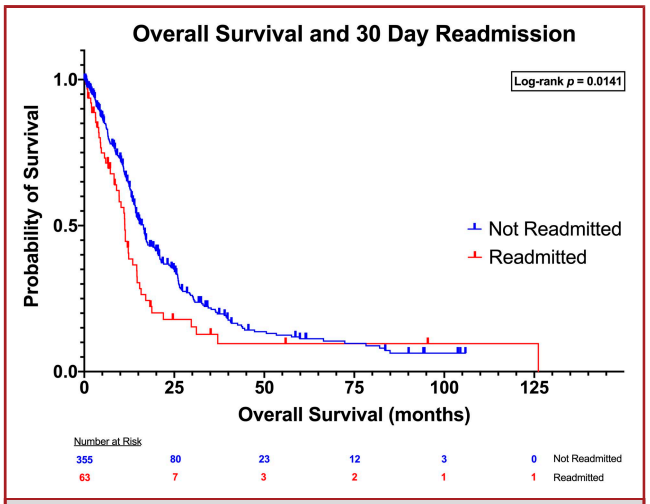

FIGURE. *Overall survival of readmitted vs nonreadmitted patients with glioblastoma—Kaplan-Meier curve.*

DISCUSSION

Study Rationale

Evolutions in the healthcare landscape, including the introduction of the HRRP and novel payment models such as bundled payments, have incentivized healthcare systems to improve care quality while reducing healthcare costs.[2,21] A key driver of costs is unplanned 30-day readmissions, which have cost healthcare systems more than $2 billion in penalties since the HRRP's inception.[2] Beyond financial implications, early readmissions have been associated with decreased health-related quality of life and increased mortality rates.[9,10,22-24] Despite the financial and clinical importance of unplanned readmissions, they remain a relatively understudied area within neurosurgical oncology, including in primary and recurrent patients with GBM. We undertook this study to identify predictors of unplanned readmissions, elucidate the clinical impact of readmissions, and provide a foundational evidence base for quality improvement (QI) efforts to reduce future readmissions.

Interpretation and Prior Literature

Our data augment the extant literature on readmissions in patients with GBM and offer multiple new findings that may help improve patient management. Our readmission rate (12%) aligns with large neurosurgical services demonstrating readmission rates ranging between 7.5% and 15.8%,[10,11,20] suggesting generalizability of our findings and a general benchmark to use for QI initiatives. Specifically, the IDH1 mutation rate among our patient cohort was similar to previous multicenter studies, whereas the MGMT methylation rate was lower.[25,26] Drivers of preventable readmissions in our cohort were similar to those described in other studies,[9,10,20,27-30] suggesting processes related to

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TABLE 3. Cox Proportional Hazard Model for Death—All Patients

Variable	Multivariable HR (95% CI)	*P* value
STR; ref: GTR	1.803 (1.453-2.237)	**<.0001**
30-day readmission	1.961 (1.456-2.641)	**<.0001**
KPS score; decreasing, 10 points	1.161 (1.085-1.244)	**<.0001**
Age; increase, 1 year	1.020 (1.012-1.029)	**<.0001**
Total surgery no.; continuous, increasing	0.873 (0.752-0.981)	**.0211**
(+) *MGMT* methylation; ref: unmethylated	0.506 (0.376-0.680)	**<.0001**

GTR, gross total resection; HR, hazard ratio; KPS, Karnofsky Performance Scale; MGMT, O(6)-methylguanine-DNA-methyltransferase; STR, subtotal resection.
Boldface type indicates statistical significance.

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underlying disease and current treatment paradigms rather than institutional differences in management.

Alongside reducing readmissions, LOS has been a target for optimizing efficiency and cost. In our study, longer LOS was not associated with increased readmission risk which aligns with previous GBM-specific readmission literature[9,10] but contrasts with larger neurosurgical reports of longer LOS predicting higher readmission rates.[28,31,32] In addition, Lakomkin and Hadjipanayis[33] previously demonstrated that nonroutine discharges were associated with increased postoperative complications and returns to the operating room in patients with brain tumor. We found that readmissions were associated with nonhome discharges on bivariate but not multivariable analysis. We speculate that these differences stem from our practice of discharging patients with GBM with a high readmission risk to inpatient rehabilitation where complications (eg surgical site infections and DVTs/PEs) are managed accordingly, thereby preventing some readmissions. This may also account for the association seen between older age and mildly decreased readmission risk (OR: 0.960, $P = .0004$). This paradox is further supported by our finding that patients

TABLE 4. ORs for 30-Day Readmissions—All Surgeries

	Logistic regression			
Variable	Univariate OR (95% CI)	*P* value	Multivariable OR (95% CI)	*P* value
Older age at surgery	0.984 (0.965-1.002)	.0850	**0.960 (0.939-0.982)**	**.0004**
Male; ref: female	1.471 (0.855-2.533)	.1635		
Surgery no.; continuous, increasing	0.825 (0.559-1.217)	.3319		
Preoperative characteristics				
Greater mFI-5	1.322 (0.996-1.757)	.0536	**1.506 (1.081-2.098)**	**.0155**
Admitted through ED; ref: elective admission	0.623 (0.259-1.495)	.2890		
KPS score; decreasing, 10 points	1.291 (1.115-1.499)	**.0007**	**1.322 (1.112-1.582)**	**.0016**
Cognitive deficit at presentation	1.805 (1.041-3.129)	**.0355**	**2.114 (1.168-3.824)**	**.0134**
Seizure at presentation	1.470 (0.852-2.537)	.1665		
Headache at presentation	0.842 (0.481-1.476)	.5487		
Operative characteristics				
STR; ref: GTR	1.603 (0.902-2.847)	.1075		
Received carmustine wafers	1.215 (0.574-2.575)	.6104		
Postoperative characteristics				
Greater LOS	1.017 (0.986-1.049)	.3389		
DVT/PE	3.181 (1.343-7.533)	**.0085**	2.370 (0.890-6.308)	.0841
Intracranial hematoma	2.986 (0.568-15.694)	.1964		
Seizure	1.996 (0.783-5.089)	.1479		
New motor deficit	2.495 (1.401-4.445)	**.0019**	1.925 (0.972-3.814)	.0603
Palliative care consultation	1.278 (0.429-3.803)	.6593		
Nonhome disposition	1.991 (1.183-3.350)	**.0095**	0.944 (0.476-1.870)	.8686
Tumor characteristics				
(+) *MGMT* methylation	0.614 (0.271-1.388)	.2411		

DVT/PE, deep vein thrombosis/pulmonary embolism; ED, emergency department; GTR, gross total resection; KPS, Karnofsky Performance Scale; LOS, length of stay; mFI-5, 5-factor modified frailty index; MGMT, O(6)-methylguanine-DNA-methyltransferase; OR, odds ratio; STR, subtotal resection.
Boldface type indicates statistical significance.

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with nonhome disposition were older relative to home disposition counterparts (62.5 vs 58.2 years, $P = .001$). The potential relationships between these outcomes highlight the need for QI initiatives targeting underlying drivers, which may be highly fruitful in reducing healthcare costs.

Our finding that readmitted patients experienced a 5.1-month reduction in OS aligns with those of Nuño et al[9] and Dickinson,[10] who found that readmitted patients experienced OS reductions of 1.6 and 9 months, respectively. We note that this relationship held across the 3 studies despite differences in patient cohorts, institutions, and geography. Whereas our data do not demonstrate whether this relationship is correlative or causative, prior surgical oncology literature posits the role of readmissions in delaying adjuvant treatment as a mechanism for the observed reduction in OS.[34] Although intuitive, the effects of readmission on treatment delay have not been studied in GBM. Delays in radiotherapy, however, have demonstrated mixed effects on survival. A meta-analysis, conducted by Loureiro et al,[35] found no relationship between time to radiotherapy and OS. Meanwhile, a 2018 study by Pollom et al[36] found decreased OS in newly diagnosed patients with GBM who had >42-day delay in receiving radiotherapy. Ultimately, the relationship between readmissions and survival suggests that reducing readmissions is not only financially beneficial but may be critical for improving patient outcomes.

An important, novel contribution of our study was that repeat resection was not associated with increased risk of unplanned readmissions. Although the efficacy of repeat resections has been previously reviewed, the potential morbidity associated with additional surgery in these patients is less known.[15,37] Thus, in addition to supporting the role of repeat resection in improving survival, our results provide confidence that repeat resection will not unnecessarily increase the risk of some adverse outcomes in appropriately selected patients.

Strategies to Reduce Readmissions in Patients With Glioblastoma

Interestingly, all factors in our multivariable analysis that predicted 30-day readmissions were based on data available in the preoperative period. This represents a potentially significant opportunity for targeted initiatives to reduce the risk of postoperative 30-day readmissions. Based on our data, we note some potential areas for QI initiatives to reduce readmissions in GBM: preoperative rehabilitation and improved discharge planning.

We postulate that patients' frailty and functional status could be used as key metrics for preoperative risk stratification. Prior literature has suggested that postoperative outcomes of frail, dependent patients could potentially be improved through preoperative prehabilitation.[38] In the degenerative spine surgery literature, prehabilitation led to improved postoperative mobility and increased quality of life[39] while also remaining cost-effective.[40] Delaying primary resection to undergo prehabilitation, in patients with brain tumor, has unknown potential effects on survival[41]; however, Rivera-Rivera et al[42] underscored the potential functional benefits of prehabilitation in patients with tumors in eloquent areas. Similarly, in surgical oncology, prehabilitation has been associated with reduced postoperative complications[43] and early readmissions.[44] Furthermore, 2 randomized clinical trials from the lung cancer literature demonstrated significant functional benefits of 2- and 3-week prehabilitation programs in patients undergoing lung lobectomy. Importantly, these delays in resection were not associated with an increased risk of mortality.[45,46] In our cohort, each 1-point increase in mFI-5 score presented a 50% elevated risk of readmission on multivariable analysis ($P = .016$). The KPS score was lower in readmitted patients ($P = .005$), and each 10-point decrease elevated the risk of readmission by 32% ($P = .002$). Taken together, the demonstrated propensity of frail and lower functional status patients to be readmitted reinforces the potential opportunity for prehabilitation-related efforts in preoperative interdisciplinary neurosurgical care.

Reasons for nonpreventable readmissions (**Supplement**, http://links.lww.com/NEU/D227) varied widely but were primarily due to neurological symptoms concerning for disease-related progression. Although rapid disease progression requiring inpatient management is an unfortunate characteristic for some patients with GBM, knowledge of the predictors identified in this work may help enhance disposition planning while encouraging patient/family engagement and close outpatient follow-up. Appropriate discharge disposition may also optimize medication adherence, a contributory factor to 2 readmissions in our cohort. Patients discharged to SAR facilities had the highest readmission rate among all dispositions ($P = .0034$), a finding that aligns with prior literature by Lakomkin and Hadjipanayis.[33] Although this probably reflects differences in patient functional status and treatment goals after resection, it also identifies a potential role for predischarge planning among those discharged to SAR. In a quasiexperimental pilot study, early predischarge planning, along with patient education and scheduled postoperative telephone follow-ups, minimized unplanned readmissions in patients who underwent craniotomy.[47] Wider adoption of early and holistic discharge planning may help reduce a significant proportion of unplanned readmissions after craniotomy for GBM.

Limitations

As a retrospective study from a single healthcare system, our findings would be strengthened by external and/or prospective validation. We also recognize the inability to capture readmissions omitted from the patient's EMR, which we attempted to minimize by judiciously reviewing provider notes both from within our institution and from sister institutions throughout our state using Chesapeake Regional Information System for our Patients, a shared EMR system. The increasing use of readmissions as an indicator of healthcare quality necessitates deeper investigation and external validation, and we are hopeful that our findings add this to the growing body of clinical research.

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CONCLUSION

Early readmissions remain a widely used surrogate for hospital quality, and excess readmissions are a target for Centers for Medicare and Medicaid Services reimbursement penalties. Readmissions have been strongly associated with poor outcomes; however, predictors of readmission in patients with GBM and the impact of readmission on OS remain relatively understudied. We examined readmissions in a large GBM cohort, confirmed previous findings of decreased OS in readmitted patients with GBM, and demonstrated that patients with higher mFI-5 scores, lower KPS scores, and those presenting with cognitive deficits are at greatest risk for readmission after GBM resection. The preoperative nature of these risk factors underscores a potential opportunity for intervention with prehabilitation and early, thorough discharge planning. Understanding and enhancing risk stratification for readmission holds the potential to benefit the quality and value of care delivered to future patients with GBM.

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Dr Brem is a paid consultant to Insightec and chairman of the company's Medical Advisory Board. Insightec is developing focused ultrasound treatments for brain tumors. This arrangement has been reviewed and approved by the Johns Hopkins University in accordance with its conflict-of-interest policies. Dr Brem is a consultant for Consultant for AsclepiX Therapeutics, StemGen, InSightec*, Accelerating Combination Therapies*, Catalio Nexus Fund II, LLC*, LikeMinds, Inc*, Galen Robotics, Inc.* and Nurami Medical* (*includes equity or options). Dr Lim has grants/payments from Stryker. The other authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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