Unplanned readmissions and survival following brain tumor surgery

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OBJECT Research on readmissions has been influenced by efforts to reduce hospital cost and avoid penalties stipulated by the Centers for Medicare and Medicaid Services. Less emphasis has been placed on understanding these readmissions and their impact on patient outcomes. This study 1) delineates reasons for readmission, 2) explores factors associated with readmissions, and 3) describes their impact on the survival of glioblastoma patients.

METHODS The authors conducted a retrospective review of 362 cases involving patients with glioblastoma undergoing biopsy or tumor resection at their institution between 2003 and 2011. Reasons for re-hospitalization were characterized according to whether or not they were related to surgery and considered preventable. Multivariate analyses were conducted to identify the effect of readmission on survival and determine factors associated with re-hospitalizations.

RESULTS Twenty-seven (7.5%) of 362 patients experienced unplanned readmissions within 30 days of surgery. Six patients (22.2%) were readmitted by Day 7, 14 (51.9%) by Day 14, and 20 (74.1%) by Day 21. Neurological, infectious, and thromboembolic complications were leading reasons for readmission, accounting for, respectively, 37.0%, 29.6%, and 22.2% of unplanned readmissions. Twenty-one (77.8%) of the 27 readmissions were related to surgery and 19 (70.4%) were preventable. The adjusted hazard ratio of mortality associated with a readmission was 2.03 (95% CI 1.3–3.1). Higher-functioning patients (OR 0.96, 95% CI 0.9–1.0) and patients discharged home (OR 0.21, 95% CI 0.1–0.6) were less likely to get readmitted.

CONCLUSIONS An overwhelming fraction of documented unplanned readmissions were considered preventable and related to surgery. Patients who were readmitted to the hospital within 30 days of surgery had twice the risk of mortality compared with patients who were not readmitted.

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KEY WORDS unplanned readmission; glioblastoma; complications; functional status; oncology

IN recent years, early hospital readmissions have emerged as a proxy measure for hospital quality of care, leading legislation regarding hospital reimbursement policy to undergo significant revision.³⁸ As of October 1, 2012, hospitals with higher standardized early readmission rates for medical conditions such as heart failure, acute myocardial infarction, and pneumonia have been challenged with payment penalties assessed by the Centers for Medicare and Medicaid Services.²⁹ As readmission rates have already begun to affect hospital reimbursement and will continue to do so in the future, clear understanding of early readmission, as a reliable quality indicator across medical subspecialties, is critical. If early readmissions are to be used as a universal measure of quality of

care, it is imperative to establish that these hospitalizations are correlated with adverse patient outcomes. Many studies in recent years have investigated early readmissions—the majority of which focus on the financial and resource burden that early readmissions place upon the health care system.^{9,10,19,20,22,34,37} However, fewer studies have assessed the factors driving 30-day readmissions, their association with patient outcomes, and the possible implications for quality of care. Several studies in surgical oncology have demonstrated that readmission status is associated with survival in patients with high-grade neoplasms, such as pancreatic²⁸ and colon¹⁵ cancers. As glioblastoma is the most common and malignant of the primary brain tumors,²⁵ and surgical resection remains an important treat-

ABBREVIATIONS DVT = deep venous thrombosis; HR = hazard ratio; KPS = Karnofsky Performance Status; LOS = length of hospital stay; PE = pulmonary embolism; SOI = severity of illness; SSI = surgical site infection; UTI = urinary tract infection; VTE = venous thromboembolism.

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ment paradigm,³ investigating readmissions in association with survival in this cohort challenged by a poor prognosis is critical.

The objectives of this study were to first establish the correlation between postsurgical 30-day readmissions and survival in glioblastoma patients and to further explore factors associated with these re-hospitalizations. In delineating reasons for readmission, we aim to elucidate potential areas of improvement in hospital care in an effort to reduce these adverse patient events.

Methods

Data Source and Variables

We performed a retrospective review of 362 cases involving newly diagnosed glioblastoma adult (> 18 years) patients who underwent surgery (including biopsy) at our institution for tumor resection between January 2003 and December 2011. Patient characteristics such as age, sex, race, extent of resection, and treatment (radiation and temozolomide) were included. Tumor size, perioperative Karnofsky Performance Status (KPS), disease severity, risk of mortality, and comorbidities were among some of the factors captured for these patients. Severity of illness (SOI) is defined as the extent of organ system derangement or physiological decompensation for a patient. Classified as minor, moderate, major, or extreme, SOI is meant to provide a basis for evaluating hospital resource use and to establish patient care guidelines. Patients with higher SOI classifications are likely to use more health care resources and experience more extended lengths of hospital stay (LOS) than patients with lower SOI within related cohorts. Similarly, the risk of mortality provides a medical classification to estimate the likelihood of in-hospital death for a patient. Levels of mortality risk are similar to those of SOI.

Discharge disposition (home, rehabilitation, or transfer) and type of admission (routine, emergency room, or transfer) were also considered. Detailed documentation describing the reasons for readmission was examined for each patient. Missing data for race were noted in 1.1% of cases and missing data for tumor size were noted in 18.2%.

Outcomes of Interest

A patient's overall survival and the occurrence of a readmission within 30 days of surgery were the main outcomes of interest. A readmission was defined as an admission lasting at least overnight under the care of a service other than the emergency service. Overall survival was calculated as the time between surgery and the date of death or most recent follow-up for censored patients. Furthermore, a detailed assessment of complications that led to these readmissions was described, and the readmissions were categorized into either preventable or non-preventable. A readmission was considered to be preventable if the chief complaint included any of the following: 1) a condition that was described and coded in the index hospitalization, 2) nosocomial surgical site infection (SSI) or fluid and electrolyte imbalances, 3) deep venous thrombosis (DVT) and pulmonary embolism (PE), and 4) postoperative CSF leaks that required repair.³⁴ Non-preventable

readmissions include those related to disease progression, such as seizures,¹ side effects of treatment, and hydrocephalus.³⁴ Each readmission was further described in terms of whether it was deemed to be related to surgery. In this cohort a readmission was presumed unrelated if it was a direct result of any of the following: 1) treatment side effects, 2) new conditions not coded at index hospitalization, (3) disease progression.

Statistical Analysis

Descriptive statistics accounted for whether patients were readmitted within 30 days of index surgery. Continuous variables were described using means and medians, while categorical variables were described with frequencies. Univariate comparisons of patient characteristics by readmission were conducted using Wilcoxon rank-sum, chi-square, and Fisher's exact tests, where appropriate. The Kaplan-Meier estimation method was used to obtain median survival times and rates. The Cox proportional hazards model was used to assess the association of readmission and survival while adjusting for multiple covariates. Multivariate logistic regression was used to determine predictors of readmission; factors associated with a readmission at the univariate level with a *p* value of 0.25 or lower were considered in the model. A *p* value less than or equal to 0.05 was considered statistically significant. All statistical analyses were conducted in SAS 9.2 (SAS Institute).

Results

Demographics

Our cohort had a median age of 63 years, with a male preponderance among both readmitted (59.3%) and non-readmitted (61.2%) patients (Table 1). The proportion of white patients was lower in the readmitted cohort than in the non-readmitted cohort (74.1% vs 86.7%, *p* = 0.09). Readmitted patients had significantly lower perioperative KPS scores (67.0 vs 74.5, *p* < 0.0001) than non-readmitted patients. The extent of resection was similar in the 2 cohorts (*p* = 0.51). Discharge disposition at the index hospitalization was strongly associated with readmission; the proportion of patients who were discharged home was substantially lower in the readmitted cohort than in the non-readmitted cohort (33.3% vs 76.7%, *p* < 0.0001).

Overall Survival and Readmission

The median overall survival for patients who were readmitted within 30 days of surgery was significantly shorter than for non-readmitted patients (6.9 vs 16.0 months, *p* = 0.003) (Fig. 1). After adjusting for confounders in a multivariate model, we found that the occurrence of a readmission (HR 2.03, *p* = 0.001), older age (hazard ratio [HR] 1.03, *p* < 0.0001), and a level increase in disease severity (HR 1.21, *p* = 0.03) were significantly associated with higher hazard of mortality. Additionally, higher KPS score (HR 0.85, *p* = 0.001), near/gross-total resection compared with biopsy (HR 0.51, *p* < 0.0001), and temozolomide treatment (HR 0.44, *p* < 0.0001) were associated with a significant reduction in the hazard of mortality (Table 2).

TABLE 1. Characteristics of 27 readmitted and 335 non-readmitted patients with newly diagnosed glioblastoma treated between January 2003 and December 2011*

Variable	Readmitted (n = 27 [7.5])	Non-Readmitted (n = 335 [92.5])	p Value
Age at diagnosis (yrs)			0.62
Mean	62.4 ± 14.0	61.1 (13.3)	
Median	63	62	
IQR	52–74	52–70	
LOS (days)			0.10
Mean	8.3 ± 6.6	6.3 (6.3)	
Median	6	4	
IQR	3–12	3–8	
Female sex	11 (40.7)	130 (38.8)	0.84
Race			0.11
White	20 (74.1)	287 (86.7)	
Black	3 (11.1)	21 (6.3)	
Asian	2 (7.4)	16 (4.8)	
Other/unknown	2 (7.4)	7 (2.1)	
Missing	0 (0)	4 (1.2)	
Periop KPS score			<0.0001
Mean	67.0 ± 16.4	74.5 (14.1)	
Median	70	80	
IQR	60–80	70–90	
Tumor size			0.92
<4 cm	7 (33.3)	108 (39.3)	
>4 cm	14 (66.7)	167 (60.7)	
Missing	6 (22.2)	60 (17.9)	
EOR			0.51
Biopsy	11 (40.7)	160 (47.8)	
PR	8 (29.6)	68 (20.3)	
N/GTR	8 (29.6)	107 (31.9)	
Radiation†	25 (92.6)	276 (82.4)	0.17
Temozolomide†	19 (70.4)	243 (72.5)	0.81
LOS (days)			0.10
Mean	8.3 ± 6.6	6.3 (6.3)	
Median	6	4	
IQR	3–12	3–8	
Discharge disposition			<0.0001
Home	9 (33.3)	254 (76.7)	
Rehab/transfer/died	18 (66.7)	77 (23.3)	
Missing	0 (0)	4 (1.2)	

EOR = extent of resection; IQR = interquartile range; PR = partial resection; N/GTR = near- or gross-total resection; rehab = rehabilitation.

* Values inside parentheses are percentages; means are given with SDs.

† Initial treatment.

Predictors of Readmission

Higher KPS score (HR 0.96, $p = 0.04$) and home discharge disposition (HR 0.21, $p = 0.003$) at index hospitalization were associated with a significantly lower risk of readmission within 30 days; a single-level improvement in functional independence (a 10-point increase in KPS

score) reduced the risk of readmission by 4%, while being discharged to home as opposed to being discharged to a rehabilitation facility or being transferred had a 79% reduction of the hazard of readmission (Table 3).

Readmission Cohort

Among the 27 patients (7.5%) who were readmitted within 30 days of initial surgery, 6 (22.2%) were readmitted by Day 7, 14 (51.9%) by Day 14, and 20 (74.1%) by Day 21. The average time to readmission was 15.3 days (median 14 days). The average LOS during the index hospitalization was 8.3 days, and the average LOS upon readmission was 7.0 days. The most frequent causes of readmission were neurological complications (37.0%), followed by infectious complications (29.6%) and thromboembolic events (22.2%). Of the 10 patients readmitted for neurological complications, 4 were readmitted for hydrocephalus/fluid collection, 2 for seizure, 1 for leptomeningeal disease, 1 for hyponatremia, and 1 for hemorrhage (intratumoral). Of the 8 patients readmitted for infectious reasons, 3 were readmitted for surgical site wound infection (SSI), 2 for urinary tract infection (UTI), 2 for neutropenic fever, and 1 for leukocytosis. Finally, of the 6 patients readmitted for thromboembolic events, 5 were admitted for PE and 1 was admitted for DVT (Table 4).

Upon close review of the readmitted cohort, it was observed that 6 patients (22.2%) died within 3 months of their index surgery; 2 of these patients had been readmitted for pulmonary embolism (thromboembolic), 2 for infection (including a UTI and an SSI; infectious), 1 for back pain (musculoskeletal), and 1 for hematuria secondary to Foley catheter-induced trauma (other). Five (83.3%) of these 6 patients were discharged to an acute physical rehabilitation facility after their index hospitalization. The median time in days to readmission for these 6 patients was longer than that for patients surviving more than 3 months (21 vs 13, $p = 0.24$).

Preventable and Surgery-Related Readmissions

Reasons for readmissions in this cohort were carefully analyzed based on the previously described criteria to determine whether each readmission was preventable or non-preventable. Among the 27 readmissions in which patients returned to the hospital within 30 days of surgery, 19 (70.4%) were classified as preventable. The majority of these readmissions classified as preventable were for thromboembolic, neurological, or infectious reasons. Six patients were readmitted for venous thromboembolism (VTE), 3 for SSIs, 2 for a UTI, 2 for subgaleal/extraxial fluid collection, 1 for leukocytosis, 1 for seizure (due to noncompliance with medication), 1 for intratumoral hemorrhage, 1 for back pain, 1 for hyponatremia, and 1 for hematuria second to Foley catheter-induced trauma. The reasons for readmission in the remaining 8 cases (29.6%) were classified as non-preventable and included disease progression and side effects of treatment (radiotherapy, chemotherapy). More specifically, non-preventable reasons for readmission included 2 cases of neutropenic fever (classified as non-preventable because it is a complication of chemotherapy), 1 case of cerebral edema (second to radiation therapy), 1 patient experiencing seizure (classified

FIG. 1. Overall survival (OS) functions for 327 non-readmitted and 27 readmitted patients within 30 days of the index hospitalization. Kaplan-Meier estimates for overall survival times in months for non-readmitted and readmitted patients.

as non-preventable because the patient was compliant with the prophylactic medication regimen), 1 instance of chest pain (second to coronary artery disease and bypass graft), and 2 for hydrocephalus. Readmissions were further described in terms of whether they were related to either the tumor or treatment of the tumor. For instance, a patient with preexisting coronary artery disease returning to the hospital after a craniotomy with cardiac complications would be considered to have an unrelated readmission. Two (11.1%) of the 27 readmitted patients were readmitted for reasons unrelated to the disease or treatment. One patient presented with chest pain secondary to coronary artery disease (and was listed as having a cardiac com-

plication in Table 4), and another patient (with a known history of chronic back pain and scoliosis) was readmitted for back pain (listed as a musculoskeletal complication in Table 4).

Discussion

In 2004, the Centers for Medicare and Medicaid Services reported that unplanned hospital readmissions resulted in \$17.4 billion in costs to Medicare alone.²⁶ As a result, in October of 2012 Medicare instituted a 1% payment penalty for hospitals with excessive early readmissions, as high readmission rates had emerged as indicators

TABLE 2. Adjusted hazard ratio for mortality, 95% confidence interval, and p values for 354 patients with newly diagnosed glioblastoma*

Variable	HR (95% CI)	p Value
Readmission	2.03 (1.31–3.12)	0.001
Age, yr increment	1.03 (1.02–1.04)	<0.0001
KPS, level increment	0.85 (0.78–0.94)	0.001
EOR (ref: biopsy)		
PR	0.62 (0.44–0.87)	0.007
N/GTR	0.51 (0.39–0.69)	<0.0001
Radiation†	0.89 (0.57–1.40)	0.62
Temozolomide†	0.44 (0.30–0.66)	<0.0001
SOI	1.21 (1.02–1.44)	0.03

ref = reference.

* Eight patients of the cohort of 362 were excluded from survival analysis since they died during hospitalization or were discharged to hospice.

† Initial treatment.

TABLE 3. Adjusted odds ratio for readmission, 95% confidence interval, and p values for 354 patients with newly diagnosed glioblastoma*

Variable	OR (95% CI)	p Value
Race (ref: non-white)		0.21
White	0.53 (0.20–1.43)	
Radiation (ref: no radiation)		0.28
Radiation	2.33 (0.50–10.8)	
Admission type (ref: non-routine)		0.93
Routine	0.95 (0.35–2.62)	
LOS, day increment		0.26
KPS, level increment	0.96 (0.93–1.0)	0.04
Discharge disposition (ref: rehab/transfer)		0.003
Home	0.21 (0.08–0.59)	

* Factors significant at the 0.25 or lower level in the univariate setting were adjusted for in the multivariate model.

TABLE 4. Characteristics of 27 patients readmitted within 30 days of surgery*

Case No.	Age (yrs), Sex	KPS Score	EOR at Index Op	LOS at Index Admission	Discharge Disposition	Days to Readmission	LOS at Readmission	Survival in Months†	Reason for Readmission‡
1	75, M	70	N/GTR	3	Transfer	5	3	3.7	Cardiac (P)
2	60, M	70	Biopsy	1	Home	20	7	11.1	Neurological (R)
3	89, F	70	PR	20	Rehab	25	13	17.9	Infectious (R)
4	80, F	40	PR	6	Rehab	29	15	1.8 (0.7)	Infectious (R, P)
5	61, M	80	PR	2	Home	30	2	20.2	Infectious
6	44, M	100	PR	1	Home	14	3	54.7§	Infectious (R, P)
7	69, F	90	PR	4	Home	12	5	5.4	Infectious (P)
8	46, M	80	Biopsy	6	Home	10	5	10.6	Neurological
9	52, F	60	PR	20	Rehab	22	5	1.5 (0.2)	Infectious (R, P)
17	33, M	90	N/GTR	7	Home	29	6	50.7§	Infectious (R, P)
10	75, F	50	PR	10	Rehab	17	4	5.5	Infectious (R, P)
11	84, M	60	N/GTR	16	Rehab	23	28	2.1 (1.0)	Musculoskeletal (P)
12	69, M	60	N/GTR	13	Rehab	15	12	6.9	Neurological (R, P)
13	47, M	70	N/GTR	7	Rehab	22	6	12.8	Neurological (R)
14	67, M	70	Biopsy	1	Home	7	1	3.6	Neurological (R, P)
15	64, M	70	Biopsy	6	Home	5	6	7.1	Neurological
16	61, F	40	Biopsy	3	Rehab	12	3	4.4	Neurological (R)
18	63, M	70	PR	3	Rehab	10	4	30.0	Neurological (R, P)
19	59, F	100	PR	2	Home	17	1	7.5	Neurological (R, P)
20	61, M	50	Biopsy	9	Rehab	5	9	5.5	Neurological (R)
21	65, F	70	PR	27	Transfer	19	9	1.7 (0.3)	Other (R, P)
22	70, F	50	PR	10	Rehab	10	4	2.9	Thromboembolic (R, P)
23	54, M	50	Biopsy	5	Rehab	13	5	9.3	Thromboembolic (R, P)
24	76, F	70	N/GTR	12	Rehab	9	13	1.5 (1.0)	Thromboembolic (R, P)
25	52, M	60	N/GTR	6	Rehab	7	13	20.4	Thromboembolic (R, P)
26	34, F	60	PR	14	Rehab	6	5	20.6	Thromboembolic (R, P)
27	74, M	60	Biopsy	11	Rehab	21	4	3.7	Thromboembolic (R, P)

* Gray highlighting indicates patients who died within 3 months of their index surgery.

† Values in parentheses indicate duration of survival after readmission.

‡ Letters in parentheses indicate complications that were related to surgery (R) and/or preventable (P).

§ Still alive as of data analysis.

of poor quality of delivered care during index hospitalization.^{9,10,19,20,22,34,37}

Some studies that investigated the correlation between early readmission and overall patient survival concluded that adverse readmissions are associated with shorter patient survival.^{28,32,37} For example, Reddy et al. found that patients readmitted within 30 days of discharge had shorter overall median survival than patients who were not readmitted during that period (11.8 vs 16.5 months, $p = 0.04$).²⁸ Fewer studies have investigated the association between early readmission and overall patient survival in a surgical cohort.¹⁸ Our study is the first to consider an internal cohort to investigate the correlation between early readmission and survival in patients with newly diagnosed glioblastoma undergoing a craniotomy. We have shown that an unplanned readmission within 30 days of discharge is associated with a 9-month survival reduction ($p = 0.003$), consistent with previous studies reporting that readmission within 30 days of surgery is associated with poorer overall survival in hepatopancreatobiliary, thyroid,

and pancreatic malignancies.^{15,28,33,37} Furthermore, these findings are supported by the results of our previous nationwide cohort study, which demonstrated that readmissions within 30 days of discharge are associated with a 30% increase in the hazard of mortality in glioblastoma patients documented in the SEER-Medicare (Surveillance, Epidemiology and End Results) database.²⁶

In addition to investigating the association between readmission within 30 days of discharge and survival, we also aimed to elucidate the means by which readmission rates could be reduced. Using an internal database was imperative as this allowed us to carefully review individual medical records for each patient and determine specific reasons for readmission utilizing our preventable versus non-preventable criteria. Although the use of an internal database was advantageous, there are limitations to our study, such as biases of a retrospective study and lack of certain details, including clinician biases and tumor biology. Although factors such as MGMT status, *IDH1* mutations, and EGFRvIII may well have an impact on survival

in this patient population, detailed review of our current data showed significant levels of missing data (more than 40%). Thus, attempting to draw inferences based on the data from the limited cohort for which complete data are available is likely to reduce the validity of this study, the primary aim of which was to assess the role of readmissions in overall survival. Despite these limitations, this study was unique in its ability to address in detail the course of patients' hospital stays.

As a large portion of the readmitted cohort had preventable readmissions (70.4%), especially VTE events and SSIs, we further investigated whether appropriate prophylactic measures were taken during index hospitalization. In the 3 cases of SSI, it was determined that all 3 patients were given 2 doses of antibiotics within 24 hours of surgery, indicating that appropriate prophylactic measures were taken. Five of the 6 patients readmitted with a VTE event were given DVT/PE prophylaxis in the form of a compression device, a practice mirrored in the non-readmitted cohort. None of these patients received chemoprophylactic anticoagulation therapy during their initial admission for surgery, likely due to the increased risk of severe intracranial hemorrhage.³⁴ While VTE prophylactic measures have remained unchanged for many years^{4,35} in neurosurgical patients, VTE prophylaxis remains a controversial issue, as the risk-benefit balance is unique for each patient and not clearly defined. Lack of chemoprophylaxis presents a potentially increased risk of postoperative VTE, but administration of anticoagulants such as unfractionated heparin presents the added risk of life-threatening intracranial hemorrhage.⁶

Several of our patients readmitted for preventable reasons had clear inconsistencies in medical care that presumably resulted in their re-hospitalization. For instance, 1 patient was readmitted for hematuria second to Foley catheter-induced trauma, which illustrates a mechanical error resulting in readmission. Furthermore, 1 patient admitted for back pain likely did not have appropriate post-discharge management of pain. The patient readmitted for preventable seizure had seizure due to noncompliance with medication. Additionally, 1 patient with DVT did not receive prophylaxis in the form of a compression device or chemoprophylactic therapy, demonstrating a discrepancy in prophylactic care likely resulting in readmission. The 7 remaining patients of the 19 readmitted for preventable reasons did not have documented discrepancies in their medical care during their index hospitalization to explicitly explain the occurrence of these adverse effects.

Ideally, complications leading to readmission should be prevented to reduce readmissions within the 30 days after discharge, although preventing these readmissions may not alter the course of the disease process. Presentation of the above complications in spite of compliance with accepted standards of care suggests that perhaps current prophylactic standards are inadequate in neurosurgical patients. In orthopedics, it has been suggested that to establish effective SSI prophylaxis, patient-related, surgery-related, and infection risk factors should be quantified.^{16,40} Specific measures have also been proposed to prevent the occurrence of UTIs. Several studies have reported that patients often undergo unnecessary catheterization and

that catheters are left in place for longer than needed,³⁰ and limiting catheter use has been found to be associated with significant decreases in rates of UTI.^{17,30} Use of silver alloy urinary catheters and catheters impregnated with antimicrobial agents have been shown to reduce bacteriuria,^{7,13,17,30} and even simple measures, such as ensuring that the drainage tube sits below the level of the bladder but above the collecting bag, have a significant effect on decreasing the incidence of UTIs.²³ Therefore, assessment of hazards specific to craniotomy patients may result in increased efficacy in prevention and treatment of these postoperative complications.

In addition to improvements to the in-hospital standard of care, previous studies have also suggested that modifications in care upon discharge and post-discharge follow-up have the potential to significantly reduce readmission rates postoperatively. Randomized prospective trials have demonstrated that 12% to 75% of all readmissions can be prevented simply through patient education, pre-discharge assessment, and adequate domiciliary aftercare.² Readmission rates have been reported to decline after the instatement of pre-discharge reviews and improved post-discharge follow-up care.^{1,36} This may be especially effective in reducing readmissions due to noncompliance with medications post-discharge, a prime example being the patient in our cohort readmitted for seizure due to noncompliance with anticonvulsant medication. These reported studies present a specialized window of opportunity for prevention of readmission: if simple alterations in in-hospital homeostatic care and post-discharge follow-up can help reduce these common complications, reduction in rates of postoperative readmission for patients with newly diagnosed glioblastoma can be achieved on a more definitive basis.

While a primary goal for health care providers is to eliminate unnecessary readmissions, glioblastoma patients present a greater challenge than most medical patients, as the pathophysiology of their disease is unpredictable.³⁴ Although SSIs and VTEs, are considered preventable occurrences, the methodology of prevention is more complex in neurosurgical patients, as this cohort is inherently more prone to these complications.^{14,21,27,39} With respect to VTE, tumor biology,³¹ operation time,²⁴ and inability to administer prophylactic anticoagulation during surgery due to risk of intracranial hemorrhage may sometimes supersede adequate prevention of this complication.⁸

Furthermore, complications that would routinely be managed on an outpatient basis require readmission in this cohort due to the sensitivity of postoperative craniotomy patients. In patients who have recently undergone biopsy or resection of glioblastoma, SSIs require readmission due to the imminent risk of CNS infection if the focal infection were to spread subdurally.³⁴ Additionally, complications such as postoperative VTE necessitate careful medical management. All 6 patients readmitted for presentation of VTE were in rehabilitation and had lower perioperative KPS scores than the non-readmitted cohort when their DVT/PE was discovered. In a less sensitive cohort, these postoperative events could likely be managed within the rehabilitation facility on an outpatient basis without readmission to a hospital. However,

postoperative neurosurgical patients require inpatient readmission as a result of the inability to administer a therapeutic level of anticoagulation within 30 days after craniotomy due to the risk of intracranial hemorrhage.³⁴ Several studies involving large cohorts of neurosurgical patients have consistently demonstrated a non-zero rate of VTE complications in neurosurgical patients, implying that these adverse events are not entirely preventable in this cohort.^{5,11,12}

While some of these complications may not be completely preventable in this patient population due to pathophysiology and preexisting conditions, some complications resulting in adverse readmissions have the potential to be reduced by modification of current practices. Examples include previously mentioned prophylactic measures for UTI as well as improvements in post-discharge patient education and follow-up care. For complications in which alterations in the standard of care may reduce occurrence and thus the resulting readmissions, an effort should be made to universalize these practices. While a reduction in early readmissions may not necessarily result in increased overall survival in this cohort, it is still important to reduce instances of readmission, as this has the potential to relieve some cost and resource burden of this particular patient cohort on the health care system as well as improve patient safety and satisfaction.³⁴

Conclusions

In patients with newly diagnosed glioblastoma, re-hospitalization within 30 days of index surgery was associated with a 9-month reduction in survival. Infectious, neurological, and thromboembolic complications were the leading reasons for readmission. Detailed patient chart reviews demonstrated that 70% of readmissions were preventable. While some of these complications are inherently not entirely preventable in this cohort, simple improvements in care during hospitalization and after discharge have the potential to reduce the overall occurrence of early readmissions.

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Conception and design: Patil. Acquisition of data: Dickinson, Carico. Analysis and interpretation of data: Nuño. Drafting the article: Dickinson, Carico, Nuño. Critically revising the article: Patil, Dickinson, Carico, Nuño, Mukherjee, Ortega. Reviewed submitted version of manuscript: Dickinson, Carico, Nuño, Mukherjee, Ortega, Black. Administrative/technical/material support: Ortega. Study supervision: Patil, Mukherjee, Black.

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