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Predictors of Venous Thromboembolism After Non-Emergent Craniotomy: A Nationwide Readmission Database Analysis

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Abstract

Background—Venous thromboembolism is responsible for a significant number of hospital readmissions each year, particularly among post-surgical cohorts. Because early and indiscriminate VTE prophylaxis carries catastrophic consequences in post-craniotomy cohorts, identifying factors associated with a high risk for thromboembolic complications is important for guiding postoperative management.

Objective—To determine VTE incidence in patients undergoing non-emergent craniotomy and to evaluate for factors, which predict 30- and 90-day readmission with VTE.

Methods—The 2010–2014 cohorts of the Nationwide Readmissions Database were employed to generate a large heterogeneous craniotomy sample.

Results—There were 89,450 non-emergent craniotomies that met inclusion criteria. Within 30-days, 1513 patients (1.69%) were readmitted with VTE diagnoses; among them 678 (44.8%) had a diagnosis of DVT alone, 450 (29.7%) had PE alone and 385 (25.4%) had both. The corresponding 30-day DVT and PE incidences were 1.19% and 0.93%, respectively. In multivariate analysis, several factors were significantly associated with VTE readmission namely, craniotomy for tumor, corticosteroids, advanced age, greater length of stay and discharge to institutional care.

Conclusions—Craniotomies for tumor, corticosteroids, advanced age, prolonged length of stay and discharge to institutional care are significant predictors of VTE readmission. The implication of steroids, coupled with their ubiquity in neurosurgery, makes them a potentially modifiable risk

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factor and a prime target for VTE reduction in craniotomy cohorts. Furthermore, the fact that dose is proportional to VTE risk in the literature suggests that careful consideration should be given towards lowering regimens in situations where use of a lower dose might prove equally sufficient.

Keywords

venous thromboembolism (VTE); pulmonary embolism (PE); deep vein thrombosis (DVT); craniotomy; nationwide database; readmission; adult cohort

Introduction

Venous thromboembolism (VTE) refers to the pathologic entity encompassing deep vein thrombosis (DVT) and pulmonary embolism (PE). Approximately 550,000 patients are affected in the United States each year, with an economic toll as high as $39.3 billion dollars [1,2]. VTEs carry substantial patient-related morbidity, as evident from the need for long-term anticoagulation and its numerous attendant complications, longer inpatient stays, higher 30-day hospital readmission rates and the potential to delay adjunctive therapies that influence long-term survival (e.g. chemotherapy, radiation) [3]. VTEs also result in higher overall mortality; for example, the risk of death within 30 days after being diagnosed with DVT and PE are estimated at 6% and 12%, respectively [4]. VTEs are the second most common cause of prolonged inpatient stays and the third most common cause of excess mortality in hospitalized patients [5,6]. Their perceived preventability [7,8], coupled with the aforementioned standings, have made them a target for quality improvement by the Centers for Medicare & Medicaid Services, such that pay-for-performance measures now link hospital reimbursement to VTE incidence.

Among surgical patients, those undergoing neurosurgery are thought to be particularly susceptible to thromboembolic phenomena [9,10]. The risks are further increased by operations undertaken for malignancy, for those of prolonged duration or that have a resulting deficit with limb paresis or plegia [11]. VTE rates in neurosurgery are highly variable, complicating anywhere from 1.7 to 34% of procedures [12–14]. Despite early postoperative mobilization and widespread support for mechanical and chemical prophylaxis, VTEs remain a significant concern in neurosurgery. Part of the challenge is that chemoprophylaxis in patients who have undergone craniotomy is encumbered by concerns for catastrophic intracranial hemorrhage (ICH), particularly if administered within the first several postoperative days, a time when patients are most likely to remain bedridden and at high risk for VTE. Although several systematic reviews in neurosurgical cohorts have deemed chemoprophylaxis both safe and effective at reducing thromboembolic phenomena without added ICH-related morbidity [15–17], there are others which provide cautionary reminders that the risk-benefit profile is only slightly favorable [18]. Studies evaluating VTE risk factors in craniotomy cohorts are therefore essential for identifying the most susceptible groups when balancing thromboembolic against hemorrhagic complications.

Here we employed the newly available Nationwide Readmissions Database (NRD) to characterize VTE readmission trends in patients who underwent non-emergent craniotomy. NRD is a pooled database of hospital admissions from numerous contributing states, in

which patients are assigned unique linkage numbers that effectively allows them to be tracked for subsequent readmission. It has previously been employed in the literature to analyze readmission patterns for various neurosurgical pathologies [19–22]. The goals of this investigation were: (1) to estimate VTE incidence among patients undergoing non-emergent craniotomy, and (2) to identify patient and hospital factors associated with VTE in order to establish high-risk features that could warrant early anticoagulation use.

Methods

Data Source

We used the 2010–2014 cohorts of the NRD for this study. This database represents all hospital discharges from 20–27 participating states, constituting roughly half of all discharges in the United States. NRD assigns anonymized identifiers to patients, which enables their tracking within a given state over the course of a calendar year.

Study Cohort

All adults > 18 years who underwent non-emergent craniotomy were included. Craniotomies for ventricular shunting, deep brain stimulation (DBS) and transphenoidal approaches were excluded because their cranial and dural openings are significantly smaller compared to standard neurosurgical operations that require more invasive access to pathology. Craniotomies for trauma were also excluded to isolate our cohort to controlled craniotomies where associated factors such as systemic injury, emergent treatment, and immobilization would not create a confounded and heterogeneous cohort. The final group comprised craniotomies for primarily three diagnoses: tumor, cerebrovascular conditions and epilepsy. Patients were extracted using a combination of International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9CM) diagnosis and procedure codes (Table 1).

Patients with a personal history of thromboembolism (453.7x, 453.5x, V12.51, V12.55) or a diagnosis of VTE on index presentation were excluded from the original cohort. Additional exclusion criteria include those who died or were missing relevant data (e.g. length of stay or time to procedure). Based on this cohort, we determined readmission trends for VTE (451.1, 451.1x, 451.2, 451.81, 451.83, 451.9, 453.2, 453.3, 453.4x, 453.6, 453.8x, 453.9, 415.1, 415.1x) at both 30- and 90-days from index hospitalization.

Because the NRD only permits tracking patients within a single calendar year, appropriate cutoffs were designated to allow sufficient time to capture the relevant study parameters. As such, 30-day readmissions include only patients discharged from January to November while 90-day readmissions include January through September.

Figure 1 demonstrates study design.

Patient and Hospital Demographics

Numerous patient and hospital characteristics were evaluated for readmission with VTE. Hospital factors included: teaching status, bed size and annual craniotomy volume (high volume being defined as at or above 90th percentile). Patient factors included: age, gender, insurance payer, underlying comorbidities, length of stay and disposition on discharge. Age

is a continuous variable in the NRD and was categorized into the following four cohorts for final analysis: 18–44, 45–59, 60–74 and ≥75. Additional variables of interest, chosen for their previously noted associations with VTE in the literature, were also evaluated, namely obesity (278.0, V85.3-V85.4), tobacco use (305.1, V15.82), diabetes (250.xx), chronic steroid use (V58.65), SIRS criteria (995.9x, 785.52), ventilator dependence (V46.1x), history of chemotherapy (V58.11, V87.41), and chronic lung disease.

Statistical Analysis

The clinical outcomes of this investigation were readmission for VTE after non-emergent craniotomy within 30- and 90-days. The NRD was queried using standard HCUP methodology for extracting readmission data. If multiple readmissions were identified for a single patient, only the first readmission was captured in data analysis. Multivariable models were built using two-level mixed-effects modeling accounting for clustering. Data were reported as odds ratios with 95% confidence intervals. All statistical analysis was performed using SAS 9.4 (Cary, NC). Significance was defined as $p < 0.05$.

Results

Patient and hospital baseline characteristics

Using the 2010–2014 cohorts of the NRD we identified 89,450 non-emergent craniotomies. The majority of surgeries were for tumor (81%, n = 72,571) followed by cerebrovascular conditions (18%, n = 15,937) and epilepsy (1%, n = 942). The median length of stay for all patients on index hospitalization was 5 days with a median cost of $98,063. There were slightly more females (56%, n = 50,451) than males (n = 44%, n = 38,999) in the index cohort. Most patients were between 45 and 74 years (69%, n = 62,382) and had at least one or more underlying comorbidities based on the Elixhauser index[23] (68%). The majority had private (48%) or Medicare insurance (33%) and received care at hospitals designated with a teaching status (82%) or large bedsize (80%). See Table 2 for a summary of key demographic data.

VTE incidence, readmission demographics

1513 patients were readmitted within 30 days of index craniotomy with a diagnosis of new VTE, corresponding to an incidence of 1.69%. Of those with VTE, 678 (44.8%) patients were diagnosed with DVT alone, 450 (29.7%) with PE alone and 385 (25.4%) with both DVT and PE. The 30-day DVT and PE incidences were thus determined to be 1.19% and 0.93%, respectively. The median time to 30-day readmission was 13 days with a median readmission cost of $44,527.

Within 90 days, there were 2582 readmissions with a diagnosis of VTE, corresponding to an incidence of 3.51%. There were 1117 (43.3%) patients diagnosed with DVT alone, 753 (29.2%) with PE alone and 712 (27.6%) with both. The 90-day DVT and PE incidences were therefore 2.49% and 1.99%, respectively. The median time to 90-day readmission was 32 days with a median readmission cost of $43,092.

See Table 3 for breakdown of VTE incidence by craniotomy cohort.

Factors associated with VTE within 30- and 90 days

In multivariate analysis, several factors were associated with readmission for VTE at both 30-and 90 days. Relative to cerebrovascular operations, craniotomies for tumor had increased risk for VTE at both 30 days (OR 2.01–2.43, $p < 0.0001$) and 90 days (OR 2.08–4.36, $p < 0.0001$). Increased age correlated with higher VTE risk, with the elderly (≥ 75 years) having close to, or twice, the odds of a thromboembolic complication compared to those aged 18–44 years (OR 1.69–2.03, $p < 0.0001$). Other patient-related characteristics predictive of VTE include: male gender, length of stay on index hospitalization and non-routine hospital disposition (e.g. transfer to another short-term hospital or skilled nursing facility).

Steroid use was a significant predictor of VTE at 30 days (OR 1.41, $p = 0.03$), however, the relationship was not significant at 90 days. In like manner, presence of one or more underlying comorbidities as determined by the Elixhauser index had variable association with VTE risk based on time, being significant at 90 days only (OR 1.25, $p < 0.0001$).

See Tables 4 and 5 for details.

Discussion

Venous thromboembolism (VTE), which comprises deep vein thrombosis (DVT) and pulmonary embolism (PE), accounts for a significant number of hospital readmissions each year. Their assumed preventability, potential for high mortality and exorbitant costs have resulted in a widespread campaign for primary prevention and risk reduction, particularly within the perioperative window. Consistent with this effort, the Surgical Care Improvement Project (SCIP) was implemented in 2006 in the hopes of reducing the incidence of preventable complications like VTEs. This has dramatically transformed the healthcare landscape so much so that hospital reimbursement is increasingly being tied to certain quality of care metrics, one of which corresponds to VTE rates. Because institutional referral streams and their ultimate financial viability depend on meeting these imposed measures, hospitals have devised surgical protocols addressing VTE prophylaxis. However, no guidelines exist for risk stratification, particularly in neurosurgical populations where indiscriminate chemoprophylaxis can have catastrophic hemorrhagic consequences. Here we sought to identify modifiable risk factors associated with the development of postoperative VTE in cranial neurosurgery in order to optimize risk profiling for susceptible groups.

VTE rates are known to be higher in surgical cohorts due to venous stasis from general anesthesia, intraoperative immobilization, limited postoperative mobility and the inevitable activation of inflammatory and coagulation pathways that occurs in response to tissue injury [24]. This propensity for thromboembolism is purported to be even higher in patients undergoing neurosurgery [10,11,25]. A retrospective study of 38,058 spine and cranial neurosurgery patients from the 2006–2011 NSQIP database found an overall VTE incidence of 1.7% within 30 days of follow-up [14]. Another investigation of 10,477 craniotomy patients from 2011–2012 reported a VTE incidence of 3.2%, with rates of DVT and PE of 2.4% and 1.3%, respectively [26]. Routine DVT surveillance studies would seem to corroborate these numbers: of 1277 consecutive neurosurgical patients who underwent routine admission and

weekly lower-extremity venous duplex ultrasonography surveillance, the overall DVT incidence was 2.8% [27]. In our study, the overall VTE rate at 30 days was 1.7%, which is in line with aforementioned values. The rates of DVT and PE at 30 days were 1.19 % and 0.93%, respectively. Although our DVT rates were slightly lower than some of these reported values, this discrepancy likely has to do with differences in study methodology (e.g. length of follow-up, composition of patient cohort, DVT detection by routine surveillance versus workup triggered by symptomatology, among others). Alternately, it is also possible that our exclusion of VTE diagnoses during the index hospitalization contributed to this underestimation of VTE incidence.

Patients who underwent craniotomy for tumor resection had twice the likelihood of a VTE diagnosis on readmission compared with operations for cerebrovascular disorders (Table 3). The literature is replete with reports, which similarly document postoperative VTE rates as being markedly higher in craniotomy for tumor relative to craniotomy for non-neoplastic disease [28–36]. In fact, the link between thromboembolic phenomenon and neoplasia is well-established. Among patients with neoplasms, those with malignant gliomas have one of the highest lifetime risk for VTE, second only to pancreatic cancer [37,38]. The pathophysiologic basis for this is multifactorial. One possibility is chronic activation of the coagulation cascade through tumor secretion of prothrombotic factors [39–41]. For example, Sartori *et al* found that patients with glioblastoma multiforme harbored higher levels of circulating microparticles (MP) relative to healthy subjects [42] MPs are membrane vesicles shed from tumor cells following their activation or apoptosis, which when coupled to tissue factor can initiate clotting [43,44]. Interestingly, circulating levels of MPs have been linked to both tumor burden and subsequent likelihood for VTE development [42,45,46]. Other circulating markers have been implicated as well. Brain tumors have increased levels of circulating factor IX, diminished tissue plasminogen activator activity and elevated levels of plasminogen activator inhibitor-1, all of which enhance thrombogenicity [47,48]. Altogether, these data suggest that tumor-related factors modulate coagulation, a process exacerbated in the context of surgery due to further release of procoagulants into the circulation [42].

Other reasons cited for the correlation between neoplasia and thromboembolism include chemotherapy and underlying limb paresis/plegia, which both predispose to thromboembolism [30,39]. It is also possible that the perioperative management inherent to tumor surgery has some contribution to increased VTE likelihood. In other words: were tumor patients started on chemical prophylaxis later due to hemorrhagic concerns in the wake of resection? Or were they more likely to be administered medications (e.g. steroids) with the potential to unduly influence VTE risk? However, the methodology of research derived from administrative databases such as the NRD cannot answer these questions. Nonetheless, the finding that tumor operations carry higher VTE risk is concerning not only because of the resultant morbidity, but because such a diagnosis may hinder or delay adjunctive therapies (e.g. chemotherapy, radiation) with the potential to influence long-term survival. Aggressive postoperative mobilization as well as timely administration of chemical prophylaxis is therefore imperative in this cohort, especially in patients diagnosed with malignant tumors.

Corticosteroids are widely prescribed throughout neurosurgery for their anti-inflammatory and immunosuppressant effects as well as their benefits on blood-brain barrier integrity. In multivariate analysis, steroids proved to be a significant predictor of 30-day readmission with VTE even after accounting for collinearity with potential variables such as neurologic deficit. The association between VTE and exogenous steroids has previously been noted [49,50]. In a prospective population-based case-control study from Denmark, glucocorticoid administration led to an increased risk of VTE, particularly PE. Patients who were recently started on steroids (< 90 days) had a 3-fold increased risk of VTE [49]. Moreover, VTE risk was temporally associated with steroid administration, being highest at the onset of therapy and tapering off with increasing duration of use. Thromboembolic risk was also proportional to dose: whereas low-dose prednisolone (<5 mg) had a two-fold higher risk of PE, high-dose regimens (prednisolone >30 mg) carried a 10-fold risk of PE [51]. A putative explanation for steroid-induced hypercoagulability is that it increases clotting factor and fibrinogen levels [52]. In addition, in vitro studies suggest that there is increased synthesis and secretion of von Willebrand factor and plasminogen activator inhibitor-1, which in effect promote coagulation and inhibit fibrinolysis [53,54].

The relationship between steroids and VTE has also been documented in neurosurgery cohorts [14,55]. In one of the largest studies to date, Lieber et al [55] found that corticosteroids carried a higher risk of both PE (OR 1.47, $p = 0.004$) and DVT (OR 1.55, $p < 0.001$). Because of their ubiquity, steroids are therefore a prime target for risk modification in patients undergoing craniotomy. While it is understandable that their administration is often times necessary, the VTE risks incurred, at the very least, warrant careful consideration towards a lower dose in the perioperative setting. Interestingly, while steroid use was a significant predictor at 30 days in our study, the relationship lost significance at 90 days. One explanation for this observation is that the majority of craniotomies in our cohort (81%) were for tumor and steroids tend to be discontinued in the wake of surgery addressing any underlying pathology. Hence, by 90 days any steroid-related effect would naturally have been lost from drug discontinuation, paralleling the temporal effects of steroid use noted in the Denmark population-based study above.

In multivariate analysis, advanced age correlated with VTE risk. Patients aged ≥75 years had nearly twice the odds of VTE compared to those 18–44-years old. Throughout the literature, age has been one of the most commonly implicated risk factors in venous thromboembolism [56,57]. The reasons for this relationship are not well understood but likely feature some combination of waning mobility and accruing medical comorbidities. Prolonged length of stay (≥ 12 days) and eventual discharge to institutional care (e.g. skilled nursing facility) also proved to be independent predictors of VTE after accounting for collinearity within final analyses. Others have similarly reported on these variables and their associations with VTE [26,29,55,58,59]. It seems plausible that patients with a prolonged hospital course and those eventually discharged to institutional care are not at their functional baseline and thus have some degree of restricted mobility. This might explain their higher VTE rates, but as we are unable to adjust for neurologic or dependent functional status within the NRD, we are unable to verify this claim.

Our study is subject to several limitations. As is typical with nationwide database investigations, estimates are susceptible to coding errors at the time of data entry. This may have influenced reported values in an indeterminate direction. Because the NRD does not afford tracking across state lines or calendar years, VTE readmissions may have been undercounted, thereby skewing determined incidences. Additionally, as we excluded VTE diagnoses on the index hospitalization to minimize confounding from preexisting events, this may have underestimated VTE incidence. Other notable limitations include the absence of data on socioeconomic determinants of healthcare, diagnostic workup and perioperative management. Knowledge on heparin prophylaxis strategies, for instance, would have proven useful for contextualizing our derived rates vis-à-vis other published figures in neurosurgery. Another important consideration is that there are studies which suggest a subset of patients may already have VTE events present by the time of their index admission [60]. Subsequent detection would thus lead to them erroneously being counted as hospital-acquired VTE events, when in fact they are not. We are unable to adjust for any such potential confounding, as we are limited to formal diagnoses captured through ICD-9 coding after admission.

Conclusion

We employed the 2010–2014 cohorts of the NRD to estimate venous thromboembolism rates after non-emergent craniotomy and to identify potentially modifiable risk factors associated with increased risk. The 30-day VTE incidence was determined to be 1.69%, with corresponding DVT and PE rates of 1.19% and 0.93%, respectively. The 90-day VTE incidence was 3.51%, with corresponding DVT and PE rates 2.49% and 1.99%, respectively. In multivariate analysis, several factors were predictive of VTE, namely advanced age, length of stay, discharge to institutional care, craniotomy for tumor and corticosteroids. These results advocate for increased VTE vigilance and early chemical prophylaxis in the postoperative period, particularly for patients with malignant brain tumors who are currently on steroids. Because VTE risk is known to be proportional to steroid dose, consideration should therefore be given towards lowering medication regimens in cases where a smaller dose might prove equally sufficient.

Acknowledgments

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Abbreviations

NRD	Nationwide Readmissions Database
NSQIP	National Surgical Quality Improvement Project
ICD-9CM	International Classification of Diseases, Ninth Edition, Clinical Modification
VTE	venous thromboembolism
DVT	deep vein thrombosis

PE	pulmonary embolism
ICH	intracranial hemorrhage
SNF	skilled nursing facility
LTAC	long-term acute care

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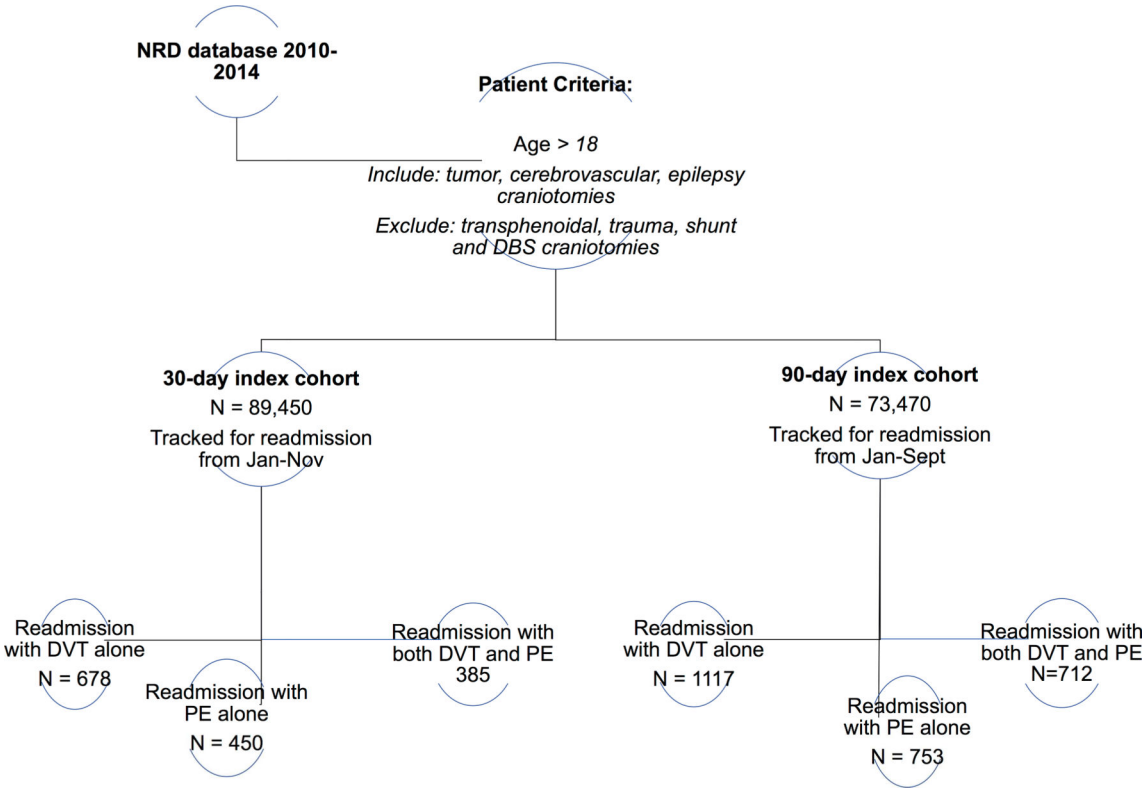

Figure 1.
Schematic of Nationwide readmissions database (NRD) study design

Table 1.

Combination of International Classification of Diseases, 9th edition, diagnosis and procedures codes used to extract index cohort

Craniotomy cohort		ICD-9 Diagnosis code	ICD-9 Procedure code
Epilepsy		345.x	1.53, 1.52
Tumor	Benign	192.1, 225.2, 237.6	1.51
		225.1	4.01
		237.0	7.61, 7.64
		225.0	1.59
	Malignant	191.0–191.9	1.53, 1.59
		198.3	1.59
Vascular	Aneurysm	430, 437.3	39.51
	AVM	747.81	1.59
	Moya-Moya disease	437.5	39.28
	Cerebroocclusive disease	433.00, 433.10, 433.20, 433.30, 433.80, 433.90, 434.10, 434.90, 437.0, 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 434.91, 435.x, 437.1	39.28

Table 2.

Demographics of patients readmitted within 30 days of index craniotomy.

Variables		N	%
Diagnosis	Malignant Tumor	960	63.45
	Benign Tumor	409	27.03
	Vascular	139	9.19
	Epilepsy	DS	DS
	Total	1513	1.7
Age	18–44	181	11.96
	45–59	466	30.8
	60–74	637	42.1
	>=75	229	15.14
Gender	Male	744	49.17
	Female	769	50.83
Primary insurance	Medicare	630	41.64
	Medicaid	182	12.03
	Private insurance	596	39.39
	Self-pay	43	2.84
	No charge	DS	DS
	Other	53	3.5
Hospital bedsize	Small	87	5.75
	Medium	209	13.81
	Large	1217	80.44
Teaching status	Teaching	1233	81.49
	Non-Teaching	280	18.51
Disposition	Routine	723	47.79
	Short-term Hospital	49	3.24
	Transfer Other	399	26.37
	Home Health Care	342	22.6
	Against Medical Advice	DS	DS
Volume	Above 90th percentile	757	50.03
	<= 90th percentile (115 / year)	756	49.97
Elixhauser comorbidity	Yes	1154	76.27
	No	359	23.73
Medical complication	Yes	84	5.55
	No	1429	94.45
Neurological complication	Yes	329	21.74
	No	1184	78.26
Obesity	Yes	DS	DS
	No	1510	99.8

Variables		N	%
Tobacco	Yes	481	31.79
	No	1032	68.21
Diabetes	Yes	262	17.32
	No	1251	82.68
Hypercoagulable state	Yes	DS	DS
	No	1510	99.8
Index Length of stay	0–3 days	303	20.03
	4–5 days	236	15.6
	6–10 days	416	27.5
	>=11 days	558	36.88
Median household income for patient's ZIP code, based on current year	0–25 percentile	350	23.13
	26–50 percentile	335	22.14
	51–75 percentile	391	25.84
	76–100 percentile	408	26.97
Steroid use	Yes	43	2.84
	No	1470	97.16
SIRS criteria	Yes	26	1.72
	No	1487	98.28
Hx of chemotherapy	Yes	69	4.56
	No	1444	95.44
Ventilator dependence	Yes	DS	DS
	No	1506	99.54
Chronic lung disease	Yes	218	14.41
	No	1295	85.59

* DS = Data suppressed in accordance with HCUP/NRD guidelines.

Table 3.

Breakdown of VTE events by indication for craniotomy

	30-day readmission		90-day readmission	
Study Cohort	**DVT (# events/rate)**	**PE (# events/rate)**	**DVT (# events/rate)**	**PE (# events/rate)**
Vascular	96 (0.60%)	65 (0.41%)	114 (0.87%)	74 (0.57%)
Benign tumor	287 (1.08%)	239 (0.90%)	362 (1.65%)	265 (1.21%)
Malignant tumor	675 (1.47%)	529 (1.15%)	1347 (3.57%)	1124 (2.98%)

Table 4.

Predictors of 30-day readmissions for VTE by multivariate analysis using surveyadjusted logistic regression

Variables		Odds Ratio	95% CI		p-value
Craniotomy cohort	Malignant Tumor	2.431	2.021	2.923	<.0001
	Benign Tumor	2.015	1.654	2.454	<.0001
	Vascular	Ref			
	Epilepsy	0.863	0.352	2.117	0.7468
Age	18–44	Ref			
	45–59	1.364	1.146	1.622	0.0005
	60–74	1.613	1.36	1.913	<.0001
	>=75	1.69	1.375	2.077	<.0001
Gender	Male	1.15	1.037	1.276	0.0082
	Female	Ref			
Disposition	Routine	Ref			
	Short-term Hospital	2.623	1.939	3.549	<.0001
	Transfer Other	1.736	1.506	2	<.0001
	Home Health Care	1.327	1.155	1.524	<.0001
	Against Medical Advice	*			
Index Length of stay	0–3 days	Ref			
	4–5 days	1.232	1.037	1.465	0.0178
	6–11 days	1.526	1.305	1.784	<.0001
	>=12 days	1.959	1.674	2.291	<.0001
Steroid use	Yes	1.408	1.034	1.917	0.03
	No	Ref			

* OR cannot be computed due to small sample size

Table 5.

Predictors of 90-day readmissions for VTE by multivariate analysis using surveyadjusted logistic regression

Variables		OR	95% CI		p-value
Craniotomy cohort	Malignant Tumor	4.357	3.683	5.156	<.0001
	Benign Tumor	2.083	1.733	2.503	<.0001
	Vascular	Ref			
	Epilepsy	1.007	0.443	2.29	0.9872
Age	18–44	Ref			
	45–59	1.531	1.325	1.77	<.0001
	60–74	1.895	1.64	2.188	<.0001
	>=75	2.027	1.709	2.405	<.0001
Gender	Male	1.111	1.025	1.205	0.0103
	Female	Ref			
Disposition	Routine	Ref			
	Short-term Hospital	1.836	1.398	2.411	<.0001
	Transfer Other	1.438	1.284	1.61	<.0001
	Home Health Care	1.218	1.095	1.356	0.0003
	Against Medical Advice	0.61	0.149	2.487	0.4903
Elixhauser comorbidity	Yes	1.254	1.13	1.391	<.0001
	No	Ref			
Index Length of stay	0–3 days	Ref			
	4–5 days	1.293	1.134	1.475	0.0001
	6–11 days	1.512	1.341	1.705	<.0001
	>=12 days	1.85	1.635	2.094	<.0001
Chronic lung disease	Yes	0.865	0.772	0.969	0.0121
	No	Ref			