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Multiple significant trauma with craniotomy: What impacts mortality?

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ABSTRACT

Objective: The management of patients suffering traumatic brain injury (TBI) in the context of multiple significant trauma represents one of the most challenging scenarios in trauma critical care. The identification of risk factors, utilizing large national databases, may help in developing medical strategies and health care policies aimed at improving outcomes in these patients. In this study, our aim was to assess in-hospital mortality following craniotomy for multiple significant trauma in the United States.

Patient and methods: A retrospective cohort study was conducted using the Nationwide Inpatient Sample (NIS) on subjects having "Craniotomy with Multiple Significant Trauma" between 2008–2016. Multivariate logistic regression was used to find the impact of selected variables on the odds of mortality.

Results: There were 26,650 discharges within the study period that were predominantly male (73.2%), white (65.1%), with a mean age of 39.7 ± 22.3, and in-hospital mortality of 35.4%. During the study period, the mortality of this population increased from 34.8% to 38.3% (p = 0.18). In a multivariate logistic regression analysis, the following conditions were associated with higher mortality: being on pressors (OR: 8.41; CI 95% 5.55–12.75, p = 0), having Status Epilepticus (OR: 3.33; CI 95% 1.26–8.81, p = 0.015), self-pay (OR: 4.81; CI 95% 1.49–2.59, p = 0), privately insured (OR: 1.97; CI 95% 1.49–2.59, p = 0) and discharge from urban teaching hospitals (OR = 1.4; CI 95% 1.16–1.68, p = 0).

Conclusion: Patients who underwent craniotomy with multiple significant trauma had high mortality, at a rate of about one in three; mortality has been increasing during recent years. Those who required vasopressors and those who developed Status Epilepticus had a significant association with higher death. These associations may be due to the complexity of injuries in this population. Patients with these conditions should seek further attention by the clinicians. Further studies are warranted to characterize these differences.

1. Introduction

The management of patients suffering traumatic brain injury (TBI) in the context of multiple significant trauma represents one of the most challenging scenarios in trauma critical care [1,2]. Multiple significant trauma involving spine, craniofacial fractures, chest and abdominal injuries often requires surgery and hemodynamic stabilization prior to neurosurgery, which poses risk for blood loss, consequent hypotension, delayed neurosurgical intervention, and overall poorer neurological outcome [3]. Accordingly, brain injury associated with multiple significant trauma contributes to substantial mortality, accounting for up to 60% of all trauma related deaths with delayed timing to craniotomy as a major determinant [4–6]. Therefore, the identification of risk factors, utilizing large national databases, may help in developing medical strategies and health care policies aimed at reducing mortality in these patients [7].

Although mortality following elective craniotomies and craniotomies for primary TBI have been well documented, there is a general dearth of literature with regards to craniotomies done in patients with multiple significant trauma [8–11]. As such, our aim was to assess in-hospital mortality following craniotomy for multiple significant trauma in the United States.

2. Patients and methods

This study analyzed data from the National Inpatient Sample (NIS), a part of the Healthcare Cost and Utilization Project (HCUP), run by the federal Agency for Healthcare Research and Quality. The NIS is a 20 percent stratified sample of all discharges from United States community hospitals (excluding rehabilitation and long-term acute care

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hospitals). We created the cohort by sorting for observations that indicated the Diagnosis-Related Group (DRG) Craniotomy for Multiple Significant Trauma (MS-DRG 955). To be assigned to this DRG the patient must either have: 1) a principal diagnosis from a significant trauma body site category and a secondary diagnosis from a different significant trauma body site category (requires 2 diagnoses), or 2): a principal diagnosis from the trauma diagnosis as well as two different secondary diagnoses derived from two different significant trauma body site categories (requires 3 diagnoses), as summarized in Appendix 1 that is defined by the Centers for Medicare and Medicaid Services (CMS).

Any patient of any age that had a DRG of 955 between 2008 and 2016 were included. Within the United States 26,650 observations of craniotomy for multiple significant trauma met inclusion criteria over the interval. Some years had insufficient data for certain variables, such as lacking median household income (by zip-code) and/or race, resulting in us dropping a small portion of the observations. In the end, this caused the drop of approximately 15% of the observations for the final multivariate regression. Our primary outcome measure was all-cause in-hospital mortality.

Multivariate logistic regression was utilized to calculate odds ratios for the likelihood of mortality during the inpatient stay based on Critical Care Conditions (CCC) of our interest by using ICD9 (January 2008-September 2015) or ICD10 (October 2015-December 2016) codes (see Appendix 1). These CCC included: Infusion of Vasopressor Agent, Status Epilepticus (SE), Sepsis, Urinary Tract Infection (UTI), and Ventilator Associated Pneumonia (VAP). First, a logistic multivariate regression of only in-hospital complications and odds of death were obtained. Only SE and infusion of vasopressor agents were associated with increased odds of mortality. Subsequently, other covariates were added into the final regression, of which included: age, gender, insurance type, median household income quartile (based on zip-code of residence), teaching status/location of hospital, and race.

Kaplan-Meier survival curves were generated for two critical care conditions of interest within the cohort: use of vasopressor agent, and status epilepticus. For each condition, the odds of survival were graphed by the length of stay (in days) in the sub-cohort who had the condition of interest, and the sub-cohort who did not have the condition of interest. Our institution exempted this analysis from full review by the Institutional Review Board (IRB: HSC20150408N).

All statistical analysis was two-sided with $p < 0.05$ used as a cut off value for significance. Stata Version 15.1 for Mac was utilized for the entirety of the study.

3. Results

3.1. Demographics

Within the study period from 2008 to 2016, the United States had 26,650 discharges for craniotomy with multiple significant trauma that met our inclusion criteria. The patients were likely to be young (average age: 39.7 ± 22.3), male (73.2%), and white (65.1%). The average length of stay was 13.5 days, highly likely to be an admission to an urban teaching hospital (84.3%), with a total in-hospital mortality rate of 35.4% (Table 1). A graph of the mortality shows that the mortality of the study subjects increased slightly from 34.8% to 38.4% during the study period, although this increase was not statistically significant ($p = 0.18$) (Fig. 1).

They were likeliest to be from the geographic region of the South (40.0%), have a private insurance payer (42.8%), and be from the poorest income quartile (30.9%).

3.2. Multivariate logistic regression

Multivariate logistic regression analysis demonstrated that certain patient characteristics and hospital conditions had an association with increased odds of mortality (Table 2).

Table 1
Cohort Demographics of Craniotomies in the United States, 2008-2016.

	n (%)
Sample size, *n*	26,650
Age, years	39.67 (22.3)
Length of stay, days	13.47 (15.7)
Female	7,130 (26.8)
Region	
Northeast	4,025 (15.1)
Midwest	4,915 (18.4)
South	10,670 (40.0)
West	7,040 (26.4)
Critical Care Conditions	
Infusion of Vasopressor Agent	835 (3.1)
Status Epilepticus	120 (0.5)
Teaching status/location	
Rural	380 (1.5)
Urban non-teaching	3,775 (14.3)
Urban teaching	22,115 (84.3)
Payer	
Medicare	3,975 (15.0)
Medicaid	5,235 (19.7)
Private payer	11,350 (42.8)
Self-payer	3,180 (12.6)
No Charge	245 (0.9)
Other	2,535 (9.6)
Race	
White	15,650 (65.1)
Black	2,560 (10.7)
Hispanic	3,875 (16.1)
Asian or Pacific Islander	645 (2.7)
Native American	275 (1.1)
Other	1,035 (4.3)
Income quartile by zip code	
First (lower income -$42,000) *	7,940 (30.9)
Second ($43,000 - $53,999)	6,800 (26.5)
Third ($54,000 - $70,999)	6,145 (23.9)
Fourth (higher income, $ 71,000 +)	4,780 (18.6)

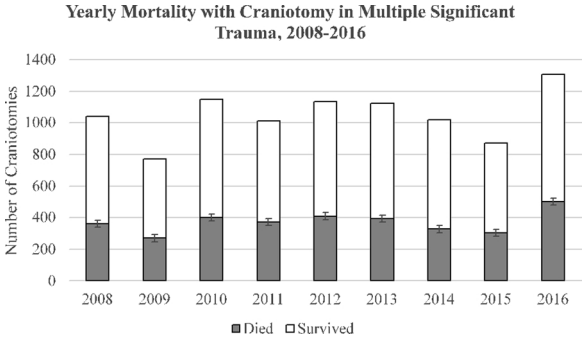

Fig. 1. Trend of mortality in craniotomy with multiple significant trauma, 2008-2016.

3.2.1. Demographic conditions

Age had significant and positive association with mortality; each additional year of age was associated with about a 2-percentage point increase in the odds of mortality (OR: 1.02; CI 95% 1.01–1.02, $p = 0$). However, gender had no impact on death (Female OR: 1.12; CI 95% 0.96–1.30, $p = 0.13$). Looking into the ethnicity, none of the known ethnicities reached a statistically significant association with mortality ($p > 0.05$). In our cohort, 64% of all craniotomy for multiple significant trauma were related to motor vehicle accidents, 20% were due to falls, and the remaining 16% have been due to other various causes.

3.2.2. Socioeconomic factors

Compared to the Medicare cohort, those that were self-pay (i.e.

Table 2
Multivariate Regression of In-hospital Mortality With Selected Characteristics, United States 2008-2016.

	OR	95% CI (Lower)	95% CI (Upper)	*P*-Value
Critical Care Conditions				
Usage of Vasopressors	8.41	5.55	12.75	0
Status Epilepticus	3.33	1.26	8.82	0.015
Teaching status/location				
Rural	1.01	0.52	1.97	0.972
Urban teaching	1.40	1.15	1.68	0
Patient characteristics				
Age	1.02	1.01	1.02	0
Gender				
Male	Reference			
Female	1.12	0.97	1.30	0.129
Race				
White	Reference			
Black	0.85	0.68	1.06	0.147
Hispanic	0.94	0.78	1.13	0.482
Asian or Pacific Islander	0.88	0.59	1.32	0.543
Native American	0.81	0.40	1.67	0.571
Other	1.50	1.09	2.05	0.013
Income quartile by zip code				
First	Reference			
Second	1.00	0.85	1.19	0.96
Third	1.07	0.90	1.28	0.424
Fourth	0.83	0.68	1.00	0.055
Insurance type				
Medicare	Reference			
Medicaid	1.26	0.96	1.65	0.096
Private insurance	1.56	1.24	1.96	0
Self-pay	1.97	1.49	2.59	0
No charge	1.64	0.82	3.29	0.163
Other	1.42	1.06	1.91	0.02

uninsured) had higher mortality (OR: 1.97; CI 95% 1.49–2.58, p = 0) as did those with private insurance (OR: 1.56; CI 95% 1.23–1.96, p = 0). Median household income by zip-code was not found to have a statistically significant association with mortality (p > 0.05).

3.2.3. Hospital characteristics

In general, 84.3% of this population was admitted in urban teaching institutions, followed by 14.3% in urban non-teaching and 1.5% in rural hospitals. Patients admitted to urban teaching hospitals had significant association with higher odds of mortality compared to urban non-teaching hospitals (OR: 1.40; CI 95% 1.49–2.59, p = 0), while rural hospitals had no significant association with death (OR: 1.01; CI 95% 0.52–1.97, p = 0.972).

3.2.4. Critical care conditions

Patients requiring an infusion of a vasopressor agent were more than 8 times likely to die (OR: 8.41; CI 95% 5.55–12.75, p = 0). Those with SE had greater than 3 times higher odds of mortality (OR = 3.33; CI 95% 1.26–8.82, p = 0.015). These results are depicted in the Kaplan-Meier survival curves of death with pressor usage (Fig. 2A) and SE (Fig. 2B).

4. Discussion

According to the centers for disease control and prevention (CDC), trauma is the leading cause of death in patients younger than 45 and the third leading cause of death older than 45, only third to heart disease and cancer [12]. Our own study supported that craniotomies for multiple significant trauma are associated with upwards of one third of patients dying after craniotomy. Moreover, our analysis indicated that this mortality is steadily rising in recent years with documented mortality approaching 40% in 2016. Therefore, the significant mortality rates associated with craniotomy for multiple significant trauma

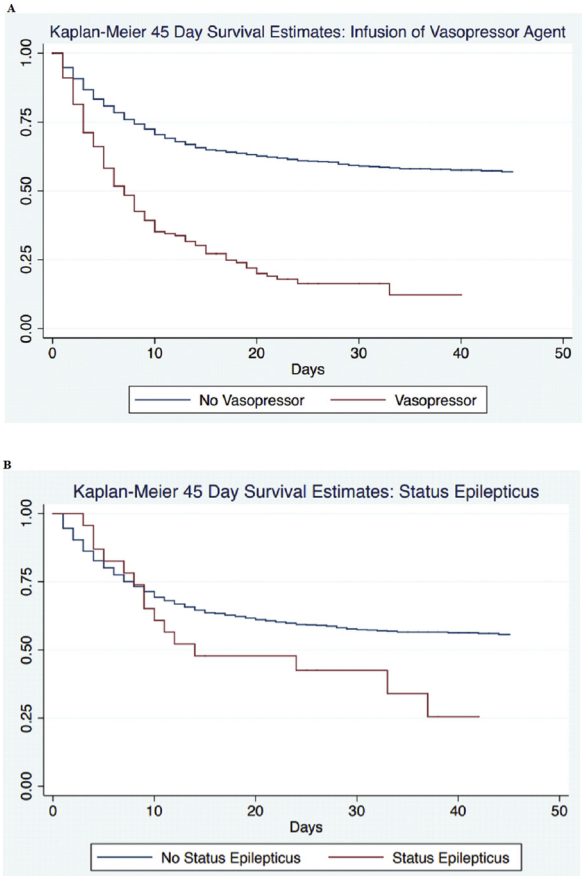

Fig. 2. A: Kaplan-Meier 45-day survival curves for subjects who required infusion of vasopressor. B: Kaplan-Meier 45-day survival curves for subjects with status epilepticus.

demand more attention towards optimizing care for this cohort. In this analysis we desired to understand the factors that may impact mortality in order to identify methods to reduce overall mortality from this condition. While several previous studies have attempted to characterize mortality following craniotomy in general, we believe that this is the first analysis that studies mortality following craniotomy in the setting of multiple significant trauma, specifically. Here, we performed a retrospective cohort review using the Nationwide Inpatient Sample, a large and proven national database, in order to better understand the contributors of mortality in this type of neurological patient.

4.1. Demographics

Consistent with prior studies, we find advancing age to be associated with greater mortality following craniotomy [13–15]. Falls account for a major proportion of multiple significant trauma in the elderly and overall multiple significant trauma cases, as such we also reported an estimated 20% fall rate in this cohort. For example, several studies have shown that advanced age is a poor prognostic indicator in multiple trauma, corresponding with longer stays, greater need for rehabilitation, and lesser likelihood for functional independence after surgery [13–15]. In the context of an aging population, increasing number of elderly out-of-pocket payers who may not be able to afford care with increasing costs for cranial neurosurgery, health care providers must consider the financial burden and effects on patients receiving specialized neurosurgical care [16].

4.2. Socioeconomic factors

Our results indicated that patient insurance payer type was

associated with significant differences in mortality. Specifically, we found higher odds of death in self-pay and privately insured patients compared to those insured under Medicare. The average of self-pay patients (36.6 ± 14.6 years) was similar to privately insured (35.1 ± 19.4 years) and Medicaid patients (29.4 ± 17.8), but starkly different than Medicare age groups (71.2 ± 15.4). Considering the known poor prognostic outcomes of elderly patients, higher mortality in the younger self-pay cohort suggests insurance status may have an even greater effect on patient outcomes following craniotomy than indicated by the data. Median household income level (determined by zip-code of residence), which is often used as an indirect measure of patient socioeconomic status, did not show statistically significant differences in mortality according to income quartile.

In an ideal world, all patients would have access and receive equal care to one another. In the United States, elective care is largely determined by the type of insurance one holds as not all providers accept all forms of insurance. Investigating the outcomes of patients created by this tiering of care is thus of even greater importance to identify and address this issue. For example, uninsured patients may be unable to receive proper follow-up care after elective surgical procedures resulting in increased complications [17,18].

Previous studies have shown that patient characteristics and insurance coverage may be implicated in mortality following craniotomy [7,17–19]. Research reviewing craniotomies done for tumors has shown that minority groups and poorly insured patients are associated with greater mortality and more frequent adverse discharge dispositions. Other studies identify an “allocation bias” in which uninsured patients had lesser likelihood of receiving craniotomies for extra-axial intracranial hemorrhage compared to their insured counterparts [7]. Curry et al. also explored reasons for worsened outcome disparities among racial groups one of which being patients presenting to a lower-volume surgery hospital. In light of increasing costs for neurosurgical procedures the financial burden uninsured patients pose is evident. However, as physicians we must form a solution to address the needs of an increasingly diverse nation that may or may not have the means to fund their care.

Unlike elective cases, trauma cases are unique as all efforts should be focused on salvaging the patient’s life without allowing socioeconomic factors to affect care. Unfortunately, our study corroborated with multiple other studies demonstrating that self-paid patients had among the worst outcomes compared to Medicaid, Medicare, and private insurance [7,17,20,21]. Mortality for patients in our study is most likely under-accounted for as our analysis is from a single admission, failing to capture long-term mortality as uninsured patients face further obstacles to follow-up care. Bell et al. explains such findings by describing how this patient group experiences a greater rate of “failure to rescue” events—events where there was a failure to address preventable mortality and manage complications [20]. Other studies analyzed the amount of resources used for patients with various insurance types and showed uninsured patients received statistically significant differences in intensive care and operative management [22,23]. This demonstrates unequal care provided to uninsured trauma patients and an opportunity for improvement. Even though uninsured trauma may generate significant cost burden, they still only result in 9% of total trauma inpatient costs; thus, improving the system so that uninsured patients fare well should also not be overly costly [23].

Interestingly our study found that trauma patients with private insurance fared worse than those with public insurance, deviating from the findings of most studies [7,8,17,20,21]. Jentzsch et al. provided insight from Switzerland literature showing that privately insured tended to be older with greater likelihood of comorbidities in their patient population. While this was not the case in our study, this is a finding worth further exploration regarding injury severity or other factors explaining the greater in-hospital mortality [18]. Another explanation not clearly captured in our study due to follow-up length is loss of coverage in the privately insured group as traumatic brain injuries can be severely devastating and result in loss of employment [24,25]. These findings could further be explained by investigating which resources were used for each patient subgroup and whether the operative or non-operative rate of other injuries resulted in increased mortality.

4.3. Hospital teaching status

Our study showed that a large percentage of the cohort was discharged from an urban teaching hospital; an admission to an urban teaching hospital was associated with a higher mortality as well. Generally, in traumatic injuries patients are less likely to choose which trauma facilities they will receive care. Instead, they are routed to the closest facility that can stabilize the patient before they are transferred to an institution that can provide ultimate medical and surgical management [26]. These hospitals primarily represent tertiary referral centers for trauma, which are hospitals that can provide specific subspecialty care, including specialists on site and sophisticated intensive care facilities. Teaching hospitals represent a large cohort of these tertiary referral centers, accepting trauma patients from primary and secondary centers that are unable to provide appropriate care for these cohort of patients. As such, teaching hospitals are able to accept more complex and sicker populations, which may contribute to an overall higher propensity for death, in spite of better overall care. Since trauma patients cannot actively choose where they will receive care in this process, whether it be a teaching or non-teaching institution, it is imperative for teaching hospitals to account for factors to achieve similar survival with private counterparts.

The effect of hospital teaching status on neurosurgical outcomes has been controversial with substantial debate not only in neurosurgery but also in other surgical and trauma related fields [27]. Some studies show that the “July Effect” and the process of training physicians may be involved in increased case-fatality and longer length of stays at teaching institutions [28,29]. Others refute that neurosurgical procedures at teaching hospitals have fewer complications than non-teaching counterparts due to advanced training and availability of intensive care staffing and technologies [30].

For example, whereas a study conducted by Lieber et al. argued in favor of sufficient guidance and support at teaching hospitals, rejecting a July Effect, Bekelis et al. showed that differences in the impact of teaching and non-teaching hospitals in many current studies are likely due to less control for unmeasured confounders and selection biases. In their retrospective review of spine and cranial operations within New York, the authors utilized an instrumental variable analysis to better control for confounders and showed that teaching hospitals demonstrated higher mortality, citing decreased resident experience in medical management, poorer operative skills, increased number of handouts and fragmentation of care as reasons behind observations [29]. Accordingly, in an analysis by Dimick et al. comparing complex non-neurosurgical surgeries at teaching and non-teaching hospitals, the authors initially showed less mortality with teaching hospitals. However, when multivariate regression of mortality was controlled for patient volume, it was determined that the lower mortality was likely secondary to a greater number of complex surgical procedures conducted at teaching hospitals [30]. The authors noted that teaching hospitals were also likely to undertake more complex procedures, but were likely to have fewer complications following surgery [27]. Nonetheless, mortality alone at teaching hospitals may not speak to the functional outcomes of patients undergoing craniotomy for multiple significant trauma. Therefore, the literature suggests that craniotomies at teaching hospitals have worse overall outcomes than non-teaching hospitals when controlled for patient volume and confounding variables, albeit with greater number of complex procedures and fewer follow-up complications.

In our study, we found there to be increased odds of mortality for craniotomies for multiple significant trauma patients at urban teaching

hospitals, which is consistent with the literature. In our review of the NIS, 84% of the sample represented craniotomies that were done at urban-teaching hospitals, which reflects a notion of increased mortality secondary to higher volume. Overall, we speculate that increased mortality at teaching hospitals was attributed to a combination of factors, which involved teaching hospitals receiving higher complexity of cases, greater volume of craniotomies, along with increased management with resident physicians.

4.4. Critical care conditions

Our multivariate model controlled for medical complications and showed that usage of pressors and status epilepticus was associated with significantly higher odds of mortality. Interestingly, a need for infusion of vasopressors during admission was associated with 8 times greater mortality. In general, trauma patients who require pressors represent more complex polytraumas and are likely in shock. Traditionally, vasopressors are indicated when vasoplegic shock ensues and blood pressure cannot be controlled by resuscitation [31]. Therefore, the need for vasopressors may indirectly correlate to the degree of trauma sustained, which reflects worse prognosis following craniotomy [32,33]. Due to the importance of resuscitation, it is possible that craniotomy gets delayed for trauma management. These findings support the implementation of a team approach in multiple significant trauma, as discussed by Rosenfeld et al., in which neurosurgery may be performed during laparotomy to ensure a timelier craniotomy [1]. Knowing the high impact on mortality of patients who have required pressors will be helpful in managing shock in these patients early on to lower mortality.

Similarly, status epilepticus following craniotomy was associated with a greater than 3 times increase in mortality in trauma patients. This echoes the findings of the author's previously published paper, which showed that SE in subdural hemorrhage further contributes to pulmonary, hematologic, and renal dysfunction with respiratory failure as the major contributor of mortality. Seizures occurring after craniotomy are considered an added burden as they can be complicated by injury, aspiration, need for tracheostomy, venous thromboembolism, respiratory failure, and even death. Physiologically, increased epileptic activity is hinged on the principle that acute ischemia in addition to cytotoxic mediators is the basis for neuronal injury and subsequent excitability. Detection of these epileptiform discharges via continuous EEG monitoring may have a positive mortality benefit and prevent the aforementioned complications associated with SE [34]. While a study by Al-Dorzi et al. showed that seizures following craniotomy for primary brain tumor resection did not worsen mortality for patients, this highlights the need for a different approach in trauma patients [35]. Contrary to cancer patients, trauma patients may be less likely to recover from seizures following craniotomy, and prophylactic anti-epileptics may be warranted in their management. Further SE is often preventable with active management and a high degree of suspicion based on other clinical findings, including but not limited to, detection with 24 -h EEG and prophylactic treatment. Identification of high-risk post-craniotomy patients that are complicated with SE, may optimize management and reduce overall mortality [36,37]. Nevertheless, while SE showed significant associations with mortality in this analysis, SE clinically represented a small proportion of all mortality following craniotomy for multiple significant trauma, comprising of just 0.5% of patients within our study. This low percentage, however, could be a consequence of missed detection due to the lack of continuous EEG for routine monitoring in this population. The grave impact of SE on mortality in our findings will seek attention on the need for more prospective studies on the role of continuous EEG in these subjects with the hope that early detection can lead to early treatment and less mortality.

4.5. Limitations

While the advantages of the study design included a large sample size over several settings, the retrospective design had several limitations and areas for improvement. Although our analysis may suggest greater mortality for certain demographics, the information available from NIS does not allow us to comment on the functional outcomes after discharge, as well as the detail of surgeries, severity of illness, and radiographic and/or laboratory data. Also, post-discharge complications and need for re-evaluation of surgery is not included in our analysis. Future studies would evaluate patient discharge disposition, including discharges to skilled nursing facilities and other rehabilitation facilities, along with patient survival. Additionally, in the context of multiple significant trauma, the timing to craniotomy may be another key determinant of patient outcome. Our hypothesis is that delay to craniotomy from initial admission is associated with greater mortality. However, we did not have access to the timing to craniotomy in this analysis. In our study, the southern geographic region represented nearly 40% of all observed craniotomies. In future studies it may be interesting to stratify geographic region by payer type and hospital teaching status in order to better understand if there is a regional impact on mortality in the United States. Likewise, a review of payer type, age and hospital characteristics for those patients who required vasopressors or those who died from post-operative SE may help to clarify the associations of our variables with one another and limit potential for confounders. Lastly, despite the use of trained coders, labeled DRG codes may be variable. Nevertheless, NIS proves an invaluable tool towards the characterization of craniotomies performed in the United States, allowing for interpretation and analysis of large cohorts of data and ultimately providing insight into health care quality improvement.

5. Conclusion

Multiple significant trauma with traumatic brain injury requiring craniotomy is a severely catastrophic event with high mortality despite significant care in the hospital setting and prompt surgical intervention. Those who required vasopressors and those who developed SE had a significant association with higher mortality. Patients with having these conditions should seek further attention by the neuro intensivists knowing the association with a higher risk of death. Similarly, significant associations with mortality exist for the elderly, self-pay, and privately insured patients, especially in major urban teaching hospitals. Although some of these factors are controllable to an extent by clinicians, such as SE, the others, such as insurance and hospital teaching status, are mainly associated with overall healthcare infrastructure. For patients with craniotomies and multiple significant trauma, physicians should be vigilant and have a higher suspicion of the controllable factors like SE by prophylactically monitoring for seizures when relevant to the patients' condition. A further prospective review of contributing factors and long-term dispositional outcomes is necessary to better understand these differences and implement changes to improve our healthcare.

Contributions

All authors contributed to: conception and design, acquisition of data, and analysis of data; drafting the article and revising it critically; and final approval of the version to be published

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Declaration of Competing Interest

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Appendix A

Appendix Codes Used for the Study (39)

1. Diagnosis-Related Group (DRG) Codes

A **955: Craniotomy for Multiple Significant Trauma**

Procedure	Clinical Concept Inclusions
Craniotomy, other	• Burr Holes • Cranial decompression, exploration, trephination • Craniotomy NOS • Craniotomy with removal of epidural abscess, extradural hematoma, foreign body of skull
Incision of brain, other	• Drainage of intracerebral hematoma
Incision of cerebral meninges	• Drainage of intracranial hygroma subarachnoid abscesses (cerebral) and subdural empyema
Insertion or replacement of skull tongs or halo traction devices	• Crutchfield tongs • Gardner Wells tongs • Halo device
Repair of central meninges	• Closure of fistula of cerebrospinal fluid • Dural graft • Ligation of meningeal vessel • Repair of cerebrospinal fluid (dural) leak in cerebral or intracranial sites • Repair of meninges NOS • Subdural patch • Suture of dura mater of brain
Ventriculostomy	• Insertion or replacement of external ventricular drain (EVD) • Intracranial ventricular shunt or anastomosis • Insertion of Holter valve via ventriculostomy Ventriculostomy is defined as the creation of a shunt between the cerebral ventricle and cisterna.

B **Significant Trauma Body Site Category 1 – Head, detail description**

Diagnosis	Clinical Concepts Inclusions
Fracture of skull with loss of consciousness	• Fractures of base and vault of skull • Open and closed fractures • With and without mention of cerebral alteration and contusion • With and without mention of subarachnoid, subdural, extradural or other intracranial hemorrhage • With and without mention of intracranial injury Must have LOC associated with the injury to classify as a Significant Trauma Body Site Category 1- Head injury
Hemorrhage, intracranial, following injury (S06.34-S06.36, S06.4-S06.6 with initial encounter only)	• Extradural (epidural) hemorrhage • Intracranial hemorrhage • Subarachnoid hemorrhage • Subdural hemorrhage • Cerebral unspecified hemorrhage Also includes with and without mention of open intracranial wound
Injury, intracranial, of other and unspecified nature (S06.1X-S06.30, S06.81-S06.82, S06.893, S06.899A, S06.9X with initial encounter only)	• With and without mention of open intracranial wound • Includes traumatic cerebral edema, diffuse traumatic brain injury, focal traumatic brain injury, and injury to intracranial portion of internal carotid artery
Laceration and contusion, cerebral (S06.31-S06.33, S06.37-S06.38 with initial encounter only)	Lacerations or contusions of: • Brain Stem • Cerebellum • Cortex With and without mention of open intracranial wound

C **Significant Trauma Body Site Categories:**

Category 1- Head
Category 2 -Chest
Category 3- Abdomen
Category 4-Kidney
Category 5- Urinary
Category 6- Pelvis and Spine
Category 7- Upper Limb
Category 8- Lower Limb

2. ICD 9 Codes

Medical Complications	Codes
Infusion of Vasopressor Agents	00.17
Status Epilepticus	345.3

3. ICD 10 Codes

Medical Complications	Codes
Infusion of Vasopressor Agents	3E030XZ, 3E033XZ, 3E040XZ, 3E043XZ
Status Epilepticus	G41

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