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The Profile of Blunt Traumatic Supratentorial Cranial Bleed Types

Aaron C Shpiner, BS^a, Nikolay Bugaev, MD^b, Ron Riesenburger, MD^c, Isaac Ng, MS^a, Janis L Breeze, MPH^d, Sandra S Arabian, MBA^b, and Reuven Rabinovici, MD^b

^aTufts University School of Medicine, 136 Harrison Avenue, Boston, MA, 02111, United States.

^bDivision of Trauma & Acute Care Surgery, Tufts Medical Center, Tufts University School of Medicine. 800 Washington st, #4488, Boston, MA, 02111, Boston, MA, 02111, United States

^cDepartment of Neurosurgery, Tufts Medical Center, Tufts University School of Medicine. 800 Washington st, #8484, Boston, MA, 02111, United States

^dTufts Clinical and Translational Science Institute, Tufts University, and Institute for Clinical Research and Health Policy Studies, 35 Kneeland st, Boston, MA, 02111, United States

Abstract

The characteristics of blunt traumatic supratentorial cranial bleed (STCB) types have not been directly compared. The National Trauma Data Bank (NTDB) 2014 was queried for adults with an isolated single STCB $n=57,278$. Patients were grouped by STCB categories: subdural (SDH), subarachnoid (SAH), epidural (EDH), intraparenchymal (IPH), and intraventricular hemorrhage (IVH). Frequency, demographics, clinical characteristics, procedures, and outcomes were compared among groups. SDH was the most common STCB (53%) and occurred mostly in elderly patients after a fall (78%), 30% underwent craniotomy and their mortality was 7%. SAH occurred in 32% of patients and carried the lowest mortality (3%). SAH were least likely to have a severe brain injury (7%), and had the lowest Injury Severity Score (ISS, median 8) and complication rate (1%), as well as the shortest hospital length of stay (HLOS, 4.6 ± 6.4 days). EDH was uncommon (2%), occurred in younger patients (median 35 years), and had the highest percentage of traffic related injuries (28%). While EDH patients presented with the poorest neurological status (16% Glasgow Coma Scale ≤ 8 , ISS median 18) and were operated on more than any other STCB type (51%), their mortality was lower (4%) and they had the highest discharge to home rate (71%). IVH was the least common (2%), but most lethal (9%) STCB type. These patients had the highest HLOS and intensive care unit LOS, and the lowest craniotomy rate (21%). STCB types have different clinical course, and outcomes. Understanding these differences can be useful in managing patients with STB.

Corresponding Author: Nikolay Bugaev MD, Division of Trauma & Acute Care Surgery, Tufts Medical Center, Tufts University School of Medicine., 800 Washington st, #4488, Boston, MA, 02111, Boston, MA, 02111, United States, Phone: +1 617 636-4488, Fax: +1 617 636-8172, nbugaev@tuftsmedicalcenter.org.

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There are no conflicts of interest to declare.

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Keywords

traumatic brain injury; intracranial bleed; supratentorial bleed

Introduction

Each year, approximately 1.6 million people experience a Traumatic Brain Injury (TBI), the most common cause of disability and mortality among trauma patients [1, 2]. The leading causes of TBI are falls, traffic accidents, and assaults [3]. A common complication of TBI is an intracranial bleed (ICB), which can be classified into specific categories based upon injury location: subdural hemorrhage (SDH), subarachnoid hemorrhage (SAH), epidural hemorrhage (EDH), intraparenchymal hemorrhage (IPH), and intraventricular hemorrhage (IVH).

The presence of an intracranial bleed (ICB) is attributed to poorer outcomes, including higher rates of long-term disabilities and mortality, than a TBI without an ICB [4,5]. Other predictive factors for unfavorable outcomes from a TBI include age [6, 7], Glasgow Coma Scale (GCS) [8–10], coagulopathy [1], elevated intracranial pressure [11], and midline shift [7, 11]. Although previous studies have determined that ICB attributed to TBI may have prognostic importance [6, 11, 12], an examination of the overall distribution and profile of traumatic supratentorial ICB (STCB) in a large population has not been reported. Specifically, previous studies did not conduct a broad analysis and direct comparison of the various STCB types and their implications for patient care.

Deep understanding of supratentorial cranial bleeds' clinical outcomes, such as discharge disposition and mortality, can contribute towards better understanding and potentially predicting long-term outcomes in TBI patients. We used a large cohort derived from the National Trauma Data Bank (NTDB) data set to distinguish among different types of supratentorial bleeds through describing their clinical profiles, frequencies, distribution, management and clinical outcomes.

Methods

Patients and Methods

The methods presented in this study were also utilized in a concurrent study we submitted which investigated the profile of blunt traumatic supratentorial cranial bleed types (Ng, I et al. 2018).

Data Abstraction

The study was approved by the Tufts Medical Center Institutional Review Board. The American College of Surgeons (ACS) granted access to the data from the NTDB 2014. The NTDB remains the full and exclusive copyrighted property of the ACS. All patients with a single, isolated, blunt trauma-related, supratentorial bleed were extracted. For each of these patients, the following information was collected: demographics, comorbidities, mechanism

of injury, GCS, Injury Severity Score (ISS), procedures, complications, intensive care unit (ICU) length of stay (LOS), hospital LOS (HLOS), discharge information, and mortality.

Exclusion Criteria

Excluded were patients with posterior fossa (infratentorial) ICB, multiple bleed types, penetrating (combined or not with blunt trauma) or unknown mechanism of injury, diffuse axonal injury (isolated or with any ICB type), and those who were dead upon arrival.

Definitions

1. ICB.—Patients with SDH, SAH, EDH, ICH, and IVH were defined as ICB. The identification of these patients was based on information retrieved from the Abbreviated Injury Scale (AIS) code globally mapped to AIS version 1998 as follows: **SDH:** 140650.3, 140650.4, 140651.3, 140652.4, 140652.4, 140654.4, 140654.5, 140655.5 and 140656.5; **SAH:** 140684.3; **EDH:** 140630.4, 140631.2, 140630.4, 140632.4, 140634.5, and 140636.5; **ICH:** 140638.4, 140639.2, 140640.4, 140642.2, 140642.4, 140645.4, 140642.4, 140640.4, 140647.3, 140646.5, 140648.5, 140641.5, 140629.3, 140629.4, 140688.3, 140688.4, 140687.3, 140686.4, 140688.4; **IVH** 140678.4.

2. Injury Mechanism.—“Falls” – both falls from standing, identified based on ICD-9 diagnosis codes “fall from standing” (885.1, 885.2, 885.3, 885.4, 885.9), and falls from height.

“Traffic Related” - all NTDB E-codes involving motor vehicle crash (MVC) motorcyclist, MVC occupant, MVC other, MVC pedal cyclist, MVC pedestrian, MVC unspecified, pedal cyclist, pedestrian other, transport other.

“Other” - non-ground transportation, such as boats, planes, helicopters, space vehicles, as well as injuries involving machinery and assault.

3. Hypertension.—Defined by the NTDB as “History of a persistent elevation of systolic blood pressure >140mm Hg and a diastolic blood pressure >90mm Hg requiring an antihypertensive treatment (e.g., diuretics, beta blockers, angiotensin-converting enzyme (ACE) inhibitors, calcium channel blockers.)”

4. Anti-Coagulation/Bleeding disorders.—Bleeding disorders and coagulopathy is an NTDB element described as “any condition that places the patient at risk for bleeding in which there is a problem with the body’s blood clotting process (e.g., vitamin K deficiency, hemophilia, thrombocytopenia, chronic anticoagulation therapy with Coumadin, Plavix, or similar medications). Do not include patients on chronic aspirin therapy.” Patients with cirrhosis were also included under this category as cirrhosis is attributed to many bleeding disorders¹⁵. Cirrhosis is an NTDB element described as “documentation in the medical record of cirrhosis, which might also be referred to as end stage liver disease. If there is documentation of prior or present esophageal or gastric varices, portal hypertension, previous hepatic encephalopathy, or ascites with notation of liver disease, then cirrhosis should be considered present. Cirrhosis also should be considered present if documented by diagnostic imaging studies or a laparotomy/laparoscopy”.

p. Procedures.—The International Classification of Diseases, Ninth Revision, Procedure Coding System (ICD-9-PCS) was used to identify: Craniotomy/craniectomy: (01.24, 01.25). Intraparenchymal or Intraventricular Device: ICP monitoring (01.10), “Brain drain” (01.39), “Ventriculostomy” (02.21, 02.22), “Burr holes” (01.28), “Inserting burr holes” (01.26).

7. Complications.—Defined by the NTDB Data Dictionary. Specific complications included are unplanned OR return, unplanned ICU return, stroke, and venous thromboembolism.

8. Outcomes.—Mortality refers to in-house mortality only. Discharge disposition “Other” refers to discharge to any facility other than the patient’s home, including rehabilitation/long-term care facility, skilled nursing home, hospice care or other undistinguished institution. Discharge information was determined according to specific designations, as defined by the NTDB.

Statistical Analysis

Demographic, injury, and clinical characteristics (including hospital course and outcomes) among the five ICB groups were compared using chi square tests and t-tests (or Mann-Whitney tests), depending on the type of variable. Differences in HLOS and ILOS were compared using negative binomial models. These tests were performed to identify overall significant differences among the groups; post-hoc (pairwise) comparisons were not performed. SAS v9.4 (Cary, NC) was used for data analysis. All testing was two-tailed tests with $\alpha=0.05$.

Results

Frequencies and Distribution

A total of 57,278 ICB were identified. Detailed results are provided in Table 1. Of note, SDH was the most common ICB (53%) followed by SAH (32%) whereas IVH (2%) and EDH (2%) were the least common.

Demographics, Pre-existing Comorbidities and Clinical Characteristics

These parameters are presented in detail in Table 2.

Several observations should be emphasized. First, SDH patients were older (median 72 years) and sustained more falls than any of the other ICB groups (78%). Second, patients with SAH were slightly younger (median 63 years) and presented with the highest frequency of mild TBI (89%) and lowest ISS (median 8). Third, EDH patients were the youngest (median 35 years) and had the highest proportion of traffic related injuries (28%). They were least likely to have hypertension (20%) or bleeding disorders (6%). These patients were also more likely to have severe TBI (GCS 8, 16%) and a high ISS (median 18). Patients with IVH were the oldest (median 75 years) and tended to be injured mostly from falls (74%). ICH patients were neither the highest nor lowest for any of the examined end points.

More than half of the patients with SDH or IVH had previously diagnosed hypertension (52% and 53%). These patients also had the highest percentage of bleeding disorders, 17% and 20% respectively.

Procedures, and Complications

Detailed results are provided in Table 3.

EDH patients were the most likely to undergo a craniotomy/craniectomy (51.2%) or have an intraparenchymal or intraventricular device placed (5.8%). The highest complication rate occurred in SDH and IVH patients (3% each one) while SAH patients had the lowest (1%

Clinical Course and Outcomes

This information is presented in detail in Table 4.

Patients with an IVH had the longest hospital HLOS (6.3 ± 8.0 days) and ILOS (4.7 ± 5.8 days). Although EDH patients had the next longest average hospital stay (6.0 ± 7.6 days), less of those days were spent in the ICU (3.8 ± 4.4 days) compared to IVH and SDH patients (4.7 ± 5.8 days and 4.1 ± 5.0 days). IVH patients had the worst overall outcome due to their highest mortality (9.2%) and highest discharge rate to a facility other than home (44.6%). While EDH patients most often presented with more severe TBI (GCS = 8) and the highest average ISS (Table 1), they had positive outcomes, as indicated by being discharged to home more frequently than the other ICB types (71.2%), and by having the second lowest mortality (3.6%). The lowest percent mortality occurred in SAH patients (2.7%).

Discussion

This large study has illuminated trends that define patient characteristics, clinical presentation, hospital course and outcome for each of the traumatic supratentorial cranial bleed subtypes.

SDH is the most frequently occurring ICB, and tends to occur in older patients after falls. Although these patients mostly present with mild TBI (GCS = 13), they have high rates of comorbidities, complications and mortality. Brain atrophy, which is more common in elderly, creates a potential space for an expansion of subdural hemorrhage [16]. The increased size of the subdural space in these patients could account for the initial mild injury presentation due to greater blood accumulation required to cause significant mass effect. Increased subdural space also allows for greater intracranial movement after minor trauma, leading to simple falls alone generating enough force to rupture subdural veins [17]. A large percentage of elderly SDH patients were also noted to have bleeding disorders or taking anticoagulation medication, which is attributed to an increased risk of SDH from minor trauma, SDH recurrence after treatment, and mortality [18]. SDH is likely the most common ICB type because it can occur with minor trauma in an elderly patient on anti-coagulation.

SAH patients tended to present with a mild TBI and ISS, showed a large percentage of discharge to home, and did not require surgical intervention or long ICU stays. This is consistent with previous studies indicating that isolated, traumatic SAH tended to have better

outcomes overall compared to other ICB subtypes [19]. Small, isolated SAH have been shown to resolve without long term neurological deficit and do not require intensive surgical intervention or ICU stay [20]. While uncommon, more severe SAH can be correlated to a low initial GCS and can cause significant mass effect, requiring more intensive intervention and ICU management [21]. In cases of large SAH with poor GCS, non-traumatic reasons for SAH must be considered. This is important, because the management of non-traumatic subarachnoid hemorrhage differs significantly from the management of traumatic SAH. In addition, aneurysmal subarachnoid hemorrhage is much more likely than traumatic SAH to present with large hemorrhage volume and poor GCS, and therefore should be kept within the differential diagnosis.

The NTDB data presented herein indicate that EDH patients are different than patients in the other STCB categories. EDH patients tend to be younger, have a higher proportion of traffic related injuries, and had generally worse initial presentations. The larger proportion of younger patients in this group may be due to their less adherent dural attachments to the skull [22]. In contrast, the more adherent attachments in the elderly obliterate the potential space for an EDH, and thus, make this type of STCB uncommon in the elderly. EDH is typically caused by a temporal bone fracture lacerating the middle meningeal artery. Therefore, EDH is primarily caused by high-energy mechanisms, such as MVC or severe blows to the head, as opposed to falls [23]. This also contributes to the higher rates of EDH in younger patients, as this population segment tends to be more involved in high-speed MVC, assaults and falls from height. It is common for patients with EDH to initially lose and then quickly regain consciousness after the precipitating trauma. This “lucid interval” can account for the large percentage of low admission GCS in EDH patients, since many of these patients seek medical intervention only later when the accumulating extradural blood causes mass effects such as lethargy, hemiplegia, coma and death, if untreated [24]. Despite their poor initial presentation, EDH patients had the best overall outcomes, including lowest mortality and highest percentage of patients discharged to their homes. Prompt CT imaging and surgical removal of the hematoma is essential treatment for these patients. These interventions have been shown to significantly reduce mortality and long term neurological dysfunction, with patients often making full recoveries [24, 25].

Traumatic IVH is a rare occurrence in isolation, which has limited the size of cohorts in previous studies [26]. In clinical practice, it most often occurs secondary to the extension of a large ICH or SAH into the ventricle. Trends previously shown, however, are consistent with the NTDB national data, and show traumatic IVH tends to occur in the elderly as a result of a fall, and often result in a poor outcome [10]. Anticoagulation medication, such as coumadin, has been correlated to spontaneous IVH [27], and the NTDB data indicates this trend exists in traumatic IVH as well. However, the predominance of patients being elderly and anticoagulated makes it challenging to assess whether a traumatic IVH is in fact caused by the trauma itself or if trauma (such as a fall) is precipitated by a spontaneous IVH. The utilization of an intraventricular drain to evacuate intraventricular hemorrhage is most commonly utilized to treat hydrocephalus that sometimes results from intraventricular blood products, obstructing the normal CSF pathways [28].

Traumatic IVH carried the highest likelihood of mortality of any ICB. Of note, a previous study [10], which also showed poor outcomes in patients with IVH, concluded that these poor outcomes were not necessarily related to the IVH per se. The data presented herein support this conclusion, as IVH patients were the oldest and had the highest percentage of hypertension and anti-coagulation/bleeding disorders compared to all other STCB groups. From our statistical analysis, it cannot be concluded that the high mortality of these patients is related to the type of STCB or other factors.

The present study has several limitations. First, NTDB data is not a population based data set, but rather an aggregate of multiple registries, which has well recognized drawbacks [29]. Participating institutions voluntarily provide their own data to the data bank, which can lead to potential differences and inconsistencies in reporting across institutions. Variability in complication and comorbidity data has been reported, introducing potential bias and difficulty accurately interpreting these data points [30]. In addition, each NTDB entry is coded as an “incident key,” which can be assumed to be a single patient. However, it is possible that the same patient can be in the dataset multiple times for any number of injuries she/he might have experienced that year, at the same or different institutions. Regardless, the statistical analyses in the present study assumed that each record is independent (i.e., a patient is only present once). Despite the above-mentioned shortcomings, this article is valuable, as it reviewed a large number of patients, which could not have been assembled otherwise.

CONCLUSIONS

Our study described the largest cohort of patients with traumatic isolated supratentorial intracranial bleeds, which included patient characteristics, frequency, clinical course, and outcomes associated with each STCB subtype.

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Highlights

- There are clinically significant differences in distributions, clinical courses and outcomes of different subtypes of traumatic infratentorial bleeds.
- Subdural hemorrhage is the most common traumatic supratentorial bleed
- The most common mechanism of injury was from falls.
- The majority of traumatic infratentorial bleeds present as mild severity traumatic brain injury and are managed non-operatively.
- Subdural and intraventricular supratentorial hemorrhages carry the highest risk of mortality.

Table 1

Distribution of single Traumatic Supratentorial Bleeds

	SDH	SAH	EDH	IPH	IVH
Infratentorial bleeds, n(%)	30395 (53)	18389 (32)	1113 (2)	6323 (11)	1058 (2)

SDH, subdural hemorrhage; SAH, subarachnoid hemorrhage; EDH, epidural hemorrhage; IPH, intraparenchymal hemorrhage; IVH, intraventricular hemorrhage.

Table 2

Demographics and Clinical Characteristics of single Traumatic Supratentorial Bleeds

	SDH	SAH	EDH	IPH	IVH	p-value
Male *, n (%) (missing n=6)	17473 (58)	9992 (54)	837 (75)	3840 (61)	603 (57)	<0.0001
Age (years), median(IQR)	72 (55–83)	63 (45–78)	35 (23–58)	63 (41–80)	75 (55–85)	<0.0001
A) Pre-existing comorbidities (missing n = 1219)	15379 (52)	7565 (42)	214 (20)	2566 (42)	552 (53)	<0.0001
Hypertension *, n (%)						
Anti-coagulation/Bleeding Disorders *, n (%)	4744 (17)	2076 (12)	56 (6)	683 (12)	193 (20)	<0.0001
Mechanism of injury						
Falls *, n (%)	23718 (78)	11839 (64)	564 (51)	4098 (6)	778 (74)	
Traffic Related *,n (%)	4107 (14)	4468 (24)	312 (28)	1496 (2)	208 (20)	<0.0001
Other *, n (%)	2570 (9)	2082 (11)	237 (21)	729 (12)	72 (7)	
GCS (missing n = 3178)						
GCS 13–15 *, n (%)	24347 (85)	15654 (89)	854 (80)	5178 (87)	799 (81)	
GCS 9–12 *, n (%)	1322 (5)	696 (4)	54 (5)	302 (5)	59 (6)	<0.0001
GCS 3–8 *, n (%)	2855 (10)	1194 (7)	166 (16)	486 (8)	134 (14)	
ISS median (IQR)	16 (10–21)	8.00 (5–10)	18 (11–26)	10 (9–16)	8 (5–14)	<0.0001

* percentage within the supratentorial bleed group; SDH, subdural hemorrhage; SAH, subarachnoid hemorrhage; EDH, epidural hemorrhage; IPH, intraparenchymal hemorrhage; IVH, intraventricular hemorrhage IQR, interquartile range; GCS, Glasgow Coma Scale; ISS, Injury Severity Score.

Table 3

Procedures, and Complications of single Traumatic Supratentorial Bleeds

	SDH	SAH	EDH	IPH	IVH	p-value
Craniotomy/Craniectomy *, n (%) (missing n=51)	8981 (30)	4848 (26)	569 (51)	1784 (28)	226 (21)	<0.0001
Intraparenchymal or Intraventricular Device *, n (%)	1264 (4)	256 (1)	64 (6)	117 (2)	52 (5)	<0.0001
Complications *, n (%) (missing n = 73)	809 (3)	245 (1)	25 (2)	91 (2)	27 (3)	<0.0001

SDH, subdural hemorrhage; SAH, subarachnoid hemorrhage; EDH, epidural hemorrhage; IPH, intraparenchymal hemorrhage; IVH, intraventricular hemorrhage

* percentage within the supratentorial bleed group; ICP, intracranial pressure monitoring.

“Complications” included unplanned return to the operating room or intensive care unit, stroke, and venous thromboembolism.

Table 4

Clinical Course and Outcomes of single Traumatic Supratentorial Bleeds

	SDH	SAH	EDH	IPH	IVH	p-value
ICU LOS, mean days $\pm$ SD	5.8 $\pm$ 7.2	4.6 $\pm$ 6.4	6.0 $\pm$ 7.6	4.9 $\pm$ 6.0	6.3 $\pm$ 8.0	<0.0001
HLOS, mean days $\pm$ SD	4.1 $\pm$ 5.0	3.3 $\pm$ 4.5	3.8 $\pm$ 4.4	3.5 $\pm$ 4.6	4.8 $\pm$ 5.9	<0.0001
The study Outcomes (missing n = 3434)						
Disposition Home [*] , n (%)	15840 (55)	12109 (70)	753 (71)	3641 (63)	453 (46)	
Disposition "Other"	10772 (38)	4686 (27)	266 (25)	1925 (33)	437 (45)	0.08
Mortality [*] , n (%)	2134 (7)	468 (3)	38 (4)	232 (4)	90 (9)	

* percentage within the supratentorial bleed group; SDH, subdural hemorrhage; SAH, subarachnoid hemorrhage; EDH, epidural hemorrhage; IPH, intraparenchymal hemorrhage; IVH, intraventricular hemorrhage; SD, standard deviation; ICU LOS, intensive care unit length of stay; HLOS, hospital length of stay; "Other", discharge to rehabilitation or long term care facility, skilled nursing home, hospice care, and other institutions.