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The Profile of Blunt Traumatic Infratentorial Cranial Bleed Types

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Abstract

Infratentorial traumatic intracranial bleeds (ICBs) are rare and the distribution of subtypes is unknown. To characterize this distribution the National Trauma Data Bank (NTDB) 2014 was queried for adults with single type infratentorial ICB, n=1,821: subdural hemorrhage (SDH), subarachnoid hemorrhage (SAH), epidural hemorrhage (EDH), and intraparenchymal hemorrhage (IPH). Comparisons were made between the groups with statistical significance determined using chi squared and t-tests. SDH occurred in 29% of patients, mostly in elderly on anti-coagulants (13%) after a fall (77%), 42% of them underwent craniotomy, their mortality was the lowest (4%). SAH was the most common (56%) occurring mostly from traffic related injuries (27%). Furthermore, 9% of them had a severe head injury Glasgow Coma Scale 8 (GCS), but had the lowest Injury Severity Score (ISS, median 8) as well as a short hospital length of stay, 5.1 ± 6.2 days. These patients were most likely to be discharged to home (64%). They had the lowest mortality (4%). EDH was the least common ICB (5%), occurred in younger patients (median age 49 years), and it had the highest percentage of associated injuries (13%). EDH patients presented with the poorest neurological status (26% GCS 8, ISS median 25) and were operated on more than any other ICB type (55%). EDH was the highest mortality (9%) ICB type and had a low discharge to home rate (58%). IPH was uncommon (10%). Infratentorial bleeds types have different clinical courses, and outcomes. Understanding these differences can be useful in managing these patients.

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Declarations of Interest:

There are no conflicts of interest to declare.

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Keywords

Traumatic brain injury; traumatic infratentorial bleeds; Traumatic intracranial hemorrhage

INTRODUCTION

Traumatic brain injury (TBI) is a serious and common health problem in the United states [1–3] with known predictors [4–9], and poor outcomes [10, 11]. Despite previous studies pointing towards the prognostic importance of intracranial bleeds [4, 9, 12], an examination of the overall distribution and profile of each bleed subtype presenting in trauma patients has not yet been classified.

Furthermore, these bleeds can be further classified and assessed based on whether the cerebrum or the cerebellum is affected. Cerebellar hemorrhages account for a small percentage of trauma induced intracranial bleeds [13]. The most of these bleeds result from non-traumatic mechanisms [14]. In fact, traumatic cerebellar bleeding is so rare it accounts for <1% of all head injuries [15, 16]. Because of the rarity of cerebellar hemorrhages, very few small cohort studies have attempted to characterize traumatic intracranial bleeds in the infratentorial region and their outcomes. Previous studies have examined the correlation between hemorrhage location, vascular location and clinical outcomes of traumatic and non-traumatic cerebellar bleeds [13, 17–21]. Only one study used the National Trauma Data Bank (NTDB) to show that patients with SAH were less likely to require surgical intervention [22]. Although these studies provided preliminary insight into the distribution of traumatic infratentorial bleeds (ICB), they did not set out to specifically define and compare the actual distribution of ICB subtypes.

The aim of this study was to determine the clinical profiles, frequencies, and distributions of isolated, infratentorial intracranial bleeds categories, and discern differences among these types using a large data set within the NTDB. We aimed to evaluate discharge disposition and mortality of ICB types. Such information can contribute towards better understanding, managing and predicting long-term outcomes in ICB patients.

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 (Shpiner, A et al. 2017).

Data Abstraction

The Institutional Review Board of Tufts Medical Center granted a permission to conduct this review. The American College of Surgeons (ACS) granted access to the data from the NTDB for the admission year of 2014. The NTDB remains the full and exclusive copyrighted property of the ACS. All patients with a single, isolated, blunt trauma-related infratentorial bleeds (ICB) were extracted and narrowed down. For these patients, the following

information was collected: demographics (age, gender), preexisting co-morbidities (hypertension and anticoagulation/bleeding disorders), mechanism of injury, GCS, ISS, therapeutic procedures, in-hospital complications, intensive care unit (ICU) length of stay (LOS), hospital length of stay (HLOS), discharge disposition, and mortality.

Exclusion Criteria

Excluded were patients with anterior and middle fossa (supratentorial) intracranial bleeds, multiple simultaneous ICB types, penetrating (combined or not with blunt trauma) or unknown mechanism of injury, diffuse axonal injury (isolated or with any ICBs), and those who were dead upon arrival.

Definitions

1. ICB.—Patients with infratentorial SDH, SAH, EDH, and ICH were defined as ICB. The identification of these patients was based on information retrieved from the Abbreviated Injury Scale version 1998 (AIS-98) code as follows: **SDH:** 140438.4, 140418.4. **SAH:** 140466.3. **EDH:** 140414.4, 140418.4, 140422.5. **IPH:** 140426.4, 140430.4, 140434.5, 140474.4.

2. Injury Mechanism.—“Falls” – all NTDB E-codes of “fall from standing” 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: non-ground transportation, such as boats, planes, helicopters, space vehicles, as well as injuries involving machinery and assault.

3. Hypertension—This is an NTDB data element, described 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 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 disorders²³. 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”.

6. 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 Devices: intracranial pressure monitoring (01.10), “Brain drain” (01.39), “Ventriculostomy” (02.21, 02.22), “Burr holes” (01.28), and “Inserting burr holes” (01.26)

7. Complications—This was defined according to the NTDB Data Dictionary. Specific complications included unplanned return to the operating room (OR), unplanned ICU return, stroke, and venous thromboembolism.

8. The study outcomes—Mortality referred to in-house mortality only. Discharge disposition “other” referred 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

Demographics, injury, and clinical characteristics (including hospital course and outcomes) among the four ICB groups were compared using chi square tests and t-tests (or Mann-Whitney tests), depending on the type of variable and the distribution. Differences in HLOS and ICU LOS 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 with $\alpha = 0.05$.

RESULTS

Frequencies and distribution of infratentorial bleeds

A total of 1,821 ICB subjects were identified. These cases accounted for only 3% of all traumatic intracranial bleeds. Detailed results are provided in Table 1. Of note, SAH (56%) was the most common ICB, followed by SDH (29%), and IPH (10%), whereas EDH (5%) was the least common.

Demographics, pre-existing comorbidities and clinical characteristics

Detailed results are provided in Table 2. SDH patients were the greatest age 73 (28) (median (interquartile range) [IQR]) and were the most likely to have anti-coagulation/bleeding disorders (13%). They had a fall as the leading mechanism of injury (77%) that most commonly (92%) resulted in mild TBI, GCS 13–15. They had the lowest number of traffic related ICBs (17%), and other (neither fall nor traffic related) mechanisms of injury (7%). SAH patients were most likely to have ICB from a traffic related mechanism (27%), but they were least likely to have a fall related ICBs (63%), and they had the lowest injury burden with ISS 8 (5), median(IQR).

EDH had the highest percentage of males (59%), although this difference in gender percentages amongst bleed subtypes did not reach statistical significance. EDH was least likely to have hypertension (25%), and anti-coagulation/bleeding disorders (6%). EDH patients had the highest number ICBs caused by other mechanisms (neither fall nor traffic

related) (13%), the highest moderate severity TBI, GCS 9–12, (7%), and severe TBI, GCS 3–8, (26%), and the highest ISS 25(16), median (IQR). Their mean age was the lowest 49(45), median (IQR), and they had the lowest rate of mild TBI, GCS 13–15 (67%).

IPH patients were most likely to have a pre-existing hypertension (52%).

Therapeutic Procedures and in-hospital complications

Detailed results are provided in Table 3.

SDH were least likely to undergo placement of Intraparenchymal or Intraventricular Device. EDH patients were the most likely to undergo a craniotomy/craniectomy (55%), to have an Intraparenchymal or Intraventricular Device (9%) placed, and they had the highest complications rate (3%).

IPH least likely to have a craniotomy/craniectomy (33%), and had the lowest complications rate (1%).

Clinical Course, Outcomes

Detailed results are provided in Table 4.

SDH patients had the shortest ICU LOS 3.5 ± 4.2 , mean $\pm$ SD and HLOS 4.4 ± 4.7 (mean $\pm$ standard deviation [SD]).

SAH patients were the most likely to be discharged home (64%), least likely to be discharged to other locations (32%), and they had the lowest mortality (4%).

EDH patients had the longest average hospital stay (7.1 ± 8.8), mean $\pm$ SD, and the highest mortality (9%).

IPH patients had the second longest average hospital stay, and the longest ICU LOS 5.5 ± 8.7 , mean $\pm$ SD. IPH patients were most likely to be discharged to other locations, but not home (39%).

The differences in percentage of patients discharged home and of mortality did not reach significant difference amongst the different bleed subtypes.

DISCUSSION

This study is the first, and the largest to use a national database to characterize and describe trends in the distribution of isolated infratentorial ICBs. The present study found that traumatic infratentorial ICBs are exceedingly rare occurrences, which is supported by the literature [15, 16]. Therefore, there is not a good number of publications focused on traumatic infratentorial bleeds. Our data suggested that SDHs happen most frequently from falls in the elderly on anticoagulation medication [24–26]. Young people typically have a well-developed cerebellum without atrophy that occupies most of the posterior fossa and leaving little subdural space. On the other hand, elderly patients tend to have cerebellar atrophy compared to their younger counterparts, increasing the cranial space not occupied

by the brain and potentially a larger subdural space [26, 27]. This makes it more likely for subdural blood accumulation after traumatic injury in older individuals compared to younger. In addition, a larger subdural space could explain the initial mild injury presentation due to greater blood accumulation required to cause significant mass effect [28]. Increased subdural space also allows for greater intracranial movement after minor trauma, leading to simple falls alone generating enough force to rupture subdural veins [29]. Another explanation for increased SDH in elderly patients could be that the bridging veins running from the arachnoid into the dura in the subdural space of elderly patients are more susceptible to shearing and bleeding because the brain is allowed to move around a larger space in the cranial vault [30, 31].

SAH patients had the highest likelihood of being discharged home. An explanation for this is that SAHs tend to be very small hemorrhages and do not typically cause neurological deficits [32, 33]. Smaller hemorrhages could explain why data showed SAH patients had the second lowest percentage for procedures done, which is supported by other studies [32, 33]. SAHs were most likely caused by traffic-related mechanisms. One possibility is that the cerebellum is more protected than the cerebrum from direct trauma given that direct trauma usually occurs over the frontal or occipital bones leading to SAH. The cerebellum and posterior fossa are more protected than the cerebrum by the posterior cervical bony musculature from falls. Therefore, SAHs would be least likely to occur in patients with falls. Furthermore, to have a traumatic cerebellar SAH requires a large amount of energy brought on by something such as a motor vehicle accident (MVA) [31, 34].

EDH patients represented the smallest number of TBIs as supported by the literature [35]. These patients were generally young males whose ICB was due to neither fall nor traffic related mechanisms of injury, most likely from assault with a weapon [35–37]. A high amount of energy and skull fracture is commonly the cause of an epidural hematoma. The large portion of young male patients with EDH is likely because this demographic is more likely to be involved in high risk behavior such as assaults and high speed motor vehicle accidents (38,39). Furthermore, since the dura is not adherent to the skull in young patients, the epidural area is a potential space to collect blood. Conversely, dural adhesion to the skull with obliteration of the epidural space is common in the elderly (40). This the likely reason that EDH is rare in the elderly [41]. EDHs in the posterior fossa are very dangerous because a rapidly expanding space occupying lesion in that area can lead to brainstem compression [42]. That could account for why the average GCS of EDH patients is so low, which is contrary to findings in the literature [43]. All patients presenting with neurological deficits who are considered salvageable will need surgery, which is why procedure rates are so high [37, 44]. Once the brainstem is compressed by a posterior fossa EDH it may not recover even with surgery if the patient presented with a poor GCS [45]. Poor recoveries lead to the high complication rates, long LOSs and high mortality [46]. Furthermore, these patients have low rates of comorbidities because EDHs happen in young men who are not old enough to develop hypertension or to need to be on anti-coagulation medications [47].

IPH patients were the most likely to present with hypertension [48]. This could be because these patients essentially had spontaneous hypertensive hemorrhages that were misclassified as traumas because they had a hemorrhage that resulted in loss of balance or consciousness

and a subsequent fall. The cerebellum is one of the most common locations for a spontaneous hypertensive hemorrhage [49]. The reason why these patients had long ICU stays is because IPHs are unpredictable thus requiring intensive monitoring; this usually means multiple CT scans during their ICU stay [50, 51]. These hemorrhages can blossom. Hemorrhages greater than 3 cm often cause worsening neurological deficits that indicate the need for surgery [52]. IPH patients are more likely to require placement into rehabilitation rather than being directly sent home because they are more likely to suffer cerebellar dysfunction, a result of direct injury to the cerebellar parenchyma which results in ataxia and a lack of coordination [53].

The present study has several limitations. First, this was a retrospective study, which has a weaker internal validity than a prospective study. Second, the NTDB is not a population based dataset, but rather consists of an aggregate of multiple registries, which has well recognized drawbacks [54]. 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 in accurately interpreting these data points [55]. 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 at different institutions. Regardless, the statistical analyses in the present study assumed that each record is independent (i.e., a patient is only present once). One final limitation in this present study is the size difference between the comparison groups. The number of SAH and SDH patients were much larger than EDH and IPH. This was unavoidable, given the high rate of SAH patients in the TBI patient population in general (56%).

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

In summary, this large-scale analysis of patients with traumatic infratentorial bleeds provides novel insights into patient characteristics, incidences, clinical courses, and outcomes associated with each ICB subtype. Additional studies of these national trends are required to establish possible outcome predictors for each ICB subtype and to discern their potential clinical relevance.

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Highlights

- Traumatic infratentorial bleeds are exceedingly rare.
- There are clinically significant differences in distributions, clinical courses and outcomes of different subtypes of traumatic infratentorial bleeds.
- 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.
- Epidural and intraparenchymal infratentorial hemorrhages carry the highest risk of mortality.

Table 1

Distribution of single Traumatic Infratentorial Bleeds

	Total	SDH	SAH	EDH	IPH
Infratentorial bleeds, n(%)	1821(100)	520(29)	1020(56)	96(5)	185(10)

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

Table 2

Demographics and Clinical Characteristics of single Traumatic Infratentorial Bleeds

	SDH	SAH	EDH	IPH	p-value
Male *, n (%)	295(57)	587(58)	57(59)	107(58)	0.97
Age (years), median(IQR)	73(28)	64(36)	49(45)	69 (41)	<0.0001
A) Pre-existing comorbidities (missing n = 55) Hypertension *, n (%)	245 (49)	398 (40)	23 (25)	92 (52)	<0.0001 *
Anticoagulation/Bleeding Disorders *, n (%)	64 (13)	82 (8)	5 (6)	22 (12)	0.0050 *
Mechanism of injury Falls *, n (%)	398 (77)	642 (63)	64 (67)	140 (76)	
Traffic Related *,n (%)	86 (17)	270 (27)	20 (21)	31 (17)	<0.0001
Other *, n (%)	36 (7)	108 (11)	12 (13)	14 (8)	
GCS (missing n = 120)					
GCS 13–15 *, n (%)	453 (92)	815 (86)	60 (67)	153 (87)	
GCS 9–12 *, n (%)	13 (3)	45 (5)	6 (7)	10 (6)	<0.0001
GCS 3–8 *, n (%)	27 (6)	84 (9)	23 (26)	12 (7)	
ISS median (IQR)	10 (2)	8 (5)	25 (16)	16 (12)	<0.0001

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

Table 3

Procedures, and Complications of single Traumatic Infratentorial Bleeds

	SDH	SAH	EDH	IPH	p-value
Craniotomy/Craniectomy [*] , n (%)	217 (42)	344 (34)	53 (55)	61 (33)	<0.0001 [*]
Intraparenchymal or Intraventricular Device [*] , n (%)	6 (1)	35 (3)	9 (9)	11 (6)	<0.0001 [*]
Complications [*] , n (%) (missing n = 73)	10 (2)	20 (2)	3 (3)	2 (1)	0.7

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

^{*}percentage within the Infratentorial 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 Infratentorial Bleeds

	SDH	SAH	EDH	IPH	p-value
ICU LOS, mean days $\pm$ SD	3.5 $\pm$ 4.2	4.1 $\pm$ 5.0	4.8 $\pm$ 4.9	5.5 $\pm$ 8.7	<0.0001
HLOS, mean days $\pm$ SD	4.4 $\pm$ 4.7	5.1 $\pm$ 6.2	7.1 $\pm$ 8.8	6.9 $\pm$ 10.6	<0.0001
The study Outcomes (missing n = 170)					
Disposition Home *, n (%)	293 (62)	597 (64)	50 (58)	90 (55)	
Disposition "Other"	162 (34)	294 (32)	28 (33)	64 (39)	0.08
Mortality *, n (%)	19 (4)	36 (4)	8 (9)	10 (6)	

*percentage within the Infratentorial bleed group; SDH, subdural hemorrhage; SAH, subarachnoid hemorrhage; EDH, epidural hemorrhage; IPH, intraparenchymal 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.