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Delineation of Criteria for Admission to Step Down in the Mild Traumatic Brain Injury Patient

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Abstract

Patients that suffer a mild traumatic brain injury with intracranial hemorrhage are commonly admitted to an ICU with repeat imaging in 12–24 hours. This is costly to the healthcare system. This study aimed to evaluate this practice and to identify criteria to triage patients to lower levels of monitored care.

A retrospective review was performed at a university based level I trauma center. Patients with mild TBI were included. Data was collected on demographics, neurologic status at 6, 12 and 24 hours, CT scan results, and medical or surgical interventions required.

389 patients were evaluated, 53 had a documented neurologic decline while admitted. Factors found to be associated with a neurologic decline included GCS<15 (p=0.002), age greater than 55 (p<0.001), and warfarin use (p=0.039). Aspirin and Plavix were not associated with neurologic decline. No patient age<55 with a GCS of 15 had a documented decline.

Several risk factors were found to be associated with neurological decline after mild TBI. These include age>, GCS<15, and warfarin use. Patients age<55 with GCS 15, posed minimal risk for deterioration. Patients age <55 and with a GCS of 15 can be admitted to a monitored step-down bed with less frequent neurologic checks.

Keywords

Mild traumatic brain injury; neurologic exams; CT brain; ICU admission

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Author Contributions
All authors contributed to the design of this study. The literature search was conducted by JT, PB and JMB. Data collection was performed by JT, JMB and PB. The data was analyzed and interpreted by JMB, JT, GH and AW. JT, JMB and AW then wrote the manuscript and all authors participated in editing.

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No competing financial interests exist for any of the authors.

Background

Each year in the United States, more than 1.5 million people will suffer some degree of a traumatic brain injury (TBI).[1] TBI results in more than 300,000 hospitalizations and $17 billion dollars in healthcare expenditures.[2] As awareness of symptoms and risk factors become more prevalent among citizens and healthcare providers the incidence of diagnosis of mild TBI will continue to rise. There are established practice management guidelines for management of severe TBI that are utilized by most trauma centers. These include guidelines for intra-cranial pressure management, neurologic exams, and therapeutic interventions. For less severe TBI, the consensus is not as clear.

At many Trauma Centers, it is common practice to admit all patients with CT findings of intracranial hemorrhage to an intensive care unit (ICU) for hourly neurologic exams and routine interval follow up brain CT scans.[1–10] Routine interval CT scans are commonly performed at 12–24 hours to document stability of the hemorrhage. The efficacy, cost effectiveness and the differences in patient outcomes due to these practices have been debated and the results are not clear. As efforts to improve outcomes and decrease costs continue to dominate the healthcare stage, it is critical that evidence based practices are developed and validated. The goal being to provide high quality care manifested by good patient outcomes while eliminating healthcare resource waste. Strategies that identify lower risk patients who do not benefit from some of these practices would allow the opportunity to streamline care without increasing risk.

There is an emerging body of literature that is attempting to address some of these questions. The practices of routine ICU admission and scheduled, interval CT scans are being questioned as efficient and efficacious practices. [1,5,7] Changes in a neurologic exam typically prompt a physician assessment and often an immediate unscheduled, STAT, CT scan. That scan may or may not change the patient's plan of care. Some of these patients will require urgent medical or surgical treatment based on changes seen on these unscheduled CT scans. Others will continue to be monitored, with an additional interval follow up CT ordered in another 12–24 hour. However, there is likely an identifiable subset of patients that are more at risk for neurologic deterioration requiring more aggressive medical or surgical interventions for their traumatic brain injury. Some risk factors that have been described in the literature include GCS < 15[5], age > 65[4,5,9], and intracranial hemorrhage volume > 10(ml).[9] This group of patients is at a significant risk of deterioration or need for intervention. However, there is likely a subset of patients that could be safely and appropriately admitted to a non-ICU monitored bed with frequent neurological checks and no scheduled, interval imaging. These patients would only have additional imaging performed for changes in neurological status. The primary objective of this study was to determine the efficacy of the standard practice of ICU admission with scheduled, interval CT scan. The secondary objective was to define characteristics that could be utilized to identify patients who could be safely and appropriately managed in a step down rather than ICU environment.

Methods

This was a retrospective study conducted a university based, Level I trauma center. Patients in this center are admitted to the trauma service with a neurosurgery consult and managed in the surgical intensive care unit. There is not a separate neuro-intensive care unit. The trauma registry was queried for adult admissions from 2009 through 2011. Inclusion criteria were diagnosis of blunt traumatic brain injury, age >18, admission GCS of 13, 14, or 15, and ISS less than 25. Patients with GCS < 13, penetrating TBI, ISS > 25 or age < 18 were excluded. Primary outcome was defined as a documented neurological decline. A documented neurological decline was chosen as the primary endpoint as this is the first event that will result in physician assessment and possible intervention. Secondary outcomes were the need for medical or surgical interventions, specifically use of hypertonic saline, mannitol, intra-cranial pressure monitoring or surgical decompression.

Data points included mechanism of injury, admission GCS, 6 hour GCS, 12 hour GCS, 24 hour GCS, incidence of documented neurologic decline, type of intracranial bleed present, total number of head CT scans obtained, indications for repeat CT scans, STAT CT order, bleed progression, use of aspirin, clopidogrel, warfarin, admission coagulation labs, head abbreviated injury score (AIS), injury severity score (ISS), anthropomorphic data, hospital days, ICU days, use of hypertonic saline or mannitol usage, incidence of EVD or craniotomy, and all cause inhospital mortality. A STAT CT was defined as an unscheduled CT ordered by physicians in response to a change in neurological status or decline in GCS. Neurological decline was defined as decrease in GCS ≥2.

Data was analyzed by a biostatistician using Chi-Squared analysis and Fischer's Exact Test as appropriate. Decision trees were used to subsequently establish optimal grouping to separate events from non-events. Statistical significance was defined as $p<0.05$.

Results

389 patients met the study criteria. All patients had a head CT scan on arrival to the trauma center and all patients in this group had evidence of intracranial hemorrhage. The average age of the study population was 63 years old, with a range from 18–100. Overall inhospital mortality for the 389 patients was 5.1%. The average ICU stay was 1.9 days (SD±3.6, range 0–32) with an overall average hospital length of stay of 4.7 days (SD±6, range 0–40). 310 (79.7%) patients presented with a GCS of 15 on presentation, 64 (16.5%) had a GCS of 14, and 15 (3.8%) had a GCS of 13. 154 patients were taking aspirin, 67 patients clopidogrel and 46 patients warfarin at the time of injury. Fall was the most common mechanism of injury (67%). Other mechanisms of injury included motor vehicle crashes (18%), assault (7%), motorcycle crash (4%) and All-Terrain Vehicles (4%). (Table 1) The distribution of intracranial hemorrhage reported on CT included subdural hematoma (58%), subarachnoid hemorrhage (48.8%), intraparenchymal hematoma (22.1%), intraventricular hemorrhage (5.4%) and epidural hematoma (1.5%).

Neurological Decline

Fifty-three patients (13.6%) had a documented neurologic decline. Factors found to be associated with neurologic decline included admission GCS<15 (P=.0002), age ≥ 55 (P<0.0001), and warfarin use (p=0.039). A neurologic decline was also associated with increased ICU days (p<0.001) and increased hospital days (p<0.001). A decline in neurologic status also was associated with a greater number CT scans (p<0.001). Injury severity measures were not associated with a neurologic decline ISS (P=0.22), Head AIS (P=0.12). The type of intracranial hemorrhage was not predictive of a documented neurological decline for SAH (P=0.15), EPH (P=0.18), IPH (P=0.42), and IVH (P=0.051). However the presence of a SDH (P=0.0025), was associated with increased likelihood of neurologic decline. Pre-injury aspirin (P=0.54) or clopidogrel (P=0.17) use were not associated with incidence of neurologic decline. (Table 1)

Decision Tree and Sub-Group Analysis

Subgroup analysis and decision trees were performed to examine which cohort of patients may have identifiable risk factors for neurologic decline and/or the need for medical or surgical interventions. This analysis identified age 55 as the initial split point for groups. Zero of the 107 patients' age less than 55 and a GCS of 15 had a documented neurological decline. 203 patients were age 55 or greater with a GCS of 15 on arrival. When that subgroup was analyzed 31/203 (15.3%) had a documented neurological decline. 33/203 (16.3%) would require medical or surgical intervention during their admission with 22/203 (10.8%) requiring craniotomy.

There were 23 patients under the age of 55 admitted with a GCS less than 15, 6/23 (26.1%) had a neurological decline documented. Two of these patients would require medical and surgical intervention, with both patients of them requiring craniotomy, 2/23 (8.7%). Of patients older than age 55 with a GCS less than 15, 16/56 (28.6%) patients had a documented neurological decline. Medical or surgical interventions were required in 11/56 (19.6%) with a craniotomy performed in 4/56 (7.1%).

The current literature suggests patients up to age 65 may be low risk for neurologic decline. 46 patients in this cohort were between age 55 and 65. 8/46 (17.4%) of those patients would have experience a neurological decline with 6/8 (75%) requiring craniotomy

Anticoagulant effects

Warfarin use was found to be a risk factor for neurologic decline (p=0.039). 46 patients within this population presented on Warfarin. Any patient admitted with an intra-cranial hemorrhage with a reported history of warfarin use plus an INR above 1.6 was treated with four factor activated prothrombin complex. Mean INR was 2.5 with a standard deviation of 1.9. Median INR was 1.95. 11 of the 46 (23.9%) patients on warfarin would have a neurological decline, with 4/46 (8.7%) requiring craniotomy. Admission labs were reviewed. Admission PTT (p=0.0028), and PT (p=0.042) were found to associated with risk of neurologic decline. Admission INR (p=0.42) was not found to be statistically significant for risk of neurologic decline.

Aspirin (P=0.54) and clopidogrel (P=0.17) were not found to be significant risk factors for neurologic decline. These patients would also be treated with platelet transfusion per trauma center protocol. Of the 154 patients taking aspirin, 23 (14.9%) had a neurologic decline. 13 of the 67 (19.4%) patients taking Clopidogrel had a documented decline. Attempts as analysis for combination regimens of anticoagulants were made but group size left these evaluations under powered. (Table 2)

Scheduled, Interval CT Scans

Of the 389 patients, 376 underwent a scheduled, interval follow-up CT brain as per neurosurgical recommendations between 12–24 hours post trauma to document stability of the intracranial hemorrhage. An enlargement of the initial bleed, or a new area of hemorrhage, was seen in 69/376 scans (18.4%). 0/69 required a medical or surgical intervention based on the new CT findings. Conversely, 42 patients had a STAT CT ordered for change in condition or neurological decline. In this group, 21 had an increase of their bleed (50%). 14 of these 21 (66%) required a medical or surgical intervention. (Table 3)

Discussion

Mild traumatic brain injury remains a difficult condition to treat secondary to an array of confounding patient and pathophysiologic factors. Common practice remains both ICU admission with scheduled interval CT of the brain to document stability of the intracranial lesion in 12–24 hours. From this data, there is no clinical value in performing scheduled, interval CT brains in any mild TBI patient. Of the 389 patients that had an admission CT brain, 376 had a scheduled follow up scan that was done for surveillance only. In 69/376 (18.4%) there was some progression of the bleed seen, however, this did not alter the clinical care or need for medical or surgical intervention in any of the 69 patients (0/69, $p<0.001$.) The only difference would have been more days in the ICU for serial neurologic exams and another repeat CT brain for surveillance. These results are comparable to results from Schuster et al, and Brown et al who also found that without deterioration in exam, the scheduled interval CT did not impact care. These studies were also single center and retrospective in nature, however, they included all degrees of TBI and admission to the ICU. A prospective study by Sifri et al evaluated 130 patients with a documented intra-cranial bleed. 76% had a normal neurologic exam at the time of scheduled follow up CT and required no neurosurgical intervention. Their conclusion was that the negative predictive value of a normal neurologic exam was 100%. It is important to recognize that study excluded patients on anti-coagulants or anti-platelet medications. The argument will remain that while the risk of a worsening bleed is so small, the potential morbidity is too high, but multiple authors have evidence that routine repeat imaging does not cause changes in management. Similar to our experience it is only the CT scan that is obtained for clinical reasons, that may lead to an intervention.[1,3,4,7,10]

As healthcare resources continue to be taxed, it will become imperative for providers to utilize resources in an evidence based, justified manner. ICU care is one of our most limited and costly resources. Intensive care comprises less than 10% of US inpatient hospital beds, yet accounts for more than 25% of acute care costs. Admission to the ICU will need clear guidelines and it is important that physicians help develop these admission guidelines. It appears that there is a subgroup of patients that seem to be less at risk for clinical deterioration and the need for medical or surgical intervention. Based on our results patients age 55 years and younger, with an admission GCS of 15, and not on anti-coagulants are very unlikely to require medical or surgical intervention for a traumatic brain injury. As none of these patients were on anti-platelet or anti-coagulant medications we cannot provide recommendations in that age group who are on these medications.

Nishijima et al questioned the need for ICU admission in a retrospective, cohort study. However, in that manuscript need for ICU care was defined as ultimately needing surgical intervention, requiring mechanical ventilation, cardiac arrest, need for vasopressors and other significant critical care interventions. Our purpose was to identify patient characteristics that could be used at time of admission that allow for safe admission to a non-ICU unit with neurochecks by identifying patients who were at low risk for neurological decline. Several authors report similar findings, but few have elucidated risk factors that could be used for triage on admission. Some identifiable high risk factors from the literature include GCS < 15[5], age > 65[4,5,9], and ICH volume >10(ml).[9] This data supports a strategy for low risk patients to be admitted to a non-ICU bed where neurologic checks can be performed every 2 hours, and no repeat CT scan in the absence of a change in status.

Within this review, subgroup analysis found the low risk group included those patients only up to age 55. 46 additional patients in this cohort would have been included in the low risk group if previous authors' turning point of 65 was used. 8/46 (17.4%) of those patients would have experience a neurological decline with 6/8 (75%) requiring craniotomy. While a possible change in outcome with non-ICU admission cannot be assumed, this data supports a more conservative criterion of age 55 for triage of patients on admission.

As healthcare providers we are now consistently challenged to find safe methods to safely streamline care and reduce costs. The cost of a non-contrast CT of the brain at the institution at which this study was performed is $1274. The daily charge for and ICU room without use of a ventilator is $3,700.00 per day as compared to a step down room with a charge of $2800 per day. In this study there were 107 patients that fit the low risk criteria of age less than 55 and GCS 15. In the same 107 patients, there was an average 2.5 CT scans performed, costing over $340,000. Patients in this group averaged 1.3 days in the ICU at a cost of $514,000. If these patients had been admitted to a step down bed for even 48 hours with no repeat CT scan, the net savings would have been $230,000.

Conversely, higher risk patients will require continued frequent neurologic checks as they remain at risk for neurologic changes which are typically the first sign of bleed progression. The factors identified with neurologic decline were age greater than 55, admission GCS 13 or 14, and warfarin use. Unlike the surveillance, scheduled CT scans, the urgent/STAT CT scans ordered for changes in patient neurologic status did frequently detect clinically significant bleed progression which did then alter medical and/or surgical care. In the 42 patients that had a STAT CT brain ordered, 21/42 (50%) showed bleed progression and this led to medical or surgical intervention in 14/21 cases (66%). Even in the high risk groups the repeat CT scan can be avoided, with CT scans only ordered for changes in neurological exams while the patient is being monitored.

Being a retrospective study this data does have its limitations. Some factors may not have shown statistical significance due to a relatively low incidence in this single center study. Severely injured, poly trauma patients as represented by an ISS greater than 25 were excluded from this study. The purpose for that was the interest to focus primarily on the impact of the documented brain injury and minimize the effect on length of stay and ICU stay from other significant injuries. This attempt by the authors may introduce bias and certainly limits the application of the results of the study to the severely injured.

Conclusions

This data adds to a growing body of literature that refutes the need for scheduled repeat CT scans of the brain following mild TBI, with additional imaging only obtained for change in neurological status. Additionally, based on this data, patients younger than age 55 with an admission GCS of 15, and not on any type of anticoagulant comprise a low risk group that could safely be considered for non-ICU admission with frequent neurochecks. Patients admitted with a GCS less than 15 and those older than age 55 all showed a significant rate of neurologic decline and should continue to be managed in an ICU setting. A prospective study comparing these two treatment algorithms will be necessary to show efficacy.

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Table 1

	No Decline	**Decline**	***p* value**
GCS 15	83%	58%	0.002
GCS 13,14	17%	42%	0.002
SDH	55%	77%	0.0025
Number of CT's	3	5	<0.001
STAT CT	5.9%	41.5%	<0.001
Ventilator Days	0.11	2.87	<0.001
ICU Days	1.35	5.79	<0.001
Hospital Days	4.07	10.5	<0.001
Craniotomy	3.2%	33.9%	<0.001

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Table 2

Anticoagulant Effect

	No Decline	Decline	*p* value
Warfarin	76.1%	23.9%	0.039
Aspirin	85.1%	14.9%	0.54
Clopidogrel	80.5%	19.4%	0.17

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Table 3

Outcomes of Routine and STAT CT scans

	Progression of Bleed	Medical/Surgical Intervention
Routine Repeat CT scan	69/376 (18.4%)	0/69 (0%)
STAT CT for neuro decline	21/42 (50%)	14/21 (66%)
	p<0.001	p<0.001