

Is a stepdown unit safe for patients with mild traumatic intracranial hemorrhages?

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Abstract

Purpose Traumatic brain injuries (TBIs) are a major source of disability in the United States. The ideal unit in the hospital for patients with mild traumatic intracranial hemorrhages (ICHs) has not been elucidated. We sought to investigate whether patients treated in the surgical stepdown area had worse outcomes than those treated in the surgical ICU.

Methods We compared patients with ICHs and a Glasgow Coma Scale (GCS) upon admission of 14 or 15 who went to the ICU to those who went to the stepdown area from April 2014 to November 2016. We compared age, gender, Injury Severity Score (ISS), admission GCS (14 or 15), operative intervention, discharge destination, hospital length of stay (HLOS), mortality, and cost between these two groups.

Results Patients admitted to the ICU had a significantly longer HLOS. Admission costs for patients admitted to ICU were also significantly higher than their stepdown area counterparts. This was true for both total charges ($p=0.0001$) and for net revenue ($p=0.002$) (Table 2). There was no statistically significant difference in mortality, operative intervention, or discharge destination.

Conclusion A surgical stepdown unit can be a safe disposition for patients with mild traumatic ICHs and represents an effective use of hospital resources.

Keywords Traumatic brain injury · Intracranial hemorrhage · Trauma · Stepdown unit · Cost analysis

Introduction

Traumatic brain injuries (TBIs) are a major source of disability in the United States. Approximately, 1.7 million new cases are reported each year, 200,000 of whom are admitted to the hospital and 90,000 of whom experience long-term disability [1–3]. While clear therapeutic guidelines exist for severe TBIs in the acute phase, patients with less severe injuries are non-uniformly managed, depending on local protocols and practice patterns [4]. This is most evident in patients with intracranial hemorrhages (ICH) who are awake and alert. This diversity in clinical care creates inconsistencies in triage. As the potential for clinical decline is balanced against proper allocation of hospital resources, the ideal unit in the hospital for this patient population has not been elucidated.

The surgical intensive care unit (ICU) is a costly and labor-intensive location, with a low nurse to patient ratio. There are clear indications for admission to the ICU to properly manage and monitor patients with critical illness, inclusive of more frequent assessments of vital signs and any neurologic deterioration. On average, a day in the ICU costs upwards of \$3500 [5]. Intensive care units occupy 5–10% of inpatient beds in a given hospital and yet they account for 20–35% of total hospital costs [6].

Zimmerman et al. suggested that historically, up to 35.4% of ICU admissions were for low-risk patients who were being monitored closely but are not actively being treated prior to the widespread institution of stepdown or intermediate care units [7]. These low-risk patients, such as mild TBIs, if identified prior to admission, could be managed on

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an intermediate care unit, resulting in an 8.2% cost savings, or \$5500 per patient, in addition to freeing up the ICU for more critical patients [7]. However, the safety of acute TBI patients, specifically, being managed in the stepdown unit has yet to be established.

The stepdown area is an intermediate level care unit that has a slightly higher nurse to patient ratio, but includes telemetry, video and additional monitoring compared to a ward-type room. In our institution, vital signs and neurologic checks are conducted by nursing every 2 h. We sought to compare the clinical outcomes of patients who were admitted with mild traumatic ICHs to the ICU to those admitted to the stepdown area. An intermediate care area may be ideal for patients who do not require the close monitoring of the ICU, but who are still too tenuous for the general surgical floor.

Methods

Saint Francis Hospital and Medical Center is an American College of Surgeons Verified Level II Trauma center in Hartford, Connecticut. This project was approved by our institutional review board.

Our institution routinely places all traumatic ICH patients in the ICU. In the ICU, nurse to patient ratio is at least one to one, patients have neurologic exams every hour, and continuous monitoring of vital signs. The stepdown area has a staff ratio of one nurse to two patients and allows neurologic exams every two hours and remote monitoring of vital signs by a monitor technician in the immediate vicinity. After anecdotal observations that the vast majority of these ICH patients with a Glasgow Coma Scale (GCS) of 14 or 15, did not deteriorate neurologically, infrequently had progression of their ICH on repeat CT, and then left the ICU quickly, an observational study was created. We changed our institutional policy to allow mild TBI patients to be admitted straight to the stepdown area. Patients who met appropriate admission criteria, including a GCS of 14 or 15 and no history of anticoagulant use were instead sent directly to the stepdown unit for monitoring. This was done in the absence of a protocol and at the discretion of the attending.

We compared patients with ICHs and an admission GCS of 14 or 15 who were admitted to the ICU to those who went to the stepdown area from April 2014 to November 2016. We compared age, gender, Injury Severity Score (ISS), admission GCS, Abbreviated Injury Scale (AIS) head scores operative interventions, discharge destination, hospital length of stay (HLOS), mortality, and cost between these two groups.

Age and AIS head scores were analyzed using student's *t* test. Gender, GCS, operative intervention, mortality, and discharge destination were all analyzed using Chi-Square

analysis. ISS and HLOS were analyzed with Kruskal–Wallis test due to the non-normal distribution. Wald Chi-Square Logistic Regression was employed to determine the odds ratio estimates for gender and HLOS.

Results

Three hundred and thirty-four patients met inclusion criteria. Two hundred and ninety-one patients were admitted to the ICU with mild TBI and 42 patients were admitted to the stepdown area with mild TBI. The two groups of patients were similar with respect to age and severity of injuries (Table 1). They did differ with respect to gender. The percentage of women who were placed in the ICU was 91.55% while only 8.45% went to the stepdown area. This is a significantly higher percentage when compared by Chi-Square analysis with men who went to the ICU at a rate of 84.29% ($p=0.049$). Of the patients in the ICU group, 44.67% were female, while in the stepdown group 27.91% of the patients were female. Female gender was also noted to be a significant factor when using logistic regression to compare the populations in the ICU vs. the stepdown area ($p=0.037$). Odds ratio estimates revealed that women were twice as likely to be admitted to the ICU rather than to stepdown area (point estimate 2.14, 95% CI 1.05–4.38).

Patients admitted to the ICU had a significantly longer HLOS. Their odds ratio point estimate was 1.15 (95% CI 1.02–1.30). Admission costs for patients admitted to ICU were significantly higher than their stepdown area counterparts as well. This significant monetary difference was true for both total charges ($p=0.0001$) and for net revenue ($p=0.002$) (Table 2).

All nine of the mortalities were patients who had been in the ICU. There was no statistically significant difference in mortality between ICU and stepdown patients ($p=0.25$). There were also no significant differences in operative intervention or discharge destination between the two groups (Table 2).

Table 1 Demographics

	ICU ($n=291$)	Stepdown ($n=43$)	<i>p</i> value
Age	68.18 (± 19.50)	66.12 (± 19.33)	0.52
Gender			
Male ($n=192$)	84.29%	15.71%	0.049
Female ($n=142$)	91.55%	8.45%	0.049
ISS			
Mean	14.5 (± 7.08)	12.90 (± 6.17)	0.20
Median	14	11	0.20

ICU intensive care unit, ISS Injury Severity Score

Bold numbers indicate statistical significance

Table 2 Results

	ICU (<i>n</i> = 291)	Stepdown (<i>n</i> = 43)	<i>p</i> value
GCS			
14 (<i>n</i> = 86)	27.49%	14.29%	0.07
15 (<i>n</i> = 247)	72.51%	85.71%	0.07
AIS head	3	3	1.00
Operative intervention	56/291 (19.24%)	4/42 (9.52%)	0.13
HLOS	5.26 (± 5.28)	3.33 (± 2.84)	0.003
Mortality	100%	0%	0.25
Discharge destination			
Home (<i>n</i> = 161)	45.70%	64.29%	0.23
Rehab (<i>n</i> = 52)	16.84%	7.14%	0.23
SNF (<i>n</i> = 98)	29.90%	26.19%	0.23
Hospice (<i>n</i> = 8)	2.75%	0%	0.23
Cost			
Charge	\$59,788.11 (± 64,014.01)	\$34,386.18 (± 23,810.00)	0.0001
Revenue	\$18,317.59 (± 23,624.08)	\$9979.98 (± 9,285.79)	0.002

ICU intensive care unit, GCS Glasgow Coma Score, AIS Abbreviated Injury Scale, HLOS hospital length of stay, SNF skilled nursing facility

Bold numbers indicate statistical significance

Discussion

TBIs have been steadily increasing in frequency over the last decade, which has partially been attributed to the increased availability of very sensitive CT scans and the increased use of anticoagulants in the elderly [8]. At the same time, the mortality rates for TBI have been steadily declining for the last two decades. This decrease in mortality is attributed to more standardized care of severe TBIs in the critical care setting. However, this improved survival has also led to rising numbers of those living with a TBI-related disability [8]. Although the majority of TBIs are mild, up to 10% of these mild TBI patients may continue to have symptoms for a year and beyond [9]. As high as 1.1% of the population is estimated to live with a TBI-related disability in the United States [8]. Finkelstein et al. estimated that lost productivity, wages, and health-care costs contribute to a total of 60.43 billion dollars lost annually [10]. This economic burden is the greatest for any organ system [8].

As this was a retrospective study, the majority of patients (87%) initially went to the ICU according to our protocol rather than the stepdown area. This led to a discrepancy in the sample sizes of our two comparison groups. Despite this sample size difference, patients were similar in the two groups with respect to age and the severity of their injuries. AIS and ISS were not significantly different between ICU and stepdown patients. Despite being triaged to different levels of care, these patient populations had similar outcomes with no higher mortality rate or rate of operative intervention for those sent to the stepdown area (Table 2).

There is extensive evidence suggesting that gender bias interferes with medical care. The treatment of cardiovascular disease in particular, is delayed for female patients. Women with myocardial infarctions receive cardiac catheterizations at a lower rate than their male counterparts [11], and experience prolonged time to cardiac catheterization, despite similar clinical indicators [12]. In-hospital mortality rates for women are, therefore, understandably higher [13]. Under-triaging may also play a role in women after a trauma, as mortality rates are higher in female patients suffering from TBIs and ICHs as well [13]. Female patients constitute, on average, one-third of the trauma patient population [14]. We found that female patients were significantly more likely than their male counterparts to be up-triaged to the ICU rather than the stepdown area. In addition to less experience with females, it is possible that this conservative move represents a subconscious association of women with fragility by their care providers.

ICUs are expensive places to manage any patient and should, therefore, only be utilized when truly necessary. The first day in the ICU has also been cited as the most expensive for the entire stay, costing an average of \$6667 for patients who are not mechanically ventilated [5]. This figure would apply to our ICU mild TBI group, as patients would undergo a period of observation in the ICU, a repeat interval computed tomography (CT) scan, and subsequently were transferred to the stepdown area if the neurological exam and imaging demonstrated stable or improved pathology. This transition from ICU to stepdown often led, in our study, to patients staying in the hospital for an extra day. The ICU is the most costly unit not only for the first day of

admission, but also on a daily basis, at an average of \$3500 per day [5]. Our study echoed this finding as patients admitted to the ICU had significantly more costly hospitalizations than their counterparts who were admitted to the stepdown area (Table 2).

Resource utilization is important in an atmosphere of accountable, cost-conscious care. We found that patients were no more likely to have operative intervention, to die, or to be discharged to a skilled nursing facility (SNF) or Hospice from the stepdown area as compared to ICU. In fact, patients left the hospital sooner when they were admitted to the stepdown area. However, our study was not powered to determine no true differences. Thus, in the future, the stepdown area, given that it is less expensive and is associated with a shorter HLOS, should be considered safe for patients who are admitted with traumatic ICHs who have a GCS of 14 or 15.

While there is currently no protocol or scoring system to determine which patients are at the highest risk of enlargement of their ICH, previous studies have found GCS < 15, age \geq 55, and warfarin use to be associated with neurologic decline in mild TBIs, and have thus suggested using these factors to up-triage patients. This evidence is helpful moving forward, so that clinicians can admit high-risk patients to the ICU. Through closer observation and hourly neurologic checks, a clinically worsening ICH can be swiftly identified and intervention can be activated.

While attempting to streamline the management of our traumatic ICHs, we noted that in addition to high ICU admission rates, all patients underwent or were scheduled for an interval CT scan, regardless of neurologic status. These CTs on patients with stable neurologic assessments, are costly, and there is evidence suggesting that they may not be necessary [15, 16]. Recent studies support the idea that interval CTs of the brain are not useful in patients with mild TBIs unless there is evidence of neurologic decline [4, 15]. Even in patients with progression of their ICH on a scheduled CT, care is not often altered [4]. Sifri et al. found that negative neurologic exams are extremely clinically valuable and have a 100% negative predictive value of a worsening ICH [17]. Repeat CT scans performed for worsening neurologic exams, however, are far more revealing. In one study, CTs after a neurologic decline showed worsening ICH in 67% of cases and even necessitated operative intervention in 33% [15]. Neurologic status, therefore, is an important clinical indicator of decline, and should be regularly monitored before reflex triaging to the ICU and ordering of repeat imaging. We have adjusted our practice based on these findings. Covering neurosurgeons have refined their requesting process for interval CTs on all patients.

There are several limitations to our study. First, this was a retrospective review, introducing possible selection bias. It is possible that the ICU patients were sicker and were being

triaged to the ICU for reasons other than their ICH. While all of the mortalities did occur in the ICU patient population, this resulting difference was not statistically significant. One patient died several days after being transferred to the regular surgical floor with a stable brain CT, while the other eight patients declined neurologically, had worsening ICHs and had care transitioned to a focus on comfort and end of life, regardless of operative intervention. The ISS and AIS head scores were not significantly different between the two populations. This suggests that the ICU patients were similar in the severity of their injuries, overall and of their ICH specifically, to the stepdown area patients.

Another limitation is that we utilized our trauma database to find these patients. While the database is prospectively collected, there is always the possibility that an error was introduced in this data collection stage. Prospective surveillance of these patients should thus be undertaken to further validate our findings.

Finally, these are small sample sizes and although we found statistically significant differences in HLOS and costs, we were underpowered to determine that there were no differences for other endpoints. To determine this, we would require a larger sample size. This would most likely require a multi-institution trial to achieve.

Conclusion

In conclusion, a surgical stepdown unit can be a safe disposition for patients with traumatic ICHs who have a GCS of 14 or 15.

Compliance with ethical standards

Conflict of interest Dr. Laura C. Lamb, Monica DiFiori, Dr. James M. Feeney, Dr. Joel Calafell, Dr. Christopher Comey and Dr. David S. Shapiro declare no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helenski Declaration and its later amendments or comparable ethical standards. For this type of study, formal consent is not required. The article does not contain any studies with animal performed by any of the authors.

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