The American Journal of Surgery 214 (2017) 14–18

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

Utility of clinical decision rule for intensive care unit admission in patients with traumatic intracranial hemorrhage

Brandt D. Whitehurst, M.D. [a], Jared Reyes, M.Ed. [a], Stephen D. Helmer, Ph.D. [a, b], James M. Haan, M.D. [a, c, *]

[a] Department of Surgery, The University of Kansas School of Medicine – Wichita, Wichita, KS, USA
[b] Department of Medical Education, Via Christi Hospital Saint Francis, Wichita, KS, USA
[c] Department of Trauma Services, Via Christi Hospital Saint Francis, Wichita, KS, USA

ARTICLE INFO

Article history:
Received 19 May 2016
Accepted 30 September 2016
Presented at the 68th Annual Meeting of the Southwestern Surgical Congress, Coronado, CA, April 3 – 6, 2016.

Keywords:
Trauma
Traumatic intracranial hemorrhage
Clinical decision rule
Triage
Intensive care unit admission

ABSTRACT

Background: Recent literature suggests the majority of traumatic intracranial hemorrhage does not require intervention. One recently described clinical decision rule was sensitive in identifying patients requiring critical care interventions in an urban setting. We sought to validate its effectiveness in our predominately rural setting.

Methods: A retrospective study was conducted of adult patients with traumatic intracranial hemorrhage. The rule, based on age, initial Glasgow coma scale score, and presence of a non-isolated head injury, was applied to externally validate the previously reported findings.

Results: In our population, the rule displayed a sensitivity of 0.923, specificity of 0.251, positive predictive value of 0.393, and negative predictive value of 0.862. The area under curve was 0.587. While our population has a similar adjusted head injury severity score as that from which the rule was developed, significant differences in age and intracranial hemorrhage pattern were noted.

Conclusions: The rule displayed decreased performance in our population, most likely secondary to differences in age and intracranial hemorrhage patterns. Prospective evaluation and cost-savings analysis are appropriate subsequent steps for the rule.

1. Background

Traumatic brain injury (TBI) is a frequent occurrence in the adult trauma population with an estimated incidence of 1,700,000 cases per year with 275,000 requiring hospitalization.[1] Traumatic intracranial hemorrhage (tICH) is a frequent finding on imaging for TBI patients that require hospitalization. Clinical observation, often in an intensive care unit (ICU), is the standard-of-care in many trauma centers for patients with tICH. Intensive care unit observation affords timely identification of symptoms associated with hemorrhage progression and secondary brain injury.[2–5] Due to rising health care expenditures, appropriate utilization of high cost resources, such as ICU monitoring, has received great interest.[6] Because published data suggest that rates of clinical progression and neurosurgical intervention for tICH is low,[7,8] the cost-effectiveness of routine ICU admission is now questioned.[9–12]

A previously published clinical decision rule, derived from a retrospective review of 432 tICH patients in an urban Level 1 trauma center, was designed to identify patients at high risk for requiring a critical care or neurosurgical intervention, and thereby needing ICU admission. The decision rule utilizes three clinical parameters: Glasgow coma scale (GCS) score <15, presence of non-isolated head injury, and age greater than 65.[4] While simple and rapid to utilize, the performance characteristics of this clinical decision rule have not yet been externally validated. While interested in this rule as an aid for assigning appropriate disposition, we suspected population characteristics, such as our significant rural catchment area, would impact its performance. Therefore, we sought to examine the performance characteristics of this clinical decision rule in our population.

* Corresponding author. Department of Trauma Services, Room 2514, Via Christi Hospital Saint Francis, 929 N. Saint Francis St., Wichita, KS 67214, USA.
E-mail address: James.Haan.Research@viachristi.org (J.M. Haan).

http://dx.doi.org/10.1016/j.amjsurg.2016.09.057
0002-9610/

2. Methods

Utilizing the *International Classification of Diseases, Ninth Revision* (ICD-9) codes for traumatic intracranial hemorrhage (851-854) to query our trauma registry, we identified a cohort of all patients, 18 years of age or greater, treated at our American College of Surgeons verified Level I trauma center between January and December 2013.

Database capture from our trauma registry included patient demographics (age and gender) and markers of injury and intervention such as: mechanism of injury, injury severity score (ISS), GCS score, ethanol use and level, initial vital signs, ICU length of stay, need for mechanical ventilation and ventilator days, hospital length of stay, disposition, and mortality. Retrospective chart reviews were subsequently conducted to identify clinical, physical, and objective parameters for analysis as well as the occurrence of critical care interventions.

Clinical parameters recorded included loss of consciousness, nausea, emesis, headaches, focal neurologic deficits, amnesia and seizures. Physical parameters recorded included the presence of focal neurologic deficits, non-frontal scalp injury including hematoma and lacerations, basilar skull fracture signs such as raccoon eyes, Battle's sign, and hemotympanium. Objective parameters recorded included time from injury to presentation to the hospital, use of anticoagulants, presence of isolated head injury, and initial GCS score. Because hemorrhage size and volume are not utilized in applying the clinical decision rule, imaging reports were utilized to determine hemorrhage type in our cohort.

Critical care interventions included arterial catheterization, central line placement, intracranial pressure monitoring, mechanical ventilation, use of vasopressor, antiarrhythmic or antihypertensive drips, transfusion of blood products, or performance of advanced cardiac life support protocols. Therapeutic and surgical procedures such as interventional radiology procedures, craniotomy, skull fracture elevation, or Burr hole placement were considered critical care interventions for purposes of this study.

Data were abstracted, summarized, and reported as mean with 95% confidence interval or median with interquartile range as appropriate for the respective data type. The data were examined for statistical relationships using SPSS Software, Version 19 (IBM Corp., Somers, New York). Univariate analyses were conducted using chi-square tests. Comparable to the methods employed by Nishijima et al,[4] a binary decision tree was used to validate the clinical decision rule. A receiver operating characteristic curve was plotted with the area under the curve (AUC) used to evaluate the performance of the decision rule for distinguishing between true positives (ICU admissions requiring critical intervention) and false positives (ICU admissions not requiring critical intervention). This study was approved for implementation by the institutional review board of Via Christi Hospitals Wichita, Inc.

3. Results

A total of 355 adult patients with traumatic intracranial hemorrhage were identified as meeting the initial study criteria. During the review process, 14 patients were excluded from further analysis. Nine patients did not have imaging or imaging reports demonstrating a tICH despite the sometimes-associated presence of findings such as skull fractures. Two registry entries did not correlate with an electronic medical record. One patient was not evaluated by the trauma team. One patient without a trauma mechanism was transferred to another service after a characteristic hypertensive bleed was identified. The final patient presented with pulseless electrical activity secondary to asphyxiation from hanging and did not undergo intracranial imaging. The remaining 341 patients were included in the final analyses.

Examination of the patient population meeting inclusion criteria revealed that 63.3% were male and the majority were over the age of 65 with a mean age of 61.6 years (Table 1). Patients were on average moderately brain-injured as evidenced by a median GCS score at presentation of 15 and median ISS of 10. Alcohol was detectable in 16.4% of patients. Few patients presented in shock (3.5%). Anticoagulant therapy was common and noted in 39.2% of patients. A significant proportion (18.6%) of patients presented more than twenty-four hours after the inciting event.

Falls were the most common injury mechanism (59.2%), with motor vehicle collisions representing the second most common mechanism (21.4%; Table 2). Isolated head injury was present in the majority of patients (71.8%). Multiple hemorrhages were present in 41.1% of patients with subdural hematoma being the most frequent type of hemorrhage, whether isolated or not (Table 3). Mechanical ventilation was the most frequently performed critical care intervention (22.9%) followed by central or arterial line placement (13.5%; Table 4). Neurosurgical intervention was necessary in 15.9% of patients. Average hospital length of stay was 5.1 ± 5.9 days (median = 3 days) and we observed a 10.3% mortality rate in our population.

Validation of the clinical decision rule used the occurrence of a critical care intervention as the gold standard for indicating requisite ICU admission (Table 5). In our population, the rule displayed a sensitivity of .92 (95% CI .89 - .95), specificity of .25 (95% CI .21- .30), positive predictive value of .39, and negative predictive value of .86. The AUC was .587 (95% CI .53 - .65; $P = .008$). In evaluating those patients with delayed presentation (>24 hours), the rule suffered from diminished sensitivity, and loss of statistical significance.

Numerous presenting parameters were associated with an increased likelihood of undergoing a critical care intervention such as: GCS less than 9 ($P < .001$), increasing ISS ($P<.001$), presence of

Table 1
Patient population and clinical characteristics.

Parameter	N	Value
Number of observations	341	100%
Age (years)	341	61.6 ± 22.6
Age >65	178	52.2%
Male gender	216	63.3%
Initial GCS score	340	15 (13, 15)
GCS 13− 15	259	76.2%
GCS 9 − 12	21	6.2%
GCS 3 − 8	60	17.6%
Injury severity score	341	10 (9, 18)
AIS head	341	3 (3, 4)
Positive blood alcohol level	56	16.4%
Blood alcohol concentration	56	199.7 ± 110.9
Initial vital signs		
Systolic blood pressure (mm Hg)	341	144.3 ± 30.9
Diastolic blood pressure (mm Hg)	340	88.6 ± 19.4
Heart rate	341	86.4 ± 19.3
Respiratory rate	341	17.0 ± 7.5
Temperature (°F)	331	97.8 ± 1.0
Oxygen saturation (%)	331	97.3 ± 3.0
Systolic blood pressure <90 mm Hg	12	3.5%
Anticoagulant therapy	132/337	39.2%
Interval from injury to presentation (days)	338	1.4 ± 5.2
Delayed presentation (≥1 day)	63	18.6%

Data are presented as percent, mean ± SD, or median (interquartile range).