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Original Contribution

Factors associated with adverse outcomes in patients with traumatic intracranial hemorrhage and Glasgow Coma Scale of 15

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ABSTRACT

Patients with mild traumatic brain injury (mTBI) with associated intracranial injury, or complicated mTBI, are at risk of deterioration. Clinical management differs within and between institutions. We conducted an exploratory analysis to determine which of these patients are unlikely to have an adverse outcome and may be future targets for less resource intensive care.

This single center retrospective cohort study included patients presenting to the ED with blunt complicated mTBI between January 2001 and December 2010. Patients with a Glasgow coma score (GCS) of 15, an initial head CT with a traumatic abnormality, and a repeat head CT within 24 h were eligible. We defined the composite adverse outcome as death within two weeks, neurosurgical procedure within two weeks, hospitalization >48 h, and worsened second head CT. Classification and Regression Tree methodology was used to identify factors associated with adverse outcomes.

Of 1011 patients with two head CTs performed in a 24-h period, 240 (24%) had complicated mTBI and GCS 15. Of these, 56 (23%) experienced the composite adverse outcome defined above. Age, headache, and subarachnoid hemorrhage, correctly classified 93% of patients with an adverse outcome. No instance of death or neurosurgical procedure was missed.

Our analysis highlighted three factors associated with adverse outcomes in persons who have complicated mTBI but a GCS of 15. Absence of these risk factors suggests low risk of adverse outcomes, and may suggest that a patient is safe for discharge home. Additional research is required before utilizing these findings in clinical practice.

1. Introduction

1.1. Background

Traumatic brain injuries (TBIs) may account for upwards of 1.8 million annual emergency department (ED) visits in the United States (US) [1]. In 2010, 0.7% of all ED visits were for TBI [2]. When the neurologic exam is normal and the initial head computed tomography (CT) is negative, it is considered safe to discharge patients home from the ED [3-5]. However, about six to 9% of patients with a Glasgow Coma Score (GCS) of 15 demonstrate traumatic intracranial hemorrhage on head CT [6], and are referred to as complicated mTBI [7]. There is great variability in the ED management of patients with GCS 15 complicated mTBI [8].

In 2002, the European Federation of Neurological Societies recommended that complicated mTBI patients should be routinely admitted to an intensive care unit (ICU) [9]. This practice, as well as the common practice of obtaining a repeat head CT, has been questioned [10], yet some centers still routinely admit all TBI patients with trauma-related intracranial abnormality to an ICU and obtain routine repeat imaging, regardless of GCS [11]. It is not uncommon for patients to be transferred to hospitals with neurosurgical coverage, further contributing to increased resource utilization. Conversely, about one in ten patients with complicated mTBI are discharged home from the ED [8]. This

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does not include patients who had ED observational stays, however, as ED observation units are increasing in number, this may be an alternative approach for patients with complicated mTBI [12]. Given the lack of contemporary guidance for the management of patients with complicated mTBI with GCS 15, there is a critical need for research to help inform clinical decision-making.

1.2. Importance

Up to 95% of TBI patients with complicated mTBI and GCS 16-15 who are admitted to the ICU do not require critical care or neurosurgical intervention [13]. We have previously reported that about two-thirds of TBI patients with GCS 14-15 with associated trauma-related intracranial abnormality can be safely discharged from the ED after monitoring for six hours followed by a stable repeat head CT. The 14-day mortality rate among patients with GCS 14 or 15 discharged in this way was <0.5%, and <1% required a neurosurgical procedure [14]. Admitting all patients with complicated mTBI is a potential over-utilization of resources, particularly for those with GCS 15.

1.3. Goals of this investigation

It is possible that some patients with a normal neurological exam and GCS 15 can be safely discharged from the ED despite having traumatic intracranial findings on head CT. Identifying such a cohort of patients could reduce resource utilization without incurring harm for this common clinical condition. We sought to identify variables associated with higher risk of adverse short-term outcomes in patients with complicated mTBI with GCS 15. Identifying those factors associated with increased risk could allow patients with the absence of such risks to be safely discharged from the ED.

2. Methods

2.1. Study design

This was a secondary analysis of an existing data set. The data were originally collected as part of a retrospective cohort study describing the practice pattern of repeat head CTs after mild TBI. This study was approved by the local Institutional Review Board.

2.2. Study setting and population

Patients who presented to our tertiary academic ED between January 2001 and December 2010 were included. Potential study subjects were identified from the cohort of all adult patients who underwent two head CTs within 24 h with a traumatic intracranial abnormality detected on the first CT. The practice pattern during this time period was that all patients had a scheduled repeat head CT performed if the baseline CT revealed any trauma related abnormality (defined as traumatic subarachnoid hemorrhage, subdural hematoma, epidural hematoma, and intraparenchymal hemorrhage or traumatic contusion), so all patients presenting with complicated mTBI would have been included. Our institutional protocol is that all patients with a traumatic abnormality on initial head CT have a second head CT to determine stability.

Subjects who were on antiplatelet medications or warfarin with international normalized ratio (INR) <1.4 were included. Subjects were excluded if they were <18 years old, had no documented GCS, GCS <15 based on first GCS upon arrival in the ED, unknown time of injury, had their head CT performed or interpreted at an outside hospital, were pregnant, had penetrating head injury, were intubated prior to ED evaluation, had abnormal ED vital signs (systolic blood pressure <89 mm Hg, respiratory rate >29 breaths per minute, pulse oximetry <92% on room air) at any point during the ED visit, had concomitant nonminor injuries (injuries for which a patient would require hospitalization) or had an inherited or acquired coagulopathy. Patients with polytrauma were excluded so that we could target a population of patients who may be safe for ED discharge on the basis of their head injury alone. Inherited coagulopathy was defined as hemophilia A or B, von Willebrand disease, Bernard-Soulier syndrome, Wiskott-Aldrich syndrome, or Glanzmann's thrombasthenia. Acquired coagulopathies were defined as liver failure, therapeutic warfarin use (INR ≥1.4), heparin product use, and disseminated intravascular coagulopathy (INR ≥1.4, activated partial thromboplastin time (aPTT) >39 s, and platelets <50 000/μl).

2.3. Study protocol

Chart review methods by which the data were originally obtained have been published previously [14]. Briefly, a single data abstractor reviewed each identified case using explicitly defined inclusion and exclusion criteria. Two reviewers performed a second chart review to ascertain worsening or stability on the repeat head CT. Quality checks were performed on 10% of the chart abstractions. Missing data were minimal and were left missing.

2.4. Outcome measures

A composite adverse outcome was defined to capture the cohort of patients who had an adverse clinical outcome, and those for whom ready discharge from the ED may not be clinically feasible. The composite outcome was comprised of death within two weeks, neurosurgical intervention within two weeks (defined as a procedure performed by neurosurgery either at the bedside or in the operating room for head injury, including external ventricular drain (EVD) placement or intracranial pressure (ICP) monitor placement), length of stay >48 h [15], or worsening trauma related intracranial abnormality on the second head CT. Worsening traumatic abnormality was defined as a second head CT that was described as worsened hemorrhage by the attending neuroradiologist interpretation. Length of stay >48 h was chosen because previous studies have reported that any worsening after 48 h is unlikely due to the primary neurologic cause [16,17]. Further, the time frame of 48 h is consistent with previously published guidelines [9] and likely captures a group of patients that would not be readily discharged from the ED. The social security death index was searched for patients who neither returned to the ED nor had a documented clinic visit at or beyond 14 days after their injury. This query was performed three years after the last patient was evaluated in the hospital for this retrospective review, leaving ample time for patients to be listed in the index. In all instances when this occurred, a social security number was available in our medical records system for query of the database. We did not attempt to contact patients to ascertain adverse outcomes.

2.5. Data analysis

For this analysis, we used Classification and Regression Trees (CART) to identify variables associated with risk of an adverse outcome. CART methodology is advantageous as it is able to accommodate nonlinear relationships, unexpected interactions, and missing values [18]. To maximize model sensitivity for adverse outcomes, missing an adverse outcome was set to have a cost four times greater than missing a favorable outcome. The minimum number of cases for a parent node in the CART was set to ten, and the minimum number of cases for a child node was set to five. Splitting used the Gini criteria, with minimum improvement set to 0.0001. The tree was not pruned. The model has not yet been validated and external validation is planned.

Based on prior research, biological plausibility (i.e., contribution of blood thinning medications to worsening hemorrhage, age) [19-21], and clinical observation (i.e., TBI symptoms), the following variables were determined a priori as candidate variables for consideration: age [22]; use of any home medications that affect blood clotting; nausea or vomiting at any point during ED visit; headache of any severity