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Early neurological deterioration in older adults with traumatic brain injury

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ABSTRACT

Introduction: Traumatic brain injuries (TBIs) and resulting fatalities among older adults increased considerably in recent years. Neurological deterioration often goes unrecognized at the injury scene and patients arrive at emergency departments with near-normal Glasgow Coma Scale (GCS) scores. This study examined the proportion of older adults experiencing early neurological deterioration (prehospital to emergency department), associated factors, and association of the magnitude of neurological deterioration with TBI severity.
Methods: This secondary analysis of National Trauma Data Bank Research Datasets included patients who were age ⩾65, sustained a TBI, and transported from the injury scene to an emergency department. Data analysis included chi-square analysis, *t*-tests, and logistic regression. Long-term anticoagulant/antiplatelet therapy was not associated with deterioration.
Results: Of the sample of 91,886 patients, 13,913 (15.1%) experienced early neurological deterioration. Adjusting for covariates, age, gender, head AIS_{max} injury severity, and probability of death were associated with early deterioration. Patients with severe and critical head injuries had the highest odds of early neurological deterioration (OR = 1.41 [CI = 1.22–1.63] and OR = 1.98 [CI = 1.63–2.40], $p < 0.001$).
Discussion/conclusions: Prehospital providers, nurses, physicians, and other providers have opportunities to optimize outcomes from older adult TBI through early recognition of neurological deterioration, rapid transport to facilities for definitive treatment, and targeted rehabilitation.

1. Introduction

The incidence of traumatic brain injury (TBI) hospitalizations and deaths among older adults has spiked in recent years [9]. Although many of these brain injuries are life threatening, the likelihood of treatment at a trauma center hospital declines with age [31]. Injury severity is often unrecognized at the scene and patients arrive at emergency departments (EDs) with near normal Glasgow Coma Scale (GCS) scores [7,24,35]. Falls are the primary mechanism of injury among older adults who sustain a TBI [10]. Many falls are low energy slip and trip falls, which often present as innocuous injuries to laypersons and emergency responders. Unfortunately, early presentation can be deceiving, with many low energy falls resulting in brain hemorrhage and even death.

Brain hemorrhage and swelling increase intracranial pressure, risking severe disability and death [4]. Recognizing prehospital neurological deterioration identifies opportunities for early intervention to mitigate damage [6,27], including transport of the injured person to a trauma center for timely, definitive treatment. Many prehospital trauma triage guidelines use the Glasgow Coma Scale (GCS) to guide intervention, determining the need for trauma center transport. Prehospital trauma triage guidelines in the United States indicate trauma center transport for patients with a GCS score of ⩽13 [36]. However, scientific evidence of the effectiveness of this GCS score cut-point in screening for TBI during the prehospital period in an older adult population remains controversial [8,36]. What is clear, though, is that a deteriorating GCS score warrants further evaluation and transport to a trauma center.

A noted gap in the literature is the paucity of evidence comparing *older adults'* prehospital and ED GCS scores to identify neurological deterioration and its predictors. This gap is important because previous evidence suggests that older adults, compared to younger adults, with moderate and severe head injuries, are more likely to present to the ED with normal or near-normal GCS scores, thus masking the severity of their TBIs [24]. Furthermore,

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older adults at each injury severity stratum have a higher risk of dying [35]. Therefore, the ability to identify older adults at risk for early neurological deterioration provides opportunities for early intervention and subsequent improvement of outcomes. Our study aims, which addressed this gap, were to determine the proportion of older adults with TBIs whose GCS score deteriorated from prehospital to ED assessment, factors associated with a decrease in GCS score, and the association of the magnitude of GCS score deterioration with the anatomic severity of the brain injury.

2. Background/literature

In an effort to identify brain-injured older patients at risk for neurological deterioration, we reviewed studies of injured adults that evaluated prehospital and ED GCS scores [3,5,12,13,14,15,25,27]. These studies focused on two patient populations: patients with TBIs and patients with unspecified injuries. Findings were similar for both populations, including no significant differences in prehospital and ED GCS scores [13,14], neurological deterioration among nonsurvivors [12], and a mix of improved GCS scores [5,15] and deteriorated GCS scores [27]. The proportion of patients who deteriorated was greatest for patients with ED GCS scores in the severe range [25,27], including those whose GCS deterioration was more than two points [27]. Among patients whose GCS scores improved from prehospital to ED, the GCS median score improvement was two points, from a prehospital GCS = 12 to an ED GCS = 14 [5,15]. Although these studies included adults of all ages, the mean ages ranged from 40 to 50 years and none included a sub-group analysis of older adults.

Additional evidence suggests that early GCS scores underestimate the presence and severity of TBIs among older adults who presented with near-normal GCS scores in the ED [24,35,37]. In a comparison of head Abbreviated Injury Scale (AIS) 3–5 scores (serious, severe, or critical injury) among undertriaged and correctly triaged older patients, the median ED GCS score for both groups was 14, suggesting a mild head injury, when in fact, the actual AIS severity was much greater [37]. In another study examining ED GCS severity among older adults, 90.1% of patients with head AIS 3 scores (serious injury), 83% of those with head AIS 4 scores (severe injury), and 56.3% with head AIS 5 (critical injury) scores presented with GCS scores of 13–15 [35]. Similarly, other investigators reported higher GCS median scores among older adults compared to younger adults for each head AIS category [24].

3. Methods

This study is a secondary analysis of de-identified data from the National Trauma Data Bank (NTDB) Research Dataset (RDS) from admission years of 2009–2012 [1]. The NTDB is a voluntary registry of trauma admissions from participating trauma centers in the United States. This registry includes data on the trauma admission; events during the pre-hospital, admission, and discharge phases; outcomes; and variables describing the hospital.

The university Institutional Review Board granted an exemption for this study according to 45 CFR 46.101(b), category 4, use of existing data.

3.1. Sample

Participants included in our study were age 65 years and older, had a Barell Injury Diagnosis Matrix of TBI type 1, 2, or 3 [30], and were transported directly from the injury scene to the ED. Interfacility transfers were excluded.

3.2. Measures and covariates

TBI was defined by the Barell Injury Diagnosis Matrix ICD-9-CM codes for TBI [30]. These codes include 800, 801, 803, 804.03-0.05, 804.1, 804.2, 804.3-0.4, 804.53-0.5, 804.6-0.9, 850.2-0.4, 851–854, 950.1-0.3. These diagnosis codes include open and closed skull fractures, intracranial injury with and without loss of consciousness, cerebral contusions and lacerations, and intracranial bleeding.

The head AIS score quantified TBI severity in this study. The anatomically-derived AIS score is based on diagnostic and autopsy findings [16]. AIS score severity is classified as 1 = minor, 2 = moderate, 3 = serious, 4 = severe, 5 = critical, 6 = unsurvivable [35]. The AIS scoring system is the international gold standard for classifying injury severity [16] and has been validated in several studies [23,26]. The head AIS maximum (AIS_{max}) score refers to the highest head AIS score recorded for the patient.

Early neurological deterioration was defined as a decrease in the GCS score from the prehospital assessment to the ED assessment. The GCS measures level of consciousness, including arousal, awareness, and responsiveness [39]. Scoring ranges from 3 (no response) to 15 (fully responsive) on the GCS_{total}. Three subscales assess eye opening (1–4), verbal response (1–5), and motor response (1–6). GCS_{total} scores are categorized as three severity levels: 3–8 = severe injury, 9–12 = moderate injury and 13–15 = minor injury [4].

Magnitude of early neurological deterioration was defined as a GCS score change that decreased 1 or more points from the prehospital GCS score to the ED GCS score. For example, a change in the GCS score from 14 (prehospital) to 12 (ED) would represent a neurological deterioration magnitude equal to −2.

The Trauma Mortality Prediction Model (TMPM), based on the AIS, measures the probability of mortality. This model identifies the five worst injuries for the patient, then factors into the calculations the interaction of the two worst injuries and whether these injuries were in the same body region [11,18,21,32]. Estimates of the discrimination ability of the TMPM were superior to the ICD-9 Injury Severity Score (ICISS) and Single Worst Injury (SWI) injury severity models (ROC, TMPM = 0.880 [95% CI = 0.876–0.883]; ROC, ICISS = 0.850 [95% CI = 0.846–0.855]; ROC, SWI = 0.862 [95% CI = 0.858–0.867]) [18].

3.3. Data analysis

To determine the proportion of patients whose GCS score deteriorated from prehospital to ED, we coded a variable that indicated whether the GCS score decreased or stayed the same or increased from prehospital to ED assessment. We then examined the proportion of patients whose GCS score decreased across relevant covariates to determine factors associated with early neurological deterioration. Chi-square tests and *t*-tests examined the association of covariates with GCS decrease. We performed a logit transformation of TMPM-AIS scores to convert the probability of mortality to a more normal distribution. Following this logit transformation, we examined factors associated with early neurological deterioration. For this examination, we constructed a logistic regression model to adjust for age, gender, head AIS_{max}, logit transformed TMPM-AIS probability of mortality, year, hospital type and bed size, with GCS decrease as the outcome variable and cluster-corrected standard errors for grouping of patients in the various trauma centers.

To determine the magnitude of early neurological deterioration and the association with the severity of brain injury, we calculated the head AIS_{max} score for each patient and used the highest score as a marker for overall head injury severity. Due to the small number of patients with head AIS_{max} scores of 6 (n = 32), we combined