Predictors of Outcomes in Traumatic Brain Injury

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■ INTRODUCTION: **The purpose of this study was to retrospectively evaluate patients treated for traumatic brain injuries (TBI) to determine how multiple organ trauma (MOT) and lung injuries sustained at the time of initial injury affect outcome.**

■ METHODS: **A single institution retrospective review of all patients diagnosed with TBI at a level I trauma center from 2000 to 2014 was conducted. Clinical outcome was based on Glasgow Outcome Scale at hospital discharge. Lung injury was defined as the presence of pulmonary contusions, pneumothorax, hemothorax, rib fractures, or diaphragmatic rupture proven by x-ray or computed tomography scan. MOT was defined as trauma to one body region with an Abbreviated Injury Scale (AIS) score ≥3 plus trauma to 2 additional body regions with AIS scores ≥1. Regression analysis was conducted with SPSS 21.**

■ RESULTS: **There were 409 patients reviewed. The majority of patients were male (73%), average age was 46 years (range, 16–94 years), average Glasgow Coma Scale (GCS) score was 7, and 71% had a severe TBI (GCS ≤8). Thirty percent of patients had poor outcome (Glasgow Outcome Scale = 1–2) Regression analysis indicated age (odds ratio [OR] 1.03, *P* < 0.001), initial GCS (OR 0.88, *P* < 0.001), Injury Severity Score (OR 1.03, *P* = 0.021), and head AIS ≥5 (OR 0.55, *P* = 0.019) were significant independent predictors of poor outcome. Sex, MOT, lung injury, and lung injury severity were not significant predictors of outcome.**

■ CONCLUSIONS: **Age, GCS, Injury Severity Score, and critical head injuries (AIS ≥5) were significant tools in predicting outcome in this patient cohort. MOT and traumatic lung injury may cause significant damage to a patient suffering from a severe TBI, but these injuries do not predict mortality in this patient population.**

INTRODUCTION

Nearly 2 million Americans are admitted to medical care facilities for traumatic brain injury (TBI) each year.[1] Trauma patients with concurrent injuries to the brain or skull have a 3-fold increase in mortality.[2] Recently, there has been an increased emphasis on evaluating non-neurologic complications in patients with TBI. In a 2005 study, Zygun et al.[3] found that 89% of patients with severe TBI (Glasgow Coma Scale [GCS] score ≤8) developed at least 1 organ system dysfunction, with 35% progressing to organ failure. These complications are associated with long-term neurologic impairment and poor outcomes, and they account for nearly 40%–66% of all deaths after a severe TBI.[4,5] Multiple organ trauma (MOT) with concomitant TBI has been shown to increase rates of infection, length of hospital stay, and ventilator use in pediatric patients.[6] Extracranial injuries in patients with TBI also are associated with slower physical recovery and increased return-to-work times.[7] The impact of multiple concomitant injuries outside of the brain during initial trauma in TBI patients, however, has not been well-defined.[6,8-14]

Pulmonary complications may occur either during or after the initial TBI. Acute lung injury (ALI) is one complication that develops after TBI[15] and is defined by the presence of bilateral pulmonary infiltrates and a partial pressure arterial oxygen/fraction of inspired oxygen ratio of less than 300 in the absence of left atrial hypertension.[16] ALI is a risk factor for brain tissue hypoxia independent of intracranial and systemic injuries.[17] Whereas ALI

Key words
- Outcomes
- Traumatic brain injury

Abbreviations and Acronyms
AIS: Abbreviated Injury Scale
ALI: Acute lung injury
CI: Confidence interval
GCS: Glasgow Coma Scale
GOS: Glasgow Outcome Scale
ISS: Injury Severity Score
MOT: Multiple organ trauma
OR: Odds ratio
TBI: Traumatic brain injury

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is a pulmonary complication that develops after trauma, traumatic lung injury is a term defined in this study as pulmonary complications that occur during trauma. Although there is an extensive body of literature regarding the development of ALI after TBI and the resultant increase in mortality,[15,18,19] there are a limited number of studies focusing on the influence of lung injuries that occur during the initial trauma when a TBI occurs.[20-22]

In this study we analyzed the impact of concurrent organ injury sustained at the time of initial TBI on outcomes, based on Glasgow Outcome Scale (GOS) score at hospital discharge as done by previous studies.[23-26] We hypothesized that both MOT and lung injury will correlate with lower GOS scores. We also analyzed the severity of each TBI and lung injury using Abbreviated Injury Scale (AIS) to determine whether injury severity for the individual organ system predicted a worse outcome.

METHODS

Patient Population

After obtaining Institutional Review Board approval, we conducted a retrospective chart review. Patients presenting with TBI (*International Classification of Diseases*, Ninth revision, codes 850.0–854.19) to a Level I Trauma Center at a regional University Hospital between January 2000 and June 2014 were identified. Information obtained included age, sex, GCS score at presentation to emergency department, Injury Severity Score (ISS), MOT, and lung injury. Lung injury was defined as the presence of pulmonary contusions, pneumothorax, hemothorax, rib fractures, or diaphragmatic rupture proven by x-ray or computed tomography scan. Although MOT has been defined in many ways,[27-30] here MOT was defined as trauma to 1 body region with an AIS score ≥3 plus trauma to 2 additional body regions with AIS scores ≥1.[27] Up to 3 of the greatest AIS scores for the 3 most severely injured body regions were recorded as measured by emergency department staff. The primary outcome measurement used in this study was GOS at the time of hospital discharge.

Statistical Analysis

A total of 440 patients met the inclusion criteria; however, 31 patients were excluded from the analysis because of lack of information in the medical record to determine GOS. None of the remaining patients had missing data for any variable assessed. Two groups were generated on the basis of GOS scores (scores 1–2 and 3–5), and a poor outcome was defined as GOS ≤2 (dead or vegetative state). Univariate analysis was first done with χ^2 tests for categorical variables and independent t tests for continuous variables. All variables that were significantly different between groups ($P \leq 0.05$) and nearly significant ($P \leq 0.1$) were used to create the logistic regression model. Binary logistic regression analysis was then performed with stepwise exclusion of nonsignificant variables. Significance for the binary logistic regression analysis was defined as $P \leq 0.05$. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. Statistical analysis was performed using SPSS (SPSS Inc., Chicago, Illinois, USA).

RESULTS

Baseline characteristics of the sample size are listed in Table 1. Of the total 409 patients, most were male (297/73%). Mean GCS score was 6.58 ± 4.85, with the majority of patients (71%) presenting with a severe TBI of GCS ≤8. Concurrent MOT was reported in 300 patients (73%), whereas associated lung injury at the initial presentation was noted in 240 patients (59%). Mean ISS score was 30.7 ± 11.8. Average head AIS was 3.96 ± 0.95, and the average chest AIS was 1.93 ± 1.70. One hundred twenty-three patients (30%) had a GOS of ≤2.

Table 1. Baseline Characteristics of 409 Patients Diagnosed with TBI

Parameter	Value
Average age, years	45.7 ± 21.6
Sex	
Male	297 (73%)
Female	112 (27%)
Average ISS	30.7 ± 11.8
Average GCS	6.58 ± 4.85
GCS presentation	
13–15	101 (25%)
9–12	17 (4%)
3–8	291 (71%)
CT characteristics	
IPH	71 (17%)
SAH	59 (14%)
SDH	146 (36%)
EDH	28 (7%)
DAI	41 (10%)

Frequencies are reported as number of patients (%).
Average values presented as mean ± standard deviation.
TBI, traumatic brain injury; ISS, Injury Severity Score; GCS, Glasgow Coma Scale; CT, computed tomography; IPH, intraparenchymal hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage; EDH, epidural hemorrhage; DAI, diffuse axonal injury.

Table 2 illustrates the correlation of the variables assessed with outcome. A significant association with poor outcome was found for older age ($P < 0.001$), greater ISS ($P < 0.001$), lower initial GCS ($P < 0.001$), and greater head AIS ($P = 0.001$). Sex ($P = 0.684$), MOT ($P = 0.766$), presence of a traumatic lung injury ($P = 0.360$), and severity of lung injury ($P = 0.239$) were not associated with outcome. Furthermore, serious extracranial injuries (any nonhead AIS ≥3) were not significant in univariate analysis.

Binary logistic regression analysis (Table 3) indicated that age (OR 1.03, 95% CI 1.02–1.04, $P < 0.001$), initial GCS (OR 0.88, 95% CI 0.83–0.93, $P < 0.001$), ISS (OR 1.03, 95% CI 1.00–1.05, $P = 0.021$), and head AIS ≥5 (OR 0.55, 95% CI 0.33–0.90, $P = 0.019$) were significant independent predictors of outcome. Head AIS scores ≥3 and scores ≥4 were both not significant predictors of outcome.