Predicting Mortality and Independence at Discharge in the Aging Traumatic Brain Injury Population Using Data Available at Admission

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BACKGROUND: Aging worsens outcome in traumatic brain injury (TBI), but available studies may not provide accurate outcomes predictions due to confounding associated injuries. Our goal was to develop a predictive tool using variables available at admission to predict outcomes related to severity of brain injury in aging patients.

STUDY DESIGN: Characteristics and outcomes of blunt trauma patients, aged 50 or older, with isolated TBI, in the National Trauma Data Bank (NTDB), were evaluated. Equations predicting survival and independence at discharge (IDC) were developed and validated using patients from our trauma registry, comparing predicted with actual outcomes.

RESULTS: Logistic regression for survival and IDC was performed in 57,588 patients using age, sex, Glasgow Coma Scale score (GCS), and Revised Trauma Score (RTS). All variables were independent predictors of outcome. Two models were developed using these data. The first included age, sex, and GCS. The second substituted RTS for GCS. C statistics from the models for survival and IDC were 0.90 and 0.82 in the GCS model. In the RTS model, C statistics were 0.80 and 0.67. The use of GCS provided better discrimination and was chosen for further examination. Using a predictive equation derived from the logistic regression model, outcome probabilities were calculated for 894 similar patients from our trauma registry (January 2012 to March 2016). The survival and IDC models both showed excellent discrimination ($p < 0.0001$). Survival and IDC generally decreased by decade: age 50 to 59 (80% IDC, 6.5% mortality), 60 to 69 (82% IDC, 7.0% mortality), 70 to 79 (76% IDC, 8.9% mortality), and 80 to 89 (67% IDC, 13.4% mortality).

CONCLUSIONS: These models can assist in predicting the probability of survival and IDC for aging patients with TBI. This provides important data for loved ones of these patients when addressing goals of care. (J Am Coll Surg 2017;224:680−685. © 2017 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Traumatic brain injury (TBI) remains the most common cause of death in young adults under the age of 45, but its effects on the older population are equally devastating.[1] There is a bi-modal peak in the incidence of TBI, with the first peak occurring in young adults, ages 15 to 24. The second peak affects the aging population, occurring after age 75. The rate of hospitalization for nonfatal TBI in the general population is 100.1 per 100,000; in those 65 and older, this rate more than doubles, to 294 per 100,000.[2-4] In addition to experiencing higher rates of hospitalization, the aging TBI population has a higher likelihood of death.[5,6] Other unfavorable outcomes, such as decreased ability to perform activities of daily living or severe residual neurologic deficits, are also more prevalent in the elderly brain injured.[5-7] The increasing number of older people in the US and other countries is well described, and it is estimated that by 2030, the number of people older than 65 years of age

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Abbreviations and Acronyms

AIS = Abbreviated Injury Score
CGS = Glasgow Coma Scale
IDC = independence at discharge
NTDB = National Trauma Data Bank
RTS = Revised Trauma Score
TBI = traumatic brain injury

will rise to more than 60 million and account for 17% of the US population.[8] Currently, the segment of the population older than age 85 is the fastest growing group in developed countries.[9]

Because aging patients are known to have significantly worse outcomes in many types of injuries and diseases, avoidance of futile care becomes a commonly addressed issue in the older patient population.[10] Many elderly patients want to avoid futile medical care and the risk of a nonfunctional outcome, though there is no single definition of this.[11,12] For example, 1 elderly patient may not want to undergo prolonged aggressive care if he or she is given only a 50% chance of survival, while another may want every possible chance to survive, irrespective of the functional outcome or hardships associated with care. Additionally, futile or unwanted care increases cost and resource use.

Central to providing helpful information to injured patients and their families concerning appropriate care after brain injury is the ability to understand and explain expected outcomes with some degree of accuracy. Although there is a great deal of information concerning outcomes after TBI as patients age, most of these data are confounded by the presence of other potentially severe multisystem injury. Our goal was to develop a model to accurately predict mortality and likelihood of independence at discharge (IDC) in older patients with isolated TBI, therefore avoiding the confounders of other significant injury. In addition, we sought to use variables that were easily obtainable at or shortly after hospital admission.

METHODS

This is a retrospective study using patients from the National Trauma Data Bank (NTDB) between the years 2002 and 2011. Patients included were those age 50 or older, with a blunt mechanism of injury and isolated TBI (head Abbreviated Injury Score [AIS] $\geq$ 2 and all other AIS $\leq$ 1.) Records were examined for demographics and injury characteristics. Univariate logistic regression was used to determine the association between individual variables and outcomes. Outcomes examined were survival (yes/no) and IDC from the hospital after initial admission. Independence at discharge was defined as discharge to home or prison. Multivariate logistic regression was used to determine independent predictors of the studied outcomes, and equations incorporating these variables predicting survival and IDC were developed. The discriminatory ability of the models was assessed using receiver operating characteristic (ROC) curves and C statistics that were derived by using the predicted outcomes from the models as the variable in the models for the actual outcomes (survival or IDC) in the validation data.

Patients with identical inclusion criteria were then collected from our own institutional trauma registry and were admitted during the most recent 5-year period. Demographics and injury characteristics were analyzed. The previously developed equations were then validated using these patients by comparing predicted to actual outcomes (Wilcoxon rank sum test). Discriminatory ability of the equations was again examined in the external database using receiver operating characteristic curves.

An application for computers and handheld devices was then developed based on these equations using PowerApps (Microsoft Corp). This was distributed to caregivers at our institution for use and feedback. Approval for this project was obtained through our institutional review board. Statistical analysis was performed using JMP 10.0.2 (SAS Institute Inc).

RESULTS

Between 2002 and 2011, 57,588 patients from the NTDB met inclusion criteria. General demographics and injury characteristics are shown in Table 1. Distributions of patient characteristics and outcomes for each decade of life examined are shown in Table 2. Using variables available at admission, univariate logistic regression showed increasing age, male sex, decreasing GCS, and

Table 1. Demographics and Injury Characteristics of the Patients from the National Trauma Data Bank (n = 57,588)

Variable	Value	Median	Range
Sex, m/f, %	52/48		
Age, y, mean ± SD	73 ± 12	75	50–110
GCS overall, mean ± SD	13 ± 4	15	3–15
GCS 3 to 8, n	6,909		
GCS 9 to 12, n	3,563		
GCS 13 to 15, n	47,116		
RTS, mean ± SD	7.2 ± 1.6	6.9	0–7.84
IDC, %	75		
Mortality, %	10		

GCS, Glasgow Coma Scale; IDC, independent at discharge; RTS, Revised Trauma Score.