Predicting Outcomes in Acute Traumatic Brain Injury (TBI)

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"No head injury is so serious that it should be despaired of nor so trivial that it can be ignored." — Hippocrates

INTRODUCTION

Acute traumatic brain injury (TBI) is a heterogenous disease ranging from mild concussion to contusions, extra-axial hematomas and traumatic subarachnoid hemorrhage to diffuse axonal injury. It is a leading cause of death and disability in the United States. In 2013, there were 2.5 million emergency department visits and more than 55,000 deaths due to TBI, and TBI accounts for approximately 30% of all injury-related deaths.[1] Both injuries and hospitalization rates have increased markedly between 2007 and 2013, and while death due to motor vehicle crashes have decreased, age-adjusted rates of TBI-related ED visits have increased between 2007 and 2013.[1] The aggregate leading cause of death among TBI patients is now due to intentional self harm but motor vehicle collisions, sports, and combat-related injuries continue to afflict children and adolescents/young adults (age 0–4, and 15–24 years).[1] Older adults have also suffered from an increase in TBI-related hospitalizations and deaths, primarily due to falls.[1] These numbers are likely underestimates of the prevalence of TBI, because they do not include persons with TBI sequelae who were treated and released from emergency departments, those who sought care in other healthcare settings, and those who did not seek treatment.[2,3]

Data from Rhode Island mirrors the national trend. In 2018, 134 children suffered moderate to severe TBI and 6 died. At Rhode Island Hospital, more than 800 adult patients with traumatic brain injury are hospitalized annually, and in 2018, at Rhode Island Hospital, more than 500 adult patients with TBI required long-term care and more than 100 patients died in the acute setting.

Despite significant improvements in the care of the head-injured trauma patient over the last decade, challenges remain in both the treatment and assessment of prognosis of patients who have suffered traumatic brain injuries. The higher incidence of TBI coupled with a lower death rate suggests that there is a growing population of individuals living with a disability related to their TBI.[4] Improved understanding of TBI can help guide resource allocation as well as patient and family discussions regarding goals of care in the more acute setting. Here we aim to describe some of the scoring systems and predictive models we use to best understand outcomes for patients with traumatic brain injury.

SCORING SYSTEMS

The Glasgow Coma Scale (GCS) was first described in 1974 to communicate accurately about patients with impaired consciousness. The GCS is used in more than 80 countries and, 45 years later, the original report is the most quoted paper in the neurosurgical literature.[5]

A key element of the GCS is the motor score (GCS_M). The motor score consists of 6 categories and has been validated to be specific in predicting patients with TBI.[6] With this, the Simplified Motor Score (SMS) was developed combining the components of the GCS-M and simplifying them into three categories: (1) follows commands, (2) localizes to pain and (3) withdrawals to pain or worse. Two points are given for following commands, one point for localization of pain and no points for withdrawing to pain or worse. Lower scores suggest worse head injury. [7] In 2018, Buitendag et al compared the GCS-M to the SMS and found that there was a decline in survival rate for GCS-M-<4 on admission, and was more pronounced when the score was <3. When plotted against mortality, both the GCS-M and the SMS were accurate, sensitive and specific, suggesting that these more simplified scales can accurately predict outcomes in patients with TBI when the entirety of the GCS model is difficult to assess.[8]

The Glasgow Outcome Scale (GOS), also developed by Jennett in 1974, predicts how patients with TBI recover. It consists of five categories: Death, Persistent Vegetative State, Severe, Moderate, and Low Disability.[9] This scale was refined in 1981 as the Glasgow Outcome Scale Extended (GOSE).[10] Additional categories were added to the GOSE to better describe patients' disabilities. The GOSE is also meant to be reassessed at 3, 6 and 12 months with a structured interview consisting of questions regarding the patient's disabilities. All of these scales (GCS, GOS and GOSE) have been used clinically and in research to help predict which patients will have better global outcomes from traumatic brain injury; however, the timing, utilization and application of these scales has been inconsistent.[11]

More recently, another scoring system is in use to predict the Full Outline of UnResponsiveness (FOUR). The FOUR Score is a neurological assessment score, similar to the Glasgow Coma Score, that adds additional emphasis on brainstem reflexes and respiratory pattern.[12] Alhough a newer scoring system, it is validated and has proven to be a useful measure in predicting mortality and functional recovery. A 2018 systematic review showed that FOUR score was a useful outcome predictor with good inter-rater reliability

among physicians and nurses.[13] When compared to GCS, it appeared to perform similarly in predicting mortality.[14]

Radiologic imaging scales, including the Marshall scale and the Rotterdam scale, also contribute to prognostic value as they can predict the risk for increased intracranial pressure and outcome in adults. While each of these scales can predict early death, each has limitations and does not provide accurate prognostic value for patients without severe injury.[15]

Other datasets have contributed to prognosis for severely injured patients. The CRASH trial (Corticosteroid Randomization after Significant Head injury) did not show any improvement in outcome in those patients who received steroids, but the database created was helpful in generating a prognostic calculator. This calculator (http://www.crash.lshtm.ac.uk/Risk%20calculator/index.html) can help physicians determine 14-day mortality as well as death and severe disability at 6 months in patients with TBI.[16] Similar to the database generated by the CRASH trial, in 2007, the International Mission of Prognosis and Clinical Trial-TBI (IMPACT-TBI) examined patients with traumatic brain injury over 3 decades. IMPACT investigators have analyzed the existing database to generate a prognostic score to predict 6-month outcome of patients who suffered moderate to severe TBI (GCS ≤ 12), (http://www.tbi-impact.org/?p=impact/calc).[17]

Unfortunately, none of the scoring systems are able to predict with certainty how patients with TBI will do in both the acute and long-term setting. Further complicating the utility of these scores is the clinician's ability to apply them to their individual patients. However, certain patient characteristics can suggest a better or worse outcome. Young patients continue to do better than older patients in terms of functional recovery from TBI. Not surprisingly, patients with more impairments do worse than those with less impairments. Improvement in disabilities occurs early (if at all), and then plateaus.[18] The extent of these improvements is still very heterogeneous and unpredictable, and frequently, patients who initially improve will eventually decline in their abilities.[19] Recently, Hammond followed patients 10 years post injury. Patients were evaluated at 1, 2, 5 and 10 years from injury. They demonstrated that improvement occurred throughout the 10-year period and those that recovered earlier improved more. These findings suggest that ongoing directed therapy continues to be important as far as 10 years out.[20] However, Forslund et al also followed patients with moderate to severe TBI over a 10-year period looking at change in GOSE. They found that 37% deteriorated, 7% improved and 56% showed no change in global outcome. Additionally, they sought to better define predictors and found that younger, employed patients with shorter post-trauma amnesia did better, consistent with prior literature.[21] Overall, patients with moderate to severe TBI did not improve.

CONCLUSION

The above validated measuring scales and prognosis calculators help us predict the extent of, and recovery from, TBI. Unfortunately, we are still unable to predict which patients to whom these measures best apply. Large databases generated retrospectively have helped us to get closer to predicting the future. However, the ultimate ability to determine true outcomes after TBI will be found by following these patients prospectively after their injuries, thereby generating a database in this fashion. This prospective database has the potential to improve guidance for physicians, patients and families in determining outcomes of patients with traumatic brain injury.

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