EDITORIAL

Assessing outcomes of combat-related penetrating brain injury

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SIGNIFICANT informative literature on the treatment of penetrating brain injury (PBI) is limited, and reported outcomes are poor. Much of that literature describes an extremely high mortality rate, with significant morbidity. In 2014, Aarabi et al. provided a retrospective study of the outcomes of gunshot wounds to the head in the State of Maryland.² In that study, the authors determined that the acute care hospitalization mortality was 61% and that 35% of patients achieved good outcomes, with over 3 years of follow-up. However, when they added point-of-injury and pre-hospitalization data from the office of the coroner, they determined that over 75% of patients did not reach the hospital before being pronounced dead, bringing the overall mortality up to 91%.

Data from military medical registries can be a rich source for improving our understanding of PBI, and the significance of this information in contributing to civilian neurotrauma care cannot be understated. In 1983, Rish et al. reported on a cohort of 1127 men who were followed for 15 years after sustaining a penetrating craniocerebral injury in Vietnam and surviving at least 1 week.⁷ The authors showed that the rate of death was still 8% and the likelihood of survival in the 1st year largely correlated with level of consciousness. After 3 years, life expectancy for the cohort approached actuarial norms. Subsequent military reports have concentrated a greater effort on outcomes for survivors.

In the current report, Larkin and colleagues report on a cohort of 80 male US military personnel who received care at a single joint military facility in Afghanistan over a 39-month period after sustaining a PBI; the authors followed these individuals through retrospective chart review for up to 24 months.⁵ They cite an overall mortality of 21%. In progression through the military echelons of care, a patient may encounter field treatment, aid stations, multiple modalities of transport, and resuscitation at less-equipped but critical-care-capable forward facilities

before arriving at a theater hospital with neurosurgical capability. With that understanding, inclusion of deaths from point of injury until arrival at the Role 3 facility (Role 3 Multinational Medical Unit at Kandahar Airfield in Afghanistan) would have resulted in a higher mortality rate. The addition of median time to arrival at the Role 3 facility from point of injury would have provided context for both the mortality and morbidity analyses.

The primary aim of Larkin et al. in their study was to determine the long-term functional outcome for survivors in their cohort. They provide a detailed analysis of variables that may alter outcomes as measured by the Glasgow Outcome Scale (GOS). In their *Discussion*, they acknowledge the limitations of this retrospective study. Several of these points merit additional discussion.

The GOS has been variously described to be administered as a structured in-person interview with the patient and/or caregiver, as a structured telephone interview, or through postal survey. The reliability and validity of the data obtained by the different forms of administration is variable. In a 2000 study, Hellawell et al. compared GOS scores obtained from patients' general practitioners and family members by means of a postal survey to scores calculated from the questionnaire information by experienced evaluators and found that family members and general practitioners tended to rate a patient's outcome more favorably than the experienced evaluators did.⁴ In the current paper by Larkin and colleagues, the authors assigned GOS scores by abstracting information from any available medical records in and around the time of the period 6, 12, and 24 months after injury. The limitations of this approach are evident. They did attempt to reduce error due to this method by having up to 3 independent researchers estimate outcomes.

The authors use the patients' admission Glasgow Coma Scale (GCS) score and admission Injury Severity Score (ISS) to characterize the severity of the brain injury and

total injuries. Often, early in a trauma evaluation, injuries may have yet to be discovered, or the magnitude of known injuries may not be fully appreciated. As a result, the initially assessed severity of total injuries may be artificially low in comparison to scores calculated later in the hospitalization. However, as the authors note in their *Discussion*, obtaining an admission GCS score at a Role 3 facility can be hindered by sedation and neuromuscular blockade. Despite the fact that military trauma registry data are often rich and robust, some military neurotrauma subject matter experts acknowledge that the high prevalence of patients with a GCS score of 3 noted in military records can at least in part be a reflection of the operational constraints of transporting and caring for patients safely in an austere combat environment. As a result the severity of brain injuries may be somewhat overestimated.

Notwithstanding the recognized limitations, the authors performed a detailed analysis of the functional outcomes following PBI. At each time point (6, 12, and 24 months), survivors showed a continuous trend toward improvement in GOS score. For patients with an admission GCS score of 6–15, recovery progression was statistically significant. Overall, 78% of patients achieved good recovery, defined as a GOS score of 4 or 5. This result compares favorably with the report of Aarabi¹ on the Iran-Iraq war, in which 32% of 435 PBI patients displayed good recovery at 6 months, and the separate reports of Brandvold et al.³ and Levi et al.⁶ on the conflict in Lebanon, in which 41% of 113 PBI patients showed good recovery by hospital discharge.

The current study reaffirms that patients with an admission GCS score of 3–5 are likely to have a worse outcome, but even in that population 61% of patients achieved good recovery. Larkin et al. evaluated several radiographic imaging characteristics of injury and found that only herniation was associated with worse long-term outcomes. Interestingly, the investigators also found that improved outcomes of PBI were associated with blast injury as compared to gunshot wound.

To editorialize and summarize the contributions and impact of this study in the context of known literature, PBI results in a high mortality; however, to approach this patient population fatalistically is unwarranted. Patients who survive beyond pre-hospital care and early hospitalization appear to have remarkable long-term functional outcomes following high-quality medical and surgical

care. Functionally independent outcomes, according to this study, appear to be occurring at high rates even in surviving patients who present with a low GCS score. The authors should be congratulated on this contribution to the literature and the effort required to produce this publication. Future studies should continue to focus on markers that predict survival, as well as characteristics that portend good functional recovery. Additionally, treatment paradigms that best result in good outcomes require attention.

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Disclosures

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