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Intracranial pressure monitor in patients with traumatic brain injury

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ABSTRACT

Background: Brain Trauma Foundation (BTF) guidelines recommend intracranial pressure (ICP) monitoring for traumatic brain injury (TBI) patients with a Glasgow Coma Scale score of 8 or less with an abnormal head computed tomography, or a normal head computed tomography scan with systolic blood pressure ≤90 mm Hg, posturing, or in patients of age ≥40. The benefits of these guidelines on outcome remain unproven. We hypothesized that adherence to BTF guidelines for ICP monitoring does not improve outcomes in patients with TBI.

Methods: All TBI patients with an admission Glasgow Coma Scale ≤8 admitted to our level I trauma center over a 3-y period were identified. Adherence to the individual components of our institutional TBI Bundle (ICP monitoring, SpO_2 ≥95%, $PaCO_2$ 30–39 mm Hg, systolic blood pressure ≥90 mm Hg, cerebral perfusion pressure ≥60 mm Hg, ICP ≤25 mm Hg, and temperature 36°C–37°C) was assessed. Patients were stratified into two groups as follows: patients with ICP monitoring (ICP) and patients without ICP monitoring (no-ICP). Outcome measures were survival and discharge disposition. Multivariate regression analysis was performed.

Results: We identified 2618 TBI patients, 261 of whom met the BTF criteria for ICP monitoring. After excluding those with nonsurvivable injuries ($n = 67$), 194 patients were available for analysis. The two groups were similar in demographics and severity of head injury. Survival rate was higher in the no-ICP group compared with that in the ICP group (98% *versus* 76%, $P < 0.004$). Non-monitored patients were discharged with higher levels of function per discharge location (28% home *versus* 4% home; $P < 0.001$). Patients without ICP monitoring were 1.21 times more likely to survive compared with that of patients with ICP monitoring (odds ratio: 1.21, 95% confidence interval [1.1–1.9], $P = 0.01$). In the ICP group, the overall compliance rate to the ICP and cerebral perfusion pressure goals as required by the BTF guidelines was poor.

Conclusions: Our data suggest that there is a subset of patients meeting BTF criteria for ICP monitoring that do well without ICP monitoring. This finding should provoke reevaluation of the indication and utility of ICP monitoring in TBI patients.

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1. Introduction

Traumatic brain injury (TBI) continues to remain as the leading cause of death and disability among trauma patients [1–4]. According to the Center for Disease Control and Prevention, over 1.7 million individuals sustain TBI annually, resulting in over 53,000 deaths and 500,000 patients developing permanent neurologic damage [3,4]. The primary physical insult is compounded by secondary injury due to expansion of the initial intracranial hemorrhage, disruption of the cerebral blood flow auto-regulation system, brain swelling, and tissue hypoxia [5–7]. Combination of these mechanisms results in elevated intracranial pressures (ICP), which further contributes to adverse outcomes in TBI patients [5–7].

The management of elevated ICP varies greatly in clinical practice with conflicting reports assessing the utility of ICP monitoring on the functional outcomes and survival in patients with TBI [8–14]. According to the Brain Trauma Foundation (BTF) guidelines, ICP monitoring should be performed in all TBI patients with a Glasgow Coma Scale (GCS) score of ≤8 with an abnormal head computed tomography (CT), or a normal head CT scan with systolic blood pressure (SBP) ≤90 mm Hg, posturing, or age ≥40 y [15]. Additionally, the goals prescribed by the BTF guidelines require maintenance of ICP ≤25 mm Hg and cerebral perfusion pressure (CPP) ≥60 mm Hg. Based on these guidelines, a vast majority of patients with severe TBI meet the criteria for ICP monitoring. However, only a subset of these patients receive ICP monitoring based on institutional guidelines. A recent prospective multicenter controlled trial demonstrated no difference in outcomes in patients managed with ICP monitoring *versus* patients managed with an established protocol of neuroimaging and clinical examination [8]. Despite the increasing body of knowledge reexamining the utility of ICP monitoring, there continues to be a paucity of consistent data on ICP monitoring's impact on patient outcome.

The aim of this study was to evaluate outcomes in patients meeting BTF guidelines for ICP monitoring who received ICP monitoring compared with those who did not. We hypothesized that adherence to BTF guidelines for ICP monitoring does not improve outcome in patients with TBI.

2. Methods

After approval from the Institutional Review Board of the University of Arizona, College of Medicine, we performed a 3-year (2010–2012) retrospective analysis of all patients with TBI who presented to our level 1 trauma center. We included all patients who met the BTF guidelines for placement of an ICP monitor [15]. Patients transferred from other institutions and patients with nonsalvageable brain injury were excluded. Our inclusion criteria based on the BTF guidelines for placement of ICP monitor were as follows:

1. GCS score ≤8 on presentation and an abnormal head CT scan
2. GCS score ≤8 with a normal head CT and two or more of the features noted on admission: age ≥40 y, SBP ≤90 mm Hg, or unilateral or bilateral motor posturing.

A single violation from the BTF guidelines at any time point was considered a lack of compliance. Abnormal head CT scan was defined as presence of intracranial hematomas, contusions, swelling, herniation, compressed basal cisterns, or skull fractures.

We reviewed patients' electronic medical records and recorded the following data points: demographics (age, gender, race, and ethnicity), mechanism of injury, vitals on presentation, which included GCS score, SBP, heart rate (RR), temperature (Temp), neurologic examination on presentation, intoxication details, history of loss of consciousness, abnormal posturing, initial and repeat head CT scan findings, GCS score as independently assessed by the trauma and neurosurgery teams, neurosurgical intervention, hospital and intensive care unit (ICU) length of stay, discharge disposition, and in-hospital mortality. We obtained the injury parameters, which included Injury Severity Score and head-Abbreviated Injury Scale from the trauma registry. In patients who received ICP monitoring, we also recorded the ICP, CPP, SBP, temperature, oxygen saturation, and arterial partial pressure of oxygen for the entire duration the ICP monitor was in place.

A single investigator reviewed the initial CT scan findings for the type and the size of the intracranial hemorrhage and presence of skull fracture. We defined abnormal neurologic examination as abnormal pupillary reflex and/or focal neurologic deficits in the absence of intoxication. The ICP monitors were placed by the neurosurgeons at our institution. The decisions to place ICP monitors were at the discretion of the attending neurosurgeon.

Patients were categorized into two groups as follows: patients with an ICP monitor (ICP) and patients without an ICP monitor (No-ICP). We then compared the demographics and outcomes between the two groups. Our primary outcome measures were hospital length of stay and in-hospital mortality. Our secondary outcome measures were adherence to the individual components of our institutional TBI bundle. Our institutional guidelines included SpO_2 ≥95%, $PaCO_2$ 30–39 mm Hg, SBP ≥90 mm Hg, CPP ≥60 mm Hg, ICP ≤25 mm Hg, and temperature 36°C–37°C.

Data are reported as mean ± standard deviation for continuous descriptive variables, median (range) for ordinal descriptive variables, and as proportions for categorical variables. We performed Mann–Whitney *U* and Student *t*-test to explore for differences in the two groups (with ICP and without ICP monitors) for continuous variables. We used chi-square test to identify the differences in outcomes between the two groups for categorical variables. Univariate analysis was used to assess for factors associated with survival. Variables with a significant ($P \leq 0.2$) association per our univariate analysis were then used in a multivariate logistic regression model to identify factors that were independently associated with survival. On multivariate logistic regression analysis, variables were considered significant at $P \leq 0.05$. All statistical analyses were performed using Statistical Package for Social Sciences (SPSS, version 20; IBM, Inc., Armonk, NY).