



## An analysis of Brain Trauma Foundation traumatic brain injury guideline compliance and patient outcome<sup>☆</sup>



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### ABSTRACT

**Introduction:** Evidence-based guidelines for the care of severe traumatic brain injury have been available from the Brain Trauma Foundation (BTF) since 1995. A total of 15 recommendations compose the current guidelines. Although each individual guideline has been validated in isolation, to date, little research has examined the guidelines in composite. We examined the relationship between compliance with the BTF severe TBI guidelines and mortality.

**Materials and methods:** In a Pennsylvania-verified, mature Level II trauma centre, patients with an admission Glasgow Coma Scale (GCS)  $\leq 8$  and an abnormal head CT from 2007 to 2012 were queried from the trauma registry. Exclusion criteria included: patients who sustained a non-survivable injury (AIS head 6), died  $\leq 24$  h, and/or were transferred to a paediatric trauma centre. Strict adherence to the BTF guidelines was determined in a binary fashion (yes/no). We then calculated each patient's percent compliance with total number of guidelines. Bivariate analysis was used to find significant predictors of mortality ( $p < 0.05$ ), including percent BTF guidelines compliance. Significant factors were added to a multivariable logistic regression model to look at mortality rates across the percent compliance spectrum.

**Results:** 185 Patients met inclusion criteria. Percent compliance ranged from 28.6% to 94.4%, (median = 71.4%). Following adjustment for age, AIS head, and GCS motor, patients with 55–75% compliance (AOR: 0.20; 95%CI: 0.06–0.70) and  $>75\%$  compliance (AOR: 0.27; 95%CI: 0.08–0.94) had reduced odds of mortality, as compared to  $<55\%$  compliance to the BTF guidelines. When the unadjusted rate of mortality was compared across the compliance spectrum, the odds of mortality decreased as compliance increased until 75%, and then reversed.

**Conclusion:** Our data indicate that full compliance with all 15 severe TBI guidelines is difficult to achieve and may not be necessary to optimally care for patients.

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### Introduction

Across all age groups, traumatic brain injury (TBI) is the leading cause of morbidity and mortality due to injury [1]. In 2010, approximately 2.5 million people sustained a TBI, resulting in an estimated economic cost of nearly \$76.5 billion [2]. This financial burden, coupled with the fact that TBI often afflicts patients in the

prime, productive years of their lives, makes TBI a major public health concern. Severe TBI, defined as a Glasgow Coma Score (GCS)  $\leq 8$  [3,4], can result in serious brain damage in two phases: it may occur during or immediately after the initial insult (primary) or it may develop later (secondary). Because secondary brain injury is the main cause of in-hospital deaths for patients with TBI [5], evidence-based protocols aimed at minimising secondary brain damage and maximising functional recovery have become the mainstay of current medical treatment. Significant research suggests that protocols for managing severe TBI patients are successful at improving outcomes such as disability, length of hospital stay, and mortality [4,6–10].

In 1995, the Brain Trauma Foundation (BTF) developed a set of evidence-based guidelines for the treatment of severe TBI [11]. Since their original release in 1995, the BTF guidelines have undergone two revisions to reflect new medical advances and

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treatment strategies for the care of the traumatised brain. In the most recent edition of the guidelines, published in 2007, there are 15 individual process of care recommendations [3]. Each of these guidelines has been extensively studied and individually validated as an evidence-based measure associated with improved outcome in severe TBI patients. What remains significantly understudied, but has always been the assumption, is that the singular benefits of each individual guideline can translate to similar favourable outcomes when applied as a set. Given that these guidelines cover many different aspects of prophylaxis and treatment, some of which are interrelated, we believe that a collective evaluation of the complete set of guidelines is warranted. Such an analysis will aid physicians in their evaluation of the benefit of varying levels of compliance. As a mature designated Level II trauma centre with a significant TBI patient population, we aimed to examine the relationship between compliance with the BTF Severe TBI guidelines and outcome. We seek to validate the hypothesis that higher levels of compliance with the entire set of guidelines would be correlated with decreased mortality.

## Materials and methods

All trauma activations and consults at Lancaster General Health are evaluated by board-certified trauma surgeons, staffed in-house 24/7. All trauma surgeons possess the additional qualification of surgical critical care training, and this core team of trauma surgeons provides uninterrupted critical care coverage to trauma patients. Trauma patients also benefit from robust neurosurgical coverage with mandatory emergent response within 30 min. Full medical and surgical treatment capabilities to address severe TBI are available to the trauma service, ensuring that no patients need to be transferred to a higher level of care solely for neurosurgical needs. Additionally, a trauma service specific TBI management protocol has been implemented since 1997, with regular revisions taking into account revised BTF guidelines as well as other updated literature findings.

Following study review and approval by the Institutional Review Board, all trauma admissions from 2007 to 2012 with an admitting Glasgow Coma Score (GCS)  $\leq 8$  with abnormal head CT results were queried from the trauma registry (Digital Innovations, Forest Hill, MD) of Lancaster General Hospital, a Pennsylvania-verified Level II trauma centre. Abnormal CT was defined as a CT scan revealing any intracranial haematoma, subarachnoid

haemorrhage, contusion, swelling, herniation, or compressed basal cistern. Patients with a nonsurvivable injury (Abbreviated Injury Scale score of 6), who died  $\leq 24$  h, and/or were transferred to another trauma centre were excluded from the study.

Using the modified Delphi method, a brain trauma working group composed of two senior trauma surgeons and a neurosurgeon (all board-certified) collaboratively defined compliance vs. non-compliance for each recommendation of the Brain Trauma Foundation's most updated guidelines for the management of severe TBI (Table 1). For abstraction purposes, time parameters were added to the BTF guideline definitions based upon the recommendations of the study group to concretely define compliance vs. noncompliance for those BTF guidelines that did not already contain explicit time parameters. This was a purely arbitrary decision on the part of the brain trauma working group, but nonetheless necessary for the purpose of this study. Adherence to each guideline was defined in a strictly binary fashion (yes/no) for each patient. We excluded one of the fifteen BTF guidelines: Brain Oxygen Monitoring and Thresholds (guideline X) from our analysis. Our institution does not monitor brain tissue oxygenation, thus we were not able to collect this data (guideline X). When sufficient data was not documented in a patient's medical record to confirm compliance, non-compliance was assumed. Compliance with guidelines VII–IX was only calculated for patients who received an ICP monitor. Percent compliance with BTF guidelines was calculated for each individual out of total eligible criteria: 15 criteria for patients who did not receive an ICP monitor and 18 criteria for patients who received an ICP monitor. Stepwise regression was used to develop a multivariable logistic regression model of mortality. Factors examined for significance included age, gender, mechanism of injury, Injury Severity Score (ISS), Abbreviated Injury Score (AIS) head score, full Glasgow Coma Score (GCS), GCS motor, intubation, and ICP monitoring. Significance was defined as  $p < 0.05$ . Further, rates of mortality were plotted and compared across the spectrum of compliance to visualise a trend in mortality.

## Results

From 2007 to 2012, there were a total of 185 patients that met study inclusion criteria. These patients had a median age of 40 yr (IQR: 23–59), median AIS-Head score of 4 (IQR: 4–5), median Injury Severity Score (ISS) of 26 (IQR: 22–35), and median

**Table 1**  
Compliance with each of the BTF guidelines.

No.	Guideline	Definition of compliance	Compliant n (%)
I	Blood pressure and oxygenation	SBP not $< 90$ mmHg, twice during first 48 h SaO <sub>2</sub> not $< 90\%$ , twice during first 48 h	119 (64.7) 159 (86.9)
II	Hyperosmolar therapy	Mannitol given in first 24 h ICP placed in first 24 h	83 (44.9) 75 (40.5)
III	Prophylactic hypothermia	Temp not $< 95$ F, twice during first 48 h Temp not $> 101.5$ F, twice during first 48 h	156 (84.3) 125 (67.6)
IV	Infection prophylaxis	Intubated Antibiotics given in first 24 h	178 (96.7) 111 (60.7)
V	Deep vein thrombosis prophylaxis	SCD's applied in first 24 h	158 (85.9)
VI	Indications of intracranial pressure monitoring	ICP monitor placed in first 24 h	75 (40.5)
VII	Intracranial pressure monitoring technology	ICP monitored using ventricular catheter connected to external strain gauge	75 (100.0) <sup>*</sup>
VIII	Intracranial pressure thresholds	ICP never $> 20$ mmHg, for 15+ min	29 (38.6) <sup>*</sup>
IX	Cerebral perfusion thresholds	CPP never $> 70$ mmHg, for 15+ min CPP never $< 50$ mmHg, for 15+ min	2 (2.67) <sup>*</sup> 59 (78.7) <sup>*</sup>
X	Brain oxygen monitoring and thresholds	Omitted from study	–
XI	Anaesthetics, analgesics, and sedatives	Propofol given in first 24 h	81 (44.3)
XII	Nutrition	Patients fed to attain full caloric replacement by day 7 post-injury	185 (100.0)
XIII	Antiseizure prophylaxis	Keppra, Dilantin, or Cerebyx started within first 24 h and given for 7 consecutive days	97 (53.0)
XIV	Hyperventilation	PaCO <sub>2</sub> never $\leq 25$ mmHg during first 48 h	151 (84.4)
XV	Steroids	Steroids not administered during first 24 h	152 (83.1)

<sup>\*</sup> Out of the patients that had an ICP placed.

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