Increasing Adherence to Brain Trauma Foundation Guidelines for Hospital Care of Patients With Traumatic Brain Injury

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BACKGROUND The Brain Trauma Foundation has developed treatment guidelines for the care of patients with acute traumatic brain injury. The Adam Williams Initiative is a program established to provide education and resources to encourage hospitals across the United States to incorporate the guidelines into practice.
OBJECTIVE To explore the relationship in hospitals between participation in the Adam Williams Initiative and adherence to the Brain Trauma Foundation guidelines for patients with acute traumatic brain injury.
METHOD Hospitals that participated in the Adam Williams Initiative entered data into an online tracking system of patients with traumatic brain injury for at least 2 years after the initial site training. Data included baseline hospital records and daily records on hospital care of patients with traumatic brain injury, including blood pressure, intracranial pressure, cerebral perfusion pressure, oxygenation, and other data relevant to the 15 key metrics in the Brain Trauma Foundation guidelines.
RESULTS The 16 hospitals funded by the Adam Williams Initiative had good overall adherence to the 15 key metrics of the recommendations detailed in the Brain Trauma Foundation guidelines. Variability in results was primarily due to data collection methods and analysis.
CONCLUSIONS The Adam Williams Initiative helps promote adherence to the Brain Trauma Foundation guidelines for hospital care of patients with traumatic brain injury by providing a platform for developing and standardizing best practices. Participation in the initiative is associated with high adherence to clinical guidelines, a situation that may subsequently improve care and outcomes for patients with traumatic brain injury. (*Critical Care Nurse.* 2018;38[1]:e11-e20)

Traumatic brain injury (TBI) is defined by the Centers for Disease Control and Prevention and the World Health Organization as an injury (eg, physical injury to the head or a penetrating head injury) resulting in neurological and neuropsychological changes in brain functioning.[1] The incidence of patients treated for TBI and released alive from the emergency department has increased significantly, from 434.1 per 100 000 in 1995 to 686.0 per 100 000 in 2009. At the same time, TBI-related mortality decreased significantly from 19.9 per 100 000

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in 1995 to 16.6 per 100 000 in 2009.[2] In 1995 in a systematic survey of approximately 270 trauma centers, the Brain Trauma Foundation (BTF) collected data and compared various metrics such as intracranial pressure (ICP) monitoring and treatments used for intracranial hypertension. The results indicated considerable variation in management of severe head injury, and the BTF recommended the formation of consistent, evidence-based guidelines.[3]

Consequently, in 1995 in collaboration with the American Association of Neurological Surgeons, the BTF published *Guidelines for the Management of Severe Head Injury.*[4] These guidelines were based on metrics key to in-hospital care of TBI patients and gave evidence-based recommendations for each topic.[5] A second edition was published in 2000, which spurred a follow-up study[6] that indicated poor adherence to and implementation of the updated guidelines. The third edition of the BTF guidelines, published in 2007, lists 15 key topics to help guide in-hospital treatment of patients with TBI.[7,8] In late 2017, the foundation published the fourth edition.[9] The focus of the BTF guidelines overlaps the focus of the Adam Williams Initiative (AWI) and has paved the way for a unilateral effort between the AWI and the BTF.

The AWI program has previously been described.[10] In brief, the AWI is a foundation-funded educational effort to promote adherence to guidelines-based care of patients with TBI. Findings of previous studies[11-13] have indicated that adherence to the TBF guidelines is associated with improved outcomes. The purpose of our study was to explore the relationship between participation in the AWI and adherence to BTF guidelines.

Methods

This study is a secondary analysis of data from hospitals that participated in the AWI program between 2005 and 2013. In brief, the AWI program was initiated in 2004 at Mission Hospital, Mission Viejo, California; physicians and nurses from 37 hospitals designated as level I or level II trauma centers received training, support, and equipment from AWI. As part of the agreement between the hospitals and AWI, participating sites were responsible for entering data into the online TBI-trac system for at least 2 years after the initial site training. Information entered into the TBI-trac by the AWI-trained hospital staff included baseline records and a daily hospital record for up to 10 days and a limited amount of outcome data on blood pressure and oxygenation, ICP monitoring, hypothermia, Glasgow Coma Scale (GCS) scores, infection prophylaxis, ventilation, deep venous thrombosis (DVT) prophylaxis, cerebral perfusion pressure (CPP), sedation, nutrition, antiseizure prophylaxis, and use of steroids.

Study Population

Our study was confined to data from AWI hospitals with at least 10 cases of TBI documented in the TBI-trac database and at least 12 months between the first and last case. Eligibility criteria for the TBI-trac database includes overall GCS score less than 9 for at least 6 hours after injury, with a GCS motor score less than 6 and a GCS eye score of 1, and a mechanism of injury consistent with TBI. Patients were excluded if they died in the emergency department, had do-not-resuscitate or do-not-intubate orders, or were transferred to the study hospital more than 24 hours after injury.

Data Analysis

We analyzed data from 16 of the 37 AWI participating sites. Hospital records were included if the associated

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hospital provided a minimum of 10 patient records in the BTF database, with at least 1 daily hospital record and outcome data. Total data analyzed included information on 1301 patients, with 8083 records from 16 hospitals. Data were summarized as frequency and percentage or mean and standard deviation. SAS, version 9.4, software (SAS Inc) was used for all analyses.

Results

Demographics

Table 1 gives demographic data for the sample. Most patients were non-Hispanic (93.9%), white (88.5%), and male (74.6%). Computed tomography (CT) scans were performed on 99% of the patients; 88% had abnormal findings. The GCS scores on day 1 (hospital admission) for 89% of patients were in the severe range (score 3-8). Data from daily hospital records were entered up to 10 days; a total of 8083 daily hospital records were analyzed in our study. The mechanism of injury of TBI was mostly accidents involving an automobile or a motorcycle or falls. Specifically, 34.9% of the study patients were the driver or a passenger in a motor vehicle accident, 14.0% were in a motorcycle accident, 5.1% were a pedestrian in a motor vehicle accident, and 26% had TBI caused by a fall (55% fell < 3 m; 45% fell > 3 m).

Table 1 Demographic characteristics

Characteristic	No. (%)[a] (N = 1301)
Male sex	971 (74.6)
Race/ethnicity	
White	1152 (88.5)
Hispanic	79 (6.1)
Other	70 (5.4)
Mechanism of injury	
MVA driver/passenger	454 (34.9)
Motorcycle	182 (14.0)
Fall <3 m	186 (14.3)
Fall >3 m	154 (11.8)
Assault with a blunt object	68 (5.2)
MVA pedestrian	66 (5.1)
Bicycle	41 (3.2)
Gunshot	36 (2.8)
ATV/snowmobile	29 (2.2)
Sports injury	19 (1.5)
Penetration wound	6 (0.5)
Not documented	5 (0.4)
Other	55 (4.2)
GCS score on day 1 (hospital admission)	
0, 1, or 2	34 (2.6)
3-8	1156 (88.9)
9-12	88 (6.8)
13-15	23 (1.8)

Abbreviations: ATV, all-terrain vehicle; GCS, Glasgow Coma Scale; MVA, motor vehicle accident.

[a] Because of rounding, not all percentages total 100.

Key 15 Topics in the BTF Guidelines

Data on the key 15 topics from the BTF guidelines[8] are presented in Table 2.

Blood Pressure and Oxygenation. Centers affiliated with AWI recorded systolic blood pressure less than the threshold 90 mm Hg for a total mean duration of about 30 minutes (0.56 hours) in 337 patients in the first 24 hours of admission, and an increase in mean duration to 1.05 hours in 398 patients during the first 48 hours of admission.

Hyperosmolar Therapy. A total of 68.9% of all patients had ICP monitoring. Approximately half of all patients who received hyperosmolar therapy (50.3%) had a record of meeting ICP and CPP treatment thresholds (ICP > 20 mm Hg; CPP < 50 mm Hg). Furthermore, mannitol was given more commonly (49.2%) than was hypertonic saline (26.6%).

Prophylactic Hypothermia. A total of 11.8% of TBI patients were treated with prophylactic hypothermia in the first 3 days of their hospital stay; the value increased to 13.3% for the first 10 days. Among the 532 patients who had a GCS score less than 6, only 11.3% had hypothermia prophylaxis in the first 3 days.

Infection Prophylaxis. Tracheostomies were placed in 138 patients (10.6%) in the first 10 days of admission; among these patients, 97.8% began treatment with mechanical ventilation on day 1. Furthermore, 18.9% of patients had placement of ventricular catheters; among these, 17.1% received a one-time dose of periprocedural antibiotics, and 15.9% received continuous antibiotics. Only 1.46% of patients had pneumonia, and none had records indicating infections associated with ICP monitoring or sepsis.

DVT Prophylaxis. A total of 68.8% of all patients had DVT prophylaxis (either mechanical or chemical) during the first 2 days of hospitalization, 0.3% of patients between day 3 and day 10, and 30.9% had no DVT prevention or intervention noted. Forty-one (3.2%) patients were diagnosed with DVT, of whom 97.6% had already undergone DVT prophylaxis by day 2.

Indications for ICP Monitoring. Among patients with GCS scores of 3 to 8 (severe), 72.1% had a record of

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Table 2 Results from TBI-trac data concerning 15 key topics

Key topic	Variable	Result[a]
Blood pressure and oxygenation BTF guidelines recommend blood pressure monitoring and maintaining SBP >90 mm Hg and oxygenation should be monitored and hypoxia (Pao_2 <60 mm Hg or oxygen saturation <90%) avoided.	No. of hours SBP less than threshold (90 mm Hg) during first	
	24 hours, mean (SD), No. of patients	0.56 (1.34), 337
	48 hours, mean (SD), No. of patients	1.05 (2.59), 398
Hyperosmolar therapy BTF guidelines recommend using hyperosmolar therapy for measured (>20 mm Hg) or clinically observed raised ICP and restricting its use before ICP monitoring, except in cases of transtentorial herniation or nonextracranial-related neurological worsening.	Patients with some form of ICP monitoring	68.9
	Patients who received at least once	
	Mannitol	49.2
	Hypertonic saline	26.6
	Patients who received hyperosmolar therapy who had record of meeting ICP/CPP threshold (ICP >20 mm Hg; CPP <50 mm Hg)	50.3
Prophylactic hypothermia BTF guidelines do not recommend prophylactic hypothermia.	Patients who received hypothermia	
	First 3 days with any GCS score	11.8
	Anytime during hospital stay	13.3
	GCS score <6 (n=532), patients who received hypothermia in first 3 days of any GCS score	11.3
Infection prophylaxis BTF guidelines recommend only periprocedural antibiotics to reduce incidence of pneumonia and recommend early tracheostomy to reduce duration of mechanical ventilation.	Patients with tracheostomy placement in first 10 days	10.6
	In patients with tracheostomy in first 10 days (n=138), cumulative percentage of patients who started receiving mechanical ventilation on	
	Day 1	97.8
	Day 2	99.3
	Day 5	100.0
	Patients with ventriculostomy placement	18.9
	Patients with ventricular catheters (n=246) who received	
	One-time periprocedural antibiotics	17.1
	Continuous antibiotics	15.9
	Patients with records indicating	
	Pneumonia	1.46
	Infection associated with ICP monitor	0
	Sepsis	0
DVT prophylaxis BTF guidelines recommend use of graduated or intermittent pneumatic compression stockings (mechanical prophylaxis) along with either LMWH or low-dose unfractionated heparin except in patients with risk for intracranial hemorrhage.	Patients with DVT prevention/intervention	
	Yes, on or before day 2	68.8
	Yes, after day 2	0.3
	No	30.9
	Patients with record of compression stockings intermittent pneumatic compression stockings	68.9
	Patients with record of treatment with LMWH or low-dose unfractionated heparin	12.1
	Patients with diagnosis of DVT	3.2
	Patients with diagnosis of DVT (n=41) who underwent early DVT prevention (starting by day 2)	97.6
Indications for ICP monitoring BTF guidelines recommend ICP monitoring in all salvageable patients with GCS score 3-8 after resuscitation and abnormal[b] findings on CT scan or characteristics (>40 years old, motor posturing, SBP <90 mm Hg).	Patients with GCS score 3-8 with ICP monitoring	72.1
	Patients with CT scans (n=1290) with	
	Normal findings	11.6
	Abnormal findings	88.4
	Patients with normal findings on CT scan (n=149) with	
	Age >40 years	28.2
	GCS motor score <4	28.2
	Age >40 years and GCS motor <4	11.4[b,c]

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Table 2 *Continued*

Key topic	Variable	Result[a]
ICP monitoring technology BTF guidelines make no specific recommendations but conclude that ventricular catheters connected to an external strain gauge are the best low-cost method for monitoring ICP.	Patients who received ICP monitoring	66.9
	Patients receiving ICP monitoring (n = 896) with	
	Ventriculostomy[d]	27.5
	Parenchymal bolt[d]	74.1
	Other	3.1
ICP thresholds BTF guidelines recommend treatment should be begun with ICP thresholds greater than 20 mm Hg.	Patients with record of measures taken to decrease ICP in patients with $Pbto_2$ monitoring (n = 429)	75.3
CPP thresholds BTF guidelines recommend CPP values should be 50-70 mm Hg, and aggressive attempts to maintain CPP greater than 70 mm Hg with fluids and vasopressors or to maintain CPP less than < 50 mm Hg should be avoided.	Among patients with ICP monitoring, patients with CPP 50-70 mm Hg for any time during day 1 (n = 611)	68.2
	Among above patients, those who had CPP 50-70 mm Hg for:	
	< 1 hour	20.5
	1-8 hours	51.9
	9-16 hours	21.3
	17-24 hours	6.4
	Among patients with ICP monitoring, those with CPP > 70 mm Hg for any time during day 1 (n = 611)	68.2
	Among above patients, those with CPP > 70 mm Hg for	
	< 1 hour	16.4
	1-8 hours	48.5
	9-16 hours	22.9
	17-24 hours	12.3
Brain oxygen monitoring and thresholds BTF guidelines for brain oxygenation recommend jugular venous saturation of < 50% or brain tissue oxygen tension of < 15 mm Hg as treatment thresholds.	Patients with $Pbto_2$ monitoring	33.0
	Patients with $SjVo_2$ monitoring	0.2
	Among patients with $Pbto_2$ monitoring (n = 429), those with at least 1 episode of $Pbto_2$ < 20 mm Hg	81.6
	Among above patients (n = 350), those with recorded $Pbto_2$ measurement (mm Hg)	
	16-20	80.0
	11-15	55.5
	6-10	45.2
	0-5	31.0
	Among patients with $Pbto_2$ monitoring (n = 429), those with at least 1 of the following:	
	Increase in $Paco_2$	62.3
	Increase in MAP	47.3
	Administration of PRBCs	27.0
Anesthetics, analgesics, and sedatives BTF guidelines recommend not giving barbiturates to induce burst suppression EEGs but recommend administration of high-dose barbiturates to control elevated ICP refractory to maximal standard treatment. Propofol for control of ICP is also recommended but not for improvement in mortality or 6-month outcomes.	Patients treated with high-dose barbiturates	11.3
	Patients who received mechanical ventilation (n = 1290) and received sedatives including propofol	84.8
	Patients who received mechanical ventilation (n = 1290) and received high-dose propofol	29.5
Nutrition BTF guidelines recommend that patients be given full caloric replacement feedings by day 7 after injury.	Patients who received nutritional feeding if begun by day 3	59.3
	Nutritional feeding method	
	Total parenteral	2.3
	Enteral	70.6
	Jejunal	3.0
	Multiple	0.1
	Unknown	24.0
	Patients who received supplemental nutritional feeding before day 10	72.9
Antiseizure prophylaxis BTF guidelines do not recommend prophylaxis with phenytoin or valproate to prevent late PTSs; however, anticonvulsants are indicated to decrease incidence of early (within 7 days of injury) PTS.	Patients who received antiseizure prophylaxis	48.6
	Among above patients, those who received antiseizure prophylaxis before day 7	99

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Table 2 *Continued*

Key topic	Variable	Result
Hyperventilation BTF guidelines do not recommend prophylactic hyperventilation ($Paco_2 \leq 25$ mm Hg), but hyperventilation can be used temporarily for reduction of elevated ICP, except in first 24 hours after injury.	Patients with at least 1 record of $Paco_2 < 25$ mm Hg	6.2
	Patients with $Paco_2$ monitoring (n = 1274) with day 1 $Paco_2$ values (mm Hg)	
	< 25	4.1
	25-29	5.0
	30-34	19.4
	≥ 35	61.3
	No data	10.0
Steroids BTF guidelines do not recommend steroids for improving outcomes or for reducing ICP, and in patients with moderate or severe TBI, high-dose steroids (methylprednisone) are associated with increased mortality and are contraindicated.	Patients who received steroids	3.4

Abbreviations: BTF, Brain Trauma Foundation; CPP, cerebral perfusion pressure; CT, computed tomography; DVT, deep venous thrombosis; EEG, electroencephalogram; GCS, Glasgow Coma Scale; ICP, intracranial pressure; LMWH, low-molecular-weight heparin; MAP, mean arterial pressure; $Pbto_2$, brain tissue oxygenation pressure; PRBC, packed red blood cell; PTS, posttraumatic seizure; SBP, systolic blood pressure; $SjVo_2$, jugular venous oxygen saturation; TBI, traumatic brain injury.

[a] Unless indicated otherwise, all values are percentages.
[b] Determined by 5 CT measures: basal cisterns at midbrain level, midline shift at Foramen of Monro, subarachnoid hemorrhage in the basal cisterns, intraventricular hemorrhage, and multiple parenchymal lesions.
[c] Of these patients, only 23.5% had ICP monitoring.
[d] These are not mutually exclusive events.

ICP monitoring. A total of 88.4% of all patients had abnormal findings on CT scans (see Table 2 for criteria). Among patients who had normal CT findings but were older than 40 years and had a GCS motor score less than 4, 28.2% had ICP monitoring.

ICP Monitoring Technology. A total of 66.9% of patients had some form of ICP monitoring. Among these, 27.5% were monitored via ventriculostomy devices and 74.1% via parenchymal devices (not mutually exclusive events).

ICP Thresholds. In a subset of 429 patients who had monitoring of the partial pressure of oxygen in the extracellular fluid of the brain (partial pressure of brain tissue oxygen; $Pbto_2$), 75% had a record of measures taken to decrease ICP when thresholds (ICP > 20 mm Hg) were crossed.

CPP Thresholds. Among patients with ICP monitoring, 68.2% were within target CPP ranges (50-70 mm Hg) during day 1 of hospitalization for some amount of time. The same percentage (68.2%) of patients with ICP monitoring had recorded CPP values exceeding the upper threshold (70 mm Hg) for any time during day 1; of these, 48.5% exceeded this threshold for 1 to 8 hours.

Brain Oxygen Monitoring and Thresholds. Among all patients, 33.0% had $Pbto_2$ monitoring, and 0.2% had monitoring of jugular venous oxygen saturation. Of the 429 patients who had $Pbto_2$ monitoring, 81.6% had at least 1 episode of $Pbto_2$ less than 20 mm Hg. Of patients who had $Pbto_2$ values less than 20 mm Hg, values were 16 to 20 mm Hg in 80.0%, 11 to 15 mm Hg in 55.5%, 6 to 10 mm Hg in 45.2%, and 0 to 5 mm Hg in 31.0%.

Anesthetics, Analgesics, and Sedatives. A total of 11.3% of patients were treated with high-dose barbiturates. In patients receiving mechanical ventilation, 84.8% were given sedatives or propofol at least once, and 29.5% of these patients were given high-dose propofol at least once.

Nutrition. By day 3, 59% of patients began some form of nutritional therapy; of these, 70.6% had enteral feeding. Among patients who received supplemental feeding (ie, to meet caloric needs), 72.9% received it before day 10.

Posttraumatic Early Seizure Prophylaxis. Among all patients, 48.6% received prophylaxis with antiepileptic drugs; of these patients, 99.0% had the prophylaxis started before day 7.

Hyperventilation. Among the patients in the sample, 6.2% had at least 1 record of $Paco_2$ less than 25 mm Hg. Among the 1274 patients who had $Paco_2$ monitoring on day 1, $Paco_2$ values were less than 25 mm Hg in 4.1%, 25 to 29 mm Hg in 5.0%, 30 to 34 mm Hg in 19.4%, and within the reference range (ie, ≥ 35 mm Hg) in 61.3%.

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Steroids. During the first 10 days of hospitalization, 96.6% of all patients received no steroids.

Discussion

Hospitals that participated in the AWI had generally high adherence to BTF guidelines, supporting the hypothesis that a dedicated and structured educational program is associated with high adherence to BTF recommendations. Gupta et al[11] found that higher adherence to BTF guidelines is associated with lower mortality. Our results extend those findings[11] by revealing an association between a focused educational effort and guideline adherence. By encouraging education and training, AWI helps nurses and physicians focus on key evidence-based metrics proven to improve outcomes in TBI patients. However, numerous factors affect implementation of and compliance to guidelines, including characteristics of the guidelines, the implementation strategies, the professionals involved, the patients, and the environment.[14] Additionally, measuring efficacy of guidelines without involvement of patient outcomes measures is difficult.

Methodological Characteristics of the Guideline Areas

In lieu of using a single variable to measure adherence, we looked grossly at patient data and compared the data with individual recommendations in the BTF guidelines based on 15 key areas of hospital care of TBI patients. Overall, our sample matched the general population[15] of TBI patients: mostly male and with similar mechanisms of injury (primarily falls and moving vehicle accidents). We made no adjustments for age or race, because compared with adults, fewer infants and children have TBI, and race-based differentiation factors are not available.[16] The study population was skewed toward whites; 88.5% of the sample were white. The AWI selected sites on the basis of a formal application process. Annual review of applications included an evaluation of patient volume, characteristics of the organization, and commitment to performance improvement. Perhaps the hospitals that reached out to the foundation had additional resources that allowed them to ask for the assistance, but this notion cannot be confirmed. Furthermore, the degree of injury in our population of patients was restricted to patients who required hospitalization, resulting in increased need for nursing care and increased subsequent morbidity and mortality.

Blood pressure and oxygenation control in the intensive care unit contribute greatly to improved patient outcomes. Uncontrolled and untreated hypotension or hypertension is associated with increased mortality in TBI patients.[17] Most centers in our study met blood pressure goals for almost the entire first 24 to 48 hours of admission. The availability of numerous monitoring techniques, along with vasoactive medicines, makes adherence to blood pressure guidelines a key in management of patients with TBI. However, better definition within our data set is needed to understand the adherence to oxygenation guidelines. We did not include numerous unreliable Pao_2 values and erroneous or skewed values of oxygen saturation measured by using pulse oximetry (Spo_2) in our observations. Indeed, changes in Spo_2 are not reliably predictive of equivalent changes in arterial oxygen saturation in critically ill patients,[18] and large differences between Spo_2 and arterial oxygen saturation may occur in critically ill patients with poor reproducibility of Spo_2.[19]

Hyperosmolar therapy is used to manage increased ICP. Although we could not determine whether an incident of increased ICP was followed by hyperosmolar therapy, our finding that half of the patients who did receive hyperosmolar therapy met ICP/CPP threshold criteria for such treatment leads us to think that the other half (with no record of hyperosmolar treatment) most likely would have also met those criteria but were not having ICP monitoring at the time. Furthermore, according to hospital records, mannitol was being given more commonly as hyperosmolar therapy than was hypertonic saline, a difference that is probably influenced by the BTF guidelines. Even though a meta-analysis[20] of randomized clinical trials of comparisons of mannitol and hypertonic saline indicated that hypertonic saline is more effective than mannitol for elevated ICP treatment, both solutions are still commonly used. We think that the frequent use of either form of hyperosmolar therapy indicates the usefulness of the therapy and good adherence to BTF guidelines by nurses and clinicians.

Blood pressure and oxygenation control in the intensive care unit contribute greatly to improved patient outcomes.

Although the BTF guidelines from 2007 do not recommend prophylactic hypothermia because the intervention

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is not associated with any significant decrease in mortality, scores on the Glasgow Outcome Scale reportedly improved significantly when prophylactic hypothermia was used in TBI patients.[8] We suspect this reported improvement is the reason approximately 11% of patients in our study received the intervention. Although evidence supports the use of early prophylactic mild-to-moderate hypothermia in patients with severe TBI (GCS score < 7) to decrease mortality and improve neurological recovery,[21,22] recent findings[23] indicate no better outcomes in TBI patients when hypothermia is used along with standard care. These studies have contributed to complicated adherence to the BTF guidelines on hyperthermia.[21-23]

Although infection prophylaxis to reduce pneumonia is recommended for patients when tracheostomies are created, we found no strong adherence to such prophylaxis. The low incidence of pneumonia might be attributed to use of other periprocedural or continuous antibiotics. The BTF guidelines make no recommendation for continuous antibiotics; however, other factors (preexisting infectious conditions, iatrogenic infections) and local hospital policy on antibiotic usage might have resulted in inconsistent adherence to BTF guidelines. Furthermore, additional information on tracheostomy placement in our data set is needed.

Only 68.8% of the patients in our study had DVT prophylaxis; the recommendations for TBI patients are universal mechanical or chemical prophylaxis (with exception for chemical prophylaxis in patients at risk for intracerebral hemorrhage).[24] Of our patients diagnosed with DVT, 97.6% already had received early DVT prophylaxis; most of the prophylaxis was probably mechanical, not chemical. The BTF guidelines have no recommendations on the timing, dosing, and preferred agents in DVT prophylaxis. Indeed, no national standard of care exists to guide TBI caregivers in the initiation and use of prophylactic anticoagulation, specifically chemoprophylaxis, despite the frequency and morbidity of DVT events after TBI.[25] This variance in adherence to the guidelines may be attributed to the fear of an increase in intracerebral hemorrhage after chemoprophylaxis in TBI patients; however preliminary trials[26] have indicated no significant worsening of TBI after chemoprophylaxis. We hope future TBI guidelines will use new evidence to encourage stronger adherence to the BTF recommendations.

The main concern with use of anesthetics, analgesics, and sedatives in TBI patients is avoiding high-dose propofol and high-dose barbiturates.

Currently, ICP monitoring is ubiquitous in TBI management, with guidelines recommending that all patients with severe GCS scores (3-8) and abnormal CT findings be monitored. We defined abnormal CT scans by using the 5 measures listed in Table 2. Although we were unable to determine how many patients meeting those measures were placed on ICP monitoring, we think adherence most likely was high because the emphasis on numerical or objective ICP criteria has become more important. Indeed, although guidelines do not recommend specific ICP monitoring technology, they encourage low-cost methods (ie, ventricular catheters), a practice that has increased adherence, as our results indicate.

Our observations indicate that ICP and CPP goals (ICP < 20 mm Hg and CPP 50-70 mm Hg) were fairly closely adhered to; 75.3% of the patients in our study had measures taken to decrease ICP when thresholds were crossed. Although we could not obtain data indicating that direct action was taken whenever ICP or CPP thresholds were crossed, crossing the ICP and CPP thresholds was common. More direction is needed in the guidelines about prevention of increased ICP and its efficacy.

In our data set, because CPP values were recorded in intervals of time, further refinement in the collecting process might help clarify the usefulness of measuring CPP. However, of note, CPP exceeded the upper threshold (70 mm Hg) many times; exceeding the threshold is not recommended because of the association with higher rates of acute respiratory distress syndrome.[27] Also, BTF guidelines have had different CPP goals over the years. In 2003, the goal was greater than 60 mm Hg, and in 2007 it was 50 to 70 mm Hg. The centers that reported CPP higher than 70 mm Hg might have been in the appropriate range according to which guideline recommendations they followed.[8]

Other methods for monitoring brain oxygen levels include $Pbto_2$ and jugular venous saturation. Because these methods have not been universally adopted (most likely because of high costs of placement and use of the devices required) and because of poor data quality, we could not make further conclusions about adherence.

The main concern with use of anesthetics, analgesics, and sedatives in management of TBI patients is avoiding high-dose propofol (notable for causing marked mortality)

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and high-dose barbiturates.[8] Nevertheless, among our sample, 29.5% of patients receiving mechanical ventilation were given high-dose propofol. In addition, although the BTF guidelines allowed for regular doses of barbiturates, recent evidence[28] indicates minimal benefit in outcomes for TBI patients who receive regular doses. Future clarification and suggestions for alternative therapy might help centers improve care and increase adherence to this guideline.

Adequate nutrition by day 7 is recommended. We were unable to determine the exact percentage of patients who received nutritional feedings by day 7, but we conclude that TBI patients are indeed receiving appropriate nutritional feedings in a timely manner, and are given supplemental nutritional feedings as needed to ensure that full caloric needs are met.

Our findings indicate that antiseizure prophylaxis as specified by the BTF guidelines was strictly followed. Almost all (99.0%) of patients requiring prophylaxis for early posttraumatic seizures received antiepileptic medication before day 7 of hospitalization. This high level of adherence may be due to the clarity and specificity in the recommendation itself.

Hyperventilation therapy is not recommended for TBI patients. Lowering $Paco_2$ to less than 30 to 35 mm Hg is in the first 24 hours after injury is specifically contraindicated. Yet a small percentage of patients (4.1%) had low $Paco_2$ values (an indication of hyperventilation) on day 1. However, because of the secondary use of hyperventilation in lowering increased ICP, clinical discretion with hyperventilation therapy leads to a small amount of nonadherence to the BTF recommendations.

Although steroids are not recommended for TBI patients, a small percentage of patients in our group did receive steroids. The risk of death increases in TBI patients when they receive corticosteroids,[29] resulting in the level 1 recommendation by the BTF. Despite the increased risk, we assume that comorbid conditions and clinical decisions contributed to our findings.

Factors Affecting Adherence to the Guidelines

In our study, we noted certain trends in adherence to the BTF guidelines. First, the more specific the guidelines, the better adherence was. As done in the AWI program,[10] the BTF guidelines might be revised or illustrated with specific algorithms. Second, we think that several guidelines from the BTF require revision. The third edition was published in 2007, and the AWI program ended several years afterward, possibly compromising adherence. This lack of updating is an inherent pitfall that occurs with all disease-based guidelines.[30] Undoubtedly, AWI is encouraging proactive TBI care by giving nurses and clinicians the background to evaluate whether guidelines are still valid; an acquisition of this knowledge further encourages adherence. Third, AWI-affiliated centers most likely are encouraging adherence by forcing nurses and staff to enter data—indeed, this Hawthorne-like effect is a benefit of initiatives such as AWI and may prove to be valuable.

The question of deontological versus teleological ethics is worth discussion. In short, deontology is the branch of ethics that addresses "doing the right thing" without external motivation. As it relates to the AWI, deontology is adhering to guidelines because guideline adherence is good.[31] Teleology (sometimes called consequentialism) addresses the concern that hospitals may have been (at least partially) motivated to more closely adhere to the BTF guidelines under the assumption that higher adherence would result in continued support from the BTF.[31] Of note, in the hospitals involved in our study, the AWI primarily provided educational resources, but also capital equipment, and covered the fees associated with access to the BTF database.[10]

Ultimately, the effectiveness of dissemination of the BTF guidelines to health care providers by AWI has had a markedly positive impact. Indeed, discrepancy often exists between dissemination and implementation of guidelines.[32] Translating guidelines into practice requires a multidisciplinary approach, with both nursing staff and clinicians taking a proactive role in guideline research, as well as treatment teams taking an active role in implementing these guidelines in the teams' local institutions. Implementation of the BTF guidelines relies on astute and timely nursing care; the crux of these guidelines is parameters initially observed by immediate nursing staff and then afterward by physicians. Ultimate outcomes may improve over time because of all these factors leading to improved adherence to the BTF guidelines for hospital care for TBI patients due to the work of the AWI.

Conclusion

The BTF Guidelines are important because they provide a platform for developing and standardizing best

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practice. The work of the AWI, to help promote compliance to the guidelines for hospital care of patients with TBI, is associated with high adherence to evidence-based clinical guidelines. This high adherence may subsequently improve patient care and outcomes for TBI patients. The hands-on learning, equipment support, and clinical support and teaching are important elements in promoting adherence to guidelines. CCN

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