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Original Article

Adherence to brain trauma foundation guidelines for intracranial pressure monitoring in severe traumatic brain injury and the effect on outcome: A population-based study

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ABSTRACT

Background: Severe traumatic brain injury (TBI) is a significant cause of death and disability. The objective of this study was to provide an overview of whether adherence to brain trauma foundation (BTF) guidelines improved outcomes following TBI utilizing intracranial pressure (ICP) monitoring.

Methods: This cohort study between 2000 and 2013 involved 1848 patients who sustained severe blunt TBI. Outcomes were correlated with whether or not ICP monitoring was utilized based on BTF guidelines.

Results: The BTF guideline adherence rate for utilizing ICP monitoring in patients with TBI was 30% in 1848 patients. Adherence rates positively correlated with younger age, high injury severity scores, lower Glasgow Coma Scores, abnormal computed tomography scans of the head, performance of a craniotomy, neurocritical care unit admission, the lack of alcohol intoxication, and the absence of a cardiac arrest. Greater adherence to BTF guidelines was associated with higher mortality rates (OR 2.01, 95% CI: 1.56–2.59, $P < 0.001$), and increase ICU and hospital lengths of stay ($P < 0.001$).

Conclusion: Adherence rates to BTF guidelines for ICP monitoring in patients with severe TBI were low. Further, these rates varied across centers and were correlated with higher mortality and morbidity rates. Although ICP insertion may be an indicator of TBI severity, the current BTF criteria for insertion of ICP monitors may fail to identify patients likely to benefit.

Keywords: Brain injury guideline, Brain trauma foundation guideline, Traumatic brain injury

INTRODUCTION

Traumatic brain injury (TBI) is a significant cause of death and disability around the world.[3,12] Elevated intracranial pressure (ICP) is an important cause of secondary brain injury and is consistently associated with worse outcome.[8]

The brain trauma foundation (BTF) guidelines are supposed to be strictly adhered to for the management of TBI. The BTF recommends continuous ICP monitoring in all salvageable severe TBI patients (Glasgow Coma Score [GCS] ≤8) with a computed tomography (CT) scan revealing intracranial pathology. They are also to be utilized for severe TBI patients with a normal CT scan,

but who exhibit two or more of the following risk factors: age over 40 years, unilateral or bilateral motor posturing, or a systolic blood pressure of <90 mm Hg.[2,4]

It has been suggested that implementation and adherence to BTF guidelines correlate with improvement in neurological outcome and reduction in mortality following severe TBI. However, there is significant variability in the use of ICP monitors and inconsistency in adherence to BTF guidelines across neurosurgical centers.[1,5,10,11]

Here, we evaluated the extent to which BTF guidelines for continuous ICP monitoring in severe TBI patients were being performed, and how it impacted outcomes.

MATERIALS AND METHODS

We obtained IRB approval for this population-based retrospective cohort study of TBI patients. From 2000 to 2013, 5449 patients with TBI from three trauma centers were evaluated [Table 1]. Multiple demographic and clinical variables were collected from the trauma registry database [Table 2].

The study population was stratified into two-study arms based on the adherence to BTF guidelines for insertion of ICP monitoring; (1) patients with severe TBI (GCS ≤8) and an abnormal CT scan, (2) patients with severe TBI without CT abnormalities, but with at least two of the following: age >40 years old, unilateral or bilateral motor posturing (GCS motor score ≤3), and/or a systolic blood pressure <90 mm Hg.

Evaluation of outcomes

Primary outcomes included assessment of adherence to BTF guidelines, and in-hospital mortality. Secondary outcomes assessed morbidity including ICU and hospital length of stay (LOS), discharge disposition, and others.

Statistical methods and bias

Univariate and multivariate logistic and linear regression were used to assess outcome. A purposeful selection method was deployed using variables after univariate analysis to identify the predictors of adherence and confounders effect on outcome.

All statistical analyses were performed using Stata 13.1. $P < 0.05$ was considered statistically significant.

RESULTS

Adherence rates to BTF criteria

There were 1848 patients who met the BTF guidelines for ICP monitoring; of these, 1606 had abnormal CT scans.

Table 1: Study inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Age≥18	Penetrating brain injury
ISS≥12	Nonalberta resident
AIS of head and neck>3	Patients who died in the emergency department
GCS ≤8 or ICP monitoring was inserted	

Table 2: Variables/quantitative variables and data sources/measurement.

Age
Mechanism of injury
Extraction and it's time
Sex
GCS
Systolic blood pressure
Trauma severity score including: ISS and AIS for (head, chest, abdomen, and extremity)
Alcohol level
Coagulopathy
CT head abnormality
Cardiac arrest
Craniotomy and other surgical procedures
ICU model (neurocritical care, general intensive care unit (ICU), and specialized neurological program within a general ICU)
ICU length of stay
Hospital length of stay
Discharge disposition
Over-all in hospital mortality

The adherence rate to BTF guidelines for the insertion of an ICP monitor in TBI patients was highest among those with abnormal CT studies (1606 patients; 33.31%) versus normal CT's (8.68% of 242 patients). Notably, just 556 (30.09%) patients received ICP monitors [Figure 1].

Predicting ICP monitoring adherence

Baseline demographics, injury characteristics, and the model of care systems for ICP adherence and nonadherence groups were analyzed [Table 3]. Significant predictors for guideline adherence included: younger patient age, higher injury severity scores (ISS), lower GCS, the absence of alcohol intoxication, a CT scan abnormality, requiring craniotomy, and the absence of a cardiac arrest [Table 4].

Strict adherence to BTF criteria for ICP monitoring in TBI patients was lowest in the specialized neurological program within a general ICU model (center). Further, the general ICU model (center) had a lower adherence rate versus the neurocritical model (center) [Table 4].

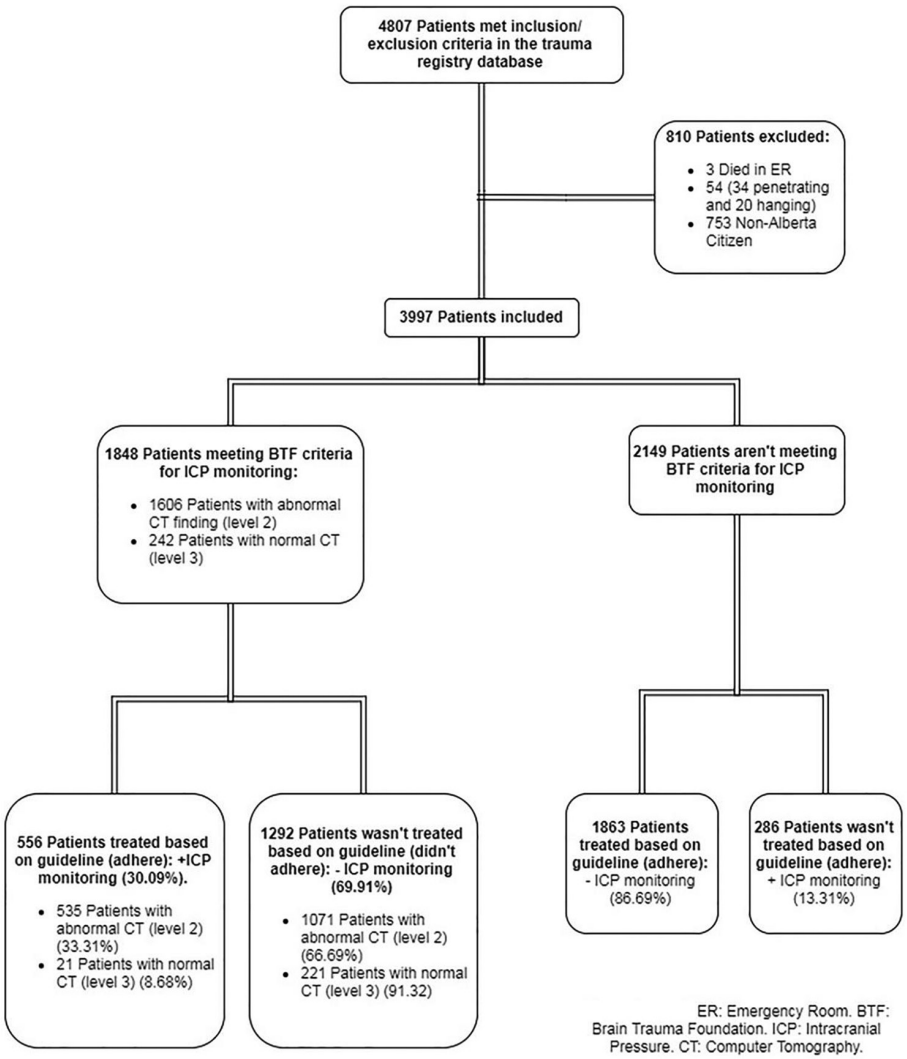

Figure 1: Flow chart.

Table 3: Patient characteristics in adherent and nonadherent group.

	Adhere % (*n*=556)	Not-adhere % (*n*=1292)	*P*-value
Age (year)			
18–37	55.58	42.41	0.0001
38–56	32.73	33.98	
57–75	10.97	17.18	
76–94	0.72	6.42	
Sex			
Male	76.98	75.00	
Female	23.02	25.00	0.364
Extraction			
No	63.24	66.50	
Yes	36.76	33.50	0.321
SBP<90			
No	92.61	88.21	
Yes	7.39	11.79	0.005

(Contd...)

Table 3: Patient characteristics in adherent and nonadherent group.

	Adhere % (*n*=556)	Not-adhere % (*n*=1292)	*P*-value
ISS			
13–23	5.40	13.47	0.0001
24–33	39.93	42.41	
34–43	32.55	26.93	
44–53	16.91	12.77	
54–75	5.22	4.41	
GCS			
7–8	15.34	23.79	0.0001
5–6	21.78	20.55	
3–4	62.88	55.67	
Alcohol intoxication			
No	53.78	49.30	
Yes (>17)	46.22	50.70	0.078
CT finding			
Normal	3.78	17.11	
Abnormal	96.22	82.89	0.0001
CPR			
No	97.84	89.55	
Yes	2.16	10.45	0.0001
Craniotomy			
No	66.01	84.83	
Yes	33.99	15.17	0.0001
Intensive care unit model			
SNP within ICU	33.63	43.11	0.001
ICU	23.56	20.05	
Neurocritical care	42.81	36.84	

Table 4: Predictors of adherence*.

	Univariate		Multivariate	
	OR	*P*-value (95% CI)	OR	*P*-value (95% CI)
Age (year)				
18–37	1		1	
38–56	0.74	0.007 (0.59–0.92)	0.94	0.625 (0.73–1.21)
57–75	0.49	0.0001 (0.36–0.67)	0.51	0.0001 (0.35–0.73)
76–94	0.09	0.0001 (0.03–0.24)	0.13	0.0001 (0.04–0.36)
ISS				
13–23	1		1	
24–33	2.35	0.0001 (1.55–3.57)	2.07	0.003 (1.29–3.33)
34–43	3.02	0.0001 (1.97–4.62)	2.71	0.0001 (1.67–4.39)
44–53	3.30	0.0001 (2.08–5.25)	3.19	0.0001 (1.89–5.40)
54–75	2.95	0.0001 (1.63–5.33)	2.83	0.002 (1.44–5.57)
GCS				
7–8	1		1	
5–6	1.64	0.003 (1.18–2.29)	1.59	0.01 (1.12–2.27)
3–4	1.75	0.0001 (1.32–2.32)	2.08	0.0001 (1.53–2.82)
Alcohol intoxication				
No	1		1	
Yes (>17)	0.84	0.078 (0.68–1.02)	0.76	0.018 (0.60–0.95)
CT finding				
Normal	1		1	
Abnormal	5.26	0.0001 (3.32–8.32)	4.67	0.0001 (2.81–7.75)
CPR				
No	1		1	
Yes	0.19	0.0001 (0.10–0.34)	0.28	0.0001 (0.15–0.53)
Craniotomy				
No	1		1	
Yes	2.88	0.0001 (2.28–3.63)	3.19	0.0001 (2.43–4.18)
Intensive care unit model				
SNP within ICU	1		1	
ICU	1.51	0.003 (1.15–1.97)	1.59	0.0001 (1.32–2.42)
Neurocritical care	1.49	0.001 (1.19–1.87)	2.08	0.0001 (1.36–2.27)

*Purposeful selection method was used for selecting variables in the model. Overall fit of the model was assessed using Hosmer-Lemeshow statistic which not statistically significant (Chi-square statistics=14.98, df=8, *P*=0.06) indicating that the model provided a good-fit for the data

Summary of morbidity and mortality rates

In-hospital, the mortality was 42% in the adherent group and 32% in nonadherent group [Table 5], (crude OR: 1.54 P = 0.0001) (adjusted OR: 2.01 P = 0.0001). Increased age, higher ISS score, lower GCS, and cardiac arrest all increased mortality rates; CT abnormality and performing craniotomies did not [Table 6].

Table 5: Percentage of in hospital death, discharge disposition, hospital and ICU length of stay and ventilation days in adhere and notadhere group.

	Adhere	Not-adhere	*P*-value
In-hospital mortality			
Survive	57.73%	67.8%	0.0001
Died	42.27%	32.2%	
Discharge disposition			
Home	5.58	18.67%	0.0001
Acute care facility	14.21%	17.82%	
Rehabilitation facility	37.95%	31.29%	
Chronic care facility	42.27%	32.22%	
Hospital LOS			
Mean (SE) (days)	34.32 (1.76)	24.41 (1.30)	0.0001
ICU LOS			
Mean (SE) (days)	13.40 (0.46)	8.06 (0.33)	0.0001
Ventilation days			
Mean (SE) (days)	11.24 (0.42)	5.83 (0.25)	0.0001

Adherence to ICP monitoring following BTF guidelines was associated with an average higher LOS in the ICU (>7 days), and hospital (>14 days). Other variables were associated with longer ventilation times, ICU and length of hospital stays are listed in [Tables 7 and 8].

In the sensitivity analysis from excluding patients who died within 48 h of admission, the association between adherence to BTF of ICP monitoring and mortality was greater (OR: 4.59 P = 0.0001).

DISCUSSION

Our study showed that ICP monitoring was performed in a minority of patients with severe traumatic brain injuries who meet the current BTF criteria (30.1%). Adherence rates were significantly different across different critical care units; this rate is even lower than those reported in UK (43% and 46%), Austria (56%),[1,6,9] and systematic review studies (46.4%).[7]

Adherence was lower in patients with a normal CT scan and two or more risk factors; age, BP, and motor GCS (9%) versus patients with abnormal intracranial finding (33%). This suggests that clinicians are likely not convinced that ICP monitoring in this subgroup of severe TBI patients is necessary.

Table 6: Crude and adjusted OR of the mortality*.

	Univariate		Multivariate	
	OR	*P*-value (95% CI)	OR	*P*-value (95% CI)
Adhere				
No	1		1	
Yes	1.54	0.0001 (1.26–1.89)	2.01	0.0001 (1.56–2.59)
Age (year)				
18–37	1		1	
38–56	1.32	0.002 (1.11–1.57)	1.59	0.001 (1.22–2.09)
57–75	2.13	0.0001 (1.75–2.59)	3.45	0.0001 (2.45–4.85)
76–94	3.24	0.0001 (2.49–4.20)	10.53	0.0001 (5.78–19.17)
SBP				
>=90	1		1	
<90	3.03	0.0001 (2.39–3.85)	2.12	0.0001 (1.43–3.14)
ISS				
13–23	1		1	
24–33	3.91	0.0001 (2.97–5.15)	4.34	0.0001 (2.59–7.27)
34–43	2.67	0.0001 (1.99–3.57)	3.19	0.0001 (1.87–5.46)
44–53	4.27	0.0001 (3.09–5.91)	3.93	0.0001 (2.21–6.99)
54–75	4.90	0.0001 (3.17–7.58)	2.46	0.016 (1.18–5.10)
GCS				
7–8	1		1	
5–6	1.61	0.006 (1.15–2.26)	1.30	0.286 (0.80–2.10)
3–4	5.03	0.0001 (3.81–6.64)	4.71	0.0001 (3.16–7.04)
CT finding				
Normal	1		1	
Abnormal	1.21	0.014 (1.04–1.42)	1.12	0.561 (0.77–1.64)
CPR				
No	1		1	
Yes	12.06	0.0001 (8.78–16.56)	8.34	0.0001 (4.84–14.36)
Craniotomy				
No	1		1	
Yes	1.02	0.826 (0.86–1.20)	1.65	0.120 (0.88–3.09)

*Purposeful selection method was used for selecting variables in the model. Overall fit of the model was assessed using Hosmer-Lemeshow statistic which not statistically significant (Chi-square statistics=11.56, df=8, P=0.17) indicating that the model provided a good-fit for the data. OR: Odd ratio

Table 7: Crude and adjusted length of stay in intensive care unit.

	Univariate		Multivariate	
	B	***P*-value (95% CI)**	**B**	***P*-value (95% CI)**
Adhere				
No				
Yes	8.05	0.0001 (6.53–9.58)	6.55	0.0001 (4.95–8.15)
Age (year)				
18–37				
38–56	−0.20	0.669 (−1.13–0.72)	0.66	0.404 (−0.90–2.22)
57–75	−0.65	0.288 (−1.85–0.55)	0.61	0.590 (−1.61–2.83)
76–94	−0.47	0.621 (−2.32–1.39)	2.60	0.282 (−2.14–7.34)
SBP				
>=90				
<90	6.88	0.0001 (5.07–8.68)	4.56	0.001 (1.76–7.35)
ISS				
13–23				
24–33	2.39	0.0001 (1.33–3.44)	1.68	0.128 (−0.48–3.83)
34–43	7.14	0.0001 (6.02–8.27)	5.74	0.0001 (3.48–8.00)
44–53	10.71	0.0001 (9.22–12.20)	9.94	0.0001 (7.26–12.62)
54–75	13.20	0.0001 (10.80–15.60)	8.26	0.0001 (4.46–12.06)
GCS				
7–8				
5–6	2.08	0.019 (0.34–3.83)	1.21	0.206 (−0.67–3.09)
3–4	4.50	0.0001 (2.99–6.01)	2.80	0.001 (1.12–4.48)
CT finding				
Normal				
Abnormal	3.01	0.0001 (2.16–3.86)	1.68	0.187 (−0.82–4.19)
CPR				
No				
Yes	7.39	0.0001 (4.32–10.46)	10.52	0.0001 (5.48–15.57)
Craniotomy				
No				
Yes	−0.95	0.050 (−1.91–0.0003)	1.49	0.097 (−0.27–3.24)

Table 8: Crude and adjusted length of stay in hospital.

	Univariate		Multivariate	
	B	***P*-value (95% CI)**	**B**	***P*-value (95% CI)**
Adhere				
No				
Yes	18.10	0.0001 (11.60–24.60)	14.4	0.0001 (7.15–21.66)
Age (year)				
18–37				
38–56	5.10	0.003 (1.71–8.49)	11.89	0.001 (4.80–18.97)
57–75	6.61	0.003 (2.20–11.02)	12.96	0.012 (2.87–23.06)
76–94	4.26	0.219 (−2.54–11.06)	22.65	0.039 (1.10–44.20)
SBP				
≥90				
<90	17.46	0.0001 (10.82–24.09)	10.67	0.099 (−2.02–23.36)
ISS				
13–23				
24–33	5.73	0.005 (1.72–9.74)	−0.12	0.98 (−9.93–9.68)
34–43	17.11	0.0001 (12.82–21.40)	11.15	0.033 (0.90–21.40)
44–53	23.63	0.0001 (17.95–29.30)	19.82	0.001 (7.64–32.00)
54–75	33.24	0.0001 (24.10–42.38)	20.9	0.018 (3.65–38.15)
GCS				
7–8				
5–6	10.94	0.003 (3.77–18.11)	9.68	0.026 (1.15–18.21)
3–4	12.85	0.0001 (6.64–19.06)	10.52	0.007 (2.88–18.15)
CT finding				
Normal				
Abnormal	7.99	0.0001 (4.85–11.13)	10.4	0.073 (−0.98–21.78)
CPR				
No				
Yes	12.94	0.025 (1.64–24.24)	23.04	0.049 (0.12–45.96)
Craniotomy				
No				
Yes	1.16	0.516 (−2.35–4.67)	6.3	0.122 (−1.68–14.27)

In this study, ICP monitoring was associated with the higher mortality and morbidity despite controlling multiple confounders.

CONCLUSION

In a large sample of Canadian TBI patients, adherence to BTF guidelines for ICP monitoring was low and varied across centers, especially if CT studies were normal. Further, ICP monitoring was associated with the higher mortality rates and ICU/hospital lengths of stay.

Declaration of patient consent

Institutional Review Board permission obtained for the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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