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Predictors of Compliance with the Evidence-Based Guidelines for Traumatic Brain Injury Care: A Survey of United States Trauma Centers

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Background: In 1995, evidence-based guidelines for the management of severe traumatic brain injury (TBI) were published and disseminated. Information regarding their implementation is limited.

Methods: During 1999 to 2000, we contacted all designated U.S. trauma centers caring for adults with severe TBI to determine the degree of guideline compliance and to identify predictors.

Results: Of 924 centers identified, 828 participated (90%). Four hundred thirty-three with intensive care units caring for severe TBI were surveyed. Three hundred ninety-five centers transferring patients were excluded. Full guideline compliance was rare (n = 68 [16%]). In multivariate analyses, treatment protocols (odds ratio [OR], 3.6; 95% confidence interval [CI], 1.9–6.6), neurosurgery residency program (OR, 5.0; 95% CI, 2.6–9.8), and state (OR, 2.7; 95% CI, 0.62–12) or American College of Surgeons (OR, 5.1; 95% CI, 1.1–23) designation increased the likelihood of full compliance versus noncompliance.

Conclusion: Although evidence-based guidelines were published and disseminated in 1995, implementation is infrequent. Focus must turn to changing physician practice and transport decisions to provide guideline-compliant care and improve patient outcome.

Key Words: Traumatic brain injury, Guideline compliance, Survey.

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Severe traumatic brain injury (TBI), defined by a Glasgow Coma Scale score of 8 or less, is a major cause of death and disability among young people,[1–4] with an estimated cost of $45 billion a year.[1–4] After severe TBI, secondary brain injury from increased intracranial pressure is a key cause of potentially preventable brain damage and death.[5–7] Secondary brain injury can be reduced by intensive care interventions such as intracranial pressure monitoring and treatment, but these therapies require considerable time and dedication of medical personnel, which may vary across trauma centers. Indeed, a prior national survey has demonstrated that trauma centers provide variable care for severe TBI,[8] but did not address predictors of optimal care. Since that survey, management guidelines have been developed,[9] according to the American Medical Association criteria.[10] These guidelines, first published in 1995, address key issues in the prevention of secondary brain injury. The American Association of Neurologic Surgeons, the World Health Organization neurotrauma committee, and the New York State Department of Health endorse the guidelines. To educate physicians on optimal TBI care, the *Guidelines* were distributed to all member neurosurgeons in the United States in 1995 by the American Association of Neurologic Surgeons.

Lives are saved and cost of care is reduced through compliance with *Guidelines.* Studies suggest that compliance significantly improves the occurrence of good outcomes at discharge,[11,12] and reduces mortality,[11–13] mean hospital days,[11,13,14] and average charges per patient.[11,13] The decrease in mortality is as high as 66%, with a corresponding 60% increase in good outcome at discharge.[12] The savings in acute care are estimated to range from $9,340 [11] to $14,611 per patient,[13] corresponding to a savings of between $841 million and $1.3 billion per year in the United States.

Are there characteristics of trauma centers associated with delivery of optimal care? To address this issue, in 2000, the Brain Trauma Foundation surveyed all designated trauma centers in the United States to determine the extent to which the scientific evidence-based guidelines for the management of patients with severe TBI have been adopted and to identify predictors of guideline compliance.

MATERIALS AND METHODS

All designated trauma centers in the United States were identified by two methods. First, a list of centers was requested from the American Hospital Association (AHA). The AHA sends a yearly questionnaire to all hospitals to determine which are trauma centers and, if they are, they query the trauma center level. Second, a letter was sent to each state health department asking for a list of all designated traumas centers. In the 16 states in which the health department does not designate trauma centers, we received a list of all hospi-

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tals in the state. Our survey is restricted to trauma centers caring for adults.

After combining the AHA and state health department lists, each trauma center was called to ask the nurse manager or nurse clinician in the intensive care unit (ICU) if they cared for TBI patients. Nurse clinicians were selected because they would be more available than physicians and would be familiar with the medical practices in the ICU. The survey was not administered in hospitals that accepted TBI patients only in the emergency department and then transferred them to another facility. Centers that were difficult to contact received a letter describing the survey, a copy of the questions, and a follow-up phone call 3 to 6 months later.

Among participating hospitals, nurse managers were asked about the number of patients seen each month, and the medical specialty of the ICU director. Nurses were then queried regarding the care of severe TBI patients at their hospital to determine guideline compliance. For example, they were asked, "In patients with intracranial pressure (ICP) less than or equal to 15 mm Hg, do you use any of the following treatment modalities?" In addition, all 94 neurosurgery residency programs were contacted to determine what the primary hospital was for each program. This study was considered exempt from institutional review board review.

Predictors of Guideline Compliance

Trauma Center Level and Designation

Trauma center level and the source of such designation (the state, the American College of Surgeons, self-designation, or unknown) were determined. Level I centers are considered to have the highest qualifications as trauma centers.

Treatment Protocols

The presence of treatment protocols specific to the care of patients with severe TBI was ascertained. The contents of these protocols was not queried.

Monthly Patient Volume

The number of patients with severe TBI seen each month was categorized as ≤ 3 patients per month, 4 to 14 patients per month, and ≥ 15 patients per month. High volume was defined as ≥ 15 patients per month.

Neurologic ICU

Presence of a designated neurologic ICU that cares for severely head-injured patients was queried.

Neurosurgical Residency Program

A hospital was considered to have a neurosurgery residency program if it was the primary hospital in the program. Care at such hospitals is most likely to reflect the teaching principles of the program.

Table 1 Guidelines for the Management of Severe Traumatic Brain Injury and Their Inclusion in the Survey

Chapter	Level	Topic	In Survey
2	Guideline	Trauma systems	Yes
3	Option	Prehospital therapies	No
4	Guideline	Resuscitation of blood pressure and oxygenation	No
5	Guideline	Indications for ICP monitoring	Yes
6	Guideline	ICP treatment threshold	Yes
7	Recommendation	ICP technology	Yes
8	Option	CPP treatment	Yes
9	Standard	Hyperventilation	Yes
10	Guideline	Mannitol	Yes
11	Guideline	Barbiturates	Yes*
12	Standard	Steroids	Yes
13	Option	Critical treatment pathway for established intracranial hypertension	Yes
14	Guideline	Nutrition	No
15	Standard	Antiseizure prophylaxis	No

* Barbiturates were assessed but not other anesthetics (such as high-dose propofol).

Guideline Compliance

We evaluated the extent to which each of the participating centers complied with the *Guidelines for the Management of Severe Traumatic Brain Injury*.[9] Each area that was assessed in the *Guidelines* was assigned a clinical degree of certainty (Table 1).

Standards: accepted principles of patient management that reflect a high degree of clinical certainty on the basis of prospective, randomized clinical trials.

Guidelines: patient management for which there is a moderate clinical certainty according to data from prospective cohort studies, cross-sectional studies, and case-control studies.

Options: patient management for which there is unclear clinical certainty and are usually derived from data from clinical series, databases or registries, case reports, and expert opinion.

Recommendations: assessments of the reliability and accuracy of pertinent technologies.

Standards, guidelines, options, and recommendations for the management of severe head injury were surveyed (Table 1). The guideline for indications for ICP monitoring was evaluated by determining which centers monitored ICP at least 75% of the time. Guidelines for intracranial pressure treatment threshold were met if some treatment to lower ICP was initiated (i.e., hyperventilation, mannitol, cerebrospinal fluid drainage, or cerebral perfusion pressure [CPP] therapy) at an ICP of 25 mm Hg or more. Recommendations for ICP monitoring technology were met if centers used ventricular or parenchymal monitors only. Standards for hyperventilation during acute management were met if hyperventilation was avoided when ICP was 15 mm Hg or less. Guidelines for mannitol were met if mannitol was given when the ICP was 25 mm Hg or more or there were signs of cerebral herniation. Standards for glucocorticoid administration were met if glucocorticoids were not used to treat TBI.

Therapies listed as options in the *Guidelines* were omitted from analyses of compliance (i.e., the CPP threshold at which to initiate therapy and protocols for treating intracranial hypertension), because there is unclear clinical certainty about these factors and centers may elect whether to follow these options. Compliance with the treatment of hypotension (a guideline), nutritional maintenance (a guideline), or anti-epileptic drug therapy (a standard) were not assessed. Finally, the barbiturate guideline was not evaluated because other anesthetics such as propofol were not assessed, and are now very commonly used. Thus, there was concern that guideline compliance would be underestimated.

The degree of compliance was categorized into nonoverlapping levels: fully compliant, partially compliant, and noncompliant. Centers were fully compliant if they fulfilled all of the six guidelines and standards assessed (i.e., indications for ICP monitoring, ICP treatment threshold, ICP monitoring technology, hyperventilation, mannitol, and steroids). Centers were partially compliant if they fulfilled guidelines for ICP monitoring and ICP technology. This was considered partially compliant because it is the minimum compliance needed to treat elevated ICP and low CPP and minimize secondary brain injury. Noncompliant centers either fulfilled no guidelines or some combination of guidelines that did not place them in at least the partially compliant category.

Table 2 Characteristics of Surveyed Trauma Centers

Characteristic	Level I (%)	Level II (%)	Level III (%)
Designation of Level[1]*			
American College of Surgeons	57 (35)	56 (25)	1 (4)
State	101 (62)	142 (64)	24 (89)
Other	5 (3)	23 (11)	2 (7)
Neurologic ICU*			
No	77 (47)	188 (80)	27 (84)
Yes	88 (53)	48 (20)	5 (16)
Neurosurgical residency programs*			
No	106 (64)	229 (97)	32 (100)
Yes	59 (36)	7 (3)	0 (0)
Treatment protocols**			
No	71 (43)	147 (62)	22 (69)
Yes	94 (57)	89 (38)	10 (31)
Volume each month[2]*			
≤3 patients/mo	17 (10)	106 (46)	20 (63)
4–14 patients/mo	120 (73)	122 (52)	11 (34)
≥15 patients/mo	27 (17)	5 (2)	1 (3)
Director of neurologic ICU[3]			
Neurosurgeon	47 (53)	15 (31)	2 (40)
Critical care physician	19 (22)	14 (29)	3 (60)
General surgeon	11 (13)	9 (19)	0 (0)
Neurologist	4 (4)	4 (8)	0 (0)
Anesthesiologist	3 (3)	1 (2)	0 (0)
Other	4 (5)	5 (11)	0 (0)

[1] n = 411, as 22 hospitals did not know; [2] n = 429, as 4 hospitals did not know; [3] n = 141 hospitals with a neurologic ICU are the denominator.

* $p < 0.0001$; ** $p = 0.0002$.

Statistical Analysis

Data were analyzed with SAS statistical software (SAS Institute, Inc., Cary, NC). The χ^2 statistic was used to evaluate the relationship between trauma center level and presence of a neurologic ICU, specialty of the ICU medical director, presence of a protocol for treating severely head-injured patients, presence of a neurosurgery residency program, source of trauma center designation, and the volume of head-injured patients seen each month. Fisher's exact test was used when cell frequencies were 5 or less.

Polytimous logistic regression[15] was used to evaluate predictors of full compliance versus noncompliance, partial compliance versus noncompliance, and full versus partial compliance. First, univariate analysis was performed for each predictor. Second, a fully saturated model was developed and backwards elimination was used to reduce the model to the final set of predictors of guideline compliance.

The results of this survey were also compared with parallel items from a similar survey we conducted in 1991,[8] reanalyzing the 1991 data when necessary. The two surveys are compared regarding indications for ICP monitoring, partial compliance, and the standard for steroid administration. This comparison was restricted to the 102 trauma centers responding to both surveys.

RESULTS

Of the 924 adult United States trauma centers contacted, 828 centers agreed to participate (89.6%). Among participating centers, 395 centers (47.7%) stabilized brain-injured patients in their emergency room and then transferred them to a higher level care facility. These trauma centers did not receive the complete survey and are excluded from this report. The remaining 433 participating trauma centers admitted patients with severe TBI to their hospital in-patient units and are the focus of this report.

Descriptives

Level I trauma centers accounted for 38% of centers surveyed (n = 165), Level II for 55% (n = 236), and Level III for 7% (n = 32). Across all trauma center levels, the state was the most likely source of trauma center designation (Table 2). Neurologic ICUs were more common at Level I centers (n = 88 [53%]) than Level II (n = 48 [20%]) or Level III centers (n = 5 [16%], $p < 0.0001$). Neurosurgical residency programs were more common in Level I trauma centers (36% for Level I, 3% for Level II, and 0% for Level III, $p < 0.0001$). Level I centers more commonly treated 15 or more patients with severe TBI each month than either Level II or Level III centers (17% for Level I vs. 2% for Level II and 3% for Level III, $p < 0.0001$) (Table 2). Compared with hospitals without neurosurgical residency programs, hospitals with neurosurgical residency programs were more likely to have treatment protocols for severe TBI (64% vs. 41%, $p = 0.001$), a neurologic ICU (62% vs. 27%; $p < 0.0001$), high volume (18% vs. 6%, $p = 0.002$), and to comply with the standard for steroid administration (70% vs. 49%, $p = 0.002$).

Predictors of Compliance with Each Guideline Assessed

Guideline compliance was evaluated according to characteristics of the trauma centers. Compliance with guidelines concerning indications for ICP monitoring was more common in Level I centers (68% for Level I, 40% for Level II, 41% for Level III, $p < 0.0001$), in centers with a neurosurgical residency program (76% vs. 46%, $p < 0.0001$), and in centers with protocols for treating patients with severe TBI (61% vs. 42%, $p = 0.0002$). Compliance with guidelines for ICP treatment threshold was unaffected by all factors studied. The recommended ICP monitoring technology was more often used in centers with a neurologic ICU (67% vs. 57%, $p = 0.05$).

The standard for not administering steroids to treat TBI was more commonly followed in centers with Level I designation (65% for Level I, 46% for Level II, 34% for Level III, $p = 0.0001$), neurosurgical residency programs (70% vs. 49%, $p = 0.002$), treatment protocols (64% vs. 43%, $p < 0.001$), neurologic ICUs (65% vs. 47%, $p = 0.0007$), American College of Surgeons (ACS) verification (68% for ACS, 49% for state, 40% for other, $p = 0.0002$), centers admitting 15 or more patients per month (67% for ≥ 15 patients/mo, 59% for 4–14 patients/mo, 38% for ≤ 3 patients/mo, $p < 0.0001$).

There was a tendency to follow the standard for hyperventilation if hospitals were Level I, had treatment protocols for severe TBI, had neurosurgical residency programs, and had high monthly patient volume; these trends were not statistically significant. The guideline for mannitol use was followed in at least 97% of centers, regardless of their characteristics. Patient volume had no effect on compliance with any of the other guidelines assessed.

Degree of Compliance

Full compliance with guidelines was rare, occurring in only 16% of surveyed centers (Table 3). Partial compliance was also rare, occurring in only 17% of surveyed trauma centers. Noncompliance with guidelines (i.e., a failure to at least follow guidelines concerning indications for ICP monitoring and ICP monitoring technology) was common, occurring in 67% of surveyed trauma centers. Full compliance occurred more commonly among hospitals with Level I designation (26% for Level I, 10% for Level II, 6% for Level III, $p < 0.0001$), a neurosurgery residency program (38% vs. 12%, $p < 0.0001$), treatment protocols (26% vs. 7%, $p < 0.0001$), a neurologic ICU (24% vs. 12%, $p = 0.004$), and ACS verification (23% for ACS, 15% for state, 1% for other, $p = 0.04$). Patient volume was not significantly associated with the degree of guideline compliance ($p = 0.2$).

Table 3 Degree of Compliance with the Guidelines by Characteristics of the Trauma Centers[1]

	Full Compliance (n = 68) (%)	Partial Compliance (n = 75) (%)	Noncompliance (n = 290) (%)
Trauma center level*			
Level I (n = 165)	43 (26)	33 (20)	89 (54)
Level II (n = 236)	23 (10)	35 (15)	178 (75)
Level III (n = 32)	2 (6)	7 (22)	23 (72)
Designation of level***			
American College of Surgeons (n = 114)	26 (23)	17 (15)	71 (62)
State (n = 267)	40 (15)	46 (17)	181 (68)
Other (n = 30)	1 (3)	9 (30)	20 (67)
Neurologic ICU**			
Yes (n = 141)	34 (24)	25 (18)	82 (58)
No (n = 292)	34 (12)	50 (17)	208 (71)
Neurosurgical residency program*			
Yes (n = 66)	25 (38)	16 (24)	25 (38)
No (n = 367)	43 (12)	59 (16)	265 (72)
Treatment protocols*			
Yes (n = 193)	50 (26)	30 (15)	113 (59)
No (n = 240)	18 (7)	45 (19)	177 (74)
Volume each month			
≤3 patients/mo (n = 143)	15 (11)	22 (15)	106 (74)
4–14 patients/mo (n = 253)	46 (18)	45 (18)	162 (64)
≥15 patients/mo (n = 33)	7 (21)	6 (18)	20 (61)
Director of neurologic ICU[2]			
Neurosurgeon	17 (27)	15 (23)	32 (50)
Critical care physician	7 (19)	4 (11)	25 (70)
General surgeon	4 (20)	3 (15)	13 (65)
Neurologist	1 (13)	0 (0)	7 (87)
Anesthesiologist	2 (50)	1 (25)	1 (25)
Other	3 (33)	2 (22)	4 (45)

[1] Full compliance: compliance with guidelines and standards concerning indications for ICP monitoring (i.e., at least 75% of qualified patients receive monitoring), ICP treatment threshold, ICP monitoring technology, hyperventilation, mannitol, and steroids. Partial compliance: compliance with guidelines for indications for ICP monitoring (i.e., at least 75% of qualified patients receive monitoring) and ICP monitoring technology. Noncompliance: other patterns of compliance with the guidelines.

[2] 141 centers with neurologic ICU.

* $p < 0.0001$; ** $p = 0.004$; *** $p = 0.04$.

Predictors of Full Compliance

Tables 4 and 5 describe the predictors of full compliance versus noncompliance, partial compliance versus noncompliance, and full versus partial compliance. In univariate analyses (Table 4), full compliance was significantly more common than noncompliance for centers with Level I designation, treatment protocols, ACS verification, state des-

Table 4 Univariate Polytimous Logistic Regression for Degree of Compliance with the Guidelines

Factor	OR for Full Compliance vs. Noncompliance	95% CI	OR for Partial Compliance vs. Noncompliance	95% CI	OR for Full Compliance vs. Partial Compliance	95% CI
Level I	5.6	1.3–24	1.5	0.33–6.7	4.5	0.89–23
Level II	1.2	0.48–3.1	0.65	0.26–1.6	2.3	0.44–12
Level III	1.0	Referent	1.0	Referent	1.0	Referent
ACS designation	6.9	1.6–31	0.76	0.33–1.7	9.2	1.8–46
State designation	4.2	0.97–18	0.80	0.39–1.7	5.2	1.1–25
Other designation	1.0	Referent	1.0	Referent	1.0	Referent
Neurologic ICU	2.5	1.5–4.4	1.3	0.74–2.2	2.0	1.0–3.9
No neurologic ICU	1.0	Referent	1.0	Referent	1.0	Referent
Neurosurgery residency	6.2	3.2–11.7	2.9	1.4–5.7	2.1	1.0–4.5
No neurosurgery residency	1.0	Referent	1.0	Referent	1.0	Referent
Protocols	4.3	2.4–7.8	1.0	0.62–1.7	4.2	2.0–8.5
No protocols	1.0	Referent	1.0	Referent	1.0	Referent
≥15 patients/mo	2.0	1.1–3.8	1.3	0.76–2.4	1.5	0.69–3.3
4–14 patients/mo	0.64	0.38–1.1	0.83	0.50–1.4	0.76	0.4–1.4
≤3 patients/mo	1.0	Referent	1.0	Referent	1.0	Referent

OR, odds ratio.

ignation, neurologic ICU, neurosurgical residency programs, and high volume. When predictors of compliance were modeled together, only three predictors remained associated with compliance—a neurosurgery residency program, trauma center designation, and treatment protocols (Table 5).

We evaluated the association between degree of compliance and the number of predictors in the final model (trauma center designation, neurosurgery residency program, and treatment protocols). Thirty-five hospitals had no predictors (8%), 197 had one predictor (46%), 160 had two predictors (37%), and 41 had three predictors (9%). Compared with hospitals with none of the above predictors of compliance, hospitals with one predictor were 2.1-fold more commonly fully compliant than noncompliant (95% confidence interval [CI], 0.27–17), hospitals with two predictors were 8.6-fold more commonly fully compliant (95% CI, 1.1–66), and hospitals with three predictors were 38-fold more commonly fully compliant (95% CI, 4.6–319).

Comparison of 1991 and 2000 Survey Results

One hundred two centers were surveyed in 1991 and in 2000. A greater percentage of these centers followed the guideline regarding indications for ICP monitoring in the 2000 survey compared with the 1991 survey (56% in 2000 vs. 45% in 1991, $p > 0.05$). Similarly, partial compliance (ICP monitoring using the recommended technology) rose over time (30% in 1991 and 45% in 2000). Compliance with the standard for steroid administration fell over time (73% in 1991 and 59% in 2000). These numbers are misleading, however, because not all of the centers that were compliant in 1991 remained compliant in 2000 (Table 6). Changes in directors of the neurologic ICU did not explain why centers that were compliant in 1991 were no longer compliant in 2000, because few hospitals had the same ICU directors in 1991 and 2000. When we examined whether there were predictors of being at least partially compliant with guidelines both in 1991 and in 2000, no predictors emerged.

Table 5 Multivariate Polytimous Logistic Regression for Degree of Compliance with the Guidelines

Factor*	OR for Full Compliance vs. Noncompliance	95% CI	OR for Partial Compliance vs. Noncompliance	95% CI	OR for Full Compliance vs. Partial Compliance	95% CI
American College of Surgeons	5.1	1.1–23	0.72	0.31–1.7	7.0	1.4–36
State	2.7	0.61–12	0.75	0.36–1.6	3.7	0.75–18
Other	1.0	Referent	1.0	Referent	1.0	Referent
Neurosurgery residency	5.0	2.6–9.8	2.9	1.5–5.9	1.7	0.79–3.7
No neurosurgery residency	1.0	Referent	1.0	Referent	1.0	Referent
Protocols	3.6	1.9–6.6	0.98	0.58–1.7	3.7	1.8–7.6
No protocols	1.0	Referent	1.0	Referent	1.0	Referent

OR, odds ratio.
* All factors adjusted for the other factors.

Table 6 **Correspondence between 1991 and 2000 Surveys**

Factor	Compliant on Both (%)	Compliant on Neither (%)	Compliant on 1991 but not 2000 (%)	Compliant on 2000 but not 1991 (%)	*p* Value
Indications for ICP monitoring	32 (31)	31 (30)	14 (14)	25 (25)	0.02
Steroids	41 (40)	9 (9)	33 (32)	19 (19)	0.4
Partial compliance*	19 (19)	44 (43)	12 (12)	27 (26)	0.05

* Compliance with guidelines for indications for ICP monitoring (i.e., monitoring in at least 75% of qualified patients) and ICP monitoring technology.

DISCUSSION

This survey demonstrates that there is continued variability in the care of patients with severe TBI. Very little had changed since the 1991 survey,[8] despite the distribution of guidelines to every member neurosurgeon in North America in 1995 by the American Association of Neurologic Surgeons. Most care deviated from published guidelines and only 16% of trauma centers were fully compliant, indicating that the publication and distribution of *Guidelines* per se does not alter medical practice. Nurse managers or nurse clinicians in charge of the ICU responded to this survey and their responses may be inaccurate, leading to an over- or underestimate of guideline compliance. We were unable to evaluate the extent to which the response of nurses to this survey may differ from the response of neurosurgeons or from actual patient data.

Three factors strongly and independently predicted guideline compliance: a neurosurgical residency program, state designation or ACS verification, and treatment protocols. Each of these factors was associated with full compliance versus noncompliance with guidelines (odds ratios ranging from 2.7–5.1). As the number of predictors increased, the likelihood of full compliance also increased. Given the published reports of decreases in mortality and costs and improved outcome with implementation of TBI guidelines,[11–14] what are the possible reasons for, and solutions to, bridging the gap between available scientific evidence-based guidelines and their implementation?

Factors Influencing Guideline Compliance

ICP monitoring in comatose TBI patients is a cornerstone of ICU management that is easy to survey. Such monitoring informs physicians about when to initiate therapies to reduce intracranial pressure, thereby preventing secondary brain injury. ICP monitors, usually placed emergently by neurosurgeons, require attention to minimize technical difficulties, monitor ICP measurements, and implement treatment.

In a survey of 34% of the membership of the American Association for the Surgery of Trauma,[16] reluctance to insert an ICP monitor for patients with isolated TBI was a major problem (44.8% of respondents). This was most common when there were no neurosurgery residents. In our survey, neurosurgery residency programs were strongly associated with full and partial compliance compared with noncompliance. Compared with centers without neurosurgery residency programs, centers with neurosurgery residency programs were more likely to have a Level I designation, a neurologic ICU, treatment protocols, and high patient volume. In trauma centers, increasing TBI patient volume is associated with decreasing mortality.[17]

Other neurosurgical assistants can also help with ICP monitor placement. Kaups et al.[18] have demonstrated that nurse practitioners and physician's assistants can be trained to place ICP monitors successfully. Because the use of midlevel practitioners for ICP monitor placement was not assessed in this survey, the true impact of neurosurgical assistants on *Guideline* compliance may have been underestimated.

In medical settings lacking neurosurgery residents, other neurosurgical assistants, or protocols to standardize nursing response to ICP measurements, ICP management is labor intensive; therefore, ICP monitors are placed infrequently. Similar difficulties are seen in the United Kingdom, where according to senior nursing staff surveyed in 39 ICUs, ICP monitoring was routinely performed in only 49% of ICUs.[19] Managing patients in a setting equipped to handle severe TBI may also contribute to compliance. In our survey, only 33% of patients were managed in a neurologic ICU, similar to the 54% of centers reported in the British survey.[19] Studies have also found protocols improve the care of patients in the intensive care unit.[20–22] In agreement, results of this survey show that protocols increase the likelihood of full compliance 3.7-fold.

The involvement of neurosurgical residents may not only facilitate ICP monitoring but also reduce the use of outdated treatments, such as steroid administration. Although results of randomized clinical trials indicate that steroid therapy does not improve outcome in severe TBI,[23,24] steroids are frequently administered in our survey (48%) and in other countries.[19,25] However, in our survey, there was a significantly higher rate of compliance with the standard for steroid administration in trauma centers with neurosurgery residency programs than in those without such programs (70% vs. 49%, $p = 0.002$).

Another factor that adversely impacts patient outcome is secondary transfer of patients with severe TBI. In a European survey[26] of 67 neurologic centers in 12 countries (1,005 patients over 3 months), 75% of patients in Britain were initially taken to another hospital and subsequently transferred to an appropriate facility, delaying the detection of intracranial mass lesions that may require emergent neurosurgical intervention. Across Europe,[26] there was variability in the frequency of secondary transfer and intracranial operations, and in ICU care. Overall, in our survey, only 45% of patients with severe TBI were admitted directly to a neurologic ICU. Secondary transfer occurred in 395 U.S. trauma centers in our survey (47.7%). Studies[27,28] show a 30% increase in mortality among transferred patients compared with patients admitted directly to a trauma center. Recently published guidelines for the prehospital management of patients with severe TBI recommend direct transport to major trauma centers that have the capability to manage these patients.[29]

Guidelines and Changing Physician Practice

Clinical practice guidelines by themselves have had a limited effect on changing physician behavior.[30] In a review of 120 different surveys investigating 293 potential barriers to physician adherence to guidelines,[30] the most common barriers identified included awareness, familiarity, agreement, self-efficacy, outcome expectancy, ability to overcome the inertia of previous practice, and absence of external barriers to perform recommendations. Systematic reviews of provider change suggest that diverse strategies are necessary to produce practice changes. Handley et al.[31] emphasized two elements they found to be essential when trying to implement clinical guidelines: adequate resource allocation (such as residents to assist with care) and plans for measuring outcomes to allow for continued improvement. Similarly, in our survey, the availability of neurosurgery residents was significantly associated with compliance with the guideline for ICP monitoring.

Studies of intervention trials to improve professional practice usually conclude that standard educational activities such as conferences, workshops, outreach visits, the use of local opinion leaders, and mailings effect little or no changes in health care professional behavior or health outcomes when used alone.[32] Others have suggested that feedback of statistical information was likely to influence clinical practice if the information was presented close to the time of decision making and if it was part of a strategy for decision makers who had agreed to review their practice.[33] Attempting to change physician practice in all trauma centers may be futile because the barrier to improved care may be insurmountable. Instead, it may be more feasible and effective to direct patients with severe TBI to centers with many predictors of compliance. Tracking patient care would provide further quality assurance and feedback for continuous quality improvement.

CONCLUSION

Compliance with scientific evidence-based *Guidelines* for the management of patients with severe TBI is rare in the United States, despite work by others demonstrating that *Guidelines* compliance reduces mortality, improves outcome, decreases length of stay, and reduces in-hospital cost.[11–14] Compliance was strongly influenced by treatment protocols, a neurosurgery residency program, and state designation or ACS verification. Therefore, one solution that also addresses the problem of secondary transfer is to change policy surrounding emergency medical systems to direct all patients with severe TBI to trauma centers known to be *Guideline* compliant. Additionally, multidisciplinary educational programs are needed for medical personnel caring for patients with severe TBI.

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