Guidelines for the Management of Severe Head Injury: Are Emergency Physicians Following Them?

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Abstract

The Brain Trauma Foundation published "Guidelines for the Management of Severe Head Injury" in 1995. These evidence-based clinical guidelines (CGs) recommended against prophylactic hyperventilation and glucocorticoid use and advocated for aggressive blood pressure (BP) resuscitation, and the careful use of mannitol. **Objective:** To survey Michigan emergency physicians (MEPs) to test their adherence to these guidelines. **Methods:** An anonymous mail survey was sent to all 566 MEPs who are members of the American College of Emergency Physicians. Three clinical scenarios involving severe head injury were presented, all with Glasgow Coma Scale (GCS) scores of 8 or less. The physicians were asked to choose from 15 diagnostic and treatment options, which included: intubation and hyperventilation, BP resuscitation, intravenous (IV) mannitol administration, and IV glucocorticoid administration. **Results:** Three hundred nineteen (56%) surveys were returned. Forty-six percent [95% confidence interval (95% CI) = 40% to 51%] of the MEPs elected to use prophylactic hyperventilation; very few administered IV glucocorticoids. Seventy-eight percent (95% CI = 75% to 81%) corrected hypotension with systolic BP < 90 mm Hg; 83% (95% CI = 80% to 86%) also administered mannitol appropriately. **Conclusions:** A majority of MEPs are managing severe head injury patients in accordance with the "Guidelines for the Management of Severe Head Injury," with the exception of avoiding prophylactic hyperventilation. More education and/or exposure to the evidence regarding prophylactic hyperventilation of severely head injured patients may improve adherence to the guidelines. **Key words:** brain; injury; guidelines; hyperventilation; head injury; emergency physicians. ACADEMIC EMERGENCY MEDICINE 2002; 9:806–812.

The Brain Trauma Foundation (BTF) published "Guidelines for the Management of Severe Head Injury" in 1995.[1] A multidisciplinary task force developed these guidelines over a two-year period and the process of development involved a standardized review of 2,941 articles. The final document underwent eight revisions prior to publishing.[2] Importantly, the guidelines recommended against prophylactic hyperventilation, a mainstay of traumatic brain injury (TBI) management for many years, and also recommended against glucocorticoid use for the control of elevated intracranial pressure (ICP). The guidelines advocated for aggressive blood pressure (BP) resuscitation in the face of hypotension (systolic BP less than 90 mm Hg) and the careful use of mannitol in the setting of elevated ICP. The Guidelines received official acceptance by the American Association of Neurological Surgeons (AANS) and were initially disseminated to all AANS members. Later they were published in toto in the *Journal of Neurotrauma*[3] and in part in the *European Journal of Emergency Medicine*.[4] The aspects of the Guidelines that are most relevant to emergency medicine (EM) practice are summarized in Figure 1. To the best of our knowledge, no systematic distribution of the guidelines to emergency physicians (EPs) was ever undertaken. Emergency physicians are in many cases the first physicians to treat severely head-injured patients, and their initial management decisions may dictate care for minutes or perhaps hours, depending on the situation. A survey of neurosurgeons has demonstrated their increased adherence to the evidence-based guidelines since their publication,[5] but, to the best of our knowledge, no information regarding EP acceptance of the guidelines or the evidence professed in them has been published. We developed a survey assessment tool to test severe head injury management practices of Michigan EPs

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1. Resuscitation of Blood Pressure and Oxygenation—Chapter 4
   I. Recommendations
      A. Standards:
         There are insufficient data to support a treatment standard for this topic.
      B. Guidelines:
         Hypotension (systolic blood pressure < 90 mm Hg) or hypoxia (apnea or cyanosis in the field or a PaO_2 < 60 mm Hg) must be monitored and scrupulously avoided, if possible, or corrected immediately.
      C. Options:
         The mean arterial pressure should be maintained above 90 mm Hg throughout the patient's course to attempt to maintain cerebral perfusion pressure (CPP) > 70 mm Hg.
2. The Use of Hyperventilation in the Acute Management—Chapter 9
   I. Recommendations
      A. Standards:
         In the absence of increased intracranial pressure (ICP), chronic prolonged hyperventilation therapy ($PaCO_2 \leq 25$ mm Hg) should be avoided after severe traumatic brain injury (TBI).
      B. Guidelines:
         The use of prophylactic hyperventilation ($PaCO_2 \leq 35$ mm Hg) therapy during the first 24 hours after severe TBI should be avoided because it can compromise cerebral perfusion during a time when cerebral blood flow (CBF) is reduced.
      C. Options:
         Hyperventilation therapy may be necessary for brief periods when there is acute neurologic deterioration or for longer periods if there is intracranial hypertension refractory to sedation, paralysis, cerebral spinal fluid (CSF) drainage, and osmotic diuretics.
3. The Use of Mannitol in Severe Head Injury—Chapter 10
   I. Recommendations
      A. Standards:
         There are insufficient data to support a treatment standard for this topic.
      B. Guidelines:
         Mannitol is effective for control of raised intracranial pressure (ICP) after severe head injury. Limited data suggest that intermittent boluses may be more effective than continuous infusion. Effective doses range from 0.25 g/kg to 1 g/kg.
      C. Options:
         1. The indications for the use of mannitol prior to ICP monitoring are signs of transtentorial herniation or progressive neurological deterioration not attributable to systemic pathology. (However, hypovolemia should be avoided by fluid replacement.)
         2. Serum osmolarity should be kept below 320 mOsm because of concern for renal failure.
         3. Euvolemia should be maintained by adequate fluid replacement. A urinary catheter is essential in the patients.
4. Role of Glucocorticoids in the Treatment of Severe Head Injury—Chapter 12
   I. Recommendations
      A. Standards:
         The use of steroids is not recommended for improving outcome or reducing intracranial pressure (ICP) with patients with severe head injury.
      B. Guidelines: None.
      C. Options: None.

Figure 1. Summary of relevant recommendations from the ''Guidelines for the Management of Severe Head Injury.''[1]

(MEPs) and compared them with the guideline recommendations.

METHODS

Study Design and Participants. This was a survey of practicing EPs in Michigan regarding their management strategies for patients with head trauma. After receiving local institutional review board approval, we solicited the Michigan College of Emergency Physicians (MCEP) for their complete member mailing list, excluding all members in residency status.

The survey instrument was developed with the intent to measure actual clinical practice as opposed to measuring knowledge or attitudes. We believed that presenting clinical scenarios and allowing the physicians to choose their actions would better represent the penetrance of the guidelines, as opposed to simply asking whether the guidelines were known and whether they were used in clinical practice. The respondents were blinded with respect to the purpose of the study by including several diagnostic and treatment options that were outside the scope of interest. These additional options were: intravenous (IV) access and monitor, IV

TABLE 1. Scenario 1: *"A 19-year-old male is brought to the ED via Emergency Medical Services (EMS) with full C-spine precautions. Witnesses state 30 minutes prior he was skateboarding down a stairway without a helmet and fell, striking his head on concrete. His vital signs are BP 84/62, HR 120, RR 14 (regular). He moans and localizes pain, but does not follow commands. His Glasgow Coma Scale (GCS) prior to arrival was 8, currently it is 8. His pupils are equal, round, and reactive."*

Diagnostic/Treatment Option	Percentage Selecting	(95% CI)
ET intubation—target PCO_2 35–40 torr	38%	(34%, 41%)
ET intubation—target PCO_2 25–34 torr	39%	(35%, 42%)
ET intubation—target PCO_2 20–25 torr	7%	(5%, 9%)
Intubation not performed	16%	(14%, 19%)
Immediate BP resuscitation	78%	(75%, 81%)
IV mannitol	8%	(6%, 10%)
IV glucocorticoids	8%	(6%, 10%)

ED = emergency department; C-spine = cervical spine; BP = blood pressure; HR = heart rate; RR = respiratory rate; ET = endotracheal; PCO_2 = partial pressure of carbon dioxide; IV = intravenous.

TABLE 2. Scenario 2: *"A middle-aged woman is brought to the ED via EMS with full C-spine precautions. A witness states she was flying in a small private plane when it apparently lost power and made an emergency landing in a farmer's field. The witness states the aircraft struck the ground and then tumbled violently several times. The woman's vital signs are BP 100/80, HR 90, RR 20 (regular). She is verbally unresponsive and localizes to pain. Her Glasgow Coma Score prior to arrival was 7, currently it is 7. Her pupils are equal, round, and reactive."*

Diagnostic/Treatment Option	Percentage Selecting	(95% CI)
ET intubation—target PCO_2 35–40 torr	42%	(39%, 46%)
ET intubation—target PCO_2 25–34 torr	41%	(38%, 45%)
ET intubation—target PCO_2 20–25 torr	5%	(4%, 7%)
Intubation not performed	12%	(10%, 14%)
Immediate BP resuscitation	22%	(19%, 25%)
IV mannitol	5%	(3%, 7%)
IV glucocorticoids	4%	(2%, 5%)

ED = emergency department; EMS = emergency medical services; C-spine = cervical spine; BP = blood pressure; HR = heart rate; RR = respiratory rate; ET = endotracheal; PCO_2 = partial pressure of carbon dioxide; IV = intravenous.

naloxone, IV glucose, type and cross, complete blood count with differential, portable chest radiograph, portable cervical spine radiograph, non-contrast head computed tomography (CT), and seizure prophylaxis.

Survey Content and Administration. The survey presented three clinical scenarios (Tables 1–3). Each scenario presented a patient with a stable but low Glasgow Coma Scale (GCS) score and a mechanism of traumatic injury compatible with severe head injury. The first two scenarios presented patients without any overt signs of increased ICP or reason to suspect impending herniation. In these two scenarios, the guidelines clearly recommend intubation with a target partial pressure of carbon dioxide (PCO_2) of 35–40 torr. Scenario 1 also included hypotension with systolic BP < 90 mm Hg and, again, the guidelines clearly recommend immediate BP resuscitation. Scenario 3 presented a patient with clinical signs and CT findings of elevated ICP and, in this case, the guidelines recommend mannitol administration. Since this scenario described a less-stable patient with evidence of high ICP, the use of hyperventilation was not considered to violate the guidelines. All three of the scenarios offered IV glucocorticoid administration as an option, even though glucocorticoids are not indicated for any of the presented patients. In review, the correct answers were: scenario 1, intubation without hyperventilation, BP resuscitation, and no glucocorticoid use; scenario 2, intubation without hyperventilation and no glucocorticoid use; and scenario 3, intubation with or without hyperventilation, mannitol use, and no glucocorticoid use.

The demographics portion of the survey instru-

TABLE 3. Scenario 3: *"A 25-year-old male is brought to the ED via EMS with full C-spine precautions. The patient was an unrestrained, intoxicated driver in a rollover MVA. His vital signs are BP 120/80, HR 100, RR 20 (regular). He is verbally unresponsive with symmetric decorticate rigidity noted. A head CT scan shows loss of the basal cisterns and cortical effacement consistent with elevated intracranial pressure. His Glasgow Coma Scale prior to arrival was 5, currently it is 5. His pupils are sluggish, but equal, round, and reactive."*

Diagnostic/Treatment Option	Percentage Selecting	(95% CI)
ET intubation—target PCO_2 35–40 torr	19%	(16%, 22%)
ET intubation—target PCO_2 25–34 torr	65%	(61%, 68%)
ET intubation—target PCO_2 20–25 torr	16%	(13%, 19%)
Intubation not performed	0%	—
Immediate BP resuscitation	6%	(5%, 8%)
IV mannitol	83%	(80%, 86%)
IV glucocorticoids	14%	(12%, 16%)

ED = emergency department; EMS = emergency medical services; C-spine = cervical spine; MVA = motor vehicle accident; BP = blood pressure; HR = heart rate; RR = respiratory rate; CT = computed tomography; ET = endotracheal; PCO_2 = partial pressure of carbon dioxide; IV = intravenous.

TABLE 4. Demographics of the Respondents

Practice setting	
Academic center	28%
Community hospital < 40,000 ED census	35%
Community hospital ≥ 40,000 ED census	37%
Group organization	
Salaried hospital employee	28%
Hospital consultants	9%
Group contract with 1 location	27%
Group contract with >1 location	44%
Certifications	
ABEM- or AOBEM-certified or -eligible	90%
Board-certified (other than EM)	15%
Not board-certified	2%
Completed an EM residency	40%
Year of last residency training	1955–1999 (mean 1986)

ED = emergency department; ABEM = American Board of Emergency Medicine; ABOEM = American Board of Osteopathic Emergency Medicine; EM = emergency medicine.

TABLE 5. Methods of Continuing Medical Education (CME)

Textbooks	55%
National or regional seminars	83%
Local seminars	67%
Audiotapes	37%
Electronic media (other than audiotapes)	22%
Average weekly Internet usage	0–40 hr (mean 6 hr)
Percentage who own an Internet-capable computer	94%

ment gathered information regarding practice location, practice organization, postgraduate training, continuing medical education (CME) methods, and Internet usage.

Survey validation. The survey was initially tested within a local EM resident physician population to check for perceived defects in clinical presentation or treatment options. Criterion validity was then established with a controlled study in which 20 fourth-year medical students were randomized to receive either: A) the survey with pertinent chapters from the guidelines or B) the survey with irrelevant reading material. Group A performed significantly better on the survey (91% correct versus 66% correct, $p < 0.01$), demonstrating a strong association between knowledge of the guidelines and performance on the survey.

Survey dissemination. An anonymous survey with an introductory letter was sent to all MEPs on our mailing list. The first surveys were sent in November 1999. Approximately three weeks later, the same group also received a reminder letter. Approximately 60 days after the initial mailing, all nonrespondents received a second survey instrument with an accompanying introductory letter. The survey responses were collected until March 2000.

Data Analysis. Point estimates were calculated for treatment options for each scenario. Proportions and 95% confidence intervals (95% CIs) were calculated considering the MCEP member list as the population with $n = 566$ and sample = 319. Chi-square analysis was used to determine whether clinical management was associated with practice setting, group organization, training, or CME methods. In analyzing practice setting, community hospitals with more than 40,000 ED patient visits per year were combined with those with less than 40,000 visits per year in instances in which there was a negligible difference between the groups. A pre-study power analysis determined that a sample size of 300 subjects would have a power of > 0.90 to detect a 15% difference between respondent groups (alpha = 0.05).

RESULTS

Five of the original 573 mailing addresses were returned as undeliverable with no forwarding address, one was returned by an office-based physician, and one was returned by a pediatric EP. All remaining 566 members were eligible to receive the survey. Three hundred nineteen (56%) completed surveys were returned. Of those, three lacked demographic data, and therefore 316 surveys were available for performing the demographic analysis.

Table 4 contains the demographic information. A majority of our respondents worked at community hospitals as opposed to academic centers. The respondents' group organization paralleled the distribution found in the practice settings. Most respondents were American Board of Emergency Medicine (ABEM)- or American Board of Osteopathic Emergency Medicine (ABOEM)-certified or -eligible, and almost 40% had completed an EM residency. Eighty-nine percent had completed their last residency in or before 1995, the year in which the guidelines of interest were published. Table 5 provides the different types of CME methods in use by our respondents, with almost 90% of them indicating they attend national or regional seminars.

Tables 1–3 represent the relevant answer distribution for clinical scenarios 1–3, respectively. The skateboarding patient in Table 1 was intubated and hyperventilated to varying degrees by almost 45% of our respondents. If we exclude those respon-

dents who chose not to intubate this patient, the remaining who did intubate used hyperventilation to $PCO_2 < 35$ torr 54.2% of the time. Approximately four out of five respondents elected to resuscitate this patient's BP in accordance with the guidelines. Very few administered IV mannitol or IV glucocorticoids.

The plane crash victim in Table 2 was treated in a similar manner to the previous patient. Although this patient was intubated more often, nearly the same proportions fell into each category of hyperventilation. Compared with treatment of the previous patient, very few physicians resuscitated BP and, again, almost no one administered IV mannitol or IV glucocorticoids.

The third patient in Table 3, who was intoxicated and involved in a rollover motor vehicle collision, was treated differently from the previous two. Respondents almost unanimously intubated this patient, and a clear majority used hyperventilation. This clinical scenario was deemed too short to effectively estimate the chances of herniation and, therefore, this patient was not used to assess adherence in our analysis of hyperventilation. Significantly, whereas IV mannitol usage was minimal in the previous scenarios, almost 83% of the survey respondents elected to administer mannitol in this scenario, in accordance with the guidelines. The use of IV glucocorticoids in this case remained low but did represent an increase from the previous two patients.

Comparisons of the different demographic groups revealed that EPs at academic centers were more likely to intubate and not hyperventilate (53% vs. 37%), resuscitate BP (89% vs. 74%), and withhold glucocorticoids (7% vs. 14%) in the three scenarios presented. Interestingly, the group of physicians most likely to intubate and use prophylactic hyperventilation were those who completed an EM residency (53% vs. 35%).

DISCUSSION

The goal of this study was to determine the management practices of a statewide population of EPs regarding severely head-injured patients and compare those practices with the published evidence-based guidelines. Emergency medicine is a specialty with a broad practice base. In some cases practice recommendations and guidelines that apply to emergency care are developed by other specialty groups or organizations with a variable amount of involvement from EPs. The dissemination of information from practice guidelines is also variable. Many of the recommendations made in the "Guidelines for the Management of Severe Head Injury" relate directly to out-of-hospital and emergency care of the TBI patient. However, the initial distribution of guidelines by the BTF was only to neurosurgeons, and other physicians who wanted a copy of the guidelines had to pay a fee to the BTF. The guidelines were published in the *Journal of Neurotrauma*, a publication that is not widely read by EPs.[3]

In 1991, Ghajar et al.[6] conducted a survey study of neurosurgical management practices. The study found that neurosurgeons' management practices for TBI patients varied widely, were not evidence-based, and relied heavily on prophylactic hyperventilation and the use of steroids to help control elevated ICP. The results of this study became the impetus for the development of the "Guidelines for the Management of Severe Head Injury."

In 1997, Marion and Spiegel conducted a follow-up survey[5] that demonstrated a shift in neurosurgical management practices. Whereas 83% of neurosurgeons formerly practiced prophylactic hyperventilation, only 36% continued to do so. Furthermore, the 64% who used steroids for elevated ICP had changed to only 19%. Ninety-seven percent of the neurosurgeons also agreed that cerebral perfusion pressure should be maintained above 70 mm Hg whenever possible. These significant changes in management were noted after the guidelines were published in toto in the *Journal of Neurotrauma*[3] and after all members of the AANS received an individual copy of the completed guidelines. As mentioned previously, no directed dissemination of the guidelines to EPs was ever undertaken. Our survey revealed similar management practice patterns within the EP ranks as compared with the survey of neurosurgeons by Marion and Spiegel. Eighty percent of MEPs immediately resuscitated the hypotensive patient in scenario 1, and steroids were used only on average 9% of the time in the three survey scenarios. The MEPs did use prophylactic hyperventilation 46% of the time in scenarios 1 and 2, which is higher than the 36% of neurosurgeons who reportedly use prophylactic hyperventilation in the first several days following injury.

It appears that even in the setting of less-than-optimal distribution of the guidelines, EPs are managing patients in a similar fashion to most neurosurgeons. However, almost one half of the EPs used prophylactic hyperventilation on patients inappropriately, and almost one fifth failed to resuscitate BP or use mannitol when indicated, based on the guidelines. The fact that EM residency-trained physicians (the great majority of whom trained when prophylactic hyperventilation was considered stan-

dard treatment for TBI) were more likely to use prophylactic hyperventilation than non-EM residency-trained physicians may suggest that it is difficult to modify practice once it has been learned in residency.

The results of this study suggest that further education in and dissemination of TBI guidelines are needed. However, since neurosurgeons and EPs display very similar rates of adherence to the guidelines despite a significant difference in dissemination to the two groups, the importance of formal dissemination is called into question. It is possible that in the four-year time period between the publication of the guidelines and the administration of this survey study, the basic information in the guidelines had filtered its way into EM education, both in the graduate medical education arena and in CME. Our survey found that 83% of EPs attend national or regional seminars, 37% use audiotapes, and 94% own an Internet-capable computer. Fifty-five percent of our respondents used textbooks for CME. However, the best way to effectively disseminate information to a geographically and educationally diverse group of physicians has not been clarified.

A recent advance in publishing and maintaining free textbooks online may decrease the amount of outdated information maintained in our emergency departments and offices, but the acceptance and routine use of these information sources have yet to be proven. The Cochrane Library represents a collection of evidence-based reviews of the literature, but use of this resource is likely to be low outside of academic circles. Clearly there are multiple sources of information available, but there is currently no consistent method to reach all EPs when important guidelines become available. ABEM has recently committed to a continuous certification process whereby maintaining certification requires the completion of annual modules. Incorporation of accepted guidelines, such as the ''Guidelines for the Management of Severe Head Injury,'' into these CME modules may improve penetrance.

LIMITATIONS

Our study was limited in several respects. The survey sample consisted of only Michigan ACEP members, leaving out those affiliated with other organizations. Also, any survey that falls short of a 100% response rate suffers from nonresponse bias. However, our response rate of 56% is higher than the average response rate of 54% for surveys of physicians.[7] One could argue that a traditional chart review might better document the actual practice of EPs in caring for patients with severe head injury. However, we believed that this partially blinded survey design would more accurately reflect the intent of EPs' management. A chart review method of assessing clinical management is subject to reviewer bias, recording errors, errors of omission, illegibility, and other problems that we were able to avoid with the survey instrument. Another limitation in the study is the lack of data from nonrespondents. The survey was designed and conducted in a manner that allowed for complete anonymity of our respondents, and demographic data were not available from the master list of physicians who received the survey. The comparisons made with Marion and Spiegel's survey required extrapolation, as the same questions were not asked of both groups. Lastly, the applicability of this study to all EPs may be called into question given that EPs in only one state were surveyed. We believe the large number of respondents from varied clinical practice settings helps mitigate any bias imposed by our single state selection.

CONCLUSIONS

The Brain Trauma Foundation has continued to be involved in development of guidelines that relate to emergency care of patients with TBI. They recently released an update to ''Guidelines for the Management of Severe Head Injury'' entitled ''Management and Prognosis for Severe Traumatic Brain Injury,[8] as well as the ''Guidelines for Prehospital Management of Traumatic Brain Injury.''[9] None of the guideline recommendations studied with our survey have significantly changed. The results of our study suggest that emergency physicians can demonstrate practice compliance with clinical guidelines, but that this is not necessarily related to effective dissemination, distribution, and teaching of evidence-based guidelines.

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