ORIGINAL ARTICLE

Survey of Management of Severe Head Injury in Canada

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ABSTRACT: ***Objective:*** To determine: 1. the degrees of consensus and disagreement among Canadian critical care clinicians regarding the appropriateness (benefit exceeding risk) of common therapeutic manoeuvres in patients with severe closed head injury (CHI), and 2. the frequency with which clinicians employed these manoeuvres. ***Methods:*** The study design was a systematic scenario-based survey of all neurosurgeons and critical care physicians treating patients with severe CHI in Canada. ***Results:*** In the scenario of acute epidural hematoma with mass effect, respondents agreed very strongly that surgery was appropriate. Clinicians reported mannitol and hypertonic saline as appropriate. Beyond these two interventions, agreement was less strong, and the use of the extraventricular drain (EVD), phenytoin, cooling, hyperventilation, nimodipine, and jugular venous oximetry (JVO) were of uncertain appropriateness. Steroids were considered inappropriate. In a scenario of diffuse axonal injury (DAI), clinicians agreed strongly that fever reduction, early enteral feeding, intensive glucose control, and cerebral perfusion pressure (CPP)-directed management were appropriate. The use of mannitol, hypertonic saline, EVD, JVO, narcotics and propofol were also appropriate. Neuromuscular blockade, surgery, and hyperventilation were of uncertain appropriateness. The appropriateness ratings of the interventions considered in the scenario of an intracranial contusion mirrored the DAI scenario. In general, correlations between the reported appropriateness and frequency of use of each intervention were very high. An exception noted was the use of the JVO. The correlation between CPP-guided therapy and the use of the EVD was weak. ***Conclusions:*** This survey has described current practice with regard to treatment of patients with severe CHI. Areas of variation in perceived appropriateness were identified that may benefit from further evaluation. Suggested priorities for evaluation include the use of osmotic diuretics, anticonvulsants, and intracranial manometry.

RÉSUMÉ: Enquête sur le traitement du traumatisme cérébral sévère au Canada. ***Objectif :*** Nous voulions déterminer le degré de consensus ou de désaccord entre les médecins réanimateurs concernant la pertinence (bénéfices/risques) de traitements couramment utilisés dans la prise en charge des traumatismes crâniens fermés sévères (TCF) et la fréquence d'utilisation de ces traitements. ***Méthodes :*** Nous avons effectué une enquête systématique basée sur des scénarios auprès de tous les neurochirurgiens et médecins réanimateurs qui traitent des patients atteints de TCF au Canada. ***Résultats :*** Les répondants étaient fortement d'accord que la chirurgie était indiquée chez les patients porteurs d'un hématome épidural aigu avec effet de masse. Les médecins réanimateurs considéraient que le mannitol et le salin hypertonique étaient des traitements appropriés. Au-delà de ces deux interventions, le consensus était moins marqué, particulièrement quant à l'utilisation du drain extraventriculaire (DEV), de la phénytoïne, de l'hypothermie, de l'hyperventilation, de la nimodipine et de l'oxymétrie veineuse par voie jugulaire (OVJ). L'administration de stéroïdes était considérée comme inappropriée. En ce qui concerne le traumatisme axonal diffus (TAD), les médecins réanimateurs considéraient comme très appropriés une diminution de la fièvre, une alimentation entérale précoce, un contrôle glycémique serré et le rétablissement ou le maintien de la pression de perfusion cérébrale. L'utilisation du mannitol, du salin hypertonique, du DEV, de l'OVJ, des narcotiques et du propofol étaient aussi considérées comme appropriées. La pertinence de l'utilisation de substances myorésolutives, de la chirurgie et de l'hyperventilation étaient considérées comme incertaines. Les taux de pertinence des interventions envisagées dans le scénario d'une contusion intracrânienne reflétaient le scénario du TAD. En général, les corrélations entre la pertinence rapportée et la fréquence d'utilisation de chaque intervention étaient très élevées, à l'exception de l'utilisation de l'OVJ. La corrélation entre le traitement guidé par la pression de perfusion cérébrale et l'utilisation du DEV était faible. ***Conclusions :*** Cette enquête décrit les pratiques en vigueur dans le traitement des patients présentant un TCF. Nous avons identifié des variations dans la perception de la pertinence de certains traitements qui pourraient faire l'objet d'une évaluation plus poussée. Nous suggérons les priorités d'évaluation suivantes: l'utilisation de diurétiques osmotiques, d'anticonvulsivants et de la manométrie intracrânienne.

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Severe closed head injury (CHI) is a significant clinical and public health problem, with the Canadian incidence estimated at 11.4 per 100000.[1] The frequency of use, perceived appropriateness, and effectiveness of preventive and therapeutic interventions for severe CHI remain unknown.[2,3] Although guidelines for the treatment of severe CHI exist,[4] some investigations have suggested that more aggressive treatment is

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associated with better outcomes.[5] Variation among clinicians in treatment of severe CHI may derive from uncertainty associated with the relative weakness of the supporting evidence.[3,4,6] Consequently, a substantial portion of clinical practice with severe CHI may be supported by consensus on 'usual practice', either by clinician or institution, leading to practice variation.

The purpose of this investigation was to determine:
1. the degree of consensus among Canadian clinicians regarding the appropriate management of patients with severe CHI
2. the frequency with which clinicians employed common therapeutic manoeuvres

Methods

The sampling frame was a census of neurosurgeons and critical care physicians treating patients with severe CHI in Canada. The study design was a systematic survey of all physicians in the census. Approval for this study was obtained from the University of Alberta Health Research and Ethics Board. Since this was a self-completed survey, consent was implied by survey response. The voluntary nature and study purpose were described in the survey cover letter.

The Canadian Hospitals Directory was reviewed to identify all Canadian hospitals. The administration of each hospital was contacted by telephone to verify whether patients with severe CHI were admitted and treated, or generally transferred. The heads of the hospital intensive care unit (ICU) and department of neurosurgery (NS) were also identified. In all hospitals where patients with severe CHI were admitted and treated, the ICU and NS heads were contacted by telephone or electronic mail (email) to identify all critical care physicians and neurosurgeons directly involved in treating patients with severe CHI. These physicians became the sampling frame of the study.

Item generation for the survey consisted of a comprehensive Medline search of all articles published between 1966 and November 2004. Item reduction was performed by a panel of ten experts in head injury management, including five experts each in ICU and NS, in order to eliminate bizarre items (e.g. herbal therapy) and those of historical interest only, and to ensure the otherwise comprehensive nature of the items. The survey was based on scenarios that were intended to suggest an acute traumatic epidural hematoma (EPI), diffuse small vessel and subarachnoid hemorrhage (DAI), and intracranial contusion (IC) (Appendix I). The survey was pilot-tested and retested on the group of experts, and the kappa correlation coefficient was calculated for each response. Responses with a test-retest kappa of 0.75 or less were removed.

The final survey was mailed to each physician of the sampling frame on January 30, 2005. The survey was announced to the head of ICU and NS at each site by fax and email, with suggestions to encourage response. Non-responders to the first mailing were sent a follow-up letter and survey on February 28, 2005. A third mailing was sent to persistent non-responders on March 30, 2005. Contact with non-responders to the first two mailings was attempted by telephone and email during April 2005.

Survey responses were tabulated and analysed using SAS® (Cary, NC). Descriptive and analytic statistics were employed, using parametric and non-parametric methods as appropriate. The Bonferroni correction for multiple comparisons was applied as appropriate.

Survey responses were analysed by a priori grouping of appropriateness and frequency scores into three main categories in order to facilitate the summary. Appropriateness scores were reported as raw scores, and then grouped for each intervention to describe them as appropriate (5.0 to 7.0), inappropriate (1.0 to 2.9), and uncertain appropriateness (3.0 to 4.9). Similarly, frequency scores were reported as raw scores, and were also grouped as frequent/always (3.7 to 5.0), rare/never (1.0 to 2.3), and occasional (2.4 to 3.6). The frequency scores were inverted between the survey and the report in order to facilitate interpretation (e.g. 1 became 5, 2 became 4, etc.).

Results

Thirty-one hospitals in Canada were identified where patients with severe CHI were admitted and treated. At these sites, 247 physicians, including 99 neurosurgeons and 148 critical care physicians, were identified as attending on these patients. Responses were received from 29 of the 31 sites surveyed (both of the non-responding sites were in Quebec). Responses were received from 59 NS and 82 ICU physicians, totalling 141 responses (57% overall response rate).

Considering the demographic characteristics of respondents (Table 1), the majority of respondents were male (90.8%) and younger than age 40 (43.9%). Respondents had been in practice for an average of 11.9 years. Most ICUs were 'closed' (57.3%) and included an average of 19 beds, which were occupied by

Table 1: Descriptors of Response Group

Unit Model		Practice Type	
Open	3 (2.2%)	Neurosurgery	59 (38.6%)
Open, consultative	32 (23.2%)	ICU Physician	94 (61.4%)
Closed, consultative	24 (17.4%)	ICU Patient Groups	
Closed	79 (57.3%)	Surgical	1 (0.7%)
Age Groups		Neurosciences	16 (11.4%)
< 40	62 (43.9%)	Trauma	2 (1.4%)
40-49	40 (28.3%)	Mixed	122 (86.5%)
50-59	27 (19.2%)	Patient Ages	
> 60	12 (8.5%)	Adults Only	106 (75.2%)
Gender		Adults and Children	35 (24.8%)
Male	128 (90.8%)	Residents	
Female	13 (92.%)	Yes	111 (78.7%)
Certification		No	30 (21.3%)
General License Only	1	Referral Pattern	
Family Practice	0	Secondary	8 (5.7%)
Specialty	134	Tertiary	132 (94.3%)
Other	6	Patients Ventilated	
Hospital Size		< 25%	2 (1.4%)
100 – 400 beds	40 (24.2%)	26 – 50%	20 (14.4%)
400 – 750	76 (55.5%)	51 – 75%	47 (33.8%)
> 750	21 (15.3%)	> 76%	70 (50.4%)
City Population		Estimated Incidence	
< 50000	1 (0.7%)	Increased	24 (17.5%)
50000 – 100000	12 (8.6%)	Decreased	51 (37.2%)
100000 – 250000	36 (25.7%)	Same	62 (45.2%)
250000 – 500000	21 (15.0%)	Other Descriptors	
> 500000	70 (50%)	Years in Practice	11.9 (9.2)
Estimated Survival		Beds in ICU	18.9 (8.8)
Increased	78 (56.9%)	Multitrauma/year	160.3 (165.3)
Decreased	1 (0.7%)	Severe head injury/year	81.7 (78.2)
Same	58 (42.3%)		

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Table 2: Summary Ranking of Interventions Appropriateness (Mean Score)

Appropriateness	EPI	DAI	IC
Appropriate (5.0-7.0)	Surgery 6.9 Mannitol 5.6	Fever Reduction 6.3 Early Feeding 6.1 Glucose Control 6.1 CPP-guided Tx 6.0 Mannitol 5.6 Hypertonic Saline 5.4 Propofol 5.4 JVO 5.3 EVD 5.3 Narcotics 5.3	Early Feeding 6.3 Glucose Control 6.3 Fever Reduction 6.2 CPP-guided Tx 5.9 Mannitol 5.6 EVD 5.5 Hypertonic Saline 5.5 Narcotics 5.5 JVO 5.3 Propofol 5.3
Uncertain (3.0-4.9)	Hypertonic Saline 4.9 Phenytoin 4.8 JVO 4.6 Cooling 4.6 Hyperventilation 4.4 EVD 4.4 Nimodipine 3.8	NMB 4.7 Hyperventilation 3.7 Surgery 3.6	Surgery 4.9 NMB 4.8 Hyperventilation 4.0
Inappropriate (1.0-2.9)	Steroids 2.6		

'adults only' in most cases (75.2%). The average hospital was between 400 and 750 beds (55.5%) and located in a city of more than 500000 (50%). Respondents estimated the incidence of head injury to be stable or decreasing (82.4%), with a stable or increasing survival (57.5%).

Appropriateness data are summarized by their a priori groupings according to scenario in Table 2 as appropriate, uncertain appropriateness, and inappropriate. Frequency data are similarly summarized in Table 3 as frequent, occasional, and infrequent.

From Table 2, clinicians agreed very strongly that EPI required surgery (6.9 (range 6.7 – 7.0)). (Data are described as means (+/- standard deviation) unless otherwise indicated.) Clinicians reported mannitol as appropriate for EPI (5.6 (1.3)), and appeared to consider hypertonic saline as appropriate (4.9 (1.7)). Beyond these two interventions for EPI, agreement was less strong, and the use of the extraventricular drain (EVD), phenytoin, cooling, hyperventilation, nimodipine, and jugular venous oximetry (JVO) were of uncertain appropriateness. Steroids (2.6 (1.1)) were considered to be inappropriate for EPI.

Table 3: Summary Ranking of Interventions Frequency (Mean Score)

Frequency	EPI	DAI	IC
Frequent/ Always (3.7 – 5)	Surgery 4.7 Mannitol 3.8	Fever Reduction 4.7 Early Feeding 4.7 Glucose Control 4.5 CPP-guided Tx 4.4 Mannitol 3.9 Narcotics 3.9	Fever Reduction 4.7 Early Feeding 4.6 Glucose Control 4.6 CPP-guided Tx 4.3 Mannitol 3.9 Narcotics 3.9
Occasional (2.3 – 3.7)	Phenytoin 3.2 Hyperventilation 3.0 EVD 2.9 Cooling 2.9 Hypertonic Saline 2.2	Propofol 3.7 EVD 3.7 NMB 2.9 Hyperventilation 2.8 Hypertonic Saline 2.7	Propofol 3.7 EVD 3.6 Surgery 3.1 NMB 2.9 Hyperventilation 2.8 Hypertonic Saline 2.7
Rare/Never (1.0 - 2.3)	Hypertonic Saline 2.2 JVO 1.6 Nimodipine 1.2 Steroids 1.2	Surgery 2.2 JVO 1.7	JVO 1.8

When DAI was considered (Table 2), clinicians agreed strongly that fever reduction (6.3 (0.8)), early enteral feeding (6.1 (1.0)), intensive glucose control (6.1 (0.9)), and cerebral perfusion pressure (CPP)-directed management (6.0 (0.9)) were appropriate. The use of mannitol (5.6 (1.0)), hypertonic saline (5.4 (1.1)), the EVD (5.3 (1.4)), and the JVO (5.3 (1.3)) were also appropriate, as were the use of narcotics (5.3 (1.4)) and propofol sedation (5.4 (1.1)). Neuromuscular blockade (4.7 (1.4)), surgery (3.6 (1.7)), and hyperventilation (3.7 (1.7)) were of uncertain appropriateness. No intervention was described as inappropriate.

The appropriateness ratings of the interventions considered for treatment of IC were very similar in direction and degree to DAI (Table 2).

Comparing the reported appropriateness of each intervention by neurosurgeons and intensive care physicians (data not shown), neurosurgeons were significantly more likely to report the use of surgery and mannitol as appropriate for EPI ($p = 0.0001$ for both), although both groups agreed that these interventions were appropriate. In the treatment of DAI and IC, both groups were similar in reported appropriateness of most interventions. However, ICU physicians reported using early enteral feeding and intensive glucose control more frequently than neurosurgeons for both DAI and IC ($p < 0.001$).

Considering the reported frequency of use of the interventions in EPI (Table 3), surgery and mannitol were reported as very frequently used (4.7 (0.6) and 3.8 (0.9) respectively). Interventions that were used occasionally in selected patients included phenytoin (3.2 (1.4)), hyperventilation (3.0 (1.0)), the EVD (2.9 (1.1)), and cooling (2.9 (1.1)). Hypertonic saline (2.2 (1.1)), steroids (1.2 (0.5)), nimodipine (1.2 (0.6)), and JVO (1.6 (0.7)) were reported as rarely if ever used.

The reported frequency of use of interventions among patients with DAI and IC were similar (Table 3). Frequently used interventions included early enteral feeding, fever reduction, intensive glucose control, and CPP-guided therapy. Interventions that were employed in selected patients included the EVD, mannitol, hyperventilation, hypertonic saline, neuromuscular blockade, and sedation with propofol or narcotics. Surgery was rarely used in DAI, but was occasionally used in patients with IC. The JVO was reported as rarely used for patients with either DAI or IC.

In Tables 4, 5, and 6, the correlations between the reported appropriateness and frequency of use of each intervention were considered in EPI, DAI, and IC. In general, the correlations were very high ($p < 0.0001$) between each intervention and itself. An exception noted was the use of the JVO, which was reported to be appropriate more frequently than it was actually used in each of the scenarios. Close correlations were noted between the reported appropriateness and frequency of use of mannitol and hypertonic saline, and generally between early enteral feeding and intensive glucose control As well, CPP-guided therapy correlated closely with the recommendation and use of mannitol. Surprisingly, the correlation between CPP-guided therapy and the use of the EVD was weak. Although clinicians reported intensive insulin therapy to be appropriate, the correlation with its frequency of use was very weak. Otherwise, few positive correlations between reported appropriateness and frequency of use were noted.

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Table 4: Correlations of Appropriateness and Frequency of Use of Interventions: Epidural Hematyoma

	Appropriateness (R, p value)					
Frequency	Surgery	EVD	JVO	Hyperventilation	Hypertonic Saline	Mannitol
Surgery	0.32 0.0001	-0.09 0.32	-0.15 0.09	-0.07 0.43	0.17 0.04	0.01 0.89
EVD	-0.17 0.05	0.66 0.0001	0.23 0.007	-0.22 0.01	0.25 0.004	0.005 0.95
JVO	-0.20 0.02	0.24 0.005	0.13 0.12	-0.10 0.23	0.18 0.03	-0.05 0.60
Hyperventilation	0.10 0.25	-0.11 0.19	-0.20 0.02	0.64 0.0001	0.03 0.73	0.28 0.001
Hypertonic Saline	-0.07 0.44	0.23 0.006	0.05 0.55	-0.14 0.10	0.39 0.0001	0.08 0.37
Mannitol	0.12 0.15	0.03 0.16	-0.13 0.14	0.23 0.007	0.25 0.004	0.53 0.0001

Table 5: Correlations of Appropriateness and Frequency of Use of Interventions: Diffuse Axonal Injury

	Appropriateness (R, p value)					
Frequency	Surgery	EVD	CPP-guided Tx	Hypertonic Saline	Mannitol	Early Feeding
Surgery	0.59 0.0001	0.05 0.51	0.15 0.09	0.03 0.73	0.06 0.51	-0.04 0.64
EVD	0.18 0.03	0.73 0.0001	0.14 0.09	0.03 0.75	-0.04 0.65	-0.06 0.50
CPP-guided Tx	0.07 0.43	0.07 0.43	0.47 0.0001	0.04 0.67	0.29 0.0007	0.24 0.004
Hypertonic Saline	0.05 0.57	-0.004 0.96	0.09 0.28	0.10 0.25	0.13 0.12	0.02 0.84
Mannitol	0.05 0.55	-0.10 0.26	0.37 0.0001	0.37 0.0001	0.64 0.0001	0.08 0.36
Early Feeding	0.17 0.05	0.02 0.79	0.13 0.12	0.05 0.53	-0.04 0.66	0.53 0.0001

Discussion

In this Canadian cross-sectional survey of intensive care physicians and neurosurgeons that treat patients with severe closed head injury, 57% of eligible respondents replied (141 of 247). These physicians replied from 29 of 31 sites identified in Canada as receiving and treating patients with severe CHI. Consequently, this survey provides a broad examination of the Canadian management of patients with severe CHI.

With its scenario-based design (Appendix 1), areas of agreement, disagreement, and uncertainty were identified. The scenarios represented acute and subacute situations of patients with severe CHI, which represented most of those realistically available. Certain therapies were considered by the expert panel as to be so simple or sensible (e.g. head kept in neutral alignment with neck, elevation of head of bed) that testing in a survey would have been redundant, and were not offered as options. Other promising manoeuvres such as microdialysis assessment remain primarily investigational, and were not entered on the survey.[7] Conversely, although surgery was an option in each of the scenarios considered, this was only considered in a general sense. Comprehensive and detailed evaluation of the role of surgery in severe CHI was beyond the scope of this survey.[8,9]

The first acute scenario described a patient with an intracranial epidural hematoma and signs of mass effect (Appendix 1). Respondents agreed extremely strongly that surgery was appropriate, and reported performing it almost always in such patients. They agreed very strongly that steroids were inappropriate in this setting. This consensus supported the face and content validity of the survey. Furthermore, the consensus against steroids is supported by randomized evidence.[10]

Surprisingly in the EPI scenario, clinicians classified hyperventilation as of uncertain appropriateness, in a patient with a space-occupying lesion and mass effect. Although this may reflect the harm observed in a trial of long-term hyperventilation after CHI,[11,12] the evidence from the cited trial would have been misapplied in this scenario. It may alternatively reflect a limitation of survey design, survey interpretation, or uncertainty about the timing of therapy. Finally, it may also reflect a limitation of study interpretation. In regard to the latter, although the overall average interpretation of hyperventilation in EPI was 'uncertain', clinicians may have been much more certain as individuals although differing from one another in the grouped assessment.

Clinicians agreed on the appropriateness of osmotic agents such as mannitol and hypertonic saline (Table 2). However, they reported using hypertonic saline less frequently than mannitol (Table 3). This may reflect a greater general familiarity with mannitol, differential access, or other factors. Nonetheless, mannitol and hypertonic saline have different durations of effect and side effect profiles, and it is reasonable to hypothesize that they may also have different effectiveness. Some preliminary evidence has suggested a longer duration of effect with hypertonic saline than with mannitol when the intent is control of intracranial hypertension.[13] Given the variability in clinician-reported appropriateness and frequency of use of these two therapies, further investigation would be beneficial.

Table 6: Correlations of Appropriateness and Frequency of Use of Interventions: Intracranial Contrusion

	Appropriateness (R, p value)					
Frequency	Surgery	EVD	CPP-guided Tx	Hypertonic Saline	Mannitol	Early Feeding
Surgery	0.64 0.0001	0.04 0.69	0.20 0.02	-0.02 0.83	0.07 0.42	0.17 0.05
EVD	0.13 0.12	0.49 0.0001	0.20 0.02	0.23 0.008	-0.03 0.70	0.19 0.03
CPP-guided Tx	0.13 0.14	0.13 0.14	0.56 0.0001	0.13 0.15	0.24 0.006	0.28 0.001
Hypertonic Saline	-0.12 0.18	0.22 0.01	0.06 0.51	0.09 0.31	0.18 0.04	0.10 0.24
Mannitol	0.18 0.03	0.06 0.50	0.32 0.0002	0.24 0.005	0.64 0.0001	0.16 0.07
Early Feeding	-0.002 0.98	0.18 0.03	0.11 0.20	-0.11 0.22	-0.12 0.19	0.29 0.0008

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Cooling was of uncertain appropriateness and was used occasionally, and this probably reflects the group opinion of the diversity of patients with severe CHI treated. While the most methodologically sound evidence does not support systematic cooling of all patients with severe CHI, some room for clinician discretion remains.[14,15] Cooling, to be beneficial, would apply particularly in the younger patient with generalized and rapid-onset intracranial hypertension, and in the absence of surgically-correctable pathology. Conversely, cooling would be less likely to benefit if applied later in the course of therapy to an older patient.

The uncertain appropriateness, and only occasional use, attributed to phenytoin in EPI was somewhat surprising. A limited course of phenytoin has been suggested to reduce the incidence of early post-traumatic convulsions, although the data on this topic are limited, and no effect on mortality has been reported.[16] Given the uncertainty found among respondents about the appropriate role of phenytoin, its potential benefit, and the availability of anticonvulsants with more favourable adverse effect profiles, further study may be beneficial.

In the two other scenarios, clinicians were presented with situations that suggested intracranial contusion (IC – Appendix 1) and diffuse axonal injury and traumatic subarachnoid hemorrhage (DAI - Appendix 1). Management of patients with these injuries was reported to be very similar, as expected. In general, considering the correlations of appropriateness and frequency of use, interventions that were reported as appropriate were also commonly used (Tables 4, 5 and 6). Respondents agreed strongly on the appropriateness of early enteral feeding, intensive insulin therapy for glucose control, reduction of fever, and CPP-guided therapy. Clinicians agreed, but less strongly than in EPI, that osmotic diuretics were appropriate. Although monitoring with the EVD and JVO were appropriate, the actual use of JVO was only occasional or rare.

In both DAI and IC, respondents reported the use of hyperventilation to be of uncertain appropriateness, which is consistent with published results. This contrasts somewhat with the respondents' opinion about hyperventilation in EPI, although this difference may be due to survey interpretation rather than practice variation. Clarification of the explanation for this difference would be beneficial.

While most 'appropriate' interventions were also commonly used, relatively few interventions were used in association with other interventions. For example, surgery was closely associated with EVD use in EPI, but little else. Both the EVD and JVO were appropriate, and correlated with each other as well as with the use of CPP-directed therapy. However, the JVO was rarely used. In practice, the EVD is both diagnostic and therapeutic, whereas the JVO is of diagnostic use only. The EVD is also necessary for CPP-directed therapy, which had been reported to be appropriate by a majority of respondents. Existing guidelines support use of the EVD in patients with severe CHI and abnormalities detected on CT scan.[4]

The appropriateness of CPP-guided therapy and EVD placement was high in patients with DAI or IC, and in accordance with guidelines.[4] Surprisingly, CPP-guided therapy was rated as more appropriate than EVD placement. Moreover, only minimal correlation between appropriateness and frequency of use was seen between these two interventions. This raises the suspicion that EVD use is less frequent than optimal, given the physiologic impossibility of delivering CPP-guided therapy without knowledge of the intracranial pressure (ICP). Alternatively, clinicians may be delivering CPP-guided therapy based on an assumed ICP, without its direct measurement. Although clinicians may be using alternative means of measuring intracranial pressures e.g. parenchymal manometer, none have the same diagnostic and therapeutic capacity as the EVD, which remains the gold standard.

Clinicians reported that the use of early enteral feeding (immediately post-admission) and intensive glucose control were very appropriate. With respect to early enteral feeding, clinicians' use is supported by a recent systematic review that revealed a relative risk for death with early enteral feeding of 0.67 (95% CI 0.41-1.07).[17] However, intensive glucose control was much more appropriate than its estimated frequency of use. Given that the original study demonstrating the benefit of tight glucose control among the critically ill included very few neurologically-impaired patients,[18] clinicians may be indicating some reservation about applying this evidence in their practice.

Neurosurgeons and intensive care physicians reported similar practice attitudes in most scenarios. Among the few notable differences were a greater preference among neurosurgeons for the use of mannitol, and a greater preference among intensive care physicians for the use of early enteral feeding and intensive insulin therapy. Since uncertainty remains about the true effect of these therapies on the outcome of patients with severe CHI, further evaluation would be beneficial.

Limitations of this survey are several. In general, a survey is limited in size because of the time required to complete it. Consequently, it was not possible to investigate all the permutations of clinical scenarios that might affect clinician judgement, including especially dose and duration of therapy, or relative priorities of therapies. A survey is not a surrogate for definitive outcome data, although it serves to illustrate variation in practice and attitude. Finally, the survey results represent averaged group opinions, and not individual opinions. This latter point is important in the interpretation of 'uncertain' appropriateness. 'Uncertain' in this context could also be interpreted to mean 'neither appropriate nor inappropriate', and must be understood to represent a group average. 'Uncertain' is not synonymous with 'do not know' on an individual basis, and simply relates to variation of opinion among the respondents.

Within the limits of study design, this survey has described current practice with regard to treatment of patients with severe CHI, and identified areas of variation that may benefit from further evaluation. In the EPI scenario, a patient virtually always requires surgery, and frequently EVD placement. In the more subacute settings of DAI and IC, consensus was best in support of CPP-directed therapy, early enteral feeding, and intensive insulin therapy. However, EVD placement may be less frequent than the use of CPP-guided therapy, which is physiologically difficult, and should be further evaluated. Finally, the roles of hypertonic saline and mannitol in the control of intracranial hypertension should be better defined. Randomized prospective evaluation of these therapies will help to direct treatment more effectively.

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