

Development of a provincial guideline for the acute assessment and management of adult and pediatric patients with head injuries

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Background: Regionalized approaches to trauma care improve patient outcomes. We developed and distributed a clinical reference poster to standardize the emergency department evaluation and management of patients with traumatic head injuries in hospitals throughout Nova Scotia. **Methods:** We conducted a MEDLINE literature search to identify publications in the fields of prehospital and emergency management of head injuries. We reviewed and collated select studies to define contemporary standards of care. **Results:** We derived a 3-tiered decision tool that summarizes the indications for resuscitation, radiography, specialty consultation and transfer of adult and pediatric patients with minor and major head injuries. A guideline poster was constructed and distributed to all provincial emergency departments upon approval by local trauma and critical care staff. **Conclusions:** This report describes the evidence for a population-based, province-wide assessment and early management tool that was developed for health care personnel who treat patients with head traumas. Comparison of outcome data from pre- and postguideline eras will ultimately shed light on the use of regionalized approaches to managing brain injuries.

Contexte : Les stratégies régionalisées de soins en traumatologie améliorent les résultats pour les patients. Nous avons créé et distribué une affiche de référence clinique afin de normaliser l'évaluation et la prise en charge, à l'urgence des hôpitaux de la Nouvelle-Écosse, des patients victimes d'un traumatisme crânien. **Méthodes :** Nous avons effectué une recherche documentaire dans MEDLINE pour repérer les publications portant sur la prise en charge de traumatismes crâniens avant l'arrivée à l'hôpital et à l'urgence. Nous avons passé en revue et réuni des études choisies pour définir des normes de soin modernes. **Résultats :** Nous avons dérivé un outil d'aide à la décision à trois niveaux qui résume les indications relatives à la réanimation, à la radiographie, à la consultation des spécialistes et au transfert de patients adultes et pédiatriques victimes de traumatismes crâniens mineurs et majeurs. Nous avons créé une affiche-guide que nous avons distribuée à tous les services d'urgence de la province avec l'approbation du personnel local de traumatologie et de soins critiques. **Conclusions :** Ce rapport décrit les données tirées d'un outil provincial représentatif d'évaluation et de prise en charge rapide mis au point à l'intention des membres du personnel de santé qui traitent des patients victimes de traumatismes crâniens. La comparaison des données sur les résultats des périodes précédant et suivant la mise en service de l'affiche-guide éclairera éventuellement l'utilisation de stratégies régionalisées de prise en charge des traumatismes au cerveau.

Regionalized emergency health services may contribute to improved clinical outcomes after traumatic brain injuries (TBIs) by providing standardized and more efficient acute care within a designated catchment area. Patients with head injuries who are assessed in the field or in the emergency department require accurate risk stratification to make management decisions that prevent secondary brain injuries.¹⁻⁴ Occult lesions and delayed

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intracranial complications have been reported in up to 17% of people with apparently trivial head injuries, emphasizing the significance of a structured evaluation of these patients at initial presentation.⁵ In contrast, the need for aggressive resuscitation and intensive care monitoring is often quickly recognized after severe TBI; however, important issues regarding the timing and nature of the resuscitative efforts, as well as the urgency of patient transport and neurosurgical consultation, may be poorly defined.⁵⁻¹⁰ Standardized algorithms and clinical predictors of intracranial^{11,12} or cervical spine^{13,14} injury have been reported and validated, yet the impact of regionalized TBI care on patient outcomes remains unknown. To our knowledge, there have been no clinical decision tools published that provide a comprehensive approach, based on the current state of knowledge, to the acute care of adult and pediatric patients who present to the emergency department with head injuries.

Trauma services in Nova Scotia are coordinated through a regionalized system that serves a population of 940 000 in an area of 53 000 km² (20 463 square miles). A single neu-

rosurgical service operates at adult and pediatric tertiary care centres located in Halifax and receives all major neurotrauma patients in the province. Ground and air ambulance activity is organized by a central dispatchment unit that is accessible province-wide via a 24-hour trauma hotline. In optimal conditions, each municipality is within 90 minutes travel by helicopter from Halifax, and all efforts are made to transport patients, by ground or air, immediately to the most appropriate hospital. The role of the neurosurgical service within this type of health system is ideal for assessing the impact of regionalized protocols in the management of acute head trauma. In this report, we present evidence for a novel reference guide that was developed as part of a population-based initiative to standardize the care of adult and pediatric patients with head injuries who present to emergency departments throughout Nova Scotia.

Materials and methods

We conducted a MEDLINE review of the literature between 1970 and 2005, using the primary medical

subject headings “head injury” and “management.” Searches were culled to identify articles regarding prehospital, emergency department and intensive care of TBI patients, as well as guideline publications and review articles that addressed regionalized approaches to trauma and TBI management. Current recommendations included those founded by multiple clinical groups, substantiated by long-term conventional applications, and supported by a well-designed cohort or randomized trials. This instrument is intended to facilitate the management of traumatic head injuries in the emergency department and, apart from resuscitative measures, does not provide recommendations regarding prehospital or definitive care. After consultation with the provincial trauma and critical care communities, we distributed this guideline to all emergency departments throughout Nova Scotia.

Results

Initial neurological evaluation

It is useful to categorize patients

Box 1: Glasgow Coma Scale (GCS)*†			
Modality	Score	Adult	Pediatric
Eye opening (E)	4	Spontaneous	Spontaneous
	3	To speech	To speech
	2	To pain	To pain
	1	None	None
Verbal (V)	5	Oriented	Appropriate for age; fixes and follows sensory cues; social smile
	4	Confused	Cries, but consolable
	3	Inappropriate	Persistently irritable
	2	Incomprehensible	Restless, lethargic
	1	None	None
Motor (M)	6	Obeys commands	Spontaneous
	5	Localizes to painful stimuli	Localizes to painful stimuli
	4	Withdraws from pain	Withdraws from pain
	3	Abnormal flexion (decorticate)	Abnormal flexion (decorticate)
	2	Abnormal extension (decerebrate)	Abnormal extension (decerebrate)
	1	None	None

*Adult and pediatric versions of the Glasgow Coma Scale.^{15,20}
 † GCS score is tabulated as the sum of individual scores (E+V+M), with a minimum value of 3 and maximum value of 15.

with head injuries according to their age and presenting Glasgow Coma Scale (GCS) score, because both of these parameters influence management and prognosis (Box 1). The GCS score remains the most widely used measure of neurological function in TBI patients and has significant prognostic value when graded in the absence of sedation, chemical paralysis or intoxication.¹⁵⁻¹⁹ The GCS has high inter- and intraobserver reliability and has been used to arbitrarily define injury severity as mild (GCS score 13-15), moderate (GCS score 9-12) or severe (GCS score 3-8). Because the acute management of moderate and severe head trauma is comparable, the current recommendations are based on the simpler dichotomy of minor (GCS 13-15) and major (GCS 3-12) categories. The pediatric GCS that is included in the guideline is a modified version of the original scale and is one of several triage-scoring systems adapted for children.^{20,21}

Minor head injuries (GCS 13-15) in adult patients

Minor head injuries are associated with a brief loss of consciousness, disorientation or amnesia in patients with a GCS score of 13 to 15.^{15,22,23} Most patients are stable at the time of examination, and it is important to recognize those at risk of occult or evolving intracranial lesions. Several groups have attempted to identify reliable indicators of intracranial injury and the need for urgent CT.^{11,12,24,25} The Canadian CT Head Rule predicts the need for neurological intervention with a sensitivity of 100% and a 95% confidence interval between 92% and 100%.^{12,26} The 3-year study data were compiled from 3121 adult patients in 10 Canadian centres and identified 5 clinical signs that have previously been associated with TBI. Patients with minor head injuries and evidence of prolonged

GCS impairment,^{23,27-29} depressed skull fracture,^{28,30,31} basal skull fracture,^{28,32} recurrent vomiting^{33,34} or age 65 years or over^{2,30} are at high risk of requiring neurological treatment and should have urgent CT imaging. Although a normal CT scan does not preclude latent hemorrhage, the incidence of significant deterioration in these patients is exceedingly low and justifies chaperoned discharge when clinically well.³⁵ In contrast, radiographic evidence of intracranial injury warrants a neurosurgical consultation. If the patient is being evaluated in a tertiary care centre, the neurosurgical housestaff should be contacted directly. However, if the emergency department encounter occurs in a nontertiary centre, the attending physician should immediately contact the local neurosurgeon on-call, which, in our system, may be accomplished by calling the Trauma Hotline. The neurosurgeon on-call is available to review the history (via telephone contact with the referring emergency department physician) and radiology (via viewing the CT scan on a province-wide real-time digital imaging system) and will provide advice regarding patient disposition and management (Box 2).

Minor head injuries (GCS 13-15) in pediatric patients

Children aged less than 2 years

Most pediatric head injuries do not require surgical intervention.³⁶⁻³⁹ Unusual or unexplained trauma in young children should raise a suspicion of abuse and be duly investigated. Those aged under 2 years require judicious management, because the growing calvarium and immature brain are susceptible to relatively low-impact forces.⁴⁰⁻⁴² In addition, clinical signs of TBI are unreliable at this age, and neurological evaluation is hampered by limited verbal and behavioural repertoires.^{43,44} Any suggestion of TBI warrants further investigation, accepting that radiographic imaging may require sedation, with the associated risks of cardiovascular and respiratory complications.^{9,43,45,46}

The highest incidence of skull fractures and intracranial injuries occurs in children aged under 1 year.⁴⁷⁻⁴⁹ Diagnosis of a skull fracture is important to ensure that clinical follow-up is arranged to monitor for the presence of a growing skull fracture. Scalp hematomas are a useful predictor of underlying fractures in young children, but up to 50% of asymptomatic patients will have skull

Box 2: Approach to adults with minor head injuries*†
CT urgently needed if all 3 of the following criteria are met¹²
1. History of blunt head trauma within past 24 h
2. History of loss of consciousness, amnesia or disorientation
3. One or more of the following risk factors present:
GCS score < 15 after 2 h after injury
Suspected open or depressed skull fracture
Signs of basal skull fracture
Recurrent vomiting
Age > 65 yr
Abnormal CT
Urgent neurosurgical consultation.
Normal CT or no CT indicated
Discharge when clinically well. Follow up with family doctor.
GCS = Glasgow Coma Scale. *GCS score 13-15. †These patients are neurologically well but may be at risk of delayed complications. Indications for CT imaging and choice of disposition are the primary issues of acute care. Patients with a deteriorating GCS or penetrating head trauma are managed as a major head injury.

or intracranial injuries without evidence of scalp trauma or neurological deficits.^{44,48,50-52} Therefore, it is recommended that children aged under 2 years undergo CT imaging if there is evidence of a neurological abnormality, such as decreased level of consciousness, nausea, lethargy or agitation. All asymptomatic children under age 1 year who present with a scalp hematoma require skull radiography and, if abnormal, a subsequent CT scan and neurosurgical consultation (Box 3).^{45,52-54}

Children aged 2 to 15 years

Children in this age group with recent head trauma and a GCS score of 13 or 14 are at high risk of harbouring an intracranial lesion and require urgent CT imaging.⁵⁵⁻⁵⁷ Post-traumatic amnesia and loss of consciousness have traditionally been considered risk factors for TBI; however, there are no prospective studies that have identified one or more clinical signs that accurately predict intracranial abnormalities.^{9,39,51,58,59} The guidelines published by the American Academy of Pediatrics recom-

mend either observation or CT scanning for neurologically normal (i.e., GCS score of 15) children who have experienced loss of consciousness and recommend observation only for those who have not.⁷ More recent guidelines favour CT studies for children with amnesia, a history of loss of consciousness, impaired mental status, focal neurological deficits, evidence of skull fracture or coagulopathy.⁶⁰ Children who meet the criteria for an urgent CT, and where the CT is abnormal, require prompt neurosurgical consultation (Box 3).

Major head injuries (GCS 3-12) in adult and pediatric patients

Standard trauma guidelines recommend that patients with major head injuries receive aggressive cardiopulmonary and hemodynamic resuscitation unless an obvious reason exists to withhold treatment.⁶¹ Cervical spine fractures and systemic injuries are present in 6% to 8% and 50% of these patients, respectively, and must be considered during the resuscitative phase of treatment.⁶²⁻⁶⁴ The incidence of secondary brain injuries can be sig-

nificantly reduced by prevention of hypoxia, hypotension and elevated intracranial pressure (ICP). Maintenance of a cerebral perfusion pressure 70 mm Hg or greater may reduce TBI mortality and, in the absence of marked ICP elevation, can usually be achieved with a mean arterial blood pressure of 90 mm Hg.⁶ Intracranial hypertension develops in 40% of patients with severe TBI and may be associated with anisocoria, papilledema, neurological deficits or a deteriorating level of consciousness.⁶⁵ Valsalva manoeuvres produced by cough, movement or pain elevate ICP and often require suppression with narcotics, sedatives or paralytic agents. Osmotic diuretics (e.g., mannitol) and hyperventilation reduce ICP, in part, by decreasing cerebral interstitial and intravascular volumes, respectively.^{66,67} These measures require prudent monitoring and fluid management, because subsequent hypovolemia and hypocarbia may exacerbate cerebral ischemia.^{68,69} Brief periods of hyperventilation are currently reserved for use in herniation syndromes with brainstem compromise. If the ICP cannot be

Box 3: Approach to children with minor head injuries*†
Age < 2 yr
Urgent CT head indicated if symptomatic (vomiting, lethargic, irritable) or neurologically abnormal.
If asymptomatic and neurologically normal, no further studies are required, except for children < 1 year with a scalp hematoma; then, obtain skull x-rays and CT head if plain radiography is abnormal.
Age 2 to 15 yr
Obtain CT head if GCS < 15.
If GCS = 15 and there is a history of loss of consciousness or posttraumatic amnesia, then either CT head or observe overnight.
If GCS = 15 with no history of loss of consciousness or post-traumatic amnesia, obtain CT head if ≥ 1 of the following are present:
Change in GCS score
Focal neurological deficit
Clinical evidence of skull fracture
Coagulopathy
All pediatric trauma patients with radiographic abnormalities of the head require urgent neurosurgical consultation.
GCS = Glasgow Coma Scale. *GCS score 13-15. †Young children (< 2 yr) are at highest risk of intracranial injury after trauma and present a difficult population to assess owing to limited verbal and behavioural repertoires. Evidence of child abuse must be thoroughly investigated.

Box 4: Approach to patients with major head injuries*†
Advanced trauma life support
Intubation required for GCS ≤ 8 or deteriorating level of consciousness; oxygen by mask for others
Global clinical assessment
Prevention of hypoxia and hypotension
Maintenance of spinal precautions at all times
Brief neurological examination
GCS score
Pupil size and reactivity
Deep tendon reflexes
Babinski response
Gross motor function
Urgent transfer to a neurosurgical service
GCS = Glasgow Coma Scale. *GCS score 3-12. †Resuscitation and transfer to a neurosurgical service should be the priority of acute care. Spinal and systemic injuries are commonly associated and must be considered during treatment. A brief neurological examination provides valuable clinical information for monitoring and assessment by the receiving physicians, particularly if performed before the administration of sedatives or paralytic agents.

controlled with medical management, invasive procedures such as ventricular drain placement or decompressive craniectomy may be considered by the attending neurosurgeon.

If a patient with severe TBI is being evaluated at the scene or requires resuscitation at a peripheral hospital, the immediate goals should be cardiopulmonary and hemodynamic stabilization followed by prompt transfer to a neurosurgical centre. Investigations that are not directly related to resuscitative efforts should be post-

poned until the patient has reached definitive care. Delayed treatment significantly impacts clinical outcome, and the mortality of specific intracranial lesions may be reduced by as much as 66% if patients receive surgery within 4 hours of injury.^{8,70-72} Referring physicians should rapidly assess and stabilize patients while maintaining spinal precautions and monitoring for acute neurological changes. A brief (2-minute) assessment of the GCS score, pupillary responses, deep tendon reflexes and

gross motor function provides a neurological synopsis for the receiving trauma team and facilitates monitoring during patient transfer (Box 4).

The recommendations outlined above for the assessment and acute care of adult and pediatric patients with TBI have been collated into a single guideline poster that has been displayed in the emergency department of each of the 8 district health centres throughout Nova Scotia (Fig. 1). These 8 centres represent all the regional hospitals that see most



HEAD INJURY GUIDELINE

DIVISION OF NEUROSURGERY: QEII HEALTH SCIENCES CENTRE, IWK HEALTH CENTRE

PERFORM ABCs OF RESUSCITATION

WHAT IS PATIENT'S GLASGOW COMA SCALE (GCS) ? *

GCS 13-15
MINOR HEAD INJURY

CT urgently needed if all 3 of the following:

1. History of blunt head trauma within the last 24 hours
2. History of loss of consciousness, amnesia or disorientation
3. One or more of the following:
 - GCS < 15 at 2 h after injury
 - Suspected open or depressed skull fracture
 - Sign of basal skull fracture (hemotympanum, "raccoon eyes", cerebrospinal fluid otorrhea, Battle's sign)
 - Vomiting x 2 or more times
 - Age > 65

Minor Head Injury Management

Abnormal CT

- Call Air Medical Critical Care Transport and Trauma Hotline at **1-800-743-1334**

Normal CT or no CT indicated

- Observe until well and discharge home
- Follow up with primary care physician

If GCS deteriorating, or evidence of penetrating head injury, treat as per "Major Head Injury"

GCS 3-12
MAJOR HEAD INJURY

Intubate (c-spine in neutral position) for GCS ≤ 8 or deteriorating GCS; oxygen by mask for all others

Spine immobilization (c-spine collar and back board)

2 minute neurological assessment:

- GCS
- pupil size and reaction to light
- biceps and knee jerk reflexes
- Babinski responses
- Gross motor function (equal movement in all 4 limbs?)

Call Air Medical Critical Care Transport and Trauma Hotline at **1-800-743-1334**

PREPARATION FOR TRANSPORT AS PER PROVINCIAL TRAUMA GUIDELINES

PEDIATRIC HEAD INJURY (AGE < 16 YEARS)

GCS 3-12 (Major Head Injury)
Treat as per adult guideline

GCS 13-15 (Minor Head Injury)
AGE 2-15 years:
GCS 13 or 14: CT Head
GCS 15:
History of LOC or PTA: CT Head or observe overnight
No LOC or PTA: CT Head if one or more of the following:

- Change in GCS
- Focal neurologic deficit
- Clinical evidence of skull fracture
- History of coagulopathy

AGE <2 years: (Consider child abuse as cause)
Symptomatic and/or neurologically abnormal: CT Head
Asymptomatic and normal neuro exam: No further imaging studies except if <1 year and scalp hematoma, then do skull x-rays

- If x-rays normal: No further investigations
- If fracture: CT Head & contact neurosurgery

† Symptomatic: LOC, vomiting, drowsy, irritable
 LOC: Loss of consciousness
 PTA: Post traumatic amnesia
 CT: Computerized tomography

*** CALCULATE GLASGOW COMA SCALE (E + V + M; RANGE 3-15)**

GCS for age ≥ 5 years			GCS for age < 5 years		
EYE OPENING	VERBAL RESPONSE	BEST MOTOR RESPONSE	BEST MOTOR RESPONSE	VERBALIZATION	EYE OPENING
BEST 4. Spontaneously 3. To voice 2. To pain 1. Not at all GCS WORST	5. Converses, oriented 4. Converses, disoriented/confused 3. Inappropriate words 2. Incomprehensible sounds 1. No verbalization	6. ObeysFollows motor commands 5. LocalizesClearly pushes painful stimuli away  4. Normal flexionOnly withdraws arm or leg to painful stimuli  3. Abnormal flexionFlexion of arms with extension of legs to painful stimuli  2. Abnormal extensionExtension of all extremities to painful stimuli  1. FlaccidNo response to painful stimuli	6. Spontaneous 5. Localizes 4. Normal flexion 3. Abnormal flexion 2. Abnormal extension 1. Flaccid	5. Appropriate for age fixes and follows, social smile 4. Cries, but consolable 3. Persistently irritable 2. Restless, lethargic 1. None	4. Spontaneously 3. To voice 2. To pain 1. Not at all
E = 1-4	V = 1-5	M = 1-6	M = 1-6	V = 1-5	E = 1-4

FIG. 1. The Nova Scotia Head Injury Guideline. The telephone numbers and directives for specific transport protocols displayed on the poster are not generalizable to other geographic regions.

of the nontertiary care head injuries in the entire province and, thus, are immediately served by this clinical guideline. A recent survey of the emergency medicine department chiefs for these regional hospitals was conducted (December 2005–January 2006). The survey was constructed with a modified Dillman technique; a copy of the survey is available from the authors on request.⁷³ Surveys were mailed out with a self-addressed envelope, and subsequent telephone follow-up was performed twice. With the small number of subjects (8), the response rate was 100%. The survey results show that the guideline is currently being used at each centre and is posted in all 8 emergency departments. The survey also demonstrates that the guideline has been “beneficial to the management of TBI patients” (100% response) and has led to modifications in local practice, such as CT imaging, earlier patient transfer or both in 50% of the regional centres.

Discussion

Injuries are the largest contributor to mortality in people aged under 40 years and represent the fourth overall cause of death in North America.^{74–77} The annual incidence of TBI in the United States has been estimated between 100 and 367 per 100 000 population, and billions of dollars are spent each year on medical, social and rehabilitation services.^{6,78,79} The high incidence of TBI in young adults contributes to an enormous loss of potential life years, with the American prevalence between 2.5 and 6.5 million individuals.⁷⁹ In Canada, population-based data are limited; nonetheless, approximately 18 000 patients are admitted to hospital annually for head injuries, and regional incidences have been reported at 16 and 7 per 10 000 per year in male and female patients, respectively (Kingston, Ontario)⁸⁰ and 14 per 10 000 population per year aged over 16 years (Nova Scotia).⁸¹ A 4-year review in eastern

Ontario revealed that closed head injuries produce some of the most common and severe anatomic lesions in pediatric trauma.⁸² Thus, the social and economic impact of head trauma in North America is substantial and provides the impetus for ongoing research into clinical prevention, management and repair strategies. Trauma system regionalization has resulted in more efficient patient management and improved clinical outcomes following systemic injuries.^{72,83–86} The development and promotion of evidence-based treatment guidelines and decision rules also facilitate injury assessment, resuscitation and patient disposition.^{87–89} Unfortunately, although there are limited studies that suggest that implementation of treatment protocols may also benefit TBI patients, many aspects of TBI care remain without objective support and current medical practices vary according to regional experiences and resource availability.^{90–92}

Conclusions

Head trauma produces a wide spectrum of injury and requires proficient early management to detect occult lesions and prevent secondary cerebral insults. We have created and disseminated a novel reference guide, based on the current state of knowledge, as part of an initiative to standardize the assessment and early management of TBI in Nova Scotia. This instrument may be easily modified for other geographical regions. Its implementation is expected to improve patient outcomes by facilitating management decisions in the emergency department and expediting the transfer of appropriate individuals to neurosurgical expertise.

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