6310.01 Neurological Trauma

INTRODUCTION

Neurological trauma includes injury to the brain and spinal cord. Whenever there is trauma sustained to the face, skull, neck, or back neurological trauma should always be considered. It is important to note that neurological trauma can also pertain to peripheral nerves. Peripheral nerve injury should be considered in patients with extremity trauma (see Extremity Trauma Guideline).

Brain injuries may be broadly categorized as either blunt or penetrating, and may result in focal or diffuse injury. The initial impact (primary injury) causes varying degrees of mechanical injury through either direct or indirect forces. Secondary brain injury is caused by various other factors, many of which are treatable or even preventable, such as hypoxia, hypotension, cerebral edema, increased intracranial pressure (ICP), hemorrhage, and ischemia. Emergency management of the head injured patient focuses on minimizing secondary brain injury, and thereby decreasing morbidity and mortality.

Traumatic spinal cord injuries may occur as a result of direct blunt and/or penetrating trauma. The spinal cord and its exiting nerve roots may also be compressed as a result of a number of chronic degenerative processes such as osteoarthritis or degenerative disc disease. Symptoms consistent with spinal cord pathology may also be seen with a variety of chronic medical conditions, such as autoimmune, inflammatory, neoplastic, or vascular disorders.

Assessment of back and spinal injuries is often difficult in the field environment. Patients may have an altered level of consciousness, distracting injuries, or they may be in severe pain. In general, acute neck and back injuries may be classified as sprains, strains, fractures, dislocations and/or actual spinal cord injuries. Injury to the spinal cord may be complete or incomplete as a result of pressure, contusion, ischemia, or laceration of the actual cord itself.

SAFETY

Ensure that the cause of the trauma is of no threat to the other responders on scene. Activate the appropriate resources if required.

As trauma can result in varying amounts of blood loss, appropriate PPE should be used to protect from direct or indirect contact with blood.

ASSESSMENT

A trauma assessment should be conducted as outlined in the General Trauma Clinical Practice Guideline if appropriate. The ABCDE approach to trauma assessment should be used, with the assessment for neurologic “deficits” being lower priority than the ABCs. Non-life-threatening injuries should be managed only after the critical concerns are dealt with.

Manual cervical spine immobilization should occur for patients with head, neck, or back trauma until the patient is fully immobilized or need for immobilization can be ruled out using the Canadian C-Spine Rule (Figure 1).

The mechanism of injury and amount of energy involved in the trauma must be thoughtfully considered, even in the absence of obvious injury. The mechanism represents the amount of energy transferred through the individual, and is a significant indicator of the potential for life-threatening injuries, even when they are not immediately apparent (e.g. patient ambulating at the scene after highway speed rollover).

Determining the mechanism of injury when there is possible c-spine involvement is an important component of the assessment. See Figure 1 for a list of “dangerous mechanisms” that independently mandate C-spine immobilization as per the Canadian C-spine Rule. The table below details some of the more common mechanisms of injury and the structures that can be injured. It is important to note that a patient may have been subjected to a combination of mechanisms (e.g. hyperflexion and rotation).

Mechanism	Example	Structures possibly injured
Hyperextension	Hanging	Spinous processes Transverse processes Laminae Pedicles Posterior ligaments Anterior ligaments
Hyperflexion	Forceful deceleration	Posterior ligaments Vertebrae (subluxation compromising the central canal, compressing the

		cord and vascular structures)
Axial compression	Diving	Vertebrae Intravertebral discs
Flexion / rotation	Rollover MVC	Supporting ligaments Possible fractures of vertebrae

There are many critical pieces of history to obtain during the initial phase of the assessment, including:

- Details regarding mechanism
- Time of injury
- Any loss of consciousness and the length of time this occurred
- The initial mental status after injury (it is important to obtain an initial GCS, especially prior to administration of any drugs that would influence mental status)
- Occurrence of any seizure-like activity
- Occurrence of any vomiting
- Presence of headache
- Has there been any movement of the extremities
- Past medical history
- Medications (especially anticoagulants) or recent drug or alcohol use

If the patient is unresponsive, bystanders should be asked to provide as much of the above information as possible.

On inspection look for evidence of broken teeth, foreign material in the oropharynx, facial swelling, and fluids draining from the nose or ears. Presence of bruising around the eyes (raccoon eyes) or over the mastoids (Battle Sign) suggests basilar skull fracture.

Other important indicators of possible neurological injury include:

- Diaphragmatic breathing
- Neurogenic shock (hypotension and bradycardia without hypovolemia)
- Obvious deformity to the neck or back
- Presence of posturing
- Pain or guarding along neck or back.
- Numbness, tingling, or loss of sensation in the extremities (paresthesia)
- Loss of movement, weakness or flaccid muscles
- Loss of bladder control
- Priapism

If time permits, a more in-depth neurological exam should be conducted for all patients with head, neck or back trauma. This may not always be possible if the clinician is occupied managing issues with the higher priority ABCs. GCS should be used to grade and monitor changes in level of consciousness. Pupils should be assessed for size, equality, and reactivity. Dilated and non-reactive pupils often indicate injury to the brainstem. A unilateral dilated pupil is a late sign that occurs in severe head injury, which may indicate intracranial pressure (ICP) is elevated.

The skull should be palpated for tenderness, deformity, or depressed areas. If there is a suspected depressed skull fracture, do not put direct pressure on the area. The C-spine, as well as the entire spinal column may be gently palpated to assess for the presence of pain or deformity if possible. This may be difficult and therefore omitted depending on the need for, or method used for, extrication and immobilization.

Motor exam should follow the outline in the box below. As a minimum assessment, the motor exam should document the patient's strength against resistance during six movements: [1] elbow flexion and [2] extension, [3] grips, [4] foot dorsi- and [5] plantar flexion and [6] big toe dorsiflexion. These are the functions most easily assessed when a patient is immobilized.

Assessing Motor Function

Certain spinal levels correspond to a particular motor function. If a patient is unable to perform any of the following, it is important to make note of this and relay the information to the receiving facility.

- Elbow flexion (C5)
- Wrist extension (C6)
- Elbow extension (C7)
- Hand grips (C8)
- Hip Flexion (L2)
- Knee extension (L3)
- Foot dorsiflexion (L4)
- Big toe dorsiflexion (L5)
- Foot plantar flexion (S1)

Figure 2 demonstrates the American Spinal Association's motor and sensory function assessment. This more thorough method of assessment and classification of spinal cord injury is

more likely to be done on arrival at the hospital

After assessing motor function, the clinician should assess for sensory function using the dermatomes (Figure 3). Determine if there are any sensory deficits and if sensory patterns are symmetrical. Each dermatome does not have to be individually assessed, but generally seek to determine if the patient has equal sensation down the length of their neck and arms, ribs, lateral aspect of the legs and bottom of their feet.

In the presence of a partial spinal cord injury, a patient may present with various patterns of weakness or numbness. For example, the upper extremities may be affected with no effect on lower extremities, or a patient may have unilateral weakness with contralateral numbness.

A rapid but thorough assessment of the patient before and after immobilization is vital. Most conscious patients with spinal injury will have pain in the region of the injury and be able to describe altered sensation or function. Use a combination of light touch and painful stimuli with the forehead as a comparison for normal sensation.

Cranial nerve assessment may also be performed if time permits (see Figure 4).

Patients with neurological injuries may also have injury to other body systems. Keep in mind that loss of sensation due to neurological trauma may disguise signs or symptoms of the other injuries (e.g. signs of peritonitis such as guarding, rigidity, or rebound tenderness may be absent).

Finally, it is useful to be aware of the Canada CT Head Rule (Figure 5), which will be used in the ED to assess whether a patient with a mild traumatic brain injury (GCS 13-15) requires a CT scan. Collecting data pertaining to this rule provides useful information that will subsequently be used in hospital.

'Red Flags' Associated with Back Pain

Back pain is a common and often disabling problem encountered in emergency medicine. It may be acute or chronic, and may arise from traumatic or atraumatic etiologies.

Regardless of the duration or underlying cause, it is important to screen ALL patients for the presence of "red flags" that may indicate risk for, or presence of, associated spinal cord or nerve root injury. If present, it is important to communicate these findings upon transfer of care. If these findings are absent, they should be documented as pertinent negatives in the PCR.

- History of cancer
- History of IV drug abuse
- Fever
- Bowel or urinary incontinence
- Urinary retention
- Saddle anaesthesia (ask patient about numbness around buttocks or genitals)
- Extremity weakness

Cushing's Reflex

Cushing's reflex is a physiological response to increased ICP which results in increased blood pressure, widening pulse pressure, irregular breathing and bradycardia.

When ICP rises to a significant level, arterioles compress in the cerebrum leading to ischemia. The sympathetic nervous system is stimulated and causes vasoconstriction, thus elevating blood pressure in an attempt to restore blood flow. The parasympathetic nervous system then responds to the increase in blood pressure leading to bradycardia. Increased ICP also leads to an irregular respiratory pattern due to pressure on the brainstem.

These signs indicate brain herniation which is a terminal event without immediate neurosurgical intervention.

MANAGEMENT

The focus during emergency management of head injuries is to minimize secondary brain injury, thereby decreasing morbidity and mortality. **Important predictors of poor outcome with head injury include even short lived episodes of [1] hypoxia and [2] hypotension.** Preventing and treating these occurrences are of utmost importance. Unregulated blood glucose may also play a role in poor outcomes.

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In the presence of head injury:

- A single episode of hypoxia (SpO_2 less than 90%) is independently associated with a doubling of mortality
- A single episode of systolic blood pressure less than 90 mmHg is independently associated with at least a doubling of mortality (with repeat episodes there can be as high as an 8x increase in mortality)
- In intubated patients, hyperventilation is independently associated with a 2 to 5.9 times increase in mortality

Patients with head or spinal injury should be given 100% oxygen. It is important to maintain an SpO_2 above 90% at all times. If oxygenation is achievable with BLS maneuvers, avoid intubation in traumatic head injury if at all possible. The potential for even transient hypoxia associated with an intubation attempt can increase the likelihood of mortality exponentially.

Patients should be maintained with normal respiratory rates (12 breaths per minute). **Hyperventilation of head injured patients has also been shown to worsen outcomes as a result of hypocapnea**. This causes cerebral vasoconstriction, and therefore decreases cerebral blood flow and oxygenation. Inadvertent hyperventilation is common in these patients, particularly post intubation, greater effort is required to avoid these occurrences in the head injured population.

Hyperventilation may be an acceptable management option during critical care transport of a very select population of patients with signs of herniation en route to emergency neurosurgery. This is only performed when end-tidal CO_2 monitoring is available.

Immobilization

Patients with a possibility of spine injury should be immobilized with a c-collar and backboard. Indications for immobilization are outlined in the Canadian C-spine Rule illustrated in Figure 1.

When there is a back injury with suspicion of spine injury, the overall goal is to minimize movement during management and transport.

It is important to remember that patients who remain on a rigid surface can be subjected to adverse events such as permanent nerve injury, increased pain, or tissue ischemia on bony prominences which can lead to decubitus ulcers. Hence it is critically important to provide padding where necessary, to note the time of spine board application, and if possible minimize the amount of time the patient spends on the backboard.

IV Access and Medications

IV access should be obtained when feasible. In the presence of head injury, isotonic fluids should be provided as needed in an attempt to maintain a systolic blood pressure of 120 mmHg. The objective is to avoid any episodes of hypotension. Refer to the Shock Guideline for assessment and management of neurogenic shock, as this may complicate the hemodynamics of patients with spinal cord injuries. Pain control should be provided as appropriate in keeping with the Pain Management guideline.

Transport

If there is an isolated head injury (i.e. no associated spine injury), patients should consider transporting the patient with head elevated (e.g. 30-45° degrees). This will help to reduce cerebral edema, aspiration and incidence of ventilatory-associated pneumonia.

Geriatric Neurological Trauma

When evaluating the geriatric patient's mental status after trauma, it is important that the clinician does not assume that alterations in mental status are due solely to an underlying cause like dementia. Gather a collateral history from family members, care workers, etc. to determine whether the patient's mental state differs from their baseline.

There is also an increased incidence of C1 and C2 fractures in the geriatric population. If a geriatric patient (age over 65) presents with neck pain after trauma, the cervical spine should be immobilized until it can be properly assessed with radiography (see Figure 1).

Pediatric Neurological Trauma

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Assessment and management of the pediatric patient with neurological trauma is generally the same as it would be for an adult.

When immobilizing a small child, it is important to ensure proper alignment by padding under the shoulders if necessary.

Trip destination

Patients with suspected neurological injury should be transported directly (if possible) to a facility with immediately available CT scanning, prompt neurosurgical care and the ability to monitor ICP and treat intracranial hypertension.

The mode of transport selected should act to reduce total pre-hospital time.

Pediatric patients should be transported directly to a pediatric trauma centre if available or an adult trauma centre with additional pediatric qualifications.

TRANSFER OF CARE

Provide all relevant details to the receiving facility in terms of initial presentation, treatment rendered and patient's response to treatment.

If the patient is immobilized ensure the staff knows what time the patient was placed on the backboard.

CHARTING

In addition to the mandatory fields it is important to document the following in the ePCR text fields:

- ✓ Scene findings including mechanism of injury
- ✓ Time of injury
- ✓ Initial presentation
- ✓ Assessment and reassessment of interventions and patient care
- ✓ Any instances of hypoxia or hypotension
- ✓ Treatment provided
- ✓ Decisions and assessment around c-spine clearance

Key Points – Neurological Trauma

Hypoxia, hypotension, and hyperventilation increase mortality in patients with head injury

Perform a detailed neurologic assessment as time permits

Apply the Canadian C-spine Rule to all patients with possible neck injuries to determine need for immobilization

Minimize discomfort of immobilization and minimize immobilization time if possible

KNOWLEDGE GAPS

There is still research to be done on the benefit of short periods of hyperventilation in patients presenting with cerebral herniation.

Pre-hospital research has also recently been focusing on the appropriate indications and devices to be used when deciding to immobilize patients.

The methods for spinal immobilization are under review at both the provincial and international level. Guidelines are subject to change.

The Canadian CT Head Rule has not yet been validated in the prehospital setting

EDUCATION

EHS is working with the Trauma Program to minimize the risk of decubitus ulcers by establishing standards where all patients transported from the field to the ED are placed on an alternative surface within 60 minutes of rigid spine board application. Hence it is important to document and communicate the time that a patient has been placed on a spine board.

QUALITY IMPROVEMENT

In the setting of major trauma, scene times should be limited, and if at all possible, procedures should be done en route to definitive care unless required for a life-threatening condition. Analgesia should be

administered to patients with pain due to neurological trauma unless contraindicated.

Request for LifeFlight, Trauma Team, and/or notification to the receiving facility should be done early in the setting of major trauma.

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Figure 1: Canadian C-Spine Rule*

For all alert (GCS=15) and stable trauma patients where cervical spine injury is a concern

1. **Any high-risk factors?**

Age ≥ 65 years
OR
Dangerous mechanism*
OR
Paresthesias in extremities

If YES – Immobilize; If NO – Move to #2

*Dangerous mechanism:
- Fall from elevation ≥ 3 feet/5 stairs
- Axial load to head
- High speed MVC, ejection, rollover
- Motorized recreational vehicle
- Bicycle struck or collision

2. **Any low-risk factor which allows safe assessment of range of motion?**

Simple rear end MVC**
OR
Ambulatory at any time
OR
Delayed onset of neck pain
OR
Absence of midline C-spine tenderness

If NO – Immobilize; If YES – Move to #3

** Simple rear end MVC excludes:
- Pushed into oncoming traffic
- Hit by bus/large truck
- Rollover
- Hit by high speed vehicle

3. **Able to actively rotate neck 45° left and right?**

If unable – Immobilize; If able – Clear c-spine

* Stiell IG, Wells GA, et al. The Canadian C-spine rule for radiography in alert and stable trauma patients. JAMA. 2001 Oct; 286(15): 1841-8.

Figure 2: American Spinal Association: Standard Neurological Classification of Spinal Cord Injury

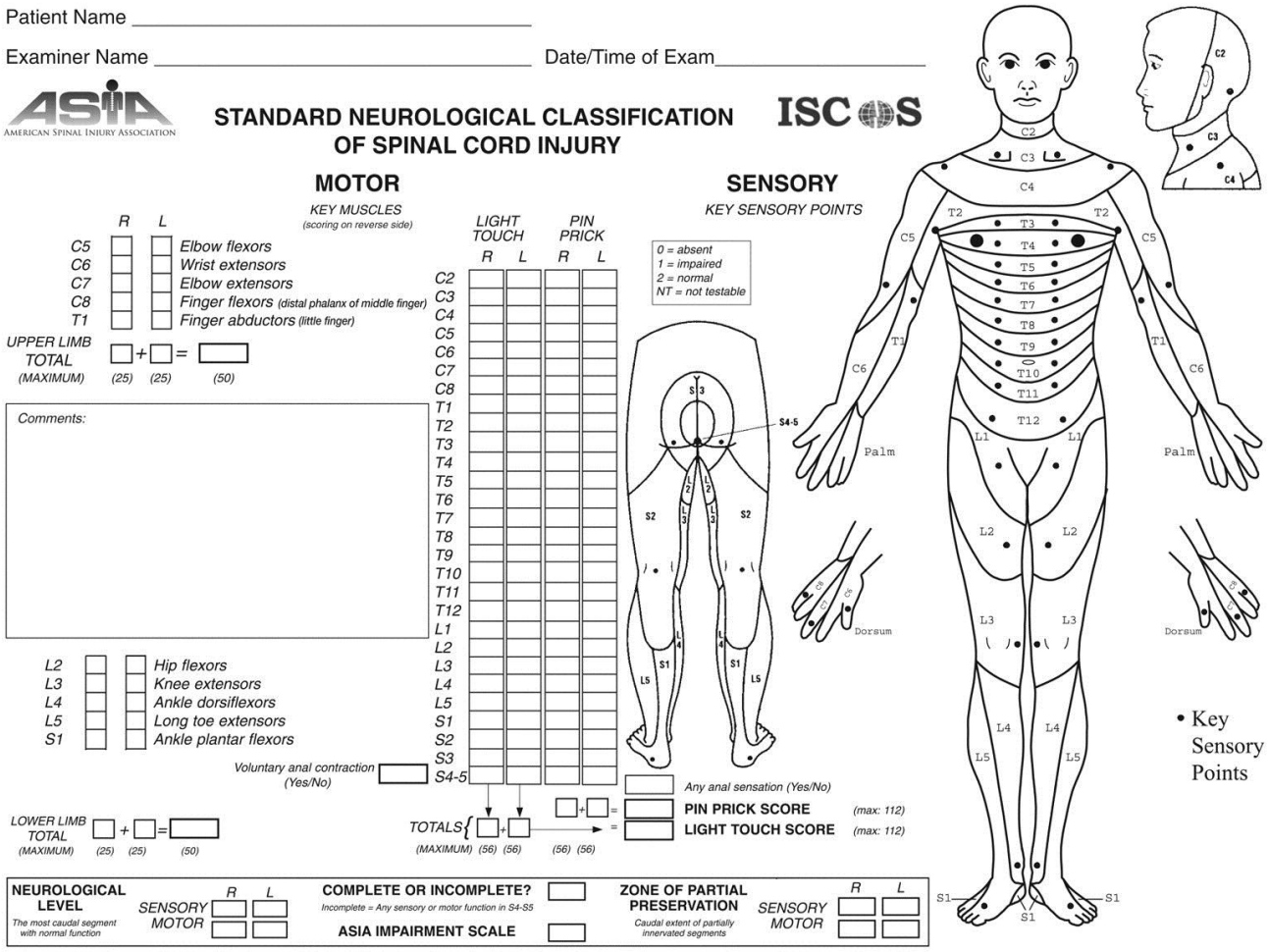


Figure 3: Dermatomes

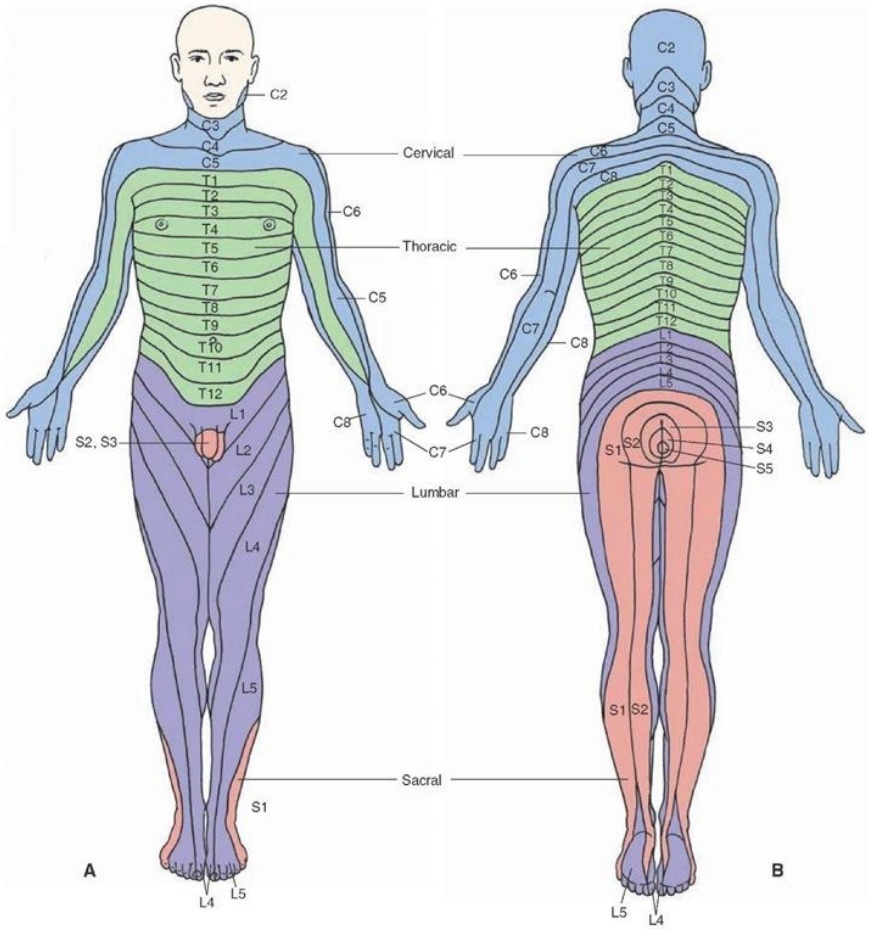
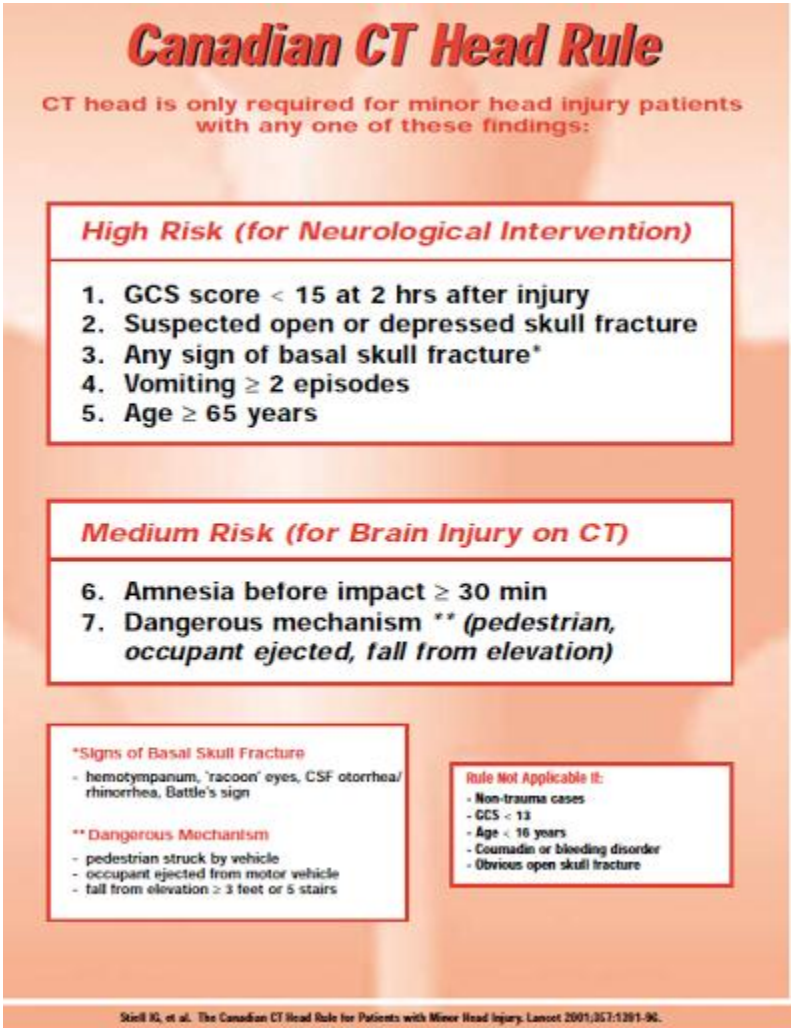


Figure 4: Cranial nerve assessment

Cranial Nerve	Function	Assessment
I (Olfactory)	Sense of smell	Ask your patient to smell an alcohol swab
II (Optic)	Vision; pupil reactivity to light	Have the patient read some text (one eye at a time)
III (Oculomotor)	Eye movement and pupil size and reactivity	Check size and shape of pupils as well as reactivity to light; have patient look up, down, laterally and diagonally
IV (Trochlear)	Eye movement (downward and lateral)	Have the patient look down and in toward the nose
V (Trigeminal)	Chewing, facial and mouth sensation	Ask patient to clench their teeth and move their jaw laterally against light pressure; test sensation of the forehead, cheeks and jaw
VI (Abducens)	Eye movement (lateral)	Have the patient move their eyes from side to side
VII (Facial)	Facial movement, taste, eyelid and lip closure	Ask the patient to smile and raise their eyebrows
VIII (Vestibulocohlear/Acoustic)	Sense of hearing and equilibrium	Assess hearing in both ears by rubbing your fingers together on both sides of the patient's head independently
IX (Glossopharyngeal)	Gagging and swallowing (sensory); taste	Ask the patient to swallow
X (Vagus)	Gagging and swallowing (motor); speech phonation	Same test as with Cranial Nerve IX
XI (Spinal accessory)	Shoulder movement and head rotation	Have the patient shrug their shoulders then turn their head side to side (avoid this if neck/spinal injury possible)
XII (Hypoglossal)	Tongue movement and speech articulation	Have the patient stick out their tongue and move it internally from cheek to cheek

Figure 5: Canadian CT Head Rule



PEP 3x3 TABLES for NEUROLOGICAL TRAUMA

Throughout the EHS Guidelines, you will see notations after clinical interventions (e.g.: **PEP 2 neutral**). PEP stands for: the Canadian **P**rehospital **E**vidence-based **P**rotocols Project.

The number indicates the Strength of cumulative evidence for the intervention:
1 = strong evidence exists, usually from randomized controlled trials;
2 = fair evidence exists, usually from non-randomized studies with a comparison group; and
3 = weak evidence exists, usually from studies without a comparison group, or from simulation or animal studies.

The coloured word indicates the direction of the evidence for the intervention:
Green = the evidence is supportive for the use of the intervention;
Yellow = the evidence is neutral;
Red = the evidence opposes use of the intervention;
White = there is no evidence available for the intervention, or located evidence is currently under review.

PEP Recommendations for Neurological Trauma Interventions, as of 2014/03/14. PEP is continuously updated. See: http://emergency.medicine.dal.ca/ehsprotocols/protocols/toc.cfm for latest recommendations, and for individual appraised articles.

Head Injury

Recommendation		RECOMMENDATION FOR INTERVENTION			
		SUPPORTIVE (Green)	NEUTRAL (Yellow)	AGAINST (Red)	NOT YET GRADED (White)
STRENGTH OF RECOMMENDATION FOR INTERVENTION	1 (strong evidence exists)		• Hypertonic Saline • Mannitol	• Hyperventilation	
	2 (fair evidence exists)	• Intubation (CCT)	• Fluid Resuscitation • Rapid Sequence Intubation • RSI (CCT)	• Intubation	
	3 (weak evidence exists)			• Colloid Infusion	

Spinal Injury

Recommendation		RECOMMENDATION FOR INTERVENTION			
		SUPPORTIVE (Green)	NEUTRAL (Yellow)	AGAINST (Red)	NOT YET GRADED (White)
STRENGTH OF RECOMMENDATION FOR INTERVENTION	1 (strong evidence exists)	• Steroid			
	2 (fair evidence exists)	• Hypertonic Saline • Scoop stretcher			
	3 (weak evidence exists)				

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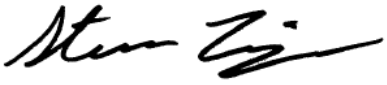
Signature of Program Director 	Signature of Program Document Coordinator 	

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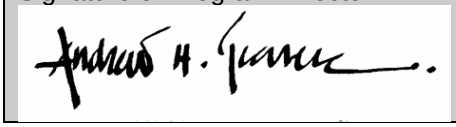
Signature of Program Director 	Signature of program Document Coordinator