

## Types of Resulting Brain Injury

Primary - occurs at time of impact

- Direct neuronal damage, axonal shear → diffuse oedema/axonal injury
- Skull #
- Concussion with risk of 2<sup>nd</sup> impact syndrome
- Cerebral contusion - diffuse, most often ant/inf parts of frontal/temporal lobes
- Intracranial haemorrhage:
  - Extradural, subdural or subarachnoid haemorrhage
  - Intracerebral haematoma - localised, 35% extend into ventricles

Secondary

- From direct effects of primary injury - cellular cascade, haematoma, oedema
- Secondary systemic insult from hypotension, hypoxia, raised ICP, acidosis

Direct - under impact site.

Contrecoup - opposite side of brain to impact site.

## Epidemiology

- Common
- Male & extremes of age more at risk
- MVA, falls & assaults are most common causes.
- Alcohol involved in up to 65% of adult head injuries.

## Assessment

Generally if  $GCS \leq 13$  or  $GCS < 15$  in patient  $> 65y$  then activate Trauma Team, and CT will be needed. Other (minor) HI use one or often a mix of CT rules from NOC, CCHR or NEXUS II

*History:*

AMPLE history plus points used in risk assessment of significant brain injury in mild HI are:

- Dangerous mechanism (fall  $> 5$  stairs, MVA with ejection, pedestrian struck)
- Focal blow to the temporal/parietal region of the head especially with a heavy implement
- Severe persistent headache
- Vomiting  $> 2$  episodes
- Seizure associated with head injury
- Post traumatic amnesia  $> 30$  minutes
- Ongoing confusion or restlessness
- Age  $> 65$  years especially if on aspirin, clopidogrel or other antiplatelet agents
- Patient on warfarin or has bleeding disorder (e.g. haemophilia, hepatic failure)

Also check:

- Drug or EtOH intoxication, pregnancy, known brain pathology or VP shunt

*Examination:*

*Airway + C-Spine:* ?protected in view of LOC and ?patent if facial/airway injury. ?C-spine injury.

*Breathing:* Check for hypoventilation/hypoxia.

*Circulation:* Check for hypoBP or causes for it. ?Cushing reflex (BP, HR, LOC).

*Disability:* GCS, focal neuro signs, ipsi/bilat blown pupil, posturing, papilloedema (late)

*Exposure:* Sign of open or depressed skull # (boggy scalp haematoma), sign of basal skull # (CSF leak, Battle's sign, racoon eyes)

## Investigations

**Bloods:** BSL, FBC, UEC, coags, trop/CK, G&H

**EKG:** ?arrhythmia/MI (trigger of fall), ST elevation in SAH, traumatic brain injury

**Imaging:** Brain CT or Skull XR/MRI/USS (see below for comparison). Trauma XRs ± CT C-spine

## Management

Initial Management of Closed Head Injury in Adults, 2nd Edition NSW HEALTH

### Initial Assessment and Stabilisation of ABCDEs

Trauma Team activation if initial GCS 3-13 or otherwise indicated

Commence minimum of hourly clinical observations of vital signs, GCS, pupils, PTA (if applicable) and clinical symptoms

GCS 3-8

#### Severe Head Injury (10%)

- Early intubation
- Supportive care of ABCDEs
- Prevent secondary brain injury by avoiding hypoxaemia and hypotension
- Early CT scan
- Early neurosurgical consult
- Early retrieval consult if transfer required
- Consider use of anticonvulsants
- Consider ICP monitoring
- ICU admission
- Brain injury rehabilitation consult

NB. Minimum supportive care aims to prevent secondary brain injury:

- PaO<sub>2</sub> >60
- SaO<sub>2</sub> >90
- PaCO<sub>2</sub> 35-40
- Systolic BP >90 (MAP >80mmHg)
- Head up 30°

GCS 9-13

#### Moderate Head Injury (10%)

- Supportive care of ABCDEs
- Prevent secondary brain injury by avoiding hypoxaemia and hypotension
- Early CT scan
- Period of clinical observation
- Consider intubation in the event of clinical deterioration or to facilitate management
- Early neurosurgical consult if not clinically improving and/or abnormal CT scan
- Early retrieval consult if transfer required
- Admit to hospital for prolonged observation unless rapid clinical improvement to GCS 15, normal CT scan and absence of other risk factors (as per mild head injury)
- Routine post traumatic amnesia testing and consider referral to brain injury rehabilitation service due to significant risk of cognitive behavioural social sequelae

GCS 14-15

#### Mild Head Injury (80%)

- Initial assessment followed by period of clinical observation to detect risk factors for significant intracranial injury.
- CT scan not routinely indicated unless one or more risk factors listed below are present.
- Discharge for home observation with head injury advice sheet at 4 hours post injury if clinically improving with either no risk factors indicating the need for CT scan or normal CT scan if performed.
- Consider hospital admission and consult network neurosurgical service if abnormal CT scan.
- Consider hospital admission for observation if clinically not improving at 4 hours post injury irrespective of CT scan result.
- Consider hospital admission for observation if elderly, known coagulopathy or socially isolated.
- Advise patients to see their local doctor if they do not return to normal within 48 hours so they can be reassessed and monitored for post concussion symptoms.

NB. Also see separate Mild Head Injury Algorithm.

### Severe HI Notes

Intubate within 10mins. Ideally avoiding ↑ICP (pre-Rx: **fentanyl**)

Head & C-Spine CT <1h. Maintain C-Spine precautions

Other supportive care:

- Neuroprotective:
  - Head 30° up, SaO<sub>2</sub>>90%, pO<sub>2</sub>>90, pCO<sub>2</sub> 35-40, MAP>80
  - Keep T & BSL normal
  - Aim [Na<sup>+</sup>] 140-145mmol/L
  - Maintain sedation ± relaxation
  - Avoid constricting the neck (e.g. with collars)
- If acute deterioration/signs of ↑ICP:
  - **3% saline** 5ml/kg (or **mannitol** 1g/kg if not hypovol) IV
  - Brief hypervent to PCO<sub>2</sub> 30-35mmHg
  - Aim [Na<sup>+</sup>] 145-150mmol/L
- Correct coagulopathy:
  - **FFP** 4u & **Vitamin K** 5-10mg IV
- Seizure prophylaxis:
  - **Phenytoin** 1g IV over 20min
- ?ABx for open skull #, not CSF leak:
  - **Cephalothin** 2g IV

NB Cochrane r/v found no evidence for hypothermia, or prophylactic anti-epileptics for late seizures.

### Deterioration of less severe HI:

- 10% of Moderate HI and 2% of Mild HI deteriorate

### High risk mild head injury

Strong indication for CT scan if...

- GCS <15 at 2 hours post injury. #1
- Deterioration in GCS.
- Focal neurological deficit.
- Clinical suspicion of skull fracture #2
- Vomiting (especially if recurrent) #3
- Known coagulopathy or bleeding disorder #4
- Age >65 years. #5
- Seizure #6
- Prolonged loss of consciousness (>5 mins).
- Persistent post traumatic amnesia (A-WPTAS <18/18 at 4hrs post injury) #7
- Persistent abnormal alertness / behaviour / cognition #8
- Persistent severe headache.

Relative indication for CT scan if...

- Large scalp haematoma or laceration #9
- Multi-system trauma. #10
- Dangerous mechanism. #11
- Known neurosurgery / neurological impairment. #12
- Delayed presentation or representation. #13

### Explanatory notes for risk factors in Mild Head Injury

- Using GCS<15 at 2 hours post injury allows clinical judgement for patients who present soon after injury or who have drug or alcohol intoxication. Drug or alcohol intoxication has not been shown to be an independent risk factor for intracranial injury but persistent GCS<15 is a major risk factor and mandates CT.
- Clinical suspicion of skull fracture includes history of focal blunt assault or injury; palpable skull fracture; large scalp haematoma or laceration; signs of base of skull fracture – haemotympanum / CSF leak / raccoon eyes / Battles sign.
- Recurrent vomiting more concerning than isolated vomiting but both are indications.
- Known coagulopathy is both a strong indication for early CT scan and to check the INR. Early reversal of anticoagulation if abnormal CT scan and consider reversal if initially normal CT scan with high INR (>4) depending on clinical situation.
- Elderly patients have increasing risk of intracranial injury with increasing age; routine CT scanning indicated unless totally asymptomatic patient with no other risk factors.
- Brief generalised seizures immediately following head injury are not significant risk factors. Prolonged, focal or delayed seizures are risk factors for intracranial injury.
- Post traumatic amnesia may manifest as repetitive questioning or short term memory deficits and can be objectively tested using the A-WPTAS. PTA > 30 mins is a minor risk factor and PTA > 4 hours a major risk factor for intracranial injury.
- Abnormal alertness/behaviour/cognition detects subtle brain injury better than GCS and should be part of the bedside assessment. Family may help establish what is normal.
- Multi-system trauma – beware patient with unstable vital signs or distracting injuries or who receive analgesia or anaesthesia, as significant head injury is easily missed.
- Clinical judgement required as to what is a large scalp haematoma or laceration.
- Dangerous - MVA ejection / rollover; pedestrians / cyclists hit by vehicle; falls >own height or five stairs; falls from horses / cycles etc; focal blunt trauma, eg bat / ball / club.
- Known neurosurgery/neurological impairment – conditions such as hydrocephalus with shunt or AVM or tumour or cognitive impairment such as dementia make clinical assessment less reliable and may increase risk of intracranial injury.
- Delayed presentation should be considered as failure to clinically improve during observation. For representation consider both intracranial injury and post concussion symptoms and have a low threshold for CT scanning if not done initially.

## Comparison of Imaging Modalities

### CT Scan

- Indications: (NB Pregnancy (excluded) & severe headache (not predictive) in CCHR)
  - $GCS < 13$ , or CCHR/NOC/NEXUS II HCT criteria for  $GCS > 13$
  - If deteriorating ( $GCS$  drop by  $\geq 2$ )
  - Also if VP shunt or brain lesion known
- CI: Unstable patient, child (radiation & need for GA)
- Outcome: abnormal rate much high (~3-4x) than significant injury rate
- Cx: Small  $\uparrow$  risk of ALL in child if XR or CT in pregnancy
- Pros: Highly spec/sens for neurosurg intervention, more avail than MRI, ED Drs can read.
- Cons: Expense, needs CT radiographer, sedation/GA/ETT for some (child, non-coop)

### Skull Xray

- Only if CT not available, detects 50% of fractures, may have a role in ?NAI

### Brain USS

- Useful in infants esp neonates if fontanelle open or bony defect
- Intraoperative USS useful to position or localize ventricular catheters
- Needs skilled operator and interpreter of result

### Brain MRI

- Pros: sensitive  $>$  CT for shearing white matter injury, SDH & EDH, contusion & sinus inj
- Cons: sensitive  $<$  CT for fractures, less avail resource, cost, time req, "tunnel of death" away from resus area, magnetism CI (no metal resus equip)

### D/C criteria

- Normal alertness/cognition/behaviour
- Clinically improving after observation
- Normal CT or CT not indicated
- Reliable person to observe at home
- Able to return if deteriorates
- Has & understands (or carer does) printed HI advice - return if:
  - Increasing drowsiness
  - Worsening headache
  - Confusion or strange behaviour
  - Two or more bouts of vomiting
  - Focal neurological problem, e.g. limb weakness
  - Dizziness, loss of balance or convulsions
  - Any visual problems such as blurring of vision or double vision
  - Blood, or clear fluid, leaking from the nose or ear
  - Unusual breathing patterns

If elderly, falls risk, on anticoagulants have lower threshold to admit.

## Complications

- **Amnesia:** common, may be retrograde and/or anterograde
- **Raised intracranial pressure** ( $\downarrow$ LOC,  $\uparrow$ HT,  $\downarrow$ HR, VIn, late: papilloedema, IIIIn, posturing)
  - See **Raised Intracranial Pressure** topic
- **Cerebral herniation:**
  - **Uncus transtentorial** - IIIIn - fixed dilated pupil. Most common.
  - **Central transtentorial** - Bilat pinpoint  $\rightarrow$  fixed midsized pupils, bilat Babinski,  $\uparrow$ tone
  - **Cerebellotonsillar:** Pinpoint pupils, flaccid paralysis, sudden death
  - **Upwards posterior fossa:** conjugate down gaze, pinpoint pupils, sudden death
- **Skull fractures:** ~50% will not have significant LOC or any neurological findings. 7% ICH. ABx if open.  $\uparrow$ Risk: temporal # crossing middle meningeal a., post. fossa #, depressed #.
- **Base of skull #** - CSF leak, Battle's sign, haemotympanum, raccoon eyes. ABx not req.
- **CSF leak** (test for glucose or double halo drop on filter paper):
  - **Nasal** - ?cribriform plate # or from ear via ET. Anosmia, may require surgery. No NGT & don't blow nose. Low risk of meningitis (but higher than aural leak).
  - **Aural** - ?petrous temporal bone #  $\pm$  VII/VIIIIn, closes spontaneously
- **Meningitis:** following skull # may occur wks to yrs later. ABx prophylaxis controversial.
- **Intracranial haemorrhage:**
  - **Extradural:** assoc with skull # + torn dural sinus or meningeal a. No/brief LOC 50%, brief lucidity 30%, Mort 30%. White, ellipse on CT, doesn't cross sutures.
  - **Subdural:** sudden accel-decel  $\rightarrow$  tearing of the bridging veins. Common in severe HI, atrophic brains (elderly, alcoholics) and children  $<2$ . May be acute ( $<1d$ ), subacute (1-14d) and chronic ( $>14d$ ). May be few signs with chronic subdurals. High morbidity & mortality if acute. CT: Crescentic, cross sutures., white (acute) to dark ( $>4w$ )
  - **Subarachnoid:** most common in mod-sev HI. May present with meningism & has a sig mortality reduced by nimodipine. Late CT (6-8h) more sensitive.
  - **Intracerebral:** cerebral contusions are common and often assoc with SAH. ICH may occur after days, often at the site of resolving contusions
- **Extracranial haemorrhage:** scalp lacerations, nasal injuries and injuries to the face and neck can lead to significant blood loss
- **Diffuse axonal injury:** shearing at white matter and brainstem. Common in MVA & 'shaken baby syndrome'. Primary insult is essentially irreversible. Rapid  $\uparrow$ ICP & coma. CT scan may be normal or haemorrhage to deep structures of brain. Rx limited to  $\downarrow 2^\circ$  damage.
- **Penetrating injuries** e.g. gunshot wounds. High incidence of infection and mortality
- **Seizures:** More common following penetrating injury or children.
- **Cranial nerve injuries** usually I-VII: I & II may be permanent, rest usually resolve.
- **Concussion:** Amnesia and confusion. Duration of amnesia is predictive of injury severity. Other symptoms include dizziness, headaches, poor concentration, N&V. Resolution is often rapid, but symptoms may persist as a post-concussive syndrome for wks-yrs.
- **Late Cx** include DIC, hyperthermia, DI (5% mod/sev HI), gastric ulcer, and later still: chronic daily headache, post-traumatic stress disorder, vertigo and cognitive impairment.

## Procedures

### *Emergency Burr Holes*

Indication: Deteriorating neurology with blown pupil and access to neurosurg >2h.

Technique: 1<sup>st</sup> try - Temporal - above midpoint of zygomatic arch 2 fingers ant to EAM (75%)

2<sup>nd</sup> try - Frontal - 4 fingers ant and 4 finger sup to EAM (10%)

3<sup>rd</sup> try - Parietal - 4 fingers post and 4 fingers sup to EAM

Then try other side

0-5% chance of return to independence

## Prognosis

HI + GCS 3 -mortality >95% (penetrating), 60% (blunt trauma)

HI + GCS<8 - mortality 30-40%, 15-20% persistent severe disability.

HI + GCS >13 - mortality <1%, morbidity <7%

Coma - 66% aware at 3d become independent. 10% vegetative at 7d become independent

Brainstem: init fixed pupils - 5% regain consciousness, none independent

Age: Bad: elderly<adult<child :better

Hypotension: Very poor prognosis

## Prevention

- Safer roads, barriers to prevent falls, and gun control legislation.
- Bicycle and motorcycle helmets, seatbelts, airbags, and soft surfaces on playgrounds are effective.

## Special Groups

### *Alcoholic*

- High risk for Cx - low platelets, coagulopathy, brain atrophy - ↑risk esp sub-dural
- Intoxication makes GCS difficult to assess
- Social situation more likely close observation at home less likely

### *Paediatric*

- More prone to develop cerebral oedema than adults
- May have subtle signs if fontanelle open - but can use USS to scan in this case
- Children <2 with ICH - 75% have skull #, 50% only have features of scalp haematoma

## Risk Stratification of Head Injury (i.e. Significant Brain Injury on CT)

### *Glasgow Coma Score*

GCS often used to initially stratify HI pats as mild (14-15), moderate (9-13) or severe (3-8).

### *New Orleans Criteria [NOC] (validated)*

*Aim:* Identify risk of significant brain injury on CT in minor HI

*Included:* GCS 15, age ≥3, LOC/amnesia, normal neuro

*Excluded:* ?

*Rule criteria:* GCS 15 + LOC AND:

- Headache
- Age ≥60y
- Vomiting
- Drug or EtOH intoxication
- Short term memory loss
- Seizure after injury
- Evidence of trauma above the clavicles

*Perf:* Deriv Sens 100% (+veCT), Spec 24.5%. Validn Sens ~99%(CT)/100%(NSx), Spec ~5%

### Canadian CT Head Rules [CCHR] (validated)

*Aim:* Identify risk of significant brain injury on CT in minor HI

*Included:* Init GCS 13-15, LOC, amnesia, disorientation

*Excluded:* Acute focal neurological deficit, bleeding disorder, PO warfarin, <16y, pregnant, obvious penetrating/depressed skull #, fit prior to ED, minimal head injury (no LOC, amnesia, disorientation), no clear Hx of trauma, returned to ED with same injury.

*Rule high risk criteria:*

- GCS<15 at 2hr post injury
- Suspected open or depressed skull #
- Sign of base of skull #
- ≥2 episodes of vomiting
- Age ≥ 65y

*Rule med risk criteria:*

- Dangerous mechanism (Ped vs MV, ejection MVA, fall>1m or 5 stairs)
- Retrograde (before impact) amnesia >30min

*Perf:* Deriv Sens 98% (+veCT), Spec ~50%. Validn Sens ~83%(CT)/100%(NSx), Spec ~40%

### Nexus II Head CT Rules (largest derivation study, but not widely validated as yet)

*Aim:* Identify risk of significant injury on CT in all HI & minor HI ()

*Included:* All with CT for blunt trauma. Minor HI subgroup had GCS 15

*Excluded:* ?

*Rule criteria:*

- **B**leeding problem
- **E**mesis persistent/forceful
- **A**ge ≥ 65y
- **N**eurological deficit
- **B**ehaviour abnormal
- **A**ltered level of consciousness
- **S**kull fracture
- **H**aematoma of scalp

*Performance:* Sensitivity 95-98%, Specificity 13-17%

### Head Injury CT Algorithms for Children (1:1500 cancer risk for 1yo, 1:6000 for 15yo)

#### NEXUS II HCT

- Sn 96-99%, Sp 15-21%
- Can use adult criteria but w/o age criteria, i.e. **BEAN BASH**

#### CHALICE

- Unvalidated
- Sig TBI: Sn 99%, Sp 87%. CT Inj: Sn 99% Sp: not calculable
- Scan is required for:

##### History

- Witnessed LOC>5 min
- History of amnesia >5 min
- Abnormal drowsiness
- >2 vomits after HI
- ?NAI
- Fit w/o Hx of epilepsy

##### Examination

- GCS<14, or <15 in infant
- ?Penetrating/depressed skull inj
- Tense fontanelle in infant
- Signs of a basal skull #
- Positive focal neurology
- Bruise/swelling/lac>5cm in infant

##### Mechanism

- High-speed MVA/Ped (>30kmh)
- Fall of >3m
- High-speed projectile injury

## PECARN

- Validated <2y: Sn 100%, Sp 55%. ≥2y: Sn 94-97% , Sp 60%

Any 1 of following?		AGE < 2y
GCS 14	(4.4% risk of ciTBI)	
Altered mental status	----->	<b>CT</b>
Palpable skull #	YES	
NO		
∨		
1 or more of following?		
Sev mechanism*	(0.9% risk of ciTBI)	
LOC ≥ 5 sec	----->	<b>OBS vs CT</b>
Non-frontal hematoma	YES	<u>Use clinical gestalt:</u>
Abnormal behaviour		• Dr experience
		• Mult vs isolated finding
NO (<0.02% risk of ciTBI)		• Worsening signs/sympt
∨		• Age < 3mo
		• Parental preference
<b>NO CT</b>		

Any 1 of following?		AGE ≥ 2y
GCS 14	(4.3% risk of ciTBI)	
Altered mental status	----->	<b>CT</b>
Signs of BOS #	YES	
NO		
∨		
1 or more of following?		
Sev mechanism*	(0.9% risk of ciTBI)	
Any LOC	----->	<b>OBS vs CT</b>
Hx of vomiting	YES	<u>Use clinical gestalt:</u>
Sev headache		• Dr experience
		• Mult vs isolated finding
NO (<0.05% risk of ciTBI)		• Worsening signs/sympt
∨		• Parental preference
<b>NO CT</b>		

\* Severe mechanism:

- MVC with patient ejection, death of another passenger, or rollover
- Pedestrian or bicyclist without helmet struck by a motorized vehicle
- Fall >3 ft (age <2 yr) or >5 ft (age ≥2 yr)
- Head struck by a high-impact object

## CATCH (Canadian Assessment of Tomography for Childhood Head Injury) Rule

- Unvalidated as yet
- Intervention: Sn 100%, Sp 70%. CT inj: Sn 98%, Sp 50%
- For child with minor HI (GCS13-15 AND any of <24h, LOC, amnesia, confusion, >1 vomit, persistent irritability if aged <2y)

High risk (100% req neurological intervention)

- GCS <15 at 2h post-HI
- Suspected open/depressed skull #
- Hx of worsening headache
- Irritability on examination

Medium risk (98.1% had brain injury on CT scan)

- Any sign of BOS#
- Large, boggy haematoma of the scalp
- Dangerous mechanism (e.g. MVA, fall >3ft or 5 stairs, bike fall with no helmet)

# A Critical Comparison of Clinical Decision Instruments for Computed Tomographic Scanning in Mild Closed Traumatic Brain Injury in Adolescents and Adults

Sherman C. Stein, MD  
 Andrea Fabbri, MD  
 Franco Servadei, MD  
 Henry A. Glick, PhD

From the Department of Neurosurgery, Hospital of the University of Pennsylvania, Philadelphia, PA (Stein); the Department of Emergency Medicine, Ospedale Morgagni-Pierantoni, Forlì, Italy (Fabbri); the Department of Neurosurgery, Ospedale Maggiore, Parma, Italy (Servadei); and the Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania School of Medicine, Philadelphia, PA (Glick).

**Methods:** We performed a secondary analysis of prospectively collected database from 7,955 patients aged 10 years or older with mild traumatic brain injury to compare sensitivity and specificity of 6 common clinical decision strategies: the Canadian CT Head Rule, the Neurotraumatology Committee of the World Federation of Neurosurgical Societies, the New Orleans, the National Emergency X-Radiography Utilization Study II (NEXUS-II), the National Institute of Clinical Excellence guideline, and the Scandinavian Neurotrauma Committee guideline. Excluded from the database were patients for whom the history of trauma was unclear, the initial Glasgow Coma Scale score was less than 14, the injury was penetrating, vital signs were unstable, or who refused diagnostic tests. Patients revisiting the emergency department within 7 days were counted only once.

**Table 1.** Findings used by 7 clinical decision rules for CT scanning in mild traumatic brain injury.

Clinical Finding	Canadian	NCWFNS	New Orleans	NEXUS-II	NICE	Scandinavian
GCS score	<15 At 2 h	<15	<15	Abnormal alertness, behavior	<15 At 2 h	<15
Amnesia	Retrograde >30 min*	Any	Antegrade	—	Retrograde >30 min	Any
Suspected fracture	Open, depressed, basal	Any	Any injury above clavicles	Any	Open, depressed, basal	Basal, depressed, confirmed
Vomiting	Recurrent	Any	Any	Recurrent	Recurrent	—
Age, y	≥65	—	>60	≥65	≥65 <sup>†</sup>	—
Coagulopathy	—	Any	—	Any	Any <sup>†</sup>	Any
Focal deficit	—	Any	—	Any	Any	Any
Seizure	—	History	Any	—	Any	Any
LOC	If GCS=14	Any	—	—	—	Any
Visible trauma	—	—	Above clavicles	Scalp hematoma	—	Multiple injuries
Headache	—	Any	Severe	—	—	—
Injury mechanism	Dangerous* <sup>‡</sup>	—	—	—	Dangerous <sup>†‡</sup>	—
Intoxication	—	Abuse history	Drug, alcohol	—	—	—
Previous neurosurgery	—	Yes	—	—	—	Shunt

NCWFNS, Neurotraumatology Committee of the World Federation of Neurosurgical Societies; NICE, National Institute of Clinical Excellence; —, indicates the item is not considered an indication for CT scanning by author(s) of the rule; LOC, loss of consciousness.

\*Used to determine medium risk for the Canadian Rule.

<sup>†</sup>CT scan only if also loss of consciousness or any amnesia.

<sup>‡</sup>Dangerous injury mechanism=ejected from motor vehicle, pedestrian struck by motor vehicle, fall of >3 feet or 5 steps.

**Table 3.** Operating characteristics for the 6 decision rules for CT scanning in mild traumatic brain injury.

Strategy	Sensitivity (95% CI)			Specificity (95% CI)	
	Hematoma	Nonsurgical Lesion	Any Lesion	No Hematoma	No Lesion
Canadian (high-risk only)	0.99 (0.94–1.00)	0.97 (0.94–0.98)	0.97 (0.95–0.98)	0.48 (0.47–0.49)	0.51 (0.49–0.52)
Canadian (medium/high risk)	0.99 (0.94–1.00)	0.99 (0.97–1.00)	0.99 (0.98–1.00)	0.45 (0.44–0.46)	0.47 (0.46–0.48)
Neurotraumatology Committee of the World Federation of Neurosurgical Societies	0.99 (0.94–1.00)	0.95 (0.93–0.97)	0.96 (0.94–0.97)	0.45 (0.44–0.46)	0.47 (0.46–0.48)
New Orleans	0.99 (0.94–1.00)	0.99 (0.97–1.00)	0.99 (0.98–1.00)	0.31 (0.30–0.32)	0.33 (0.32–0.34)
Nexus-II	1.00 (0.97–1.00)	0.97 (0.94–0.98)	0.97 (0.96–0.98)	0.44 (0.43–0.46)	0.47 (0.46–0.48)
National Institute of Clinical Excellence	0.98 (0.93–1.00)	1.00 (0.99–1.00)	0.99 (0.98–1.00)	0.29 (0.28–0.30)	0.31 (0.30–0.32)
Scandinavian	0.99 (0.94–0.99)	0.95 (0.92–0.97)	0.96 (0.93–0.97)	0.50 (0.49–0.51)	0.53 (0.52–0.54)