

Emergency Medicine  
Education and Training



## Head injury and CT

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# Presentation sequence

**Intro**

**Marco**

Paediatric head injury  
Who needs a CT?

**Neralie**

Neuroprotective measures

**Bob**

Adult head injury  
Who needs a CT?  
What about the neck?

# The problem(s)

Patients with non severe head injury who may present when CT is not easily available.

- Approximately 5% with initial CGS 15 will deteriorate – how do we find them?
- Effects of radiation – how bad is it?
- Resource issues – can we afford to CT everyone?
- Transfer issues – is it needed, where, when?
  
- 1 transfer to Adelaide with head injury every 2-3 days

What we will not cover

- Severe head injury (GCS  $\leq$  12)
- Concussion
- Head injury in multiple trauma

# How well are we doing in SA?



*Emergency Medicine Australasia* (2023)

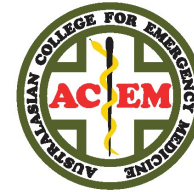
doi: 10.1111/1742-6723.14281

## ORIGINAL RESEARCH

Increased distance or time from a major trauma centre in South Australia is not associated with worse outcomes after moderate to severe traumatic brain injury

James EVENDEN ,<sup>1</sup> Daniel HARRIS ,<sup>2,3,4</sup> Adam J WELLS ,<sup>2,5</sup> Barbara TOSON ,<sup>6</sup>  
Daniel Y ELLIS ,<sup>2,3,7</sup> and Paul F LAMBERT ,<sup>2,3</sup>

No difference in mortality or discharge location according to distance.



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where knowledge + health meet

# Mild to Moderate Head Injuries in Children PREDICT

*Paediatric Research in Emergency Departments International Collaborative*

**Australian and NZ Guideline for Mild to Moderate Head Injuries in Children**

Marco Pillen

Retrieval Paramedic SAAS MedSTAR

# Assessment

Children with head injury should be assessed in a hospital setting if the mechanism of injury was severe<sup>1</sup> or if they develop the following signs or symptoms within 72 hours of injury:

- seizure or convulsion
- double vision, ataxia, clumsiness or gait abnormality
- loss of consciousness
- deteriorating level of consciousness
- weakness and tingling in arms or legs
- presumed skull fracture (palpable fracture, 'raccoon eyes' or Battle's signs)
- vomiting<sup>2</sup>
- severe headache
- not acting normally, including abnormal drowsiness, increasing agitation, restlessness or combativeness (in children aged less than 2 years, not acting normally as deemed by a parent)
- occipital or parietal or temporal scalp haematoma (in children aged less than 2 years only).<sup>3</sup>

# Age appropriate GCS

## ≤1 year old

### Eye Opening:

- 4 - Spontaneous
- 3 - To speech/shout
- 2 - To pain
- 1 - None

### Verbal Response:

- 5 - Alert, coos, babbles
- 4 - Irritable, consolable cry
- 3 - Cry to pain
- 2 - Cry/moan to pain, restless
- 1 - None

### Best Motor Response:

- 6 - Normal/spontaneous
- 5 - Withdraws to touch
- 4 - Withdraws from pain
- 3 - Flexion responses
- 2 - Extensor responses
- 1 - None

## 2 - 4 years old

### Eye Opening:

- 4 - Spontaneous
- 3 - To voice
- 2 - To pain
- 1 - None

### Verbal Response:

- 5 - Appropriate words, smile
- 4 - Consolable cry, few words
- 3 - Inappropriate words, persistent irritable cry
- 2 - Incomprehensible words, agitated, cries only to pain
- 1 - None

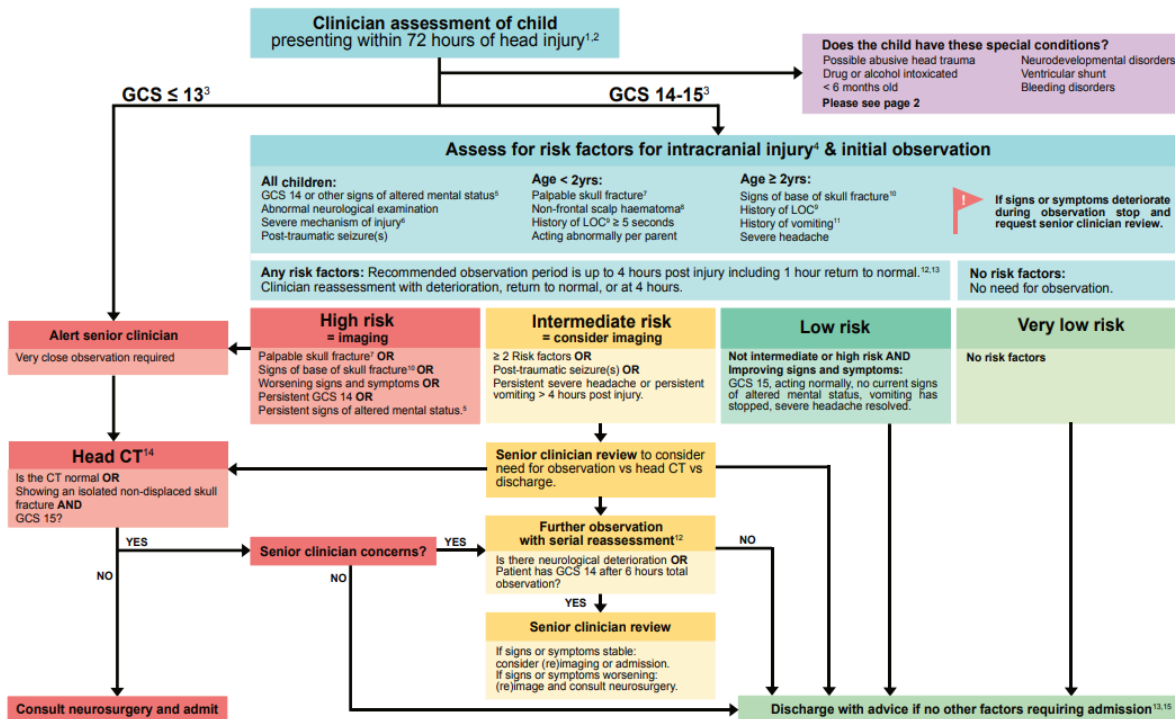
### Best Motor Response:

- 6 - Obeys commands
- 5 - Localises to pain
- 4 - Withdraws from pain
- 3 - Flexion to pain
- 2 - Extension to pain
- 1 - None



### Algorithm: Imaging & Observation Decision-Making for Children with Head Injuries

Further details and footnotes are important to interpretation of the algorithm. Please see page 2.



### Further details to aid algorithm interpretation

- <sup>1</sup> Always consider possible cervical spine injuries and abusive head trauma in children presenting with head injuries.
- <sup>2</sup> Children with delayed initial presentation (24-72 hrs post head injury) and GCS 15 should be risk stratified the same way as children presenting within 24 hours. They do not need to be assessed with a further 4 hrs of observation.
- <sup>3</sup> Remember to use an age-appropriate Glasgow Coma Scale (GCS).
- <sup>4</sup> Risk factors adapted from Kuppermann N et al. *Lancet* 2009;374(9696):1160-70.
- <sup>5</sup> Other signs of altered mental status: agitation, drowsiness, repetitive questioning, slow response to verbal communication.
- <sup>6</sup> Severe mechanism of injury: motor vehicle accident with patient ejection or rollover, death of another passenger, pedestrian or cyclist without helmet struck by motor vehicle, falls of ≥ 1m (< 2 yrs), fall > 1.5m (≥ 2yrs), head struck by high impact object.
- <sup>7</sup> Palpable skull fracture: on palpation or possible on the basis of swelling or distortion of the scalp.
- <sup>8</sup> Non-frontal scalp haematoma: occipital, parietal, or temporal.
- <sup>9</sup> Loss of consciousness.
- <sup>10</sup> Signs of base of skull fracture: haemotympanum, 'raccoon' eyes, cerebrospinal fluid (CSF) otorrhoea or CSF rhinorrhoea, Battle's signs.
- <sup>11</sup> Observation duration may be modified based on patient and family variables. These include time elapsed since injury/symptoms and ability of child/parent to follow advice on when to return to hospital.
- <sup>12</sup> Shared decision-making between families and clinicians should be considered.
- <sup>13</sup> Do not use plain X-rays, or ultrasound of the skull, prior to or in lieu of CT scan, to diagnose or risk stratify a head injury for possible intracranial injuries.
- <sup>14</sup> Observation to occur in an optimal environment based on local resources. Frequency of observation to be ½ hourly for the first 2 hours, then 1-hourly until 4 hours post injury. After 4 hours, continue 2-hourly as long as the patient is in hospital.
- <sup>15</sup> Other factors warranting hospital admission may include other injuries or clinician concerns e.g. persistent vomiting, drug or alcohol intoxication, social factors, underlying medical conditions, possible abusive head trauma.

**Special Conditions**

**Possible abusive head trauma**  
Follow local screening tools for abusive head trauma (AHT). CT should be used as initial diagnostic tool to evaluate possible intracranial injury and other injuries relevant for the evaluation of AHT e.g. skull fractures. The extent of the assessment of a child with possible AHT should be co-ordinated with the involvement of an expert in the evaluation of non-accidental injury.

**Drug or alcohol intoxicated**  
Treat as if the neurological findings are due to the head injury. Decision to CT scan or observe should be informed by risk factors for intracranial injury rather than the child being intoxicated.

**< 6 months of age**  
Consider at higher risk of intracranial injury with a lower threshold for observation or imaging. Discuss with a senior clinician.

**Neurodevelopmental disorders**  
It is unclear whether these children have a different background risk for intracranial injury. As these children may be difficult to assess, consider structured observation or head CT scan and include the paediatric team that knows the child (parents, caregivers, and clinicians) in shared decision-making.

**Ventricular shunt (e.g. ventriculo-peritoneal shunt)**  
Consider structured observation over immediate CT scan if there are no risk factors of intracranial injury. If there are local signs of shunt disconnection/shunt fracture (such as palpable disruption or swelling) or signs of shunt malfunction, consider obtaining a shunt series based on consultation with a neurosurgical service.

**Bleeding disorders or anti-coagulant or anti-platelet therapy**  
Urgently seek advice from the treating haematology team around risk of bleeding and management of coagulopathy. Consider structured observation over immediate CT scan if there are no risk factors for intracranial injury. If there is a risk factor for intracranial injury a head CT should be performed. If there is a deterioration in neurological status, perform urgent head CT scan.

**Coagulation factor deficiency**  
CT scan or decision to observe must not delay the urgent administration of replacement factor.

**Immune thrombocytopenias (ITP)**  
Check a platelet count in all patients and blood group in all symptomatic patients if not already available. For ITP with platelet counts < 20 x 10<sup>9</sup>/L, consider empirical treatment after discussion with the treating haematology team.

**On warfarin therapy or other newer anticoagulants (e.g. direct oral-anticoagulant) or anti-platelet therapy**  
Consider CT regardless of the presence or absence of risk factors for intracranial injury. Seek senior clinician review to inform timing of the CT and discuss the patient with the team managing the anticoagulation regarding early consideration of reversal agents. For children on anticoagulation therapy, if available, check the appropriate anticoagulant measure (e.g. International normalised ratio).

Citation: Babl FE, Tavender E, Dalziel S. On behalf of the Guideline Working Group for the Paediatric Research in Emergency Departments International Collaborative (PREDICT). Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children – Algorithm (2021). PREDICT, Melbourne, Australia.



# Risk Stratification

## Assess for risk factors for intracranial injury<sup>4</sup> & initial observation

### All children:

GCS 14 or other signs of altered mental status<sup>5</sup>  
Abnormal neurological examination  
Severe mechanism of injury<sup>6</sup>  
Post-traumatic seizure(s)

### Age < 2yrs:

Palpable skull fracture<sup>7</sup>  
Non-frontal scalp haematoma<sup>8</sup>  
History of LOC<sup>9</sup> ≥ 5 seconds  
Acting abnormally per parent

### Age ≥ 2yrs:

Signs of base of skull fracture<sup>10</sup>  
History of LOC<sup>9</sup>  
History of vomiting<sup>11</sup>  
Severe headache



If signs or symptoms deteriorate during observation stop and request senior clinician review.

## Mechanism of Injury

MVA death or ejection, rollover, pedestrian, cyclist.

Falls: <2 years greater than 1 M

>2 years greater than 1.5M

Head struck by a high speed object

**Any risk factors:** Recommended observation period is up to 4 hours post injury including 1 hour return to normal.<sup>12,13</sup>  
Clinician reassessment with deterioration, return to normal, or at 4 hours.

**No risk factors:**  
No need for observation.

## High risk = imaging

Palpable skull fracture<sup>7</sup> OR  
Signs of base of skull fracture<sup>10</sup> OR  
Worsening signs and symptoms OR  
Persistent GCS 14 OR  
Persistent signs of altered mental status.<sup>8</sup>

## Intermediate risk = consider imaging

≥ 2 Risk factors OR  
Post-traumatic seizure(s) OR  
Persistent severe headache or persistent vomiting > 4 hours post injury.

Senior clinician review to consider need for observation vs head CT vs discharge.

## Further observation with serial reassessment<sup>12</sup>

Is there neurological deterioration OR  
Patient has GCS 14 after 6 hours total observation?

YES ↓

## Senior clinician review

If signs or symptoms stable:  
consider (re)imaging or admission.  
If signs or symptoms worsening:  
(re)image and consult neurosurgery.

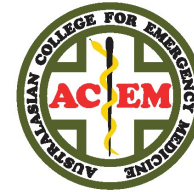
## Low risk

Not intermediate or high risk AND  
Improving signs and symptoms:  
GCS 15, acting normally, no current signs of altered mental status, vomiting has stopped, severe headache resolved.

# CTB

- 98% of Paediatric head injuries are mild to moderate, GCS  $\geq$  14
- Other useful tools i.e. CATCH, PECARN or CHALICE are highly sensitive but have poor specificity resulting in unnecessary CT imaging
- Increasing evidence to the increased risk of cancers forming in later life
- Radiation dose adjusted to body size
- Regional vs Paediatric tertiary imaging
- CT vs MRI
- Sedation ?

<https://www.predict.org.au/head-injury-guideline/>



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# Neuroprotective measures in head injury

Neralie Wearn, Retrieval Nurse, MedSTAR



# Clinical Management Head Injury

**Primary brain injury:** acute CNS insult

**Secondary brain injury:** indirect brain injury resulting from physiological changes

**Neuroprotective measures:** to prevent and/or minimise secondary injury

**Primary aim** (pre tertiary facility) = prevent secondary brain injury

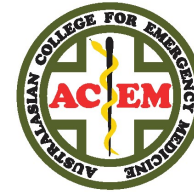
Ref: [amboss.com](https://www.amboss.com)

<https://sapmea.asn.au/echo>

# Clinical Management Head Injury

## Strategies:

- Optimise oxygenation
- Normocapnia
- Blood pressure management ( $CPP = ICP - MAP$ )
- Normoglycaemia
- Consider seizure prophylaxis
- Normothermia
- Conservative ICP management (position / sedation / analgesia)



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## CT in adult head injury

A/Prof Bob Dunn, Emergency Medicine Consultant



# Who to CT in adults?

Multiple guidelines, very similar to PREDICT

- NICE (May 2023) probably the best
  - allows a 2 hours for GCS  $\geq$  13 to reach 15
  - gives guidance on who can wait 8 hours
- Most have problems with definitions/interpretation
- None separate urgent and non-urgent CT findings
- None shown to be superior to
  - observation +/- CT if required
  - expert judgement in adults
- None specifically address issues relating to remote practice settings

# Why do you want the CT?

Injuries that need Neurosurgical intervention within 12 hours?

- Very few
- GCS always < 13 or deteriorating
  - Reliable measurement and monitoring of GCS important
- 50% of EDH's occur in patients < 18 years of age, rare > 65 years

Other injuries that don't?

- Lots of them (5-10 times more common)
- A few may still need Neurosurgery – but not urgently
- Good neuroprotective care is all that is initially required



# Risk factors for Neurosurgical intervention (NICE) – immediate CT

GCS  $\leq$  12

Focal neurological deficit

Clinical features of skull fracture

Drop in GCS 2 points or more

Pupil diameter increase of  $\geq$  2mm

Other

- Seizure
- Severe headache

## Delayed (8 hour) CT

- GCS < 15 at 2 hours
- Patients with LOC or amnesia for the event and
  - age 65 or over
  - anticoagulation / antiplatelets - except aspirin alone
  - loss of consciousness
  - external signs of head trauma
- Vomiting  $\geq 2$  times
- ‘Dangerous mechanism’
  - pedestrian struck by a car, ejection, fall > 1m
- Anticoagulation
  - external signs of significant head trauma without LOC or amnesia

# Who does not need a CT?

- Patients with initial GCS of 13 -14 that returns to 15 within 2 hours.
- Older patients
  - with ground level falls, normal mental state, and no sign of external head trauma
  - when intervention is unlikely to improve outcome
- Patients with no LOC or amnesia
  - unless anticoagulated and external features of significant head trauma

## Other points

- Sedation with midazolam to facilitate a CT is OK for the agitated patient.
- Radiation risk decreases with increasing age
  - CTB in a 1 year old has a lifetime cancer mortality risk of 0.06% (1:1600)
    - background risk of fatal cancer is approximately 25%
    - CTB risk approximately 1/40,000 of the background risk
  - negligible in the elderly
- Normal Cx spine imaging rules apply
  - lower threshold for elderly with evidence of significant frontal trauma

# Summary

System for management of head injury in regional SA is good.

Good clinical assessment (esp GCS) is key.

Expert judgement may be better than rules.

Urgent neurosurgical intervention not required if GCS  $\geq$  13.

Most CTs can be safely delayed.

Most CT findings do not require neurosurgery.

Good neuroprotective care is good for all severities of head injury.