



EM CASES SUMMARY

Episode 153 Pediatric Minor Head Injury and Concussion

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Emergency physicians should have a rock-solid approach to identify high-risk patient with minor head injury; to identify those at risk for long term sequelae, to use imaging responsibly, and to ensure ongoing appropriate care for the concussed child after they leave the ED.

Classification of pediatric head injury

The classification of pediatric head trauma is divided into minor, moderate and severe which are defined by GCS cut offs on first assessment in the ED.

GCS 14 to 15: Minor head trauma

GCS 9 to 13: Moderate head trauma

GCS \leq 8: Severe head trauma

Minor head injury is defined as injury within the past 24 hours associated with one of the following:

- Witnessed loss of consciousness
- Definite amnesia
- Witnessed disorientation
- persistent vomiting ($>$ 1 episode) or
- persistent irritability ($<$ 2 years old)
- and a GCS score of 14–15

Fortunately, only 5% of children with minor head injury will have an intracranial abnormality and about 1% will have a clinically important outcome. It is important that we use our history and physical exam to identify the patients at high risk for a clinically important outcome.

Key features on history to identify children at risk for an intracranial lesion requiring imaging

Mechanism of injury

PECARN: severe mechanism (**MVC with ejection, death another passenger, rollover, pedestrian or bicyclist w/o helmet struck by motorized vehicle, fall 0.9m or 3ft, head struck by high-impact object**)

CATCH2: high risk mechanism (**fall \geq 3ft or 5 stairs, bicycle with no helmet), worsening headache, persistent irritability if under 2 years old**)

Recurrent vomiting

Isolated vomiting in the absence of other high-risk factors is rarely associated with significant traumatic brain injury (TBI). **Recurrent vomiting (≥ 4 episodes, at least 15min apart)** is a significant risk factor for intracranial injury in children after minor head injury. The addition of ≥ 4 episodes of vomiting to CATCH2 increased sensitivity to 100% for neurosurgical intervention and 99.5% for any brain abnormality.

Age and persistent irritability

Not acting normally as per parent or persistent irritability is always a worrisome sign in a head-injured child **under the age of 2 years**. In a nonverbal child, assess whether the child can be settled by their caregiver.

CT should be more strongly considered for children with multiple findings, worsening symptoms or signs, and for infants younger than 3 months of age – owing to their limited ability to communicate and thinner skull.

Isolated features on history not associated with an intracranial lesion requiring imaging

Children who present with the following isolated clinical features with no high risk features on history or physical have an extremely low risk of clinically important TBI and can generally be safely discharged without imaging:

- Isolated headache
- Isolated loss of consciousness (LOC)

Impact seizure (seizure immediately following head injury)

Key physical exam findings/maneuvers to identify children at risk of intracranial injury or post-concussion symptoms

Assess the child's general appearance, GCS (see below), mental status and whether they are agitated, somnolent, displaying repetitive questioning or are slow to respond. Look for **signs of basal skull fracture** including hemotympanum, Battle's sign, raccoon eyes, and CSF rhinorrhea. Palpate to look for a skull fracture and for **non-frontal boggy scalp hematoma >2cm in size**, which carries a higher risk for clinically important outcomes.

Eye opening		Best verbal response		Best motor response	
Spontaneous	4	Coos, babbles	5	Normal spontaneous movement	6
To speech	3	Irritable, cries	4	Withdraws to touch	5
To pain	2	Cries to pain	3	Withdraws to pain	4
None	1	Moans to pain	2	Abnormal flexion	3
		None	1	Abnormal extension	2
				None	1

Pediatric GCS

Vestibular and oculomotor screening (VOMS) examination for concussion

In addition to the screening neurological examination to evaluate for an intracranial lesion, evaluate for vestibular and oculomotor dysfunction, which has a high predictive value in identifying

concussion and aids in prognostication for persistent concussion symptoms.

The modified VOMS examination for concussion includes tests for:

Vestibulo-ocular examination for concussion

Physical Exam Element	How to Perform Examination	Abnormal Findings
Dysmetria	Finger-nose-finger, examiner's finger moving horizontally, 10 repetitions	Slow reaction time, past-pointing, intention tremor
Nystagmus	Examiner's finger moving horizontally, progressively more rapidly, stopping centrally	>1 beat of nystagmus at center of visual field
Smooth pursuits	Examiner's finger moving horizontally, progressively more rapidly	Red/watering eyes, symptom provocation (headache, dizziness, eye fatigue)
Fast saccades	Examiner's fingers shoulder-width apart (horizontal) and forehead-chin distance (vertical), 30 repetitions	Red/watering eyes, symptom provocation (headache, dizziness, eye fatigue, fogginess)
Gaze stability	Patient fixes gaze on examiner's thumb while nodding yes and then shaking head no side-to-side, 30 repetitions	Red/watering eyes, symptom provocation (headache, dizziness, eye fatigue, fogginess)
Near-point convergence	Patient holds pen with letters at arm's length, brings toward nose until becomes double	Letters become double at >6 cm from tip of nose
Gait/balance testing	Tandem heel-toe gait forward and backward with eyes open and closed	Raises arms for stability or widens gait, extreme truncal swaying

Pediatric head injury decision tools: PECARN and CATCH2 – which to use and when?

Pediatric head injury decision rules were developed to decrease CT utilization and radiation effects of CT. In counselling parents, comparison to background radiation dose may be helpful: in comparison to a CXR which has a similar radiation dose to ~10

days of background radiation for a child, a CT head has a similar radiation dose to ~8 months of background radiation.

PECARN

US-based study, where the **baseline assumption was that everyone needed a scan**, thus the rule was developed in order to determine who **does not** need a CT scan.

Note that regardless of age group, PECARN recommends a CT scan in any child who presents with a Glasgow Coma Scale < 15, altered mental status, signs of palpable or basilar skull fracture. It included patients with **GCS of 14-15**.

[PECARN on MDcalc](#)

CATCH2

Canadian study, and the **baseline assumption was that no one needed a scan** (as to prevent radiation risk), thus rule was developed to determine who **does** need a scan. It included patients with **GCS of 13-15**.

The original CATCH study had a sensitivity of 91% for neurosurgical intervention, but the addition of "≥4 episodes of vomiting" resulted in a refined 8-item rule (CATCH2) with 100% sensitivity for neurosurgical intervention and 99.5% sensitivity for brain injury.

[CATCH on MDcalc](#) (note that CATCH2 requires "≥4 episodes of vomiting" in addition to CATCH)

Bottom line: Our experts recommend using PECARN in patients with GCS 14-15 in whom your gestalt is that they **do not** require a CT scan and using CATCH2 in patients with a GCS of 13 in whom your gestalt is that they **do** require a CT scan.

POCUS is accurate in diagnosing skull fractures but has limited role in ruling out ICH

POCUS has been shown to be useful and reliable at diagnosing skull fractures (sensitivity 77-100%, specificity 94-100%). Our experts recommend using a small interface surface, scanning suture lines and using the contralateral side as control, and to scan **around** the hematoma as fractures may not be directly underneath the hematoma. POCUS however has a limited role in identifying ICH and often still requires a CT to rule out ICH, however identifying a skull fracture on POCUS may help inform next investigative steps.

Role for Fast-MRI

In one small study, Fast MRI had a sensitivity of 92.8%, missing isolated skull fractures and small subarachnoid hemorrhage that did not require neurosurgical intervention. While larger studies are required, Fast MRI has potential as a radiation-sparing imaging modality for pediatric head injury in centers with quick access to MRI and radiologist experience with the modality for this specific indication.

Observation of the child with minor head injury

Many patients who are assessed using the PECARN tool require a period of observation and reassessment to identify evolving high risk features requiring imaging. Although an optimal duration of ED observation after minor head injury remains to be determined, a large retrospective study of children <14 years of age with minor head trauma demonstrated that only 5% of children were diagnosed with ICH more than **6 hours after the time of injury**. Therefore, the necessary ED observation length is likely no more than 6 hours from the time of injury and is reasonable to consider active observation at home with appropriate caregiver instruction.

Criteria for safe discharge

Combined with clinical judgement, home observation may be considered safe if:

- Normal mental status with improving symptoms
- No risk factors indicating need for CT scan or normal CT scan if already done
- No indications for prolonged hospital observation including worsening symptoms, bleeding disorders, multisystem injuries or comorbid conditions

Concussion diagnosis, discharge instructions

Most children with concussion recover within 2 weeks, however persistent post-concussive symptoms (PPCS) after 1 month occur in up to 30% of children after minor head injury. **Thus, in the ED, it is important to identify these children and set expectations for possible PPCS and follow-up of the above-mentioned delayed symptoms. Furthermore, there is evidence that** pediatric patients take longer to recover from mild traumatic brain injury compared to adults.

Our experts recommend using the *PPCS clinical risk score* for predicting risk of post-concussive symptoms. The tool performed significantly better than physician judgment in predicting PPCS. Consider **early referral to a multidisciplinary head injury team** for children with prolonged concussion symptoms or those at high risk for having prolonged symptoms as per the PPCS clinical risk score.

PPCS Risk Factor	Categories	PTS
Age Group	5 to 7	0
	8 to 12	1
	13 to 18	2
Sex	Male	0
	Female	2
Longest Symptom Duration	No Prior or <1 week	0
	1+ week	1
Personal History of Migraine	No	0
	Yes	1
Answers Questions Slowly	No	0
	Yes	1
Tandem Stance	0-3	0
	4+, or unable to do test	1
Headache	No	0
	Yes	1
Sensitivity to Noise	No	0
	Yes	1
Fatigue	No	0
	Yes	2

Risk score: Low (0-3), Moderate (4-8), High (9-12)

Discharge instructions for pediatric minor head injury

Cognitive rest after minor head injury and concussion

Most children require a **24-48 hour break** from school **followed by gradual return to full academic/cognitive activities.**

Prolonged rest beyond the first 24-48 hours after a concussion is no longer recommended and may be associated with harm.

Parental advice on “screen” time: AAP recognizes that young adults are highly connected through social media and electronics. Removing them may result in feelings of anxiety and isolation. Thus hand-held devices and video games should be limited in patients with particular light sensitivity or oculomotor dysfunction, but otherwise the conservative use of electronics seems to be harmless.

Physical rest after minor head injury and concussion

An initial period of **24-48 hours of rest** is recommended before starting a **graduated return to physical activity.** Patients may begin light physical activity even if symptoms are present as long as symptoms are tolerated.

Children and adolescents should return to a full school load, without accommodation, *before* they return to full-contact sport and game play.

Sleep hygiene and **adequate hydration** have been suggested as important aspects of treatment after minor head injury.

Take home points

- Minor head injury is defined as injury with one of the following: witnessed LOC, amnesia, disorientation, persistent vomiting (>1 episode), persistent irritability (<2years old) and GCS 14-15
- High risk features on history to help identify children at risk of intracranial injury include: severe mechanism of injury as per PECARN and CATCH2, recurrent vomiting ≥ 4 episodes, worsening headache, persistent irritability under the age of 2, and delayed post-traumatic seizure
- Isolated features on history that are not associated with clinically important TBI include: isolated headache, isolated loss of consciousness and isolated impact seizure
- On physical exam, examine for a non-frontal boggy scalp hematoma >2cm as this is a high risk feature for skull fracture and TBI requiring neurosurgical intervention
- Routinely evaluate for vestibular and oculomotor dysfunction, which may help identify concussed patients as well as prognosticate those at risk for prolonged recovery from concussion
- PECARN was developed in order to determine which patients *do not* require a CT scan
- CATCH was developed in order to determine which patients *do* require a CT scan. CATCH2 included “ ≥ 4 episodes of vomiting” with 100% sensitivity for neurosurgical intervention and 99.5% sensitivity for brain injury
- POCUS can be useful in the ED to assist in diagnosing skull fractures and inform next investigative steps

- Consider Fast MRI if available in your ED as an alternative to CT for high risk minor head injury patients in which there is a concern for radiation exposure, understanding that it may miss skull fractures and small subarachnoid hemorrhages
- If observation in the ED is required as per the PECARN tool, the necessary observation length has not been definitely defined, however it is likely no more than 6 hours from the time of injury
- Children take longer to recover from TBI compared to adults, and 30% have persistent symptoms at 1-month
- Use the *Persistent Post-Concussive Symptoms (PPCS) Risk score* to identify those at high risk and consider early referral to multidisciplinary services
- The mainstay of concussion treatment is a short period of physical and cognitive rest (24-48hrs) followed by gradual return to activities

Additional resources

Ontario Neurotrauma foundation

(ONF): <https://onf.org/knowledge-mobilization/acquired-brain-injury/guidelines-for-concussion-and-moderate-to-severe-traumatic-brain-injury/>

Brain Injury Guidelines: <http://braininjuryguidelines.org/>

5P Calculator: <http://www.5pconcussion.com/en/scorecalculator>

CATT – concussion assessment training

tool: <https://cattonline.com/>

Parachute Canada Concussion protocols (Return to

school/play/work): <https://parachute.ca/en/professional->

[resource/concussion-collection/concussion-protocol-resources-for-schools/](#)

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