



Useful decision aids from PECARN, AliEM and CanadiEM

<https://www.aliem.com/2017/06/pecarn-pediatric-head-trauma-official-visual-decision-aid/>

## SUMMARY OF PECARN HEAD TRAUMA DATA REPORTED IN LITERATURE

Kuppermann N, Holmes JF, Dayan PS, et al. Lancet 2009;374:1160-70

**Inclusion / Exclusion** (DON'T apply these results to patients not meeting these criteria)

< 18 years old

Presented within 24 hours of head trauma

Exclude trivial injury (ground-level fall, walk into stationary objects) & no signs/sx major head trauma

Exclude penetrating trauma, brain tumor, pre-existing neuro disorder complicating assessment

**Outcomes** (Two used, main outcome reported is ciTBI, so may still have CT+ but not be ciTBI)

**ciTBI** = clinically-important traumatic brain injury

Death from TBI

Neurosurgical intervention for TBI

Intubation > 24 hours for TBI

Hospital admission 2 nights or more for TBI + TBI on CT

**TBI on CT** = Traumatic brain injury on CT: intracranial hemorrhage, contusion, cerebral edema, traumatic infarction, diffuse axonal injury, shearing injury, sigmoid sinus thrombosis, midline shift, herniation, skull diastasis, pneumocephalus, depressed skull fracture

### **Definition of severe mechanism of injury used**

MVC with patient ejection, death of another passenger, or rollover

Pedestrian or bicyclist without helmet struck by a motorized vehicle

Fall > 1.5 m (5 feet) for  $\geq 2$  years old and > 0.9 m (3 feet) for < 2 years old

Head struck by a high-impact object

**< 2 years old:** SCALPS mnemonic = Scalp hematoma, Caregiver concern, AMS, LOC, Palpable skull fracture, Severe mechanism of injury

Overall ciTBI 0.9%, TBI on CT 8.5%

If altered mental status, ciTBI 4%

If no AMS but non-frontal scalp hematoma or LOC  $\geq 5$  seconds, ciTBI 1.6%

If none of above but mechanism of injury severe, ciTBI 0.5%

If none of above but palpable skull fracture, ciTBI 3.6%

If none of above but not acting normally per parent, ciTBI 0.6%

If none of: AMS, non-frontal scalp hematoma, LOC  $\geq 5$  seconds, severe mechanism of injury, palpable skull fracture, not acting normally per parent, ciTBI 0.02%, 95% CI for negative predictive value for TBI on CT 97.8-100%, sensitivity for TBI on CT 94.7-100%

**> 2 years old (including age 2 years):** BASILAR mnemonic = Basilar skull fracture signs, AMS, Severe mechanism of injury, LOC, Ache of head, Regurgitation (vomiting)

Overall ciTBI 0.9%, TBI on CT 4.3%

If altered mental status, ciTBI 3.9%

If no AMS but LOC (any) or history of vomiting, ciTBI 1.1%

If none of above but mechanism of injury severe, ciTBI 0.6%

If none of above but clinical signs of basilar skull fracture, ciTBI 7.5%

If none of above but severe headache, ciTBI 1.1%

If none of: AMS, LOC (any), history of vomiting, severe mechanism of injury, clinical signs of basilar skull fracture, severe headache, ciTBI < 0.05%, 95% CI for negative predictive value for TBI on CT 96.8-99.4%, sensitivity for TBI on CT 88-97.5%

**Isolated vomiting as only + PECARN predictor**

Dayan PS, Holmes JF, Atabaki S, et al. Ann Emerg Med 2014;63:657-665

Of 42,112 enrolled in PECARN trial, 5,392 had vomiting, and 815 had isolated vomiting

**ciTBI risk** with isolated vomiting AND no LOC at all, no scalp hematoma / abrasion / lac, no seizure, no neuro deficit, no amnesia for 2-18yo = 0.2% (95%CI 0 – 0.9%) vs 2.5% (95% CI 2.1 – 3%) for nonisolated vomiting, ie vomiting with any other sign or symptom of traumatic brain injury

**TBI on CT risk** with isolated vomiting and as above *and CT obtained* 1.7% (0.5 – 3.9%) vs 6.4% (95% CI 5.6 – 7.3%) for nonisolated vomiting

Non statistically significant increased odds of ciTBI and TBI on CT if vomiting within 1 hour of event vs. later, and if last episode < 1 hour before ED evaluation. No utility to # episodes of vomiting.

**Vomiting with other PECARN predictors**

Children < 2 years old	ciTBI	95% CI	TBI on CT	95% CI
Isolated vomiting	0% (0/567)	0 - 0.6%	1.1%	0.1 – 3.8%
Vomiting + AMS	0% (0/35)	0 – 10%	4%	0.1 – 20.4%
Vomiting + nonfrontal scalp hematoma	0% (0/76)	0 – 4.7%	5.1%	0.6 – 17.3%
Vomiting + LOC >= 5 seconds	5.6% (1/18)	0.1 – 27.3%	7.1%	0.2 – 33.9%
Vomiting + palpable skull fracture	0% (0/5)	0 – 52.2%	0% (0/3)	0 – 70.8%
Vomiting + not acting normally per parent	0.6% (1/158)	0 – 3.5%	1.9%	0.2 – 6.8%
Vomiting + severe mechanism of injury	0.6% (1/181)	0 – 3%	3%	0.4 – 10.5%
Children 2 to < 18 years old				
Isolated vomiting	0.7% (10/1,501)	0.3 – 1.2%	3.2%	2.1 – 4.7%
Vomiting + AMS	1.8% (9/487)	0.8 – 3.5%	4.2%	2.5 – 6.6%
Vomiting + any LOC	0.9% (3/321)	0.2 – 2.7%	2.3%	0.9 – 5%
Vomiting + signs of basilar skull fracture	18.8% (3/16)	4 – 45.6%	42.9%	17.7 – 71.1%
Vomiting + severe headache	1.4% (1/69)	0 – 7.8%	1.7%	0 – 8.9%
Vomiting + severe mechanism of injury	2.4% (2/84)	0.3 - 8.3%	5.1%	1.1 – 14.1%

**Isolated headache as only + PECARN predictor**

Dayan PS, Holmes JF, Hoyle Jr J, et al. Pediatrics 2015;135:504-12

Of 27,495 2-18 year olds, 12,675 had headaches, and 2,462 had isolated headache (19.6%)

**ciTBI risk** with isolated headache AND no LOC at all, no scalp hematoma / abrasion / lac, no seizure, no neuro deficit, no amnesia for 2-18yo = 0% (95% CI 0 – 0.1%) vs. 1.6% (95% CI 1.4% - 19.9%) in nonisolated headache, ie headache any other sign or symptom of traumatic brain injury

**TBI on CT risk** with isolated headache and as above *and CT obtained* 0.7% (95% CI 0.1 – 1.9%) vs. 4.5% (95% CI 3.9% - 5%) in nonisolated

No significant associations found with headache severity, location. Insufficient n to test timing of onset.

Predictors	ciTBI	95% CI	TBI on CT	95% CI
Isolated severe headache	1.4% (3/209)	0.3 – 4.1%	3.1%	0.9 – 7.8%
Severe HA + AMS	2.7% (2/74)	0.3 – 9.4%	3.1%	0.4 – 10.7%
Severe HA + any LOC	0% (0/121)	0 – 3%	0.9%	0 – 5.1%
Severe HA + signs of basilar skull fracture	0% (0/3)	0 – 70.8%	0%	0 – 70.8%
Severe HA + h/o vomiting	1.4% (1/69)	0 – 7.8%	1.7%	0 – 8.9%
Severe HA + severe mechanism of injury	0% (0/27)	0 – 12.8%	0%	0 – 16.1%

### **Isolated scalp hematoma as only + PECARN predictor**

Dayan PS, Holmes JF, Schutzman S, et al. Ann Emerg Med 2014;64:153-162

Of 10,659 < 24 month olds, 2,998 had isolated scalp hematomas (28.7%)

**CiTBI risk** for isolated scalp hematoma AND no LOC at all, no neuro deficits, no vomiting, no seizure, no basilar skull fx signs = 0.4% (95% CI 0.2 – 0.7%), none of whom underwent neurosurgery

**TBI on CT risk** for isolated scalp hematoma and as above *and CT obtained* 8.8% (95% CI 6.6 – 11.4%)

### **Factors associated with increased risk of TBI on CT**

<b>Factor</b>	<b>Adjusted odds ratio (95% CI)</b>
<b>Age Group</b>	
0 - <3 months	17.0 (3.7 – 78.5)
3 - <6 months	6.6 (1.4 – 31.7)
6 - <12 months	3.6 (0.8 – 17.0)
12-<24 months	Reference (1.0)
<b>Location</b>	
Frontal	Reference (1.0)
Occipital	3.3 (1.1 – 10.1)
Temporal / Parietal	4.5 (1.9 – 10.8)
<b>Size</b>	
Small (< 1 cm)	0.5 (0.1 – 1.5)
Medium (1-3 cm)	Reference (1.0)
Large (> 3 cm)	3.3 (1.6 – 6.8)
<b>Mechanism of injury</b>	
Mild – moderate	Reference (1.0)
Severe	2.4 (1.2 – 4.7)

### **Post-traumatic seizures in PECARN data**

Badawy MK, Dayan PS, Tunik MG, et al Acad EM 2017;24:595-605

Of 42,424 patients, 536 (1.3%) had post-traumatic seizures (PTS), 400/536 (74.6%) with GCS 15, 466/536 (86.9%) underwent CT scan

**TBI on CT risk** 72/466 patients scanned (15.5%, 95% CI 12.3-19.1%) had TBI on CT

**Immediate brief seizures:** Total 124 patients with immediate PTS (“impact seizure”) of duration < 1 minute, 102 got CT: 0/124 underwent neurosurgery, 1/124 (0.8%, (95% CI 0.02-4.4%) had recurrent seizure

4/102 with immediate PTS of duration < 1 minute that had CT obtained had TBI on CT (3.9%, 95% CI 1.1-9.7%), and 3 of the 4 had GCS 15

**Timing of seizure:** immediately after trauma 17/197 (8.6%, 95% CI 5.1-13.5%) TBI on CT, within 30 min of trauma 29/162 (17.9%, 95% CI 12.3-24.7%), > 30 min after 11/55 (20%, 95% CI 10.4-33%)

**Duration of seizure:** < 1 min 14/197 (7.1%, 95% CI 3.9-11.6%) TBI on CT, 1 to < 5 min 19/141 (13.5%, 95% CI 8.3-20.2%), 5-15 min 7/22 (31.8%, 95% CI 13.9-54.9%), > 15 min 6/15 (40%, 95% CI 16.3-67.7%)

**PTS and PECARN negative:** < 2yo: 29 PTS but no PECARN+ predictor, 21 had CT, 0/21 TBI on CT (0%, 95% CI 0-16.1%). ≥ 2yo: 22 PTS but no PECARN+ predictor, 15 had CT, 1/15 TBI on CT (6.7%, 95% CI 0.2-32%) – TBI was pneumocephalus, patient discharged from ED

**Isolated “child not acting normally” as only + PECARN predictor**

Nishijima DK, Holmes JF, Dayan PS, et al. JAMA Pediatr 2015;169(12):1141-1147

Of 43,399 children overall, 1,297 reported as not acting normally, with 411 (31.7%) this as only finding of concern for traumatic brain injury

**CiTBI risk** for isolated acting abnormally 0.2% (95% CI 0 – 1.3%) vs 3.3% (95% CI 2.2 – 4.7%) for non-isolated acting abnormally (ie with another sign or symptom of traumatic brain injury)

**TBI on CT risk** for isolated acting abnormally *and CT obtained* 2.2% (95% CI 0.6 – 5.4%) vs. 9.8% (7.7% - 12.3%) for non-isolated acting abnormally

**Non-isolated acting abnormally:** if add one additional PECARN predictor, ciTBI 0.8% (95% CI 0.3 – 1.8%), if add two additional PECARN predictors, ciTBI 14.4% (95%CI 9.3 – 20.8%)

**Isolated loss of consciousness as only + PECARN predictor**

Lee LK, Monroe D, Bachman MC, et al. JAMA Ped 2014;168(9):837-843

Of 40,693 with information about LOC, 6,286 had LOC, 5,850 had complete data, 2,780 had isolated LOC

**CiTBI risk** for isolated LOC 0.5% (95% CI 0.2-0.8%); if isolated LOC AND no seizure, neuro deficit, signs of basilar skull fx, scalp hematoma/abrasion/ecchymosis/lac, vomiting, amnesia in 2-18yo, acting abnormal per parent 0.2% (95% CI 0-1%)

**TBI on CT risk** for isolated LOC 1.9% (95% CI 1.4-2.6%); if isolated LOC AND no seizure, neuro deficit, signs of basilar skull fx, scalp hematoma/abrasion/ecchymosis/lac, vomiting, amnesia in 2-18yo, acting abnormal per parent 0.9% (95% CI 0.2-2.7%)

**LOC with other PECARN Predictors**

<b>Children &lt; 2 years old</b>	<b>ciTBI risk</b>
Isolated LOC > 5 seconds	1/157 = 0.6% (95% CI 0-3.5%)
LOC + AMS	0/16 = 0% (95% CI 0-20.6%)
LOC + Nonfrontal scalp hematoma	0/16 = 0% (95% CI 0-20.6%)
LOC + Severe mechanism of injury	2/51 = 3.9% (95% CI 0.5-13.5%)
LOC + Not acting normally per parent	0/20 = 0% (95% CI 0-16.8%)
<b>Children ≥ 2 years old</b>	<b>ciTBI risk</b>
Isolated LOC (any)	12/2623 = 0.5% (95% CI 0.2-0.8%)
LOC + AMS	13/695 = 1.9% (95% CI 1-3.2%)
LOC + Vomiting	3/321 = 0.9% (95% CI 0.2-2.7%)
LOC + Signs of basilar skull fracture	2/20 = 10% (95% CI 1.2-31.7%)
LOC + Severe mechanism of injury	13/539 = 2.4% (95% CI 1.3-4.1%)
LOC + Severe headache	0/121 = 0% (95% CI 0-3%)

**Basilar skull fractures in PECARN data**

Tunik MG, Powell EC, Mahajan P, et al Ann Emerg Med 2016;68:431-440

363 patients with physical examination signs of basilar skull fracture that underwent CT: 104/363 (28.7%) had basilar skull fracture on CT

266 patients with basilar skull fracture on CT: 104/266 (39.1%) had physical exam signs of basilar skull fracture

59 patients with isolated basilar skull fracture (nothing else on CT), 0/256 had adverse outcome (95% CI 0-6.1%)

### **Isolated altered mental status as only PECARN predictor**

Bressan S, Heidt R, Wang C, et al. Pediatrics 2022;150(4):e2022057138

AMS defined as GCS 14 and/or other signs of AMS (ie agitation, somnolence, repetitiveness, slow response to speech at ED presentation)

Of 5,084 children with AMS, 1,245 (24.5%) had isolated AMS, of whom 194 (15.6% of 1,245) were < 2yo

<b>Age</b>	<b>Outcome</b>	<b>N (total popn)</b>	<b>Isolated AMS</b>	<b>AMS + other predictors</b>
<2yo	ciTBI	1153	2 of 194 (1%)	46 of 959 (4.8%)
	TBI on CT	876	4 of 88 (4.6%)	97 of 788 (12.3%)
>2yo	ciTBI	3931	15 of 1051 (1.4%)	145 of 2880 (5%)
	TBI on CT	3345	27 of 697 (3.9%)	216 of 2648 (8.2%)

### **PECARN Head Trauma Rule in Infants < 3 Months Old**

Abid Z, Kuppermann N, Tancredi DJ, Dayan PS. Ann Emerg Med. 2021 Sep;78(3):321-330

1,147 (10.5%) of 10,904 children < 2 years old in the PECARN dataset

66 excluded for missing data, so 1,081 analyzed

Mechanism of injury for ~70% was fall from height

<b>Outcome</b>	<b>Age Subgroup</b>	<b>PECARN low-risk</b>	<b>Not PECARN low-risk</b>
<b>ciTBI</b>	Total	1/514 (0.19%)	24/567 (4.2%)
	< 1 month	1/141 (0.7%)	8/141 (5.7%)
	1-2 month	0/206 (0%)	9/239 (3.8%)
	2-3 month	0/167 (0%)	7/187 (3.1%)
<b>TBI on CT</b>	Total	10/197 (5.1%)	93/436 (21.3%)
	< 1 month	4/63 (6.4%)	20/105 (19.1%)
	1-2 month	4/80 (5%)	41/182 (22.5%)
	2-3 month	2/54 (3.7%)	32/149 (21.5%)
<b>Skull fx on CT</b>	Total	9/197 (4.6%)	122/436 (28%)
	< 1 month	6/63 (9.5%)	26/105 (24.8%)
	1-2 month	2/80 (2.5%)	55/182 (30.2%)
	2-3 month	1/54 (1.9%)	41/149 (27.5%)