



PECARN Pediatric Head Injury/Trauma Algorithm

Introduction: The PECARN Pediatric Head Injury Prediction Rule is a well-validated clinical decision aid that allows physicians to safely rule out the presence of clinically important traumatic brain injuries.

Points & Pearls

- The Pediatric Emergency Care Applied Research Network (PECARN) consortium produced the largest study, to date, aiming to derive and validate clinical prediction rules to identify children with very low risk of clinically important traumatic brain injury (ciTBI) following blunt head trauma, who would not require imaging. ciTBI was chosen as the primary outcome because it is clinically driven and accounts for the imperfect test characteristics of computed tomography (CT).
- In the group of patients aged < 2 years, the rule was 100% sensitive.
- In the group of patients aged > 2 years, the rule had 96.8% sensitivity.
- In those aged < 2 years with a Glasgow Coma Scale (GCS) score of 14, altered mental status, or palpable skull fracture, risk was 4.4%, and CT imaging is recommended.
- Risk with any of the remaining predictors was 0.9%, and < 0.02% with no predictors.
- In those aged > 2 years with GCS score of 14, altered mental status, or signs of basilar skull

fracture, risk was 4.3%, and CT imaging is recommended.

- Risk with any of the remaining 4 predictors was 0.9%, and < 0.05% with no predictors. The PECARN Rule outperformed both the CHALICE (Children's Head injury ALgorithm for the prediction of Important Clinical Events) and CATCH (Canadian Assessment of Tomography for Childhood Head injury) clinical decision aids in external validation studies.
- Although it was the largest trial of its kind, the PECARN study had low rates of traumatic brain injury (TBI) on head CT (5.2%) and even lower rates of ciTBI (0.9%), suggesting that overall TBI in children is rare. Head CTs were obtained in approximately 35% of patients, lower than the average estimate of 50%.

Critical Actions

ciTBI was a rare event (0.9%) and neurosurgical intervention was even more rare (0.1%). Over 50% of each age cohort did not meet any predictors, and CT imaging is not indicated for the vast majority of these patients, as risk of ciTBI was exceedingly low. Risk of ciTBI was > 4% with either of the 2 higher-risk predictors in each age cohort, and imaging is recommended.

For the remaining 4 lower-risk predictors in each cohort, the risk of ciTBI is approximately 0.9% per predictor, and CT imaging is indicated rather than observation. Judgment may be based on clinical experience, single versus multiple findings, signs of clinical deterioration during the observation period, patient age, and/or parental preference.

CALCULATOR REVIEW AUTHORS

Daniel Runde, MD

Department of Emergency Medicine
Carver College of Medicine
University of Iowa Health Care, Iowa City, IA

Joshua Beiner, MD

Department of Emergency Medicine
New York University School of Medicine, New York, NY

Why to Use

Unlike in the adult population, CT imaging of the head in pediatric patients is believed to be associated with an increased risk of lethal malignancy over the life of the patient, with the risk decreasing with age. The estimated lifetime risk of lethal malignancy from a head CT for a 1-year-old patient is 1 in 1000 to 1500, with risk decreasing to 1 in 5000 for a 10-year-old patient.

There are over 600,000 emergency department visits annually in the United States for head trauma among patients aged ≤ 18 years. Applying the PECARN Pediatric Head Injury Prediction Rule allows providers to determine which pediatric patients they can safely discharge without obtaining a head CT.

When to Use

- The PECARN is a well-validated clinical decision aid that allows physicians to safely rule out the presence of clinically important traumatic brain injuries among pediatric head injury patients without the need for CT imaging, including those that would require neurosurgical intervention.
- The PECARN Rule only applies to children with GCS scores ≥ 14 .

Next Steps

- In patients with suspected or radiologically confirmed TBI, first assess ABCs (airway, breathing, circulation) and consider neurosurgical and/or intensive care unit consultation or local policies for fluid management, seizure prophylaxis, hypertonic saline/mannitol, disposition, etc.
- Consider observation for 4 to 6 hours for patients who are not imaged, in order to assess for changes in clinical status.
- Reassurance, education, and strict return precautions are warranted for patients discharged without imaging, including direction to follow up with a primary care provider or neurologist, and anticipatory guidance on return to play/school if concussion is suspected.

Evidence Appraisal

The original PECARN trial included 42,412 children aged < 18 years presenting to one of the 25 North American PECARN-affiliated emergency departments. There were 33,785 patients in the derivation cohort (8502 of whom were aged < 2 years) and 8627 in the validation cohort (2216 of whom were aged < 2 years).

CT scans were performed at the physician's discretion in 35.3%, while medical records, telephone surveys, and county morgue records were used to assess for cases of missed ciTBI in those discharged without imaging. The potential for CT reduction quoted above is likely underestimated, given that CT utilization in this study (35.3%) was significantly lower than the estimated average in North American emergency departments (50%).

TBI occurred in 5.2% of patients. Nine percent of patients were admitted to the hospital. ciTBI occurred in 0.9% of the cohort, neurosurgery was performed in 0.1% of the overall cohort, and 0 patients died. In patients aged < 2 years who were negative for any PECARN risk factor, the aid was 100% sensitive (95% confidence interval [CI], 86.3-100) with a negative predictive value (NPV) of 100% (95% CI, 99.7-1000) for ruling out ciTBI in the validation cohort. In patients aged > 2 years who were negative for any PECARN risk factor, the aid was 96.8% sensitive (95% CI, 89.0-99.6) with 99.95% NPV (95% CI, 99.8-99.99) for ruling out ciTBI in the validation cohort.

External validation studies have demonstrated sensitivity of 100% for ciTBI and any injury requiring neurosurgery. The algorithm has reasonable specificity (53%-60%), considering its extremely high sensitivity.

Sixty of 376 patients (15.9%) with ciTBI underwent neurosurgery, 8 patients (2.1%) with ciTBI were intubated > 24 hours, and 0 patients died.

As a result of the infrequency of ciTBI, the lower bounds of the CIs of sensitivity started at 86% and 89%, respectively, for the cohorts aged < 2 years and > 2 years. The NPV CIs very closely approximated 100%.

The PECARN Rule has now been externally validated in 2 separate studies. One trial of 2439 children in 2 North American and Italian centers found the PECARN Rule to be 100% sensitive for ruling out ciTBI in both age cohorts. The rates of 0.8% (19/2439) of patients with ciTBI and 0.08% (2/2439) of patients requiring neurosurgery were similar to the rates in the PECARN trial.

A second trial at a single United States emergency department of 1009 patients aged < 18 years prospectively compared the PECARN Rule to 2 other pediatric head CT decision aids, CHALICE and CATCH, as well as to physician estimates and physician practice. In this sample, 2% (21/1009) of patients had ciTBI and 0.4% (4/1009) of patients needed neurosurgery. Again, the PECARN Rule was found to be 100% sensitive for identifying ciTBI.

The PECARN Rule outperformed both the CHALICE and CATCH decision aids, which were 91% and 84% sensitive for ciTBI, respectively). Although the goal was to rule out those with very low risk of ciTBI, the PECARN Rule also performed well to rule out TBI on head CT. In patients aged < 2 years, sensitivity and NPV were 100% for TBI on CT, with narrow CIs. In patients aged > 2 years, sensitivity was 98.4% and NPV was 94% for TBI on CT, with relatively narrow confidence intervals.

Two PECARN Rule subgroup analyses attempted to further risk-stratify patients with single predictors (eg, isolated scalp hematoma in patients aged < 2 years). ciTBI was too uncommon to apply age, hematoma size, or hematoma location predictors. There were several non-statistically significant trends for higher rates of TBI on head CT that may affect imaging tendencies (eg, age < 3 months, nonfrontal hematoma, and large size).

Another subanalysis of those with isolated vomiting (eg, no other PECARN predictors) reiterated the parent study results. In the cohort of patients aged > 2 years, there was a low rate of TBI on head CT (3.2%, 26 of 806 patients) and an even lower rate of ciTBI (0.7%, 10 of 1501 patients), so observation rather than emergent imaging is indicated in the majority of these patients. Number of vomiting episodes and timing of episodes was not helpful in predicting ciTBI or TBI on head CT, as there was a non-statistically significant counterintuitive trend towards less ciTBI/TBI on CT with more episodes.

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Calculator Creator

Nate Kupperman, MD, MPH

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Selected Abbreviations

CATCH	Canadian Assessment of Tomography for Childhood Head injury [Rule]
CHALICE	Children's Head injury ALgorithm for the prediction of Important Clinical Events [Rule]
ciTBI	Clinically-important traumatic brain injury
CI	Confidence interval
CT	Computed tomography
GCS	Glasgow Coma Scale
NPV	Negative predictive value
PECARN	Pediatric Emergency Care Applied Research Network
TBI	Traumatic brain injury

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Contact EB Medicine:

Phone: 1-800-249-5770

or 678-366-7933

Fax: 770-500-1316

Address:

5550 Triangle Parkway, Suite 150
Norcross, GA 30092



Contact MD Aware:

MDCalc

Phone: 646-543-8380

Address:

902 Broadway, 6th Floor
New York, NY 10010

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