When is it safe to forego a CT in kids with head trauma?

New clinical prediction rules make it easier to identify children at low risk of serious brain injury—and reduce the reliance on CT scanning.

Kohar Jones, MD; Gail Patrick, MD, MPP

Department of Family Medicine, University of Chicago (Dr. Jones); Department of Family and Community Medicine, Northwestern University, Chicago (Dr. Patrick)

PURLs EDITOR

John Hickner, MD, MSc
Department of Family Medicine, Cleveland Clinic

PRACTICE CHANGER

Use these newly derived and validated clinical prediction rules to decide which kids need a CT scan after head injury.[1]

STRENGTH OF RECOMMENDATION

A: Based on consistent, good-quality patient-oriented evidence.

Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet*. 2009;374:1160-1170.

ILLUSTRATIVE CASE

An anxious mother rushes into your office carrying her 22-month-old son, who fell and hit his head an hour ago. The child has an egg-sized lump on his forehead. Upon questioning his mom about the incident, you learn that the boy fell from a seated position on a chair, which was about 2 feet off the ground. He did not lose consciousness and has no palpable skull fracture—and has been behaving normally ever since. Nonetheless, his mother wants to know if she should take the boy to the emergency department (ED) for a computed tomography (CT) head scan, "just to be safe." What should you tell her?

Traumatic brain injury (TBI) is a leading cause of childhood morbidity and mortality. In the United States, pediatric head trauma is responsible for 7200 deaths, 60,000 hospitalizations, and more than 600,000 ED visits annually.[2] CT is the diagnostic standard when significant injury from head trauma is suspected, and more than half of all children brought to EDs as a result of head trauma undergo CT scanning.[3]

CT is not risk free

CT scans are not benign, however. In addition to the risks associated with sedation, diagnostic radiation is a carcinogen. It is estimated that between 1 in 1000 and 1 in 5000 head CT scans results in a lethal malignancy, and the younger the child, the greater the risk.[4] Thus, when a child incurs a head injury, it is vital to weigh the potential benefit of imaging (discovering a serious, but treatable, injury) and the risk (CT-induced cancer).

Clinical prediction rules for head imaging in children have traditionally been less reliable than those for adults, especially for preverbal children. Guidelines agree that for children with moderate or severe head injury or with a Glasgow Coma Scale (GCS) score ≤13, CT is definitely recommended.[5] The guidelines are less clear regarding the necessity of CT imaging for children with a GCS of 14 or 15.

Eight head trauma clinical prediction rules for kids existed as of December 2008, and they differed considerably in population characteristics, predictors, outcomes, and performance. Only 2 of the 8 prediction rules were derived from high-quality studies, and none were validated in a population separate from their derivation group.[6] A high-quality, high-performing, validated rule was needed

to identify children at low risk for serious, treatable head injury—for whom head CT would be unnecessary.

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STUDY SUMMARY

Large study yields 2 validated age-based rules

Researchers from the Pediatric Emergency Care Applied Research Network (PECARN) conducted a prospective cohort study to first derive, and then to validate, clinical prediction rules to identify children at very low risk for clinically important traumatic brain injury (ciTBI). They defined ciTBI as death as a result of TBI, need for neurosurgical intervention, intubation of >24 hours, or hospitalization for >2 nights for TBI.

Twenty-five North American EDs enrolled patients younger than 18 years with GCS scores of 14 or 15 who presented within 24 hours of head trauma. Patients were excluded if the mechanism of injury was trivial (ie, ground-level falls or walking or running into stationary objects with no signs or symptoms of head trauma other than scalp abrasions or lacerations). Also excluded were children who had incurred a penetrating trauma, had a known brain tumor or preexisting neurologic disorder that complicated assessment, or had undergone imaging for the head injury at an outside facility. Of 57,030 potential participants, 42,412 patients qualified for the study.

Because the researchers set out to develop 2 pediatric clinical prediction rules—1 for children <2 years of age (preverbal) and 1 for kids ≥2—they divided participants into these age groups. Both groups were further divided into derivation cohorts (8502 preverbal patients and 25,283 patients ≥2 years) and validation cohorts (2216 and 6411 patients, respectively).

Based on their clinical assessment, emergency physicians obtained CT scans for a total of 14,969 children and found ciTBIs in 376—35% and 0.9% of the 42,412 study participants, respectively. Sixty patients required neurosurgery. Investigators ascertained outcomes for the 65% of participants who did not undergo CT imaging via telephone, medical record, and morgue record follow-up; 96 patients returned to a participating health care facility for subsequent care and CT scanning as a result. Of those 96, 5 patients were found to have a TBI. One child had a ciTBI and was hospitalized for 2 nights for a cerebral contusion.

The investigators used established prediction rule methods and Standards for the Reporting of Diagnostic Accuracy Studies (STARD) guidelines to derive the rules. They assigned a relative cost of 500 to 1 for failure to identify a patient with ciTBI vs incorrect classification of a patient who did not have a ciTBI.

Negative finding=0 of 6 predictors

The rules that were derived and validated on the basis of this study are more detailed than previous pediatric prediction rules. For children <2 years, the new standard features 6 factors: altered mental status, palpable skull fracture, loss of consciousness (LOC) for ≥5 seconds, nonfrontal scalp hematoma, severe injury mechanism, and acting abnormally (according to the parents).

The prediction rule for children ≥2 years has 6 criteria, as well, with some key differences. While it, too, includes altered mental status and severe injury mechanism, it also includes clinical signs of basilar skull fracture, *any* LOC, a history of vomiting, and severe headache. The criteria are further defined, as follows:

- **Altered mental status:** GCS <15, agitation, somnolence, repetitive questions, or slow response to verbal communication.
- **Severe injury mechanism:** Motor vehicle crash with patient ejection, death of another passenger, or vehicle rollover; pedestrian or bicyclist without a helmet struck by a motor vehicle; falls of >3 feet for children <2 years and >5 feet for children ≥2; or head struck by a high-impact object.
- **Clinical signs of basilar skull fracture:** Retroauricular bruising—Battle's sign (periorbital bruising)—raccoon eyes, hemotympanum, or cerebrospinal fluid otorrhea or rhinorrhea.

In both prediction rules, a child is considered negative and, therefore, not in need

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INSTANT POLL QUESTION

Which factor carries the most weight when deciding whether a child needs a CT scan for a head injury?

- ❑ *Pediatric clinical prediction rules*
- ❑ *Glasgow Coma Scale score*
- ❑ *Clinical exam/ judgment*
- ❑ *Parental preference*
- ❑ *All of the above*
- ❑ *Other* _____

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of a CT scan, only if he or she has *none* of the 6 clinical predictors of ciTBI.

New rules are highly predictive

In the validation cohorts, the rule for children <2 years had a 100% negative predictive value for ciTBI (95% confidence interval [CI], 99.7-100) and a sensitivity of 100% (95% CI, 86.3-100). The rule for the older children had a negative predictive value of 99.95% (95% CI, 99.81-99.99) and a sensitivity of 96.8% (95% CI, 89-99.6).

In a child who has no clinical predictors, the risk of ciTBI is negligible—and, considering the risk of malignancy from CT scanning, imaging is not recommended. Recommendations for how to proceed if a child has any predictive factors depend on the clinical scenario and age of the patient. In children with a GCS score of 14 or with other signs of altered mental status or palpable skull fracture in those <2 years, or signs of basilar skull fracture in kids ≥2, the risk of ciTBI is slightly greater than 4%. CT is definitely recommended.

In children with a GCS score of 15 *and* a severe mechanism of injury or any other isolated prediction factor (LOC >5 seconds, nonfrontal hematoma, or not acting normally according to a parent in kids <2; any history of LOC, severe headache, or history of vomiting in patients ≥2), the risk of ciTBI is less than 1%. For these children, either CT or observation may be appropriate, as determined by other factors, including clinician experience and patient/parent preference. CT scanning should be given greater consideration in patients who have multiple findings, worsening symptoms, or are <3 months old.

WHAT'S NEW

Rules shed light on hazy areas

These new PECARN rules perform much better than previous pediatric clinical predictors and differ in several ways from the 8 older pediatric head CT imaging rules. The key provisions are the same—if a child has a change in mental status with palpable or visible signs of skull fracture, proceed to imaging. However, this study clarifies which of the other predictors are most important. A severe mechanism of injury is important for all ages. For younger, preverbal children, a nonfrontal hematoma and a parental report of abnormal behavior are important predictors; vomiting or a LOC for <5 seconds is not. For children ≥2 years, vomiting, headache, and any LOC are important; a hematoma is not.

CAVEATS

Clinical decision making is still key

The PECARN rules should guide, rather than dictate, clinical decision making. They use a narrow definition of "clinically important" TBI outcomes—basically death, neurosurgery to prevent death, or prolonged observation to prevent neurosurgery. There are other important, albeit less dire, clinical decisions associated with TBI for which a brain CT may be useful—determining if a high school athlete can safely complete the football season or whether a child should receive anticonvulsant medication to decrease the likelihood of posttraumatic seizures.

We worry, too, that some providers may be tempted to use the rules for after-hours telephone triage. However, clinical assessment of the presence of signs of skull fracture, basilar or otherwise, requires in-person assessment by an experienced clinician.

CHALLENGES TO IMPLEMENTATION

Over- (or under-) reliance on the rules

The PECARN decision rules should simplify head trauma assessment in children. Physicians should first check for altered mental status and signs of skull fracture and immediately send the patient for imaging if either is present. Otherwise, physicians should continue the assessment—looking for the other clinical predictors and ordering a brain CT if 1 or more are found. However, risk of ciTBI is only 1% when only 1 prediction criterion is present. These cases require careful consideration of the potential benefit and risk.

Some emergency physicians may resist using a checklist approach, even one as useful as the PECARN decision guide, and continue to rely solely on their clinical judgment. And some parents are likely to insist on a CT scan

for reassurance that there is no TBI, despite the absence of any clinical predictors. JFP

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