The PECARN Traumatic Brain Injury Prediction Rule Study

What have we learned?

Nathan Kuppermann, MD, MPH
University of California, Davis School of Medicine
Departments of Emergency Medicine and Pediatrics

Sociedad Española de Urgencias de Pediatría
Bilbao, 16-18 de Abril de 2015
Disclosure

- No financial relationships or conflict of interests related to this talk
Objectives

In 15 minutes…

- To describe the risks of serious brain injuries after minor blunt head trauma in children

- To describe the indications, risks, and benefits of computed tomography (CT) scanning

- To review the PECARN Traumatic Brain Injury study, and key sub-studies resulting from this work
Case

- 6 year-old falls 1 meter from a ladder
- 10 second loss of consciousness
- On exam, awake and alert
- Small forehead hematoma, tender at site

What are you going to do?
Epidemiology of Pediatric Head Trauma

- Trauma the leading cause of death among children > 1 year
- Traumatic brain injury (TBI) the leading cause of death and disability due to trauma (> 70% of deaths)
- On an annual basis in the U.S., BHT in children results in:
  - 6,000 deaths
  - 60,000 hospitalizations
  - 620,000 ED visits (~50% evaluated with CT scans, use of CT increasing over the past decade, much variability in care)

*NHAMCS 2006; Blackwell 2007; Centers for Disease Control 2010*
Controversy over CT for Minor BHT

Arguments for liberal use of CT:
- Preventable morbidity/mortality due to unrecognized TBIs
- Preverbal children difficult to eval.
- When indicated, benefit of CT greatly outweighs risk, however…
Controversy over CT for Minor BHT

Arguments against liberal use of CT:

- Of the large number of children evaluated with CT after BHT, fewer than 10% have TBI
- Drawbacks of CT include transport outside the ED, pharmacological sedation, costs
- Most important (theoretical) risk: *lethal malignancy risk from a single CT may be as high as 1:2500*

- *Pediatric BHT high priority for AAP, IOM, EMSC*…
CT Radiation Risks

- *Estimates* (theoretical, not observed) of risks of lethal malignancies extrapolated from survivors of WWII atomic explosions:
  - 1 per 2500 head CT scans for 5 year-olds
  - 1 per 5000 for 10 year-olds

- Age and size-based radiation-reduction efforts ongoing (“ALARA” principle)

- CT radiation risks important from a public-health view
  - ~300,000 CTs for BHT, ~6 million pediatric CTs annually in U.S.
Pediatric Emergency Care Applied Research Network (PECARN)

Supported in full by Project #U03 MC00001-01 from the Maternal and Child Health Bureau, Health Resources and Services Administration, Department of Health and Human Services
Ongoing PECARN Research Development

- Patient safety and error reduction
- Quality of PEM care
- **Evaluation of head trauma**
- C-Spine immobilization
- Steroids in acute bronchiolitis
- The burden of mental illness and psychiatric emergencies in PED
- RCT of fluids for DKA
- Magnesium for sickle cell pain
- Therapeutic hypothermia in pediatric cardiopulmonary arrest
- Diagnostic categorization of illnesses and injuries in the PED
- Management of status epilepticus
- Evaluation of abdominal trauma
- Screening for alcohol abuse
- Probiotics for AGE
- **Knowledge translation of TBI rules**
- RNA transcription biosignatures to diagnose febrile infants
The PECARN Head Injury Study

Goal: to derive a clinical decision rule to accurately identify children at near zero risk of clinically important traumatic brain injury after blunt trauma with high accuracy and wide generalizability.
Outcome Definition

Clinically-important TBI (ciTBI)
- Death from TBI
- Neurosurgical procedure
- Intubation for $> 24$ hours for head injury
- Positive CT in association with hospitalization $> 2$ nights
Results

57,030 eligible

2,869 GCS <14 or other exclusion

54,161 GCS 14-15

Not enrolled

Enrolled

11,749 (21.7%)

42,412 (78.3%)

Derivation 33,785

Validation 8,627

288 ciTBI (0.9%)

88 ciTBI (1.0%)
Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study


Summary
Background CT imaging of head-injured children has risks of radiation-induced malignancy. Our aim was to identify children at very low risk of clinically-important traumatic brain injuries (ciTBI) for whom CT might be unnecessary.

Methods We enrolled patients younger than 18 years presenting within 24 h of head trauma with Glasgow Coma Scale scores of 14–15 in 25 North American emergency departments. We derived and validated age-specific prediction rules for ciTBI (death from traumatic brain injury, neurosurgery, intubation >24 h, or hospital admission ≥2 nights).
The PECARN TBI Rules (derived and validated)

Children are at very low risk of clinically-important traumatic brain injury (TBI) if they meet all criteria in age-specific rule:

**Children < 2 years**
1. Severe mechanism of injury
2. History of LOC ≥ 5 sec
3. GCS = 14 or other signs of altered mental status
4. Not acting normally per parent
5. Palpable skull fracture
6. Occipital/parietal/temporal scalp hematoma

**Children 2-18 years**
1. Severe mechanism of injury
2. History of LOC
3. GCS = 14 or other signs of altered mental status
4. History of vomiting
5. Severe headache in the ED
6. Signs of basilar skull fracture
Recommendations for children younger than 2

The Rule

- GCS=14 or other signs of altered mental status†, or palpable skull fracture
  - Yes → CT recommended
  - 13.9% of population
  - 4.4% risk of ciTBI
  - No

- Occipital or parietal or temporal scalp haematoma, or history of LOC ≥5 s, or severe mechanism of injury†, or not acting normally per parent
  - Yes → 53.2% of population
  - 0.9% risk of ciTBI
  - No

- Observation versus CT on the basis of other clinical factors including:
  - Physician experience
  - Multiple versus isolated§ findings
  - Worsening symptoms or signs after emergency department observation
  - Age <3 months
  - Parental preference

- CT not recommended¶
Recommendations for children younger than 2

A

GCS=14 or other signs of altered mental status†, or palpable skull fracture

Yes

13.9% of population
4.4% risk of ciTBI

CT recommended

No

Occipital or parietal or temporal scalp haematoma, or history of LOC ≥5 s, or severe mechanism of injury‡, or not acting normally per parent

Yes

32.9% of population
0.9% risk of ciTBI

Observation versus CT on the basis of other clinical factors including:
- Physician experience
- Multiple versus isolated§ findings
- Worsening symptoms or signs after emergency department observation
- Age <3 months
- Parental preference

No

53.2% of population
<0.02% risk of ciTBI

CT not recommended¶
Recommendations for children 2 years and older

The Rule

- GCS=14 or other signs of altered mental status†, or signs of basilar skull fracture
  - Yes: CT recommended
  - No: 14.0% of population, 4.3% risk of ciTBI

- History of LOC, or history of vomiting, or severe mechanism of injury‡, or severe headache
  - Yes: Observation versus CT on the basis of other clinical factors including:
    - Physician experience
    - Multiple versus isolated§ findings
    - Worsening symptoms or signs after emergency department observation
    - Parental preference
  - No: 57.2% of population, <0.05% risk of ciTBI
  - CT not recommended¶
Recommendations for children 2 years and older

**B**

- **GCS=14 or other signs of altered mental status†, or signs of basilar skull fracture**
  - **Yes**: 14.0% of population, 4.3% risk of ciTBI, **CT recommended**
  - **No**: 57.2% of population, <0.05% risk of ciTBI, **CT not recommended‡

- **History of LOC, or history of vomiting, or severe mechanism of injury‡, or severe headache**
  - **Yes**: 28.8% of population, 0.8% risk of ciTBI, **Observation versus CT on the basis of other clinical factors including:**
    - Physician experience
    - Multiple versus isolated$ findings
    - Worsening symptoms or signs after emergency department observation
    - Parental preference
  - **No**: **CT not recommended‡**
Negative CT Scans

Do Children With Blunt Head Trauma and Normal Cranial Computed Tomography Scan Results Require Hospitalization for Neurologic Observation?

James F. Holmes, MD, MPH, Dominic A. Borgialli, DO, MPH, Frances M. Nadel, MD, MSCE, Kimberly S. Quayle, MD, Neil Schambam, MD, Art Cooper, MD, Jeff E. Schunk, MD, Michelle L. Miskin, MS, Shireen M. Atabaki, MD, MPH, John D. Hoyle, MD, Peter S. Dayan, MD, MSc, Nathan Kuppermann, MD, MPH, and the TBI Study Group for the Pediatric Emergency Care Applied Research Network*

From the Department of Emergency Medicine, University of California, Davis School of Medicine, Sacramento, CA (Holmes); the Department of Emergency Medicine, University of Michigan School of Medicine and Hurley Medical Center, Flint, MI (Borgialli); the Department of Pediatrics, University of Pennsylvania School of Medicine, Philadelphia, PA (Nadel); the Department of Pediatrics, Washington University School of Medicine, St. Louis, MO (Quayle); the Departments of Emergency Medicine and Pediatrics, Newark Beth Israel Medical Center, Newark, NJ (Schambam); the Department of Surgery, Columbia University Medical Center at Harlem Hospital, New York, NY (Cooper); the Department of Pediatrics, University of Utah, Salt Lake City, UT (Schunk) and PECARN Central Data Management and Coordinating Center, University of Utah, Salt Lake City, UT (Miskin); the Departments of Pediatrics and Emergency Medicine, The George Washington University School of Medicine, Washington, DC (Atabaki); the Department of Emergency Medicine, Michigan State University School of Medicine/Helen DeVos Children’s Hospital, Grand Rapids, MI (Hoyle); the Department of Pediatrics, Columbia University College of Physicians and Surgeons, New York, NY (Dayan); and the Departments of Emergency Medicine and Pediatrics, University of California, Davis School of Medicine, Sacramento, CA (Kuppermann).
Observation Before CT Decisions

The Effect of Observation on Cranial Computed Tomography Utilization for Children After Blunt Head Trauma

Authors: Lisa E. Nigrovic, MD, MPH, a Jeff E. Schunk, MD, b Adela Foerster, MSN, d Arthur Cooper, MD, e Michelle Miskin, MS, f Shireen M. Atabaki, MD, MPH, f John Hoyle, MD, f Peter S. Dayan, MD, MSc, f James F. Holmes, MD, MPH, i Nathan Kupperman, MD, MPH, i and the Traumatic Brain Injury Group for the Pediatric Emergency Care Applied Research Network

What’s Known on This Subject: Emergency-department observation of children with minor blunt head trauma for symptom progression before making a decision regarding computed tomography may decrease computed tomography use. The actual impact of this strategy on computed tomography use and clinical outcomes, however, is unknown.

What This Study Adds: Clinicians currently observe some children with head trauma before deciding whether to obtain a cranial computed tomography scan. Patients who were observed had a significantly lower rate of overall cranial computed tomography use after adjusting for markers of head injury severity.

Abstract

Objective: Children with minor blunt head trauma often are observed in the emergency department before a decision is made regarding computed tomography use. We studied the impact of this clinical strategy on computed tomography use and outcomes.
Prevalence of Clinically Important Traumatic Brain Injuries in Children With Minor Blunt Head Trauma and Isolated Severe Injury Mechanisms

Association of Traumatic Brain Injuries With Vomiting in Children With Blunt Head Trauma

Risk of Traumatic Brain Injuries in Children Younger than 24 Months With Isolated Scalp Hematomas

Isolated Loss of Consciousness in Children With Minor Blunt Head Trauma

Headache in Traumatic Brain Injuries From Blunt Head Trauma
Racial and Ethnic Disparities

Cranial Computed Tomography Use Among Children With Minor Blunt Head Trauma

Association With Race/Ethnicity

JoAnne E. Natale, MD, PhD; Jill G. Joseph, MD, PhD; Alexander J. Rogers, MD; Prashant Mahajan, MD, MPH, MBA; Arthur Cooper, MD; David H. Wisner, MD; Michelle L. Miskin, MS; John D. Hoyle Jr, MD; Shireen M. Atabaki, MD, MPH; Peter S. Dayan, MD, MSc; James F. Holmes, MD, MPH; Nathan Kuppermann, MD, MPH; for PECARN (Pediatric Emergency Care Applied Research Network)
Incidental CT findings

Incidental Findings in Children With Blunt Head Trauma Evaluated With Cranial CT Scans

WHAT'S KNOWN ON THIS SUBJECT: The evaluation of blunt head trauma in children who undergo cranial computed tomography will occasionally reveal incidental findings. These findings may require further evaluation or intervention. The prevalence of incidental findings has previously been described using small cohorts, limiting generalizability.

WHAT THIS STUDY ADDS: This study is the largest pediatric multicenter description of the prevalence of incidental findings on cranial computed tomography. Incidental findings are categorized by urgency to describe the spectrum of abnormalities, providing a context for clinicians faced with these unexpected results.

AUTHORS: Alexander J. Rogers, MD, a,b Cormac O. Maher, MD, c Jeff E. Schunk, MD, c Kimberly Quayle, MD, c Elizabeth Jacobs, MD; Richard Lichenstein, MD; Elizabeth Powell, MD; Michelle Miskin, MS; Peter Dayan, MD, MSc; James F. Holmes, MD, MPH; and Nathan Kuppermann, MD, MPH, for the Pediatric Emergency Care Applied Research Network

Departments of a Emergency Medicine, b Pediatrics, and Neurosurgery, University of Michigan, Ann Arbor, Michigan; c Department of Pediatrics, University of Utah School of Medicine, Salt Lake City, Utah; d Department of Pediatrics, Washington University School of Medicine, St Louis, Missouri; e Department of Emergency Medicine, Brown University, Providence, Rhode Island; f Department of Pediatrics, University of Maryland School of Medicine, Baltimore, Maryland; g Department of Pediatrics, Northwestern University, Chicago, Illinois; h Department of Pediatrics, Columbia University Medical Center, New York, New York; and Departments of i Emergency Medicine and j Pediatrics, University of California, Davis School of Medicine, Davis, California
Case

- 6 year-old falls 1 meter from a ladder
- 10 second loss of consciousness
- On exam, alert and awake
- Small forehead hematoma, tender at site

What are you going to do?