Head and Neck Imaging in Pediatric Trauma

Margaret Lin-Martore, MD
Associate Clinical Professor
Emergency Medicine and Pediatrics
UCSF
Disclosures

None
Case 1

- 16 yo M playing football who had a head on collision with another player. Had <5 sec LOC. Vomited x 1. Denies headache or neck pain. Normal neuro exam. GCS 15 No signs of basilar skull fracture
Case 2

- 3 mo old fell off a 3.5 foot tall changing table onto wooden floor. Cried immediately. Has a 2cm hematoma on the left parietal aspect of the head. No other focal findings, acting at baseline per family. GCS 15 no palpable skull fracture.
Learning Objectives

By the end of this lecture, learners will be able to:

- Discuss radiation exposure and how it relates to head and neck imaging
- Describe evidence-based indications for imaging in:
  - Pediatric head trauma
  - Pediatric neck trauma
Average yearly background radiation

• ~3 mSV a year

• ~0.03 mSV per X-country flight
# Radiation from CT

<table>
<thead>
<tr>
<th></th>
<th>Ave mSV</th>
<th>Equivalent background</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Brain</td>
<td>1.6</td>
<td>7 months</td>
</tr>
<tr>
<td>CT Cspine</td>
<td>4-6</td>
<td>1.3-2 years</td>
</tr>
</tbody>
</table>

Source: Radiological Society of North America, Inc.
https://epmonthly.com/article/plain-cervical-spine-x-ray-almost-dead/#:~:text=When%20it%20comes%20to%20radiation,and%20how%20they%20are%20performed.
PECARN! (Not PECAN)

PECARN algorithms for minor head trauma: Risk stratification estimates from a prospective PREDICT cohort study


PECARN Rule in diagnostic process of pediatric patients with minor head trauma in emergency department

Alessandro Gambacorta, Marianna Moro, Antonio Marcello Covino, Antonio Chiaretti, Antonio Gatto

Affiliations + expand

Validation of the PECARN head trauma prediction rules in Japan: A multicenter prospective study

Kentaro Ide, Satoko Uematsu, Shunsuke Hayano, Yusuke Hagiwara, Kenichi Tetsuhara, Tomoya Ito, Taichi Nakazawa, Ichiro Sekine, Masashi Mikami, Tohru Kobayashi

Affiliations + expand
PMID: 31522928 DOI: 10.1016/j.ajem.2019.158439
40,000 kids!!

Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study

<2 yr
<table>
<thead>
<tr>
<th>Score</th>
<th>Eye Opening</th>
<th>Verbal Response</th>
<th>Motor Response</th>
<th>Score</th>
<th>Eye Opening</th>
<th>Verbal Response</th>
<th>Motor Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>None</td>
<td>No movement</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td><strong>Open to painful stimuli</strong></td>
<td><strong>Incomprehensible sounds</strong></td>
<td><strong>Extends to pain</strong></td>
<td>2</td>
<td><strong>Open to painful stimuli</strong></td>
<td><strong>Moans to pain</strong></td>
<td><strong>Abnormal extension</strong></td>
</tr>
<tr>
<td>3</td>
<td><strong>Open to Voice</strong></td>
<td><strong>Inappropriate words</strong></td>
<td><strong>Abnormal flexion to pain</strong></td>
<td>3</td>
<td><strong>Open to Voice</strong></td>
<td><strong>Cries to pain</strong></td>
<td><strong>Abnormal flexion</strong></td>
</tr>
<tr>
<td>4</td>
<td><strong>Open Spontaneously</strong></td>
<td><strong>Confused, disoriented</strong></td>
<td><strong>Withdraws to pain</strong></td>
<td>4</td>
<td><strong>Open Spontaneously</strong></td>
<td><strong>Cries, but consolable</strong></td>
<td><strong>Withdraws to pain</strong></td>
</tr>
<tr>
<td>5</td>
<td><strong>Oriented, converses</strong></td>
<td><strong>Localizes to painful stimulus</strong></td>
<td></td>
<td>5</td>
<td></td>
<td><strong>Smiles, coos, babbles, interacts, oriented to sounds</strong></td>
<td><strong>Withdraws to touch</strong></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td><strong>Obeyes Commands</strong></td>
<td></td>
<td>6</td>
<td></td>
<td><strong>Normal spontaneous</strong></td>
<td></td>
</tr>
</tbody>
</table>
2+ yr
Head and Neck Imaging in Pediatric Trauma

*SEVERE MECHANISMS

<2yr

2+yr

Source: https://www.aliem.com/2017/06/pecarn-pediatric-head-trauma-official-visual-decision-aid/
LOC > 5 sec  
or  
Non-frontal hematoma  
or  
Not acting normally  
or  
Severe mechanism*  

Observation vs. CT Head  

History of LOC  
or  
History of vomiting  
or  
Severe headache  
or  
Severe mechanism*  

Observation vs. CT Head  

No CT Required!  

Discharge  

Discharge  

*SEVERE MECHANISMS  

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

40,000

5500

800

2 (0.2%) ciTBI

2.5% had ciTBI if vomiting+other risk factor

Source: Dayan et al 2014
LOC

40,000

13 (0.5%) ciTBI

4.4% had ciTBI if LOC+other risk factor

Source: Lee et al 2014
Severe Mechanism

40,000

16 (0.4%) ciTBI

5.1% had ciTBI if severe mechanism + other risk factor

Source: Nigrovi et al 2012
Headache

27,000

12,000

2400

0 ciTBI

1.6% had ciTBI if Headache+other risk factor

Source: Dayan et al 2015
Scalp Hematoma

12 (0.4%) cTBI- None needing neurosurgery

3.2% had cTBI if scalp hematoma + other risk factor

Source: Dayan et al 2014

Daniel Paquet. https://creativecommons.org/licenses/by-sa/4.0/
Scalp Hematoma

Low threshold to image:

- <3mo* with hematomas
- 3-6mo if nonfrontal/large hematoma
- Hematoma + severe mechanism
- Infant Scalp Score

<table>
<thead>
<tr>
<th>Risk Points</th>
<th>Patient Age (months)</th>
<th>Hematoma Size</th>
<th>Hematoma Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&gt;12</td>
<td>None</td>
<td>Frontal</td>
</tr>
<tr>
<td>1</td>
<td>6-11</td>
<td>Small</td>
<td>Occipital</td>
</tr>
<tr>
<td>2</td>
<td>3-5</td>
<td>Medium</td>
<td>Temporal/Parietal</td>
</tr>
<tr>
<td>3</td>
<td>0-2</td>
<td>Large</td>
<td></td>
</tr>
</tbody>
</table>

*lower threshold in general – Abid et al 2021

Source: Dayan et al 2014; Table Schutzman et al 2021
Pediatric Head Trauma Summary

- NOT low risk: GCS < 15, AMS, palpable skull fracture/basilar skull fracture → CT
- Other risk factors → observation vs CT
  - <2 yr: severe mechanism, nonfrontal hematoma, LOC 5+sec, not acting normally per parent
  - 2+yr: severe mechanism, headache, vomiting, any LOC
  - Low risk if in isolation
  - Higher risk if with other factors (esp. severe mechanism and LOC)
- For <2yr with scalp hematoma, age, location, size and mechanism matter
Case 1

- 16 yo M playing football who had a head on collision with another player. Had <5 sec LOC. Vomited x 1. Denies headache or neck pain. Normal neuro exam. GCS 15 No signs of basilar skull fracture
Case 2

- 3 mo old fell off a 3.5 foot tall changing table onto wooden floor. Cried immediately. Has a 2cm hematoma on the left parietal aspect of the head. No other focal findings, acting at baseline per family. GCS 15 no palpable skull fracture.
15 yo F at cheerleading competition was thrown upwards doing a jump and landed on her head. Has some right sided neck pain. No numbness, weakness or tingling. No LOC, no vomiting, no headache. No other complaints. GCS 15, Non-focal neuro exam, no signs of basilar skull fracture.
What about the neck?
Pediatric Neck Anatomy

- Head larger relative to body
  - Stress on neck as fulcrum
  - Ligaments are lax
  - In spine injury 60-80% involve the neck (versus adults 30-40%)

- Overall: Not common <1% of children presenting for trauma evaluation
Type of C-spine injury by Age

Younger kids (<8yr)

Older kids

Source: Leonard et al 2015

Image author: Anatomography License: https://creativecommons.org/licenses/by-sa/2.1/jp/deed.en
Mechanism

MVCs, falls from elevation, pedestrian struck, blunt blows to head and neck

SCIWORA

Sports, diving, ATV/motorcycle

Source: Leonard et al 2015

Image author: Anatomography License: https://creativecommons.org/licenses/by-sa/2.1/jp/deed.en
Outcomes

- Worse morbidity/mortality: Younger patients and higher level of injury
- Special populations at higher risk
  - Down’s syndrome
  - Mucopolysaccharidosis
  - SCIWORA history
  - Achondrodysplasia
  - Congenital anomalies of Cspine
    - os odontoideum

Source: Leonard et al 2015
NEXUS and Canadian Cspine Rules

Bottom Line:
Not Used in Kids

Source: Slaar et al 2017, Erlich et al 2009
PECARN Cervical Spine Injury (CSI) risk factors

- Case Control study from 2010
  - 540 children with CSI matched to controls
  - Variables
    - Sensitivity 98 (96-99)
    - Specificity 26% (23-29%)

- Prospective study from 2019
  - >4000 children (78 CSIs)
  - Variables
    - Sensitivity 91% (84-97%)
    - Specificity 46% (44-47%)

<table>
<thead>
<tr>
<th>AMS</th>
<th>Substantial injury to torso</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal neuro deficit</td>
<td>Conditions predisposing cervical spine injury</td>
</tr>
<tr>
<td>Neck pain</td>
<td>High-risk MVC</td>
</tr>
<tr>
<td>Torticollis/decreased mobility of neck</td>
<td>Diving</td>
</tr>
</tbody>
</table>

# Age and C-spine Injury Risk Factors

- 540 children with CSI

<table>
<thead>
<tr>
<th>Age</th>
<th>Risk factors</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2 yr</td>
<td>Focal neuro deficit, high risk MVC</td>
<td>67% (45-84)</td>
<td>91% (83-96)</td>
<td>27</td>
</tr>
<tr>
<td>2-7 yr</td>
<td>Focal neuro defect, high-risk MVC, AMS, neck pain, torticollis</td>
<td>98% (94-100)</td>
<td>30% (24-35)</td>
<td>140</td>
</tr>
<tr>
<td>8-15 yr</td>
<td>Focal neuro defect, high-risk MVC, AMS, neck pain, diving</td>
<td>96% (94-98)</td>
<td>24% (21-28)</td>
<td>373</td>
</tr>
</tbody>
</table>

Source: Leonard et al 2015
How to image?
Plain Films

- Retrospective review of 206 kids (subset of PECARN) with Cspine films
  - Sensitivity 90% (85-94), improved in older kids >8
  - Missed injuries which required surgical stabilization had focal neurologic findings.

Source: Nigrovic et al 2012

Image Author: Nevit Dilmen. License: https://creativecommons.org/licenses/by-sa/3.0/deed.en
Plain Film vs CT vs MRI?
Pediatric Cspine Injury Summary

- Rare finding but can have serious consequences
- <2yr: Focal neuro deficit, high risk MVC
- 2+years: Focal neuro deficit, high risk MVC, AMS, neck pain, torticollis, diving/axial load injury
- High risk populations
- Imaging: Plain films vs CT, MRI
Case 3

• 15 yo F at cheerleading competition was thrown upwards doing a jump and landed on her head. Has some right sided neck pain. No numbness, weakness or tingling. No LOC, no vomiting, no headache. No other complaints. GCS 15, Non-focal neuro exam, no signs of basilar skull fracture.
References


References


