Pediatric Trauma Clinical Decision Rules

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Faculty Disclosures

**Purpose:** To discuss clinical decision rules, their derivation, and their use in the assessment of pediatric patients in the emergency department.

**Conflicts of Interest:** None.

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Lecture Outline

- Head Trauma
- C-spine Injury
- Blunt Chest Trauma
- Blunt Abdominal Injury
- Lower Extremity Trauma
  - Hip, Knee, Ankle & Foot
On a sunny day at the emergency department, you are covering a shift for a friend when you hear over the scanner:

“Mass casualty trauma alert. Please respond with how many reds and yellows you can accept.”
Or possibly this happens to help solidify your black cloud status…

Or maybe a vintage WW II fighter plane crashes into the grandstands at the local air show on your shift…
Statistical Definitions
Definitions

In general

Positive = identified
Negative = rejected

True positive = correctly identified
False positive = incorrectly identified

True negative = correctly rejected
False negative = incorrectly rejected


Sensitivity & Specificity

Snout

Spin
Sensitivity

Imagine that everyone in the audience came down with URI sx, and someone suggested that it might be Legionnaires’ Dz.

You **all** have **symptoms**, but you want to know for **certain** you **don’t** have **Legionnaire’s**!

A highly **sensitive** test would **definitely** catch anyone that is **positive** (for Legionnaires’ Dz). So if they’re **not positive**, you can be sure that they are **negative**.

**Negative results** in a high **sensitivity test** are used to **rule-out** the **disease**.

Snout – “Sensitivity rules it out”

Specificity

Imagine that everyone in the audience felt well, but you were told that you had been exposed to the SARS Virus.

The CDC is offering treatment to everyone…but it will cost you $10,000. **You** would like to be **certain** that you **actually** have SARS before spending $10,000 on treatment!

A highly **specific** test would **definitively** show everyone that is **negative** for the disease. So if you **test positive** (for SARS), you can be sure that you are **not mistakenly positive**!

A **positive result** from a test with **high specificity** means a **high probability** of the presence of **disease**.

Spin – “Specificity rules it in”
Case #1 – 4-y/o ♀ fell off bleachers

CC: 4-y/o ♀ s/p fall off bleachers at dance class onto a concrete floor. Occurred 2 hours ago. Struck the back of her head from a height of approximately 2 feet. No LOC. Got up and completed the class. Afterward began complaining of nausea and has vomited 4 times.

PE: Afebrile. HR 96, RR 14, BP 90/61. Prominent hematoma noted over right occiput. She is somnolent and actively vomiting on exam. C-spine is nontender. Neurologic examination otherwise non-focal.
Does this patient need a Head CT?

**Case #1 – 4-y/o ♀ fell off bleachers**

**Pediatric Emergency Care Applied Research Network**

*Identify children at very low risk of clinically-important traumatic brain injuries (ciTBI) for whom CT might be unnecessary.*

**Younger than 2 years of age:**
1. GCS=14 or other signs of altered mental status, or palpable skull fracture?
   - If YES → **CT Head** is recommended.
2. Occipital / parietal / temporal scalp hematoma, or history of LOC ≥5 s, or severe mechanism of injury, or not acting normally per parent?
   - If YES → **CT Head or observation.**

**Older than 2 years of age:**
1. GCS=14 or other signs of altered mental status, or signs of basilar skull fracture?
   - If YES → **CT Head** is recommended.
2. History of LOC, or history of vomiting, or severe mechanism of injury, or severe headache?
   - If YES → **CT Head or observation.**

**PECARN**

*The Lancet, 2009.*

- Patients < 18 years
- Within 24 h of head trauma
- GCS scores of 14–15
- 25 North American EDs
- \( n = 42,412 \) children
- \( n = 376 \) (0.9%)
- \( n = 10,718 < 2 \) years-old
  - sensitivity = 100%
- \( n = 31,694 \) 2-18 years-old
  - sensitivity = 96.8%

*Neither rule missed any neurosurgery cases.*

**Canadian Assessment of Tomography for Childhood Head Injury**

CT of the head is required only for children with minor head injury and any of the following findings:

**High risk (need for neurologic intervention)**
1. GCS < 15 at two hours after injury
2. Suspected open or depressed skull fracture
3. History of worsening headache
4. Irritability on examination

**Medium risk (brain injury on CT scan)**
5. Any sign of basal skull fracture
6. Large, boggy hematoma of the scalp
7. Dangerous mechanism of injury

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**CATCH**

March 3, 2010
*Canadian Medical Association Journal*

Multicenter cohort study
Consecutive children with blunt head trauma
GCS = 13 to 15

n = 3,866 patients (avg. 9 years)
GCS = 13 for 95 (2.5%)
GCS = 14 for 282 (7.3%)
GCS = 15 for 3,489 (90.2%).
159 (4.1%) had a brain injury

The high-risk factors were 100.0% sensitive for ciTBI

The medium-risk factors were 98.1% sensitive for brain injury

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**Children’s Head Injury Algorithm for the Prediction of Important Clinical Events**

A computed tomography scan is required if any of the following criteria are present:

**History:** 6 independent criteria
**Examination:** 5 independent criteria
**Mechanism:** 3 independent criteria

If none of the above variables are present, the patient is at low risk of intracranial pathology.

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**CHALICE**

*Archives of Disease in Childhood, 2006*

Prospective cohort study at 10 EDs in NW England

n = 22,772 children over 2.5 years; 56% were < 5 years old.
281 (1.2%) had abnormal CT scans, 137 (0.6%) had a neurosurgical intervention, and 15 died.
98% sensitivity, 87% specificity for the prediction of clinically significant head injury, with a CT scan rate of 14%.

Children's Head Injury Algorithm for the Prediction of Important Clinical Events

A computed tomography scan is required if any of the following criteria are present:

History
- Witnessed LOC of > 5 min duration
- History of amnesia (either anterograde or retrograde) of > 5 min duration
- Abnormal drowsiness (defined as in excess of that expected by the examining doctor)
- > 3 vomits after head injury (a vomit is defined as a single discrete episode of vomiting)
- Suspicion of non-accidental injury (any suspicion of NAI by the examining doctor)
- Seizure after head injury in a patient who has no history of epilepsy

Examination
- Glasgow Coma Score (GCS) < 14, or GCS < 15 if < 1 year old
- Suspicion of penetrating or depressed skull injury or tense fontanelle
- Signs of a basal skull fracture (blood or cerebrospinal fluid from ear or nose, panda eyes, Battles sign, hemotympanum, facial crepitus, or serious facial injury)
- Positive focal neurology (including motor, sensory, coordination or reflex abnormality)
- If < 1 year old, presence of bruising, swelling, or a laceration > 5 cm

Mechanism
- High-speed road traffic accident either as pedestrian, cyclist, or occupant (speed > 40 mph)
- Fall of > 3 m in height
- High-speed injury from a projectile or an object

If none of the above variables are present, the patient is at low risk of intracranial pathology.

PECARN
Identify children at very low risk of clinically-important traumatic brain injuries (cTBI) for whom CT might be unnecessary.

Younger than 2 years of age:
1. GCS=14 or other signs of altered mental status, or palpable skull fracture? If YES → CT Head
2. Occipital / parietal / temporal scalp hematoma, or history of LOC ≥5 s, or severe mechanism of injury, or not acting normally per parent? If YES → CT or Observe

Older than 2 years of age:
1. GCS=14 or other signs of altered mental status, or signs of basilar skull fracture? If YES → CT Head
2. History of LOC, or history of vomiting, or severe mechanism of injury, or severe headache? If YES → CT or Observe

• All 3 CDRs were derived with high methodological standards but differed in key areas, including study population, outcomes, and severity of head injury.
• Each stated different predictor variables, and only PECARN provided a separate algorithm for young children.
• CATCH and CHALICE identify children requiring CT
• PECARN identifies children who do not.
• All perform with high sensitivity and low specificity.
• PECARN had the largest study population.

Case #1 – 4-y/o ♀ fell off bleachers

Does this patient need a Head CT?

Yes!

Baby Professor has 3 questions in Pediatric CT Head for BHI:

1. What is the risk of delayed intracranial hemorrhage with BHI and an initial GCS of 15?
2. What is the risk of delayed intracranial hemorrhage with BHI and a normal CT scan?
3. What is the risk of intracranial hemorrhage in a child with a known coagulopathy?
“Incidence of Delayed Intracranial Hemorrhage in Children After Uncomplicated Minor Head Injuries”

_PEDIATRICS_ - July, 2010

Retrospective cohort study

- Children < 14 years-old with minor head injury
- GCS = 15
- Calgary Emergency Depts.
- April 1992 – March 2000

DICH was defined as occurring > 6 hours post-injury
- 17,962 children
- 2 children with ↓d GCS identified
- 8 children w/o ↓d GCS identified

- Delayed Dx of ICH with ↓d GCS is 1.4 per 1 million cases
- Delayed Dx of ICH w/o ↓d GCS is 5.7 per 1 million cases


“Do children with blunt head trauma and normal cranial CT scan results require hospitalization for neurologic observation?”

_Annals of Emergency Medicine_ - October, 2011

Prospective, multicenter observational cohort study

- Children < 18 y/o with BHT
- 2004 to 2006
- Initial GCS = 14 or 15
- Normal ED CT scans
- 13,543 children
- 12,584 with GCS 15
- 959 with GCS 14

- 2,485 (18%) were hospitalized,
  - 17% GCS 15 and 39% GCS 14
  - Remainder had phone / mail f/u
- 197 (2%) discharged patients had subsequent CT / MRI scans
  - 5 (0.05%) were abnormal
- 137 (6%) of hospitalized patients had subsequent CT / MRI scans
  - 16 (0.6%) were abnormal

No patients required a neurosurgical intervention

NPV for NeuroSx with initial GCS 14-15 and Ø CT scan = 100%

“Intracranial Hemorrhage after Blunt Head Trauma in Children with Bleeding Disorders”

*The Journal Of Pediatrics - June, 2011*

Prospective cohort substudy

Children < 18 years-old with blunt head trauma

- GCS = 14 to 15
- 25 Emergency Depts.
- June 2004 – Sept. 2006

- Hemophilia 129 (56.1%)
- von Willebrand Dz 45 (19.6%)
- Thrombocytopenia 34 (14.8%)
- Anti-coagulation tx 15 (6.5%)

Two children had ICH (1.1%)

Both ICH cases had symptoms

- ICH incidence in coagulopathic kids = 1.1%
- ICH incidence in non-coagulopathic kids = 4.4%

Routine CT after BHT may not be needed in asymptomatic children with congenital and/or acquired bleeding disorders.

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Case #2 – 21-d/o ♀ with “bruising”

**CC:** 21-day-old female brought to the ED for evaluation of bruising.

**HPI:** Mother noted these earlier today. Patient’s most significant bruise is of her left ear involving almost the entire ear. She also feels that the left upper eyelid is bruised and noticed a red mark in the white part of the left eye.

Patient has been eating and drinking fine. No change in the quantity or quality of her wet and dirty diapers. No vomiting. No change in the level of alertness or activity.
### Case #2 – 21-d/o ♀ with “bruising”

Does this patient need a Head CT?

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### Modified Glasgow Coma Scale for Infants & Children

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Infants</th>
<th>Children</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye opening</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open spontaneously</td>
<td>Open spontaneously</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Open to verbal stimuli</td>
<td>Open to verbal stimuli</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Open to pain only</td>
<td>Open to pain only</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td>No response</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Verbal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coos and babbles</td>
<td>Oriented, appropriate</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Irritable, crying</td>
<td>Confused</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Cries to pain</td>
<td>Inappropriate words</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Moans to pain</td>
<td>Incomprehensible words or nonspecific sounds</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td>No response</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moves spontaneously and purposefully</td>
<td>Obeys commands</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Withdraws to touch</td>
<td>Localizes painful stimulus</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Withdraws to pain</td>
<td>Withdraws to pain</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Decorticate posturing</td>
<td>Decorticate posturing</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Decerebrate posturing</td>
<td>Decerebrate posturing</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td>No response</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Non-Accidental Pediatric Head Trauma

Often vague, and may mimic infection, a metabolic disorder, neurologic disorder, or ALTE. Symptoms usually immediately present after injury, but presentation is often delayed.

- Poor feeding
- Failure to thrive
- Vomiting
- Weakness
- Decreased tone
- Lethargy
- Respiratory problems
- Irritability
- Posturing
- Seizures
- Hypothermia
- Bradycardia
- Altered LOC
- Bulging fontanelle

Symptoms usually immediately present after injury, but presentation is often delayed.

Secondary analysis showed the AHT CPR identified 98% of patients ultimately diagnosed with AHT.

Clinical Prediction Rule for Pediatric Abusive Head Trauma

To minimize missed cases, every acutely head-injured infant or child < 3 years old hospitalized for intensive care who presents with 1 of these 4 predictor variables should be thoroughly evaluated for abuse:

1. Any clinically significant respiratory compromise at the scene of injury, during transport, in the ED, or before admission
2. Any bruising involving the ears, neck, or torso
3. Any subdural hemorrhages or fluid collections that are bilateral or involve the inter-hemispheric space
4. Any skull fractures other than an isolated, unilateral, non-diastatic, linear, parietal skull fracture

Sensitivity 96%
Specificity 46%

Prospective, multicenter, observational study
291 acutely head-injured children < 3 y/o admitted to PICUs at 14 sites

December 2014
PEDIATRICS

Four Variable Rule for AHT

Clinical Prediction Rule for Pediatric Abusive Head Trauma

To minimize missed cases, every acutely head-injured infant or child < 3 years old hospitalized for intensive care who presents with 1 of these 4 predictor variables should be thoroughly evaluated for abuse:

1. Any clinically significant respiratory compromise at the scene of injury, during transport, in the ED, or before admission
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3. Any subdural hemorrhages or fluid collections that are bilateral or involve the inter-hemispheric space
4. Any skull fractures other than an isolated, unilateral, non-diastatic, linear, parietal skull fracture

Problems?

1. Study focuses on very young, admitted patients.
2. Too little, too late.


AAP Recommendations for the Evaluation of Physical Child Abuse

May 2015, PEDIATRICS

AAP Child Abuse Recommendations: The History

Regarding the history, ask yourself this:
1. Does it **correlate** with the age of the child and their injury / injuries?
2. Is it **consistent** with re-telling and different historians?
3. Is there any **delay** in seeking care?


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AAP Child Abuse Recommendations: Physical Exam

Regarding the physical exam, consider **The TEN 4 Rule:**

**Bruising** over any of the following:

- **Torso, Ears, Neck** in ≤ 4 years old
- **Significant injuries** that are unexplained
- Any **bruising** in a ≤ 4 month-old

**AAP Child Abuse: Key Points**

**Completely undress** the child and pay close attention to the skin, scalp and fontanel, mouth/oral cavity, ears, genitalia.

Any **injury** in a **pre-ambulatory** child (bruises, mouth injuries, fractures, intracranial/abdominal injury) = abuse concern.

**TEN 4 Rule:** bruising of the **T**orso, **E**ars, or **N**eck in children ≤ 4 years-old and **any bruising** in children ≤ 4 months-old.

Radiographic **skeletal survey** for children <2 y/o with concern for abuse; **repeat** the skeletal survey in 2–3 weeks.

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**AAP Child Abuse: Key Points**

Young (<2 y/o) **siblings** and household **contacts** of abused children should be **examined** for injuries and undergo a **skeletal survey**.

**Screening labs** to identify **abdominal injuries** for children with serious injuries, even **without** abdominal symptoms.

**Infants** evaluated for physical abuse need **neuro-imaging** even in the **absence** of neurological symptoms.

In the U.S. and Canada, **physicians** with a **reasonable suspicion** of physical abuse have a legal mandate to report their concern to CPS.

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In child abuse, the parents aren’t your partner, and they may (deliberately) mislead your history & exam.

Children with AHT have a mortality of about 20%; 60-80% of survivors will experience long-term neurologic problems. The risk of cancer from a head CT is only 1/1000 in a newborn.

AST and ALT in every child < 5-y/o with concern for abuse. Positive abdominal labs (AST, ALT) ≈ CT Abd in about 1:5.

Children < 2- y/o hospitalized for suspected abuse with no signs of brain injury → 37% + CT Head.

If you suspect abuse, work-up more studies than you think necessary. Most clinically insignificant injuries self-resolve; in abuse, the small injury is the opportunity to rescue the child.

The Manitowoc infant suffered a skull fracture, bleeding on the brain, bruises, and swollen eyes—juries consistent with “abusive head trauma,” according to doctors at Children’s Hospital, Milwaukee.

...he was left alone with the baby and...the infant began crying. Burden told police he had been stressed out and was tired. He said he “lost it” and held the baby in his left hand while striking it hard with his right hand. He shook the baby violently...

He then put the baby on the bed and left it to cry. Eventually, he picked up the infant and said he held it for two hours, whispering to it that he was sorry for what he did.

Case #3 - 2-y/o ♂ with fall out of window

CC: A 2-year-old ♂ is brought to the ED after falling out of a 2nd story window. Patient pushed through the window screen and fell onto the lawn below. He has been ambulatory since and acting “normal.” Parents are mostly concerned with, “What if he broke his neck?”

PE: Normal vitals. Dressed in a dirty white t-shirt and a diaper, running around the exam room barefoot and yelling. Vigorously resists any physical exam attempts. RN staff reports no C-collars in stock will fit him.

Does this asymptomatic child need any imaging?
Can you use the Canadian C-Spine Rule?

- Studied only patients > 16-y/o
- Not validated for a pediatric population

Can you use NEXUS?

- NEXUS did not include any kids < 2-y/o with a C-spine injury
- NEXUS had only four kids < 9-y/o with a C-spine injury

NEXUS Criteria

The NEXUS criteria state that a patient with suspected C-spine injury can be clinically cleared provided that the following criteria are met:

1. No posterior midline cervical spine tenderness is present.
2. No evidence of intoxication is present.
3. The patient has a normal level of alertness / consciousness.
4. No focal neurologic deficit is present.
5. The patient does not have a painful distracting injury.
Summary of Recommendations (4 Strong, 3 Conditional)

1. It is possible to clinically clear the pediatric C-spine.
2. Pediatric patients should be managed with the lowest possible radiation exposure.
3. Plain radiographs should still be the initial assessment tool of choice with CT scan reserved for patients where more diagnostic certainty is required or when suspected injuries require further investigation.
4. MRI is recommended for all patients with an abnormal neurologic exam, and for patients suspected of SCIWORA.

How do you clinically clear the C-spine in kids?

- Children tend to clear / declare themselves
- Moving around & acting normally = C-spine clearance
- Be cautious in children < 2-y/o if they are not moving their head!
- C-spine injuries due to child abuse ≈ SCIWORA
- In a child < 2-years-old, who is not seriously injured enough for admission based on your exam, consider clinical C-spine clearance.

Pediatric C-Spine Injury: Key Points

**Children < 8-years-old:** 75% of C-spine injuries are C1 - C3

**Anatomy differences:** ≥ 8 years-old → C-spine like an adult

**Peds Specific C-spine Injuries:**
- AO & AA dislocations (ages 0-3, usually fatal)
- Dens fracture (< 7-y/o, forward facing MVA with rapid neck flexion)

**SCIWORA:** Spinal Cord Injury w/o Radiographic Abnormality

**Mechanism of Injury:**
- High-speed MVC (48-61%) in all ages
- Falls (18-30%) in younger patients
- High-impact sports (football, diving) in teenagers

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Case #3 – 2-y/o ♂ with fall out of window

**CC:** A 2-year-old ♂ is brought to the ED after falling out of a 2nd story window. Patient pushed through the window screen and fell onto the lawn below. He has been ambulatory since and acting “normal.” Parents are mostly concerned with, “What if he broke his neck?”

**PE:** Normal vitals. Dressed in a dirty white t-shirt and a diaper, running around the exam room barefoot and yelling. Vigorously resists any physical exam attempts. RN staff reports no C-collars in stock will fit him.

**TAC National Pediatric C-Spine Evaluation Pathway**
Divides patients into “Reliable Exam” and “Unreliable Exam” and evaluates further by screening x-rays, neurologic exam, and age

**Does this patient require any imaging?**
No.
Case #4 – 6-y/o ♂ with seatbelt sign

CC: A 6-year-old male is seen for injuries following a highway speed MVC. He was a driver’s side backseat passenger, restrained, but not in a booster seat. They were T-boned on the driver’s side.

PE: Afebrile, HR 110, RR 24. He’s awake with a GCS 15.

ED: He has a nondisplaced left orbital fracture, contused ribs, and a humerus fracture. No midline C-spine tenderness. You are planning to admit him for observation overnight. No CT imaging has been obtained.

Does the seatbelt sign mandate CT angiography?


A literature review from 1965-2005 of 179 articles

68 articles met inclusion criteria and were used to make recommendations about the following:

1. What patients are of high enough risk to warrant screening?
2. What is the appropriate modality for the screening / diagnosis?
3. How should BCVI be treated, how long should antithrombotic therapy be administered, and how to monitor response to tx?

EAST Guidelines: Screening Criteria for BCVI

Injury mechanism:
• Severe C-spine hyperextension, rotation, hyperflexion associated with
  - displaced midface / complex mandibular fracture
  - closed head injury c/w diffuse axonal injury
• Near hanging resulting in anoxic brain injury

Physical signs:
• Seat belt abrasion or other STI of the anterior neck → significant anterior neck swelling or AMS
• Fracture in proximity internal carotid / vertebral artery
• Basilar skull fracture involving the carotid canal
• Cervical vertebral body fracture

Pediatric Cervical “Seatbelt” Sign

To understand the clinical and radiologic risk factors associated with pediatric blunt cerebrovascular injury on CTA of the neck with primary attention to the cervical “seatbelt sign.”

A retrospective chart review from 2002 to 2012

Pediatric CTA neck exams w’ blunt cerebrovascular injury (BCVI)
Penetrating injury or non-trauma cases were excluded

RESULTS:

• 42/85 patients in an MVC had a + cervical SB Sign
• 0/85 had blunt cerebrovascular injury (BCVI).
• 5.8% (8/137) screened for blunt neck trauma had BCVI.
• Among BCVI patients, the GCS was significantly lower
• BCVI patients ≈ additional injuries, 1° basilar skull fracture


Case #4 – 6-y/o ♂ with seatbelt sign

Does the seatbelt sign mandate CT angiography?

CC: A 6-year-old male is seen for injuries following a highway speed MVC. He was a driver’s side backseat passenger, restrained, but not in a booster seat. They were T-boned on the driver’s side.

PE: Afebrile, HR 110, RR 24.
He’s awake with a GCS 15.

ED: He has a nondisplaced left orbital fracture, contused ribs, and a humerus fracture. No midline C-spine tenderness. You are planning to admit him for observation overnight. No CT imaging has been obtained.

GCS = 15 → No.
Additional injuries (orbital fx, humerus fx, rib contusions) → Maybe.
Case #5 – 4-y/o ♀ with neck bruise

CC: A 4-year-old female brought for evaluation of a bruise on back of her neck. Mother denies any history of trauma. Patient is back after being at Dad's for a four-day weekend.

Allgs / Meds / PMHx / SHx: Ø

PE: Afebrile, HR 90, RR 22. She's awake and without complaints. The remainder of her exam appears normal.

TEN-4 Rule: bruising of the Torso, Ears, or Neck in a child ≤ 4 y/o or any bruising in a child < 4 m/o

Does this asymptomatic child need any imaging?

Case #6 – 15-y/o ♂ with chest pain s/p MVC
Case #6 – 15-y/o ♂ with chest pain s/p MVC

CC: 15-y/o ♂ presents to the ED following a highway-speed MVC. He was the restrained passenger in a van that T-boned another car at an intersection. He arrives via EMS with full long board and C-spine immobilization. His only complaint is mid-sternal, pleuritic chest pain. He denies other injuries or c/o’s.

Allgs / Meds / PMHx / SHx: ☒

PE: Afebrile, HR 65, RR 24, BP 115/71, $\text{SaO}_2$ 99%. Heart RRR. Chest wall shows no bruising. It is exquisitely TTP, however. Lungs CTA B/L.

Does the absence of a seatbelt sign preclude any serious injuries?

What abnormality do you see on the following PA and lateral chest X-ray?

A. Pneumothorax
B. Tension pneumothorax
C. Multiple rib fractures
D. Sternum fracture
E. Pulmonary contusion
What abnormality do you see on this patient’s PA and lateral chest X-ray?

A. Pneumothorax
B. Tension pneumothorax
C. Multiple rib fractures
D. Sternum fracture
E. Pulmonary contusion
EAST Blunt Cardiac Injury Guidelines

Diagnosing blunt cardiac injury (BCI) can be difficult. To allow safe discharge home or admission to a non-monitored setting, BCI should be definitively ruled out in those at risk.

1. In general, patients with any significant blunt trauma to the anterior chest should be screened.
2. EKG alone is not sufficient to rule out BCI.
3. Adding troponin I to EKG improved the negative predictive value to 100%.
4. BCI can be ruled out only if both ECG result and troponin I level are normal.
5. Patients with new EKG changes and/or elevated troponin I should be admitted for monitoring.
6. Echocardiogram is not beneficial as a screening tool for BCI and should be reserved for patients with hypotension and/or arrhythmias.
7. The presence of a sternal fracture alone does not predict BCI.


EAST Blunt Cardiac Injury (BCI) Guidelines

*Journal of Trauma and Acute Care Surgery, 2012.*

- Derived from literature review of 599 articles from March 1997 to December 2011.
- 35 studies evaluating the diagnosis of adult patients with suspected BCI.
- The final PMG has 10 total recommendations.
Negative Predictive Value

NPV is the probability that a disease is absent when the test is negative.

The NPV of a test is the proportion of people that don’t have disease out of everyone who tests negative for the disease.

\[
\text{NPV} = \frac{\text{True Negatives}}{\text{True Negatives} + \text{False Negatives}} = \frac{\text{Total Healthy}}{\text{Total Rejected}}
\]

**Negative predictive value** describes how likely patients with a negative screening test *truly* don’t have disease.

Positive Predictive Value

PPV is the probability that a disease is present when the test is positive.

The PPV of a test is the proportion of people that have a disease out of everyone who tests positive for the disease.

\[
PPV = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}} = \frac{\text{True Disease}}{\text{Total Identified}}
\]

Positive predictive value describes how likely patients with a positive screening test truly have disease.


Case #6 – 15-y/o ♂ with sternal fx s/p MVC

• Sternal fractures are relatively uncommon
• Sternal fx usually occur in a male patient following an MVC
• An isolated sternum fracture ≠ admission. Evaluate the patient for their total injury burden.
• Sternal fractures rarely cause damage to underlying structures.
• Sternal fractures uncommonly require any surgical repair.
• A sternal fracture should be viewed as a prompt to ask the question: “What are the associated injuries?” If there are no pneumothorax, hemothorax, or rib fractures, then little needs to be done to manage an isolated sternum fracture.


Troponin I = 

EAST Blunt Cardiac Injury (BCI) Guidelines

- If troponin or EKG is positive, monitor the patient to look for the two concerning manifestations of BCI:
  1) structural injuries such as a wall / valve abnormality
  2) cardiac dysrhythmias

- When cardiac dysrhythmias occur, it’s usually A-fib and it is typically seen within the first 8-24 hours post-injury.

- If a cardiac dysrhythmia or hypotension occurs, consider an ECHO to look for structural injury.

- BCI is rare. Structural injuries are even more rare! Almost all cardiac dysrhythmias due to blunt trauma are self-limited.

Case #7 – 5-y/o ♀ with blunt abdominal injury

CC: 5-year-old female is seen for an abdominal injury while riding her bike. She lost control, and the end of the handlebar struck her just below the umbilicus. Denies vomiting.


Mom is very concerned about any imaging studies because of the risks of “ionizing radiation.”

You are concerned because the injury could be potentially serious, and if so, transfer to the tertiary care trauma center needs to happen sooner rather than later.

Is there a CDR that can help guide this child’s care?
PECARN Blunt Abdominal Trauma Rule

*Annals of Emergency Medicine*
August 2013

Prospective study of 12,044 children with blunt torso trauma at 20 US Emergency Depts.

The rule consisting of 7 history and physical exam findings (without labs or ultrasound) to identify children with blunt trauma at very low risk for intra-abdominal injury.

761 (6.3%) had intra-abdominal injuries, 203 of those (26.7%) received acute interventions.

The rule had a sensitivity of 97%, a specificity of 43%, and a Negative Predictive Value of 99.9%.

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PECARN Pediatric Blunt Abdominal Trauma Rule

*In descending order of importance.*

- No evidence of abdominal wall trauma (SBS)
- Glasgow Coma Scale > 13
- No abdominal tenderness
- No evidence of thoracic wall trauma
- No complaints of abdominal pain
- No decreased breath sounds
- No vomiting

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CC: 5-year-old female is seen for an abdominal injury while riding her bike. She lost control, and the end of the handlebar struck her just below the umbilicus. Denies vomiting.


Does this patient require imaging studies?

Yes!
**Case #7 – 5-y/o ♀ with blunt abdominal injury**


Prospective, observational study
1,095 blunt trauma patients < 16 y/o
2½ year period at a Level I Trauma Ctr.

**Elevated LFTs:** AST >200 or ALT >125

Urinalysis with > 5 RBCs / hpf

Initial Hematocrit < 30%

- 1,095 total patients, 107 with intra-abdominal injuries
- 16 patients with intra-abdominal injuries had no concerning physical exam findings (low SBP, abd tenderness) or a GCS < 14
- Of those patients, 15 had ↑d LFTs, ⊕ hematuria, or ↓d hematocrit
- Amylase was not helpful (it’s usually elevated after 24 hours)


**Summary:**

1. CT sensitivity was similar with or without oral contrast.

2. Specificity was 4% greater with oral contrast.

3. When children with blunt torso trauma undergo abdominal CT, oral contrast is unnecessary.

Baby Professor has a question about CT Abdomen in pediatric patients with blunt trauma:

1. Can clinically stable pediatric patients with blunt torso trauma and normal CT scans be safely discharged?

Can clinically stable pediatric patients with blunt torso trauma and normal CT be D/Cd?

Review of three studies comprising 2,596 patients with blunt abdominal trauma and initial negative abdominal CT showed a 0.2% had a delayed diagnosis of injury.

3 had CT identified splenic / renal injuries → no interventions.

1 serosal tear and mesenteric hematoma identified on laparotomy.

1 therapeutic laparotomy for bowel rupture.

Bottom line: 1 / 2,600 patients had a delayed diagnosis of an injury that → intervention.

If you do get a negative CT in an otherwise stable pediatric patient, you are safe discharging them home.


Case #8 – 2-y/o ♂ with a limp

CC: 2-y/o ♂ sent to the ED from the pediatrician’s office for a limp. For two days he’s been reluctant to weight bear and c/o right knee pain. He completed a course of antibiotics for pneumonia 11 days ago. Mom describes him as “clingy and sleepy.”

PMHx: Normal birth history. Immunizations are current.

PE: Temp 101.1°F (38.4°C), HR 150, RR 28, BP 112/71, SaO₂ 98%. Coarse rhonchi at right lung base. Abdomen benign. Right knee normal exam. Questionable tenderness of right hip. Ambulates reluctantly (limps) with coaxing from parents.

Caird Prediction Rule

The following are strong independent risk factors and valuable for assessing and diagnosing children suspected of having septic arthritis of the hip:

1. Temperature > 38.5°C
2. WBC > 12.0
3. ESR > 40 mm/hr
4. Refusal to bear weight
5. CRP level > 20.0 mg/L

Prospective 4-year study of 53 children who underwent hip aspiration because of a suspicion of septic arthritis.

Fever (an oral temperature >38.5°C) was the best predictor of septic arthritis followed by an elevated C-reactive protein level, an elevated erythrocyte sedimentation rate, refusal to weightbear, and an elevated serum white blood-cell count.

Patients with 5 factors had a 98% chance of having septic arthritis, those with 4 factors had a 93% chance, 3 factors had an 83% chance, 2 factors had a 62% chance, 1 factor had a 37% chance.

Case #8 – 2-y/o ♂ with a limp

**PE:** Temp 101.1° F (38.4°C), HR 150, RR 28, BP 112/71, SaO₂ 98%. Coarse rhonchi at right lung base. Abdomen benign. Right knee normal exam. Questionable tenderness of right hip.

**Labs:** WBC normal. Na⁺ 133, CRP 12.4, ESR 17. UA 1+ ketones

**X-Rays:** Chest shows right middle lobe infiltrate and bilateral perihilar infiltrates. Right knee is normal.

**Caird Prediction Rule**
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*Given these labs and x-ray findings, what is your suspicion for a septic hip?*

0 factors, 17% chance

Case #9 – 13-y/o ♀ c/o Rt knee injury

**CC:** 13-y/o ♀ c/o right knee injury from a snowmobile. The patient was “clipped” on the lateral aspect of her knee by a snowmobile. Since the injury she has been nonweightbearing. Attempts to weightbear greatly increase her pain.

**PE:** Normal vitals. Knee is swollen and tender to palpation. Patellar tendon appears intact. No gross deformities or bruising seen. Weightbearing is not assessed.

Does this patient need radiographic imaging?
Ottawa Knee Rules

Knee X-rays are indicated after acute knee injury if any of the following are present:
1. Age 55 years or over
2. Tenderness at the head of the fibula
3. Isolated tenderness of the patella
4. Inability to flex knee to 90 degrees
5. Inability to bear weight (defined as an inability to take four steps, i.e. two steps on each leg, regardless of limping) immediately and at presentation

Pittsburgh Decision Rule

Radiography is indicated for knee injury with blunt trauma or a fall as mechanism of injury plus either of the following:
1. Age < 12 years or > 50 years
2. Inability to walk four weight-bearing steps in the emergency department

Primary outcome measure was correct identification of fractures. 12 fractures (9%) were radiologically determined in phase II. Pittsburgh Decision Rule was 100% sensitive and 79% specific for correctly identifying fractures.
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- A prospective, blinded, multicenter trial in the EDs of 3 urban teaching hospitals.
- Convenience sample of 934 patients with knee pain.
- OKR: 750 patients with 87 fractures (11.6%). Ottawa rule missed 3 fractures, for 97% sensitivity, 27% specificity.
- PDR: 745 patients of whom 91 fractures (12.2%). Pittsburgh rule missed 1 fracture, yielding a 99% sensitivity and 60% specificity.


**Cases #9 – 13-y/o ♀ c/o Rt. knee injury**

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Case #10 – 12-y/o ♀ c/o Rt. ankle injury

CC: 12-y/o ♀ injures her right ankle while playing soccer. States she “rolled” her ankle. She was briefly weight-bearing initially, but has been non-weight bearing for the last hour. Dad sees you on the sidelines and asks if you’d take a look. He wants to know if they need to go to the ER for x-rays.

PE: Normal vitals. Right ankle is swollen. No bruising. Tenderness along distal lateral malleolus.

Does this patient need radiographic imaging?

Ottawa Foot & Ankle Rules

Ankle X-ray is only required if there is any pain in the malleolar zone and any one of the following:
1. Bony tenderness along the distal 6 cm of the posterior edge of the medial malleolus
2. Bony tenderness along the distal 6 cm of the posterior edge of the lateral malleolus
3. An inability to bear weight both immediately and in the emergency department for 4 steps.

Foot x-ray is indicated if there is any pain in the midfoot zone and any one of the following:
1. Bony tenderness at the base of the 5th metatarsal
2. Bony tenderness at the navicular bone
3. An inability to bear weight both immediately and in the emergency department for 4 steps.

Ottawa ankle rules have a 100% sensitivity and 27% specificity for excluding fractures of the ankle and midfoot.


OAR


Prospective cohort study in a pediatric ED of 272 children ≤ 16 years with acute ankle trauma.

47 (17.3%) had a clinically important fracture.
LRAR

CMAJ, August 2013.

6 Canadian EDs from January 2009 - August 2011
n = 2,151 children
1,055 intervention group
1,096 control group
3 consecutive 26-week phases
Phase 1 x-ray rate 97% & 90%
Phase 2 x-ray rate ↓d by 22%
LRAR Sn = 100%, Sp = 53%

Low-Risk Ankle Rule

The Low Risk Ankle Rule states that if a child (3 to 16 years-old) with an ankle injury does not need x-rays if s/he has:

Low-risk Exam - tenderness and swelling isolated to the distal fibula and/or adjacent lateral ligaments (distal to the anterior tibial joint line)

High-risk injuries - any fracture of the foot, distal tibia or fibula proximal to the distal physis, tibiofibular syndesmosis injury, and ankle dislocations.

Low-risk injuries - lateral ankle sprains, nondisplaced Salter–Harris types I and II fractures of the distal fibula, and avulsion fractures of the distal fibula or lateral talus (all of which can all be managed by splinting and return to activities as tolerated)

Case #10 – 12-y/o ♀ c/o Rt. ankle injury

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Low-risk injuries - lateral ankle sprains, nondisplaced Salter–Harris types I and II fractures of the distal fibula, and avulsion fractures of the distal fibula or lateral talus (all of which can all be managed by splinting and return to activities as tolerated)

Does this patient need radiographic imaging?

It depends…

Summary: Pediatric Trauma CDRs

PECARN CATCH CHALICE

TAC National Pediatric C-Spine Evaluation Pathway

EAST Guidelines: Screening Criteria for BCI

EAST Blunt Cardiac Injury (BCI) Guidelines

PECARN Pediatric Blunt Abdominal Trauma Rule

Caird Prediction Rule

Ottawa Knee Rules

Pittsburgh Decision Rule

Ottawa Foot & Ankle Rules

Low-Risk Ankle Rule
Summary – Adult & Pediatric CDRs
References


