Approccio al bambino con TRAUMA CRANICO MINORE

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LEARNING OBJECTIVES

To discuss the best possible approach for children coming to the PED after a minor closed head trauma

Particularly addressing these issues

- Who should get scanned?
- Who should be observed?
- Who should be safely discharged?
Head trauma is one of the most common reasons for acute visit in PED
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Traumatic brain injuries are the leading cause of death and disability in children, accounting for about 30% of deaths in the paediatric population
Head trauma is one of the most common reasons for acute visit in PED

Traumatic brain injuries are the leading cause of death and disability in children, accounting for about 30% of deaths in the paediatric population

The majority of children (> 90%) who seek medical consultation after an injury, have a minor head trauma
Head trauma is one of the most common reasons for acute visit in PED.

Traumatic brain injuries are the leading cause of death and disability in children, accounting for about 30% of deaths in the paediatric population.

The majority of children (> 90%) who seek medical consultation after an injury, have a minor head trauma.

A small number of children who appear well have an intracranial injury.
Minor head trauma: definition

- When reviewing the literature it should be noted that there is no standard definition for Minor Head Trauma.

- This definition has been based mostly on the Glasgow Coma Scale, usually 14-15 (according to some Authors > 13)

Holmes JF, Acad Emerg Med, 2005
### Glasgow coma scale and pediatric Glasgow coma scale

<table>
<thead>
<tr>
<th>Sign</th>
<th>GCS*</th>
<th>PGCS*</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye opening</strong></td>
<td>Spontaneous</td>
<td>Spontaneous</td>
<td>4</td>
</tr>
<tr>
<td>To command</td>
<td>To sound</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>To pain</td>
<td>To pain</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Verbal response</strong></td>
<td>Oriented</td>
<td>Age-appropriate vocalization, smile,</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>or orientation to sound,</td>
<td>or interacts (coos, babbles), follows objects</td>
<td></td>
</tr>
<tr>
<td>Confused,</td>
<td>Cries, irritable</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>disoriented</td>
<td>Cries to pain</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Inappropriate words</td>
<td>Moans to pain</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Incomprehensible</td>
<td>None</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>sounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Motor response</strong></td>
<td>Obeys commands</td>
<td>Spontaneous movements (obeys verbal command)</td>
<td>6</td>
</tr>
<tr>
<td>Localizes pain</td>
<td>Withdraws to touch (localizes</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>pain</td>
<td>pain</td>
<td></td>
</tr>
<tr>
<td>Withdraws</td>
<td>Withdraws to pain</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Abnormal flexion to</td>
<td>Abnormal flexion to pain</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>pain</td>
<td>(decorticate posture)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal extension</td>
<td>Abnormal extension to pain</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>(decerebrate posture)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>None</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Best total score</strong></td>
<td></td>
<td></td>
<td>15</td>
</tr>
</tbody>
</table>

The GCS is scored between 3 and 15, 3 being the worst, and 15 the best. It is composed of three parameters: best eye response (E), best verbal response (V), and best motor response (M). The components of the GCS should be recorded individually; for example, E2V3M4 results in a GCS of 9. A score of 13 or higher correlates with mild brain injury; a score of 9 to 12 correlates with moderate injury; and a score of 8 or less represents severe brain injury. The pediatric Glasgow coma scale was validated in children 2 years of age or younger.

Minor head trauma: AAP definition

- normal mental status at the initial examination (within 24 hours of the trauma)
- no abnormal findings on neurologic examination
- no physical evidence of complicate skull fracture (such as palpable bone depression, Battle's sign, hemotympanum etc.)

They may, or may not, have had:
- temporary loss of consciousness
- lethargy
- headache
- vomiting
- seizure immediately after injury
The great majority of children who sustained a minor head trauma have no sequelae and most of them can be discharged after a short observation.
The great majority of children who sustained a minor head trauma have no sequelae and most of them can be discharged after a short observation.

HOWEVER

A small number of children who appear well at the arrival develop an intracranial injury (~1% in unselected populations admitted to an ED with head trauma).
Computed tomography (CT) is the gold standard for the detection traumatic brain injuries.
Computed tomography (CT) is the gold standard for the detection of traumatic brain injuries.

However,

The decision to obtain neuroimaging for children with minor head trauma must be balanced with the risk of CT in terms of radiation exposure and need for sedation.
CONCLUSION

The best available risk estimates suggest that paediatric CT will result in significantly lifetime radiation risk over adult CT.

The lifetimes attributable risk of mortality for leukaemia or solid organ malignancy from a single pediatric head CT ranges from approximately 1:2000 for infants to 1:5000 for older children.
Current Concepts

Computed Tomography — An Increasing Source of Radiation Exposure


Figure 4. Estimated Dependence of Lifetime Radiation-Induced Risk of Cancer on Age at Exposure for Two of the Most Common Radiogenic Cancers.

Cancer risks decrease with increasing age both because children have more years of life during which a potential cancer can be expressed (latency periods for solid tumors are typically decades) and because growing children are inherently more radiosensitive, since they have a larger proportion of dividing cells. These risk estimates, applicable to a Western population, are from a 2005 report by the National Academy of Sciences and are ultimately derived from studies of the survivors of the atomic bombings. The data have been averaged according to sex.
Effect of low doses of ionising radiation in infancy on cognitive function in adulthood: Swedish population based cohort study

Per Hall, Hans-Olov Adami, Dimitrios Trichopoulos, Nancy L Pedersen, Pagona Lagiou, Anders Ekbom, Martin Ingvar, Marie Lundell, Fredrik Granath

What this study adds

Intellectual development is adversely affected when the infant brain is exposed to ionising radiation at doses equivalent to those from computed tomography of the skull

Diagnostic evaluation of children with minor head injuries needs to be re-evaluated
From the Guest Editor’s Notebook

The Image Gently Campaign: Working Together to Change Practice

There’s no question – CT helps us save kids’ lives! But… When we image, radiation matters! Children are more sensitive to radiation. What we do now lasts their lifetime. So, when we image, let’s image gently. More is often not better.

When CT is the right thing to do:
- Child size the kVp and mA
- One scan (single phase) is often enough
- Scan only the indicated area

A timely message from the Alliance for Radiation Safety in Pediatric Imaging.

One size does not fit all:

- Child size the kVp and mA
- One scan (single phase) is often enough
- Scan only the indicated area

Contact us at www.imagingly.com

This page was created using images from the Alliance for Radiation Safety in Pediatric Imaging.
The **goal** of the management of children with apparently mild head trauma is to identify those at significant risk of traumatic brain injury who may require immediate intervention or close follow-up while limiting unnecessary neuroimaging procedures.
Many controversies exist in the literature regarding the significance of each of these features in predicting intracranial injury.
...and no single feature has been demonstrated to predict TBI with sufficient sensitivity
Considering that no single clinical feature reliably predicts the presence of TBI with sufficient sensitivity, more recently investigators have sought to derive “clinical prediction rules”, that use a combination of clinical variables obtained from history or clinical examination in order to improve the accuracy in identifying children with TBI.
Predictors of intracranial injuries in children after blunt head trauma

Table 5  Measures of association between initial evaluation and intracranial injury among cases of closed head trauma. Italy, 1996–1997

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th></th>
<th>Specificity</th>
<th></th>
<th>PPV</th>
<th></th>
<th>NPV</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Initial evaluationa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal Glasgow Coma Scale or abnormal neurological examination or clinical signs of skull base fracture: yes vs. no (i.e., group E vs. groups A+B+C+D)</td>
<td>13/22</td>
<td>59.1</td>
<td>3,723/3,776</td>
<td>98.6</td>
<td>13/66</td>
<td>19.7</td>
<td>3,723/3,732</td>
<td>99.8</td>
</tr>
<tr>
<td>Abnormal Glasgow Coma Scale or abnormal neurological examination or clinical signs of skull base fracture or of skull fracture in area at risk for intracranial injury: yes vs. no (i.e., groups E+D vs. groups A+B+C)</td>
<td>19/22</td>
<td>86.4</td>
<td>3,528/3776</td>
<td>93.4</td>
<td>19/267</td>
<td>7.1</td>
<td>3,528/3531</td>
<td>99.9</td>
</tr>
<tr>
<td>Abnormal Glasgow Coma Scale or abnormal neurological examination or clinical signs of skull base fracture or of skull fracture in area at risk for intracranial injury or prolonged loss of consciousness or persistent headache or persistent drowsiness or amnesia: yes vs. no (i.e., groups E+D+C vs. groups A+B)</td>
<td>22/22</td>
<td>100.00</td>
<td>3,298/3,776</td>
<td>87.3</td>
<td>22/500</td>
<td>4.4</td>
<td>3,298/3,298</td>
<td>100.0</td>
</tr>
<tr>
<td>Any symptom: yes vs. no (i.e., groups E+D+C+B vs. group A)</td>
<td>22/22</td>
<td>100.00</td>
<td>2,748/3776</td>
<td>72.8</td>
<td>22/1050</td>
<td>2.1</td>
<td>2,748/2,748</td>
<td>100.00</td>
</tr>
</tbody>
</table>

*aFor eight children whose final outcome was no intracranial injury the initial evaluation was missing
CONCLUSIONS: Eight clinical prediction-rule derivation studies were identified. They varied considerably in population, methodologic quality, and performance. Future efforts should be directed toward validating rules with high quality and performance in other populations and deriving a high-quality, high-performance rule for young children.
<table>
<thead>
<tr>
<th>Study</th>
<th>Setting</th>
<th>n</th>
<th>Age, y</th>
<th>Age &lt;2 y, %</th>
<th>Type of Injury</th>
<th>GCS: %</th>
<th>CT Performed as Inclusion</th>
<th>Baseline CT Frequency, %</th>
<th>Abnormal Neurosurgical CT Results, %</th>
<th>Abnormal Neurosurgical Intervention, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atabaki et al²⁷ (2008)</td>
<td>4 level 1 pediatric trauma EDs in US</td>
<td>1000</td>
<td>0–21</td>
<td>18.8</td>
<td>Minor head injury</td>
<td>15: 85.2</td>
<td>Yes</td>
<td>100</td>
<td>6.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Da Dalt et al²⁸ (2006)</td>
<td>5 level 3 pediatric EDs in northern Italy</td>
<td>3806</td>
<td>0–16</td>
<td>37</td>
<td>Blunt head trauma of any severity</td>
<td>≥14: 98.7</td>
<td>No</td>
<td>2</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Dunning et al²⁹ (2006)</td>
<td>3 children’s EDs, 3 adult teaching EDs, 4 general hospital EDs in England</td>
<td>22772</td>
<td>0–16</td>
<td>27.3</td>
<td>All head injury</td>
<td>15: 98.6</td>
<td>No</td>
<td>3</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Greenes and Schutzman³⁰ (2001)</td>
<td>1 tertiary care children’s ED in US</td>
<td>422</td>
<td>0–2</td>
<td>100</td>
<td>Asymptomatic head injury</td>
<td>NA</td>
<td>No</td>
<td>18</td>
<td>17</td>
<td>0.2</td>
</tr>
<tr>
<td>Haydel and Shembekar³¹ (2003)</td>
<td>1 level 1 trauma center ED in US</td>
<td>175</td>
<td>5–17</td>
<td>0</td>
<td>Nontrivial minor head injury</td>
<td>15: 100</td>
<td>Yes</td>
<td>100</td>
<td>8</td>
<td>0.6</td>
</tr>
<tr>
<td>Oman et al³² (2006)</td>
<td>21 EDs in US</td>
<td>1868</td>
<td>0–18</td>
<td>12.5</td>
<td>All head injury</td>
<td>15: 6.9</td>
<td>Yes</td>
<td>100</td>
<td>8.3</td>
<td>NA</td>
</tr>
<tr>
<td>Palchak et al³³ (2003)</td>
<td>1 pediatric ED in level 1 trauma center in US</td>
<td>2043</td>
<td>0–18</td>
<td>16.5</td>
<td>Nontrivial head injury</td>
<td>≥14: 91</td>
<td>No</td>
<td>62</td>
<td>4.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Sun et al³⁴ (2007)</td>
<td>21 EDs in US</td>
<td>1868</td>
<td>0–18</td>
<td>12.5</td>
<td>All head injury</td>
<td>15: 6.9</td>
<td>Yes</td>
<td>100</td>
<td>8.3</td>
<td>NA</td>
</tr>
</tbody>
</table>

ED indicates emergency department; NA, not applicable.
CONCLUSIONS: Eight clinical prediction-rule derivation studies were identified. They varied considerably in population, methodologic quality, and performance. Future efforts should be directed toward validating rules with high quality and performance in other populations and deriving a high-quality, high-performance rule for young children.
A computed tomography scan is required if any of the following criteria are present.

**History**
- Witnessed loss of consciousness of >5 min duration
- History of amnesia (either antegrade or retrograde) of >5 min duration
- Abnormal drowsiness (defined as drowsiness 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 (NAI, defined as any suspicion of NAI by the examining doctor)
- Seizure after head injury in a patient who has no history of epilepsy

**Mechanism**
- High-speed road traffic accident either as pedestrian, cyclist or occupant (defined as accident with speed >40 m/h)
- 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.

**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 (defined as evidence of blood or cerebrospinal fluid from ear or nose, panda eyes, Battles sign, haemotympanum, facial crepitus or serious facial injury)
- Positive focal neurology (defined as any focal neurology, including motor, sensory, coordination or reflex abnormality)
- Presence of bruise, swelling or laceration >5 cm if <1 year old

**The presence of any of these criteria identify (sensitivity)**

98% of children with ICI (CI 96%-100%)

**The PPV is low** (8.63%; C.I. 7.68% - 9.65%)

*Dunning, Arch Dis Child 2006*
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Altered Mental Status</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Focal neurological signs</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
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<tr>
<td>Evidence of basal skull fracture</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Scalp hematoma (&lt;2y) or any evidence of skull fracture</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Prolonged LOC/amnesia</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persistent vomiting</td>
<td></td>
<td>+ (≥ 3)</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Abnormal behaviour</td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headache</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Seizures</td>
<td></td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
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<td>+</td>
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<tr>
<td>Suspected inflicted injury</td>
<td></td>
<td></td>
<td>+</td>
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<td>Coagulopathy</td>
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<td></td>
<td>+</td>
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<td></td>
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<tr>
<td>Significant mechanism of injury</td>
<td>+</td>
<td></td>
<td>+/−</td>
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</tbody>
</table>

* 0-2 years, asymptomatic
Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study


• 42412 patient 0-18 y, no trivial trauma GCS 14-15
• Identify low-risk group that does not need CT
• Outcomes: clinically important Brain Injury
  (Death, Intubation, Neurosurgical procedure, Intracranial Injury (ICI) and 2 days in hospital)
Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study

Prediction Rule: children < 2 aa

- LOC
- Altered mental status
- Non acting normally
- Parietal or occipital scalp hematoma
- Palpable skull fracture
- Severe mechanism of injury

Negative predictive value: 99.9% (IC 99.98-99.999)

Lancet, September 12, 2009
Prediction Rule: children > 2 aa

- LOC
- Altered mental status
- Repetitive vomiting
- Severe headache
- Suspicion of basilar skull fracture
- Severe mechanism of injury

Negative predictive value: 99,95% (IC 99,9- 99,998)

Lancet, September 12, 2009
Severe mechanism of trauma

- Motor vehicle collisions and
  - Ejection
  - Other passenger death
  - Rollover
  - Pedestrian
  - Unhelmeted bicyclist

- Fall >3 feet (0.9m) if < 2 yo
- Fall > 5 feet (1.5m) if ≥2 yo
- Head hit by high impact object

Lancet, September 12, 2009
Case scenario 1

A 7 m/o infant is brought to the PED after a fall on a marble floor, from the changing table almost 4 feet high (1,2 mt). No problems in the following 12 hours. He is brought to the PED the day after for the onset of a scalp hematoma noticed by his parents when he woke up. Still appearing well.

PE: normal mental status, no neurological abnormalities. Left large parietal scalp hematoma (7 x 8 cm), without skull depression. No other pathologic findings on the remaining PE.
Is a CT scan indicated?
Suggested CT algorithm

**Children < 2 aa**

**A**

1. **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 → 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 → CT not recommended¶
         - 53.5% of population
         - <0.02% risk of ciTBI

Suggested CT algorithm

Children < 2 aa

A

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

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

32.6% of population
0.9% risk of ciTBI

No

53.5% of population
<0.02% risk of ciTBI

CT not recommended¶
High-risk signs or symptoms include the following:

- Focal neurologic findings
- Acute skull fracture, including depressed or basilar fracture
- Depressed mental status
- Irritability
- Bulging fontanel
- Persistent vomiting
- Seizure
- Definite loss of consciousness (especially more than a few seconds and associated with a high-risk mechanism of injury)
- Suspicion of child abuse
- Underlying condition predisposing to intracranial injury

The risk of clinically important traumatic brain injury is 4 percent or higher for patients with one or more of these findings.
High-risk signs or symptoms include the following:

- Focal neurologic findings
- **Acute skull fracture**, including depressed or basilar fracture
- Depressed mental status
- Irritability
- Bulging fontanel
- Persistent vomiting
- Seizure
- **Definite loss of consciousness** (especially more than a few seconds and associated with a high-risk mechanism of injury)
- Suspicion of child abuse
- Underlying condition predisposing to intracranial injury

The risk of clinically important traumatic brain injury is 4 percent or higher for patients with one or more of these findings.
Case scenario 1

- Head CT scan → Left temporo-parietal extradural hematoma, 1 cm thick; no other abnormalities
Case scenario 1

- Head CT scan ➔ Left temporo-parietal extradural hematoma, 1 cm thick; no other abnormalities

He underwent neurosurgical intervention with good outcome
Case scenario 2

A 3 m/o infant is brought to the PED after a fall from his parents bed almost 3 feet high. No LOC, he cried immediately after falls and is still appearing well.

PE: alert, no neurological abnormalities.
   Left temporo-parietal scalp hematoma (4 x 5 cm),
   No other pathologic findings on the remaining PE.
Case scenario 2

- Head CT scan → Negative for intracranial injury
  Scalp hematoma
Case scenario 2

- Head CT scan → Negative for intracranial injury
- Scalp hematoma
- Temporal skull fracture
What is the role of skull X-ray in young children with suspected skull fracture?
Skull fractures are not uncommon following minor head trauma in children, particularly in those younger than two years of age.

The vast majority of skull fractures are linear.

Among children with linear skull fractures, 15 to 30 percent have associated intracranial injuries.

Most children with skull fractures will have overlying scalp hematomas.
Skull fractures in children < 2 years and skull x-rays

Skull radiographs may occasionally be useful to screen for fracture and avoid the risk of radiation and sedation from CT in selected asymptomatic patients 3 to 24 months of age with concerning scalp hematomas.

However, skull radiographs should only be performed if a radiologist with pediatric expertise is available to provide an interpretation because physicians with pediatric emergency expertise may have limited accuracy in correctly identifying skull fractures in young children.

If a screening skull radiograph shows a fracture, then a head CT should be performed.
Case scenario 3

A 6 y/o child is brought to the PED for head trauma consequent to a motor vehicle collision (reported speed around 60 Km/hr, no rollover of the car, no ejection, reported use of restraint, mother ok)

Brief LOC. After that keeping well, alert and oriented. She vomited twice prior to arrival and has been complaining of headache.

PMHx: unremarkable
Case scenario 3

PE: Normal mental status, no neurological abnormalities
No signs of skull fracture
No other abnormalities on the remaining PE

During the first hour of observation in the ED:
- persistent vomiting (4 additional episodes)
- worsening headache
Is CT scan indicated?
Suggested CT algorithm for children > 2 years of age:

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

History of LOC, or history of vomiting, or severe mechanism of injury‡, or severe headache

Yes
27.7% 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
- Parental preference

No
58.3% of population
<0.05% risk of ciTBI

CT not recommended¶
Suggested CT algorithm

Children > 2 aa

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

History of LOC, or history of vomiting, or severe mechanism of injury‡, or severe headache

Yes

27.7% 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
- Parental preference

No

58.3% of population
<0.05% risk of ciTBI

CT not recommended¶
Suggested CT algorithm

**Children > 2 aa**

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
    - 4.3% 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
      - Parental preference

- **History of LOC, or history of vomiting, or severe mechanism of injury‡, or severe headache**
  - Yes
    - 27.7% 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
      - Parental preference
  - No
    - 58.3% of population
    - 0.05% risk of ciTBI
    - CT not recommended¶
High-risk signs or symptoms include the following:

- Focal neurologic findings
- Skull fracture, especially findings of basilar skull fracture
- Altered mental status (e.g., agitation, lethargy, repetitive questioning or slow response to verbal questioning
- Irritability
- Prolonged loss of consciousness
Signs or symptoms variable associated with intracranial injury

- Vomiting
- Headache
- Questionable or brief loss of consciousness
- Injury caused by high risk mechanism of injury

An alternative to CT scan is close observation for 4-6 hours after the injury, with imaging obtained for every worsening symptom or concerns during the period.
Signs or symptoms variable associated with intracranial injury

- Vomiting
- Headache
- Questionable or brief loss of consciousness
- Injury caused by high risk mechanism of injury

An alternative to CT scan is close observation for 4-6 hours after the injury, with imaging obtained for every worsening symptom or concerns during the period.
Case scenario 3

- Head CT scan  →  right occipital extradural hematoma, 16 mm thick;
Case scenario 3

- Head CT scan → right occipital extradural hematoma, 16 mm thick;

She underwent neurosurgical intervention with good outcome
A 2 y/o boy is brought to the PED after a fall on the ground from an amusement park ride 1.5 m high, 4 hrs before. No LOC, nor other signs or symptoms reported except for vomiting twice in the first hour following the trauma.

PMHx: unremarkable apart from recurrent vomiting, especially during infections, and motion sickness.

PE: no abnormalities
During observation in the PED the child vomited another 4 times.
Case scenario 4

- Head CT scan normal

After complete awaking from sedation the child is alert, no vomiting, no neurological abnormalities
Case scenario 4

- Head CT scan normal

After complete awaking from sedation the child is alert, no vomiting, no neurological abnormalities

Discharged to home
Characteristics of Children with Vomiting after Minor Head Trauma: A Case-Control Study

Liviana Da Dalt, MD, Barbara Andreola, MD, Paola Facchin, MD, Marzia Gregolin, MD, Andrea Vianello, MD, and Pier Antonio Battistella, MD

<table>
<thead>
<tr>
<th></th>
<th>Case subjects (n = 148)</th>
<th>Control subjects (n = 296)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal history</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent vomiting</td>
<td>9 (6.1%)</td>
<td>2 (0.7%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Recurrent headache</td>
<td>9 (6.1%)</td>
<td>7 (2.4%)</td>
<td>.047</td>
</tr>
<tr>
<td>Motion sickness</td>
<td>40 (27.0%)</td>
<td>35 (11.8%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Recurrent limb pain</td>
<td>13 (8.8%)</td>
<td>24 (8.1%)</td>
<td>NS</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>12 (8.1%)</td>
<td>24 (8.1%)</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Family history</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least 1 parent with</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent vomiting</td>
<td>1 (0.7%)</td>
<td>1 (0.3%)</td>
<td>NS</td>
</tr>
<tr>
<td>Recurrent headache</td>
<td>68 (45.9%)</td>
<td>80 (27.0%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Motion sickness</td>
<td>39 (26.4%)</td>
<td>45 (15.2%)</td>
<td>.005</td>
</tr>
<tr>
<td>At least 1 sibling with</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent vomiting</td>
<td>3 (2.0%)</td>
<td>1 (0.3%)</td>
<td>NS</td>
</tr>
<tr>
<td>Recurrent headache</td>
<td>10 (6.8%)</td>
<td>12 (4.1%)</td>
<td>NS</td>
</tr>
<tr>
<td>Motion sickness</td>
<td>21 (14.2%)</td>
<td>11 (3.7%)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
Conclusion: Post-traumatic vomiting is significantly related to personal or familiar predisposition to vomit rather than to the presence of intracranial lesions.
Vomiting after mild head injury is related to migraine.
Jan MMS, J Pediatr 1997

Why do children vomit after mild head injury?

Characteristics of children with vomiting after minor head trauma: a case-control study.
Da Dalt L, Jan MMS, J Pediatr 2007

Conclusion: Vomiting after minor head injury seems to be related to individual intrinsic factors rather than specific features of the head injury
Do Children With Blunt Head Trauma and Normal Cranial Computed Tomography Scan Results Require Hospitalization for Neurologic Observation?
Do Children With Blunt Head Trauma and Normal Cranial Computed Tomography Scan Results Require Hospitalization for Neurologic Observation?

Holmes et al, Ann Emerg Med 2011

Normal CT: no intracranial hemorrhage, no cerebral edema, no pneumocephalus, no any skull fracture
43,904 patients in primary study

30,361 excluded for this analysis
- Initial ED GCS score < 14
- Cranial CT with traumatic findings
- Ventricular shunt or Coagulopathy
- No CT scan obtained

13,543 patients in current study with GCS = 14 or 15 and normal cranial CT

12,584 with a GCS = 15
- 2,107 hospitalized
- 10,477 discharged home
- 116 Repeat cranial CT/MRI
  - 11 (0.5%) traumatic findings on repeat cranial CT/MRI
  - None with neurosurgery
- 184 Repeat cranial CT/MRI
  - 4 (0.04%) traumatic findings on repeat cranial CT/MRI
  - None with neurosurgery

959 with a GCS = 14
- 378 hospitalized
- 581 discharged home
- 21 Repeat cranial CT/MRI
  - 5 (1%) traumatic findings on repeat cranial CT/MRI
  - None with neurosurgery
- 13 Repeat cranial CT/MRI
  - 1 (0.2%) traumatic findings on repeat cranial CT/MRI
  - None with neurosurgery
Conclusions. Children with blunt head trauma and initial ED GCS scores of 14 or 15 and normal cranial CT scan results are at very low risk for subsequent traumatic findings on neuroimaging and extremely low risk of needing neurosurgical intervention. Hospitalization of children with minor head trauma after normal CT scan results for neurologic observation is generally unnecessary.
The use of cranial CT scans in the triage of pediatric patients with mild head injury

400 children with MHT and negative CT/ 1 month follow up

4 readmissions
→ 2 → negative CT
→ 1 symptomatic hemorrhagic contusion → observation only
→ 1 subdural hematoma 5 days after injury in a child on oral anticoagulants → neurosurgical drainage

Conclusion:
Among children with a normal cranial CT scan after mild head injury, delayed intracranial sequelae requiring intervention are extremely uncommon.

Davis RL, Pediatrics 1995
After a negative head CT scan…

… neurologically normal children may be discharged and observed at home
CATCH: a clinical decision rule for the use of computed tomography in children with minor head injury

Martin H. Osmond MD CM, Terry P. Klassen MD, George A. Wells PhD, Rhonda Correll RN, Anna Jarvis MD, Gary Joubert MD, Benoit Bailey MD, Laurel Chauvin-Kimoff MD CM, Martin Pusic MD, Don McConnell MD, Cheri Nijssen-Jordan MD, Norm Silver MD, Brett Taylor MD, Ian G. Stiell MD; for the Pediatric Emergency Research Canada (PERC) Head Injury Study Group
Among children who sustain a minor head injury

- Who should get scanned?
- Who should be observed?
- Who should be safely discharged?
For intermediate risk patients as an alternative to immediate CT...

... an acceptable management option may be

In- Hospital Observation
Suggested CT algorithm

Children < 2 aa

A

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

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

32.6% of population
0.9% risk of ciTBI

No

CT not recommended¶

53.5% of population
< 0.02% risk of ciTBI

Lancet, September 12, 2009
Suggested CT algorithm

Children > 2 aa

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

History of LOC, or history of vomiting, or severe mechanism of injury‡, or severe headache

Yes

27.7% 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
- Parental preference

No

58.3% of population
<0.05% risk of ciTBI

CT not recommended¶
IN-HOSPITAL OBSERVATION

ADVANTAGES
- No radiation cost
- No sedation
- No risk of false positive results
- More care to the patient

DISADVANTAGES
- Cost of admission
- Risk of missing clinically silent lesions
Comparable outcomes in terms of

- Recovery
- Late complications
- Patients’ satisfaction

Lower costs for immediate CT vs admission
Immediate CT vs Admission

✓ Results can not be extended to the whole pediatric population
✓ Only patients with minor head trauma > 6 years and LOC/amnesia were included
✓ Radiation Risks not considered among the outcomes

Marcovitch H, *BMJ* 2006
Further studies are needed to better define the most cost effective strategy for the pediatric age

Decisions on individual patients have to be taken on the basis of both peculiar clinical presentation, resources available, physician experience, parental preference.


Marcovitch H, *BMJ* 2006
The Effect of Observation on Cranial Computed Tomography Utilization for Children After Blunt Head Trauma


*Pediatrics* 2011;127;1067; originally published online May 9, 2011;
DOI: 10.1542/peds.2010-3373
The Effect of Observation on Cranial Computed Tomography Utilization for Children After Blunt Head Trauma
Pediatrics 2011;127;1067; originally published online May 9, 2011;
DOI: 10.1542/peds.2010-3373

CONCLUSIONS: Clinical observation was associated with reduced computed tomography use among children with minor blunt head trauma and may be an effective strategy to reduce computed tomography use.
Among children who sustain a minor head injury

- Who should get scanned?
- Who should be observed?
- Who should be safely discharged?
SAFE DISCHARGE CRITERIA

- No suspicion of inflicted injury
- The child is easily aroused with light touch and has a normal neurologic examination
- The child has returned to baseline level of function and tolerated oral fluids, if there has been vomiting
- Caretakers are capable of reliably observing the child and can return for care if indicated
- Specific instructions have been given regarding the level of observation required, indications for seeking care, and follow-up
- There are no extracranial injuries requiring admission

Schutzman S, UpToDate, 2010
HOSPITAL ADMISSION CRITERIA

- Brain injury or depressed or basilar skull fracture
- Persistent, significant alteration in mental status despite normal head CT
- Unremitting vomiting
- Extracranial injury requiring admission
- Suspected inflicted injury
- Caretakers who are unreliable or unable to return for care

Schutzman S, UpToDate, 2010
Suggested CT algorithm

The algorithmic approach proposed in the study is likely to gain wide acceptance for management of head-injured children given its scientific rigor and easy to use.

Klig JE, Kaplan CP, Curr Opin Ped 2010

The rules my might not be perfect, but represent the best current scientific evidence.

Parkin PC, Maguire JR, Lancet 2009
Grazie per l’attenzione

Prof.ssa Liviana Da Dalt

Dipartimento Materno-Infantile

Azienda ULSS 9 - Treviso

Università di Padova

Roma 9 novembre 2011