Pediatric Head and C-Spine Trauma

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DEM Grand Rounds
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OBJECTIVES

• Review of the anatomic difference of children and discussion of child-predominant injury patterns in children with head and neck injuries.
• To discuss appropriate use of radiology in both head injury and c-spine injury in children
• To discuss decision rules to identify clinically significant head injury while decreasing the number of head CTs done on children
• To review “best practices” for the prevention and care of children with head and neck injuries.
Disclosures

• None to report
Head Trauma

• Trauma being the #1 cause of death in children > 1 year of age; and head injuries accounting for >50% of those deaths.....

• Head trauma is the principal cause of mortality in the pediatric population

• Estimated 650,000 – 1 million children present each year to ED for head trauma.

• 80% of these are considered minor events
SCOPe OF THE PROBLEM

Males aged 0 to 4 years have the highest rates of TBI-related emergency department visits, hospitalizations, and deaths.

source: www.cdc.gov/TraumaticBrainInjury

- Almost half a million (473,947) emergency department visits for TBI are made annually by children 0 to 14 years.

- There was a 62% increase in fall-related TBI seen in EDs among children aged 14 years and younger from 2002 to 2006.
Prevalance of TBI

• >95,000 children experience a traumatic brain injury each year in the US

• 10% of college and 20% of high-school football players sustain brain injuries each season

• In 1997, the CDC proclaimed that concussions in athletes have reached an epidemic proportion in the US

  • Krauss JF. The incidence of acute brain injury and serious impairment in a defined population. AM J Epidemiol 1984
  • Kelly JP. The development of guidelines for the management of concussion in sports. J Head Trauma Rehabilitation 1998
  • Centers for Disease Control and Prevention: Sports-related recurrent brain injuries, United States. MMWR 1997.
Head Trauma: Etiology

• < 2 years of age:
  – Primarily falls
• > 2 years of age:
  – MVA
  – Bicycle/MVA
  – Falls (extreme sports)
  – Direct blows

• Most severe head injuries in all ages are due to inflicted trauma (child maltreatment)
ANATOMY:
Where do the differences matter?

• Larger head on weaker neck muscles
  ➢ *more chance for contra-coup injuries*

• Softer cranium and open sutures:
  ➢ *Increased susceptibility to blunt forces*
  ➢ *Delayed onset of herniation*
ANATOMIC DIFFERENCES:

Brain

- Pediatric brain has a higher water content and less myelinization, and so is relatively heavier and softer than the adult brain.

  - More susceptible to shearing forces.
  - More diffuse axonal injury occurs.
Shaken Baby Syndrome

• Usual presentations:
  – New onset seizures
  – Failure to thrive
  – Persistent vomiting
  – Increased head circumference
  – Tense fontanelle
  – Subdural hematoma or multiple subarachnoid hemorrhages

• Focal neurologic deficits are rarely seen
Fontanelles: misconception

• Though they are easy ports for us to "feel" elevated ICP, and "see" (with ultrasound) intraventricular bleeds......

➤ An open fontanelle does not protect against increased ICP or herniation.
“DEVELOPMENT IN PROGRESS”

• Stage of development affects final neurologic outcome

• “Brain malleability” – neuroplasticity: lends itself to better long-term outcome than would be predicted

• More profound impact on neurologic recovery from secondary brain injury

• Long-term neuropsych studies must be performed to determine true extent of damage
On the ‘good’ side.....

• The overall outcome for children with head injuries is better than that of adults with the same injury score.
• Mortality rate of isolated severe pediatric head injury is 6 –10% (compare adults 30 -50%)
• 70% of pediatric patients presenting with GCS of 3 or 4 have good neurologic recovery
• 95% of children with severe head trauma over age 5 were able to return to school at same grade level

Severity of TBI

- **GCS definition:**
  - Minor: 14 – 15
  - Moderate: 9 – 13
  - Severe: 3 – 8

- Mechanism of injury and presence of LOC help determine severity.
GCS predictive in children?

- Outcome assessment based on the GCS could be used as an *early predictor* (mortality), but it has limitations in *long-term outcome* (morbidity)
- GCS: eye opening and verbal components may be influenced by sedation... *motor component* considered a more reliable assessment
- GCS not associated with elevated ICP levels
- GCS has no consistent relationship with secondary cerebral insults

Figaj et al Neurosurgical Focus 2008
Prognosis:
Severe Head Trauma

• PGCS of 4-5 mortality rate of 6-35%;
• Survivors with PGCS of 4-5:
  – 90% require rehabilitation following hospital discharge
  – 95% eventually return to school.
• PGCS of 3, mortality rate 50-60%
• Survivors with PGCS of 3 poor neurologic outcomes.
Prognosis:
Moderate Head Trauma

• PGCS of 6-8:
  – likely to regain consciousness within 3 weeks
  – one third are left with focal neurologic deficits and/or learning difficulties
  – Prognosis worse if coma > 3 weeks.

• Recovery in children takes longer, from months to sometimes years.
Table 4. Pediatric Glasgow Coma Scale For Nonverbal Children.

<table>
<thead>
<tr>
<th>Eye Opening</th>
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</tr>
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<tbody>
<tr>
<td>Spontaneous</td>
<td>4</td>
</tr>
<tr>
<td>To speech</td>
<td>3</td>
</tr>
<tr>
<td>To pain</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
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</table>

<table>
<thead>
<tr>
<th>Verbal Response</th>
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<tbody>
<tr>
<td>Coos, babbles</td>
<td>5</td>
</tr>
<tr>
<td>Irritable cry</td>
<td>4</td>
</tr>
<tr>
<td>Cries to pain</td>
<td>3</td>
</tr>
<tr>
<td>Moans to pain</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motor Response</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Follows commands</td>
<td>6</td>
</tr>
<tr>
<td>Localizes pain</td>
<td>5</td>
</tr>
<tr>
<td>Withdraws to pain</td>
<td>4</td>
</tr>
<tr>
<td>Decorticate flexion</td>
<td>3</td>
</tr>
<tr>
<td>Decerebrate extension</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
</tbody>
</table>
GCS in the pre-verbal child?

PEDIATRIC GCS – VERBAL RESPONSE

5 – **Appropriate**: smiles, oriented to sounds, follows objects, interacts

4 – **Inappropriate**: cries but is consolable, inappropriate interactions

3 – **Inconsistent**: inconsistently consolable, lethargic

2 – **Inconsolable**: irritable, agitated, moaning

1 – **Unconscious**: no vocal response

- Even this scale limited in infants......

IFS: Infant Face Scale (Verbal/Facial Response)

5 – Cries spontaneously with handling, or to minor pain, alternates with periods of quiet wakefulness when not asleep = alert

4 – Cries spontaneously as above, but no quiet wakefulness maintained = not alert

3 – Cries to deep pain only

2 – Grimaces only to deep pain

1 – No facial expression to pain = unconscious

Child with head injury: Who needs a CT scan?

• Use of CT for minor head injury is increasing, while it’s diagnostic yield remains low

• Potential harmful effects of ionizing radiation increased in children because:
  – Smaller size, doses relatively higher (protocols?)
  – Younger age: longer period for effects to occur
  – Rapidly dividing cells: more susceptible to ionizing radiation
  – Risk of secondary malignancy greatest in the first 10 years of life
Should we do a Skull X-ray?

Not routinely indicated except in:

• *Patients younger than 1 year with scalp hematoma* and/or depression

• Skull penetration

• *Preexistent shunt*

• Signs of basilar skull fracture:
  
  - CSF otorrhea and/or rhinorrhea,
  - hemotympanum, Battle’s sign, raccoon eyes
Child with head injury: Who needs a CT scan?

- Children with moderate to severe head injury based on GCS (< 14) have 20% risk of TBI on head CT – risk of TBI outweighs risk of radiation

- Asymptomatic children with trivial or low-risk injury mechanism do not require a CT
Minor Head Trauma

• 1999 AAP recommended that observation alone was sufficient for children:
  – over the age of 2 years with MHI
  – no LOC or amnesia
  – No vomiting beyond immediate injury
  – No neurologic findings
  – No evidence of skull fracture

• Based on Masters study and two smaller pediatric studies:
  – No children had intracranial injury by CT scan without LOC, amnesia, *vomiting, or headache*

  • Dietrich AM. Ann Emerg Med 1993
To Scan or not to Scan?

- Currently no widely accepted, evidence-based guidelines on the use of CT for children with minor head injury

- Multiple studies over past few years trying to address this topic.....
Are we overusing head CT?

• YES, probably

• Small retrospective study of 394 children, ages 1 mo –5 yrs, who received CT scans for head trauma.

• Identified “Red Flag” characteristics of head injury which probably require CT for evaluation. These caught 100% of the clinically significant TBI......
Red flags from Kriss study

- LOC
- Altered mental state
- Signs of fracture
- Hematoma
- Seizure
- Pain upon awaking
- Suspected non-accidental trauma
- Evidence of increased ICP
- Abnormal neurologic exam
Kriss: results

- 236 children (59.9%) identified to have high risk indications for CT
  - 89 (38%) abnormal CT
  - 23 (9.7%) deemed clinically significant
  - 3 (1.2%) required immediate action
  - 47 (20%) received more than one head CT

- Begs the question:
  Why did the remaining 40% get CT?

Kriss, Pediatric Academic Societies 2010.
How well do doctors predict intracranial injury?

• Prospective study of 1000 patients 21 years or less (mean 8.9 yrs)
• Patient variables were obtained prior to CT, and physicians asked to predict if their patient had clinically significant head injury
• 65 patients (6.5%) : CT –dx intracranial injury
• Only 6 (0.6%) required neurosurgery
• Mechanism of injury: falls in 44.4%

A patient was unlikely to have an IC injury if they had none of the following list:

- Dizziness
- Sensory deficit
- GCS < 15
- Mental status change
- Injury due to bicycle
- < 2 years old
- Palpable skull defect
- Signs of basilar skull fracture
• Using the decision rule: none of the 6 patients requiring neurosurgery was missed:
  – Sensivity: 95%  Specificity: 48.9% Neg pred value: 99.3%
  – No validating studies of this rule performed

• Despite this rule being too broad to recommend for reasons to CT....authors estimated using this rule could eliminate the need for 46% of CT scans done in this setting.

• Treating physicians:
  Sensitivity: 14.8%
“CATCH” Rule

- Canadian Assessment of Tomography for Childhood Head injury

- Prospective cohort study
- 10 Canadian pediatric teaching hospitals
- 3866 children up to age 16 years (mean 9.2)
- Acute minor head injury within 24 hours

- Problem: relatively few children < 2 yrs enrolled

Osmond et al: CMAJ 2010
“CATCH” Rule

• Minor head injury definition: blunt trauma with:
  – Witnessed loss of consciousness
  – Definite amnesia
  – Witnessed disorientation
  – Persistent vomiting (2 or more 15 minutes apart)
  – Persistent irritability (< 2yrs of age)
  – GCS of 13 -15 (2.5% -7.3% -90.2%)

• Outcome measures:
  – Need for neurological intervention
  – Presence of CT – diagnosed head injury

Osmond et al: CMAJ
2009 “CATCH” Rule

CT scan determined by treating physician:

- Results:
  - 159 patients (4.1%) had CT diagnosed brain injury
  - 24 patients (0.6%) required neurologic intervention

- CATCH rule derived but not yet validated.
- Further prospective studies of < 2 years age are required

Osmond et al: CMAJ
2009 “CATCH” Rule
A CT is required only if minor head injury and any one of the following:

HIGH RISK (neuro)
- GCS < 15 at 2 hrs
- Open or depressed skull frx
- Worsening headache
- Irritability on exam
- Sensitivity: 100%
- 30.2% would get CT

MEDIUM RISK (CT finding)
- Basal skull fracture
- Large boggy hematoma of the scalp
- Dangerous mechanism of injury
- Sensitivity: 98.1%
- 52.0% would get CT

Osmond et al: CMAJ
Better design

- Large, prospective cohort study
- Multicenter North American (PECARN)
- GOAL: Identify kids with head trauma at very low risk for clinically important intracranial injury (ciTBI)
Decision Rule to Prevent CT use

Kupperman et al Lancet 2009

• 42,212 children (age < 18) with mild head trauma (GCS > 13) presenting to ED in < 24 hrs

• Exclusion criteria:
  – Trivial injury
  – Penetrating trauma, known brain tumor
  – Pre-existing neurological disorders

• Validated for two age groups (preverbal < 2 yrs; and verbal children >2 yrs)
Decision Rule to Prevent CT use

Kupperman et al. Lancet 2009

• Derivation tool included information of mechanism of injury, clinical variables (history, symptoms, physical exam) and disposition and follow-up telephone surveys

• Outcome: clinically important head trauma (ciTBI)
  - Neurosurgery
  - Death from TBI
  - Intubation for > 24 hours
  - Hospital admission > 2 nights
  - TBI seen on head CT
Mechanism of Injury

• Severe:
  – *MVA with patient ejection, death of a passenger, or rollover*
  – *Pedestrian or bicyclist w/o helmet struck by MVA*
  – *Fall of > 1.5 m (age > 2) or > 0.9 m (age < 2)*
  – *Head struck by a high-impact object.*

• Mild: ground-level falls or running into a stationary object

• Moderate: any other mechanism

*Kuppermanet al Lancet 2009*
Decision Rule to Avoid CT
Children < 2 years

• Normal mental status
• No scalp hematoma (except frontal)
• LOC < 5 seconds
• Non-severe injury mechanism
• No palpable skull fracture
• Normal behavior

Kupperman et al. Lancet 2009
Decision Rule to Avoid CT
Children > 2 years

- Normal mental status
- No LOC
- No vomiting
- Non-severe injury mechanism
- No sign of basilar skull fracture
- No severe headache

Kupperman et al Lancet 2009
Validation of decision rule

- Validation group of 2216 children < 2 yrs
  => 100% sensitivity and 100% negative predictive value
- Validation group of 6411 children > 2 yrs
  => 96.8% sensitivity
  => 99.5% negative predictive value
- Can break children into 3 groups:
  High risk: (> 4% risk of ciTBI) : get CT
  Intermediate risk: Observe and delay CT (0.9% risk)
  Low risk: Discharge home ( < 0.02% risk)
## Algorithm: step 1

Kupperman et al Lancet 2009

<table>
<thead>
<tr>
<th>&lt; 2 years old</th>
<th>&gt; 2 years old</th>
</tr>
</thead>
<tbody>
<tr>
<td>• GCS = 14</td>
<td>• GCS = 14</td>
</tr>
<tr>
<td>• signs of altered mental status</td>
<td>• signs of altered mental status</td>
</tr>
<tr>
<td>• palpable skull fracture</td>
<td>• signs of basilar skull fracture</td>
</tr>
<tr>
<td>(skull x-ray?)</td>
<td></td>
</tr>
</tbody>
</table>

HIGH risk > 4% risk of ciTBI

Recommendation: CT scan
Algorithm: step 2

< 2 years old
• Non-frontal scalp hematoma
• History of LOC > 5 sec
• Severe mechanism of injury
• Parents report “not acting right”

> 2 years old
• History of LOC
• History of vomiting
• Severe mechanism of injury
• Severe headache

INTERMEDIATE risk > 0.9% risk of ciTBI
Suggestion: Observe, possible delayed CT
Intermediate Group: Observation vs. CT

- Physician experience
- Multiple injuries
- Worsening symptoms or signs
- Age < 3 mos (less reliable exam)
- Parental preference

Kupperman et al Lancet 2009
Low-risk group

- Those with none of the 6 characteristics had a < 0.02% chance of ciTBI.
- Recommendation for this group was discharge with good instructions, or observe.

- CT use in the study population was less than the U.S. national average; still by applying the rule 21 – 25% of CTs could have been avoided.

Kupperman et al Lancet 2009
Best Practices: Management of Severe Pediatric Head Trauma

- Rapid stabilization, diagnosis and attempts to reduce secondary brain injury
- Early definitive airway control: avoid hypoxia
- Avoid hypo/hypertension, hypo/hyperglycemia
- Limited use of hyperventilation.
- Aggressive ICP-directed therapy for all children with severe TBI (GCS < 8)
- Early seizure prophylaxis with severe TBI
Best Practices: Easy & effective

• Elevate head of bed 30 degrees to increase venous drainage

• Maintain C-spine precautions

• Fluid resuscitation as indicated
  – *Higher BP = higher survival rate*
  – *No role for inducing supranormal BP*
Best Practices: Airway

RSI: Pearls

• Pre-medication with atropine: Not needed
• Pre-medication with lidocaine: probably useless
• Sedation: Etomidate best
  – Midazolam, Propofol and Thiopental, concerns over hypotension
  – Ketamine: new studies – might be safe in TBI
• Paralytic: Succinylcholine–superior in Cochrane review
Best Practices: Ventilation

- Avoidance of hypoxia (PaO2 > 60 – 65mmHg); oxygen saturation >90% prevents secondary hypoxic damage.
- Brief periods of hyperventilation can be used to treat acute neurologic deterioration.
- Routine, severe hyperventilation appears to represent a significant risk for brain hypoxia.
- ICP-guided hyperventilation in Neuro ICU
  Maintaining optimal, age-based cerebral perfusion pressure (children >60 mmHg & infants and toddlers >45 mmHg) improves neurologic outcome.
Best Practices: Metabolic

• Tight glycemic control: avoid extremes

• Hyperosmolar therapies: mannitol or hypertonic saline solutions:
  – increase serum osmolarity, net fluid flux from brain into the serum
  – Watch for hypotension and increased urinary losses

• (Administration of hyperosmolar agents => increased serum osmolarity, net fluid flux from the brain to bloodstream, => decreased edema, relative brain dehydration and decreased ICP.)
Best Practices: Seizure prophylaxis

- With GCS <8, up to 40% will develop seizures.
- Risk of seizure increases threefold in children < 2 years of age (vs >12 years old)
- No one agent has been clearly proven superior
  - Dilantin loading: 15 – 20 mg/kg
  - Pentobarb coma: judicious use due to hemodynamics
- Early prophylaxis does not affect the risk of developing late post-traumatic seizures; but does decrease secondary insult of hypoxia, lactic acidosis, and BP swing by preventing acute seizures
Hypothermia
Mixed message

• Study of 225 prospectively randomized children received hypothermia (T 32.5 C) avg 6 hrs after head injury vs normothermia

• RESULTS: 6 mos follow-up showed hypothermic group with higher mortality rate 21% vs 12%) and poorer neurologic outcome

• Conclusion: Hypothermia does not appear to be useful in management of pediatric head injury

• (Hypothermia is known to decrease ICP both early after traumatic brain injury as a neuroprotectant or in the delayed phase as a rescue therapy for recalcitrant intracranial hypertension.)
C-Spine Injury: CSI

• Low incidence (1.5 – 2%); high morbidity

• Maintain C-spine precautions if:
  – Distracting injury
  – GCS < 15
  – Intoxicants or other mental status alteration
  – Midline C-Spine tenderness
  – Abnormal neurologic exam
## C- Spine Incidence

<table>
<thead>
<tr>
<th>Author</th>
<th>Source</th>
<th>N</th>
<th>Age (years)</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kokoska et al</td>
<td>J of Ped Surg 2001</td>
<td>24,740</td>
<td>1 – 20</td>
<td>1.6%</td>
</tr>
<tr>
<td>Patel et al</td>
<td>J of Ped Surg 2001</td>
<td>75,172</td>
<td>1 – 18</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

- Confirms Johns Hopkins data (1999 – 2%)
- High percentage morbidity associated
  - C1 – C3 more commonly injured in children < 8 years of age
ANATOMIC DIFFERENCES:
Cervical Spine

- Weaker cervical musculature, increased laxity of ligaments
  - greater mobility of upper C-spine
- Higher fulcrum:  C2 - C3 at birth => C5 - C6 at age 8 years
  - C1 – C3 more commonly injured in children < 8 years of age (above C3 >70%; compared to 15% in adults)
- Immature spinal column more elastic than spinal cord:
  - tolerate more distraction before rupture (5cm vs 5-6 mm)
- Less calcified vertebrae and more immature vertebral joints
  - SCIWORA (Spinal Cord Injury w/o Radiologic Abnl)
Radiologic differences for kids

- Less calcified: Difficult to find fractures on x-ray or CT scan (SCIWORA)
- Different radiologic criteria for pre-vertebral space
- Pseudo-subluxation of C2 on C3 up to age 8 years
- Wedging may be over-read as compression fracture; secondary ossification centers over-read as fracture
- Usual screening c-spine films for children are:
  - AP, Lateral (include C7-T1), and odontoid
  - Move directly to CT C-Spine if neurologic deficit present
Adequate lateral C-Spine?

- Loss of lordosis
- Wedging of anterior bodies
- Subluxation of C3 on C4 (Pseudo?)
- C7 not visualized
Space between odontoid and arch of atlas can be up to 5 mm in children c.f. 2.5 mm in adults.

Soft tissues closely applied to vertebral bodies from C2–C5 in adults. Varies widely with phase of respiration in infants. >7 mm opposite C2 is abnormal.

Anterior wedging of vertebral bodies is a developmental finding.

Absent lordosis is a frequent normal finding.

Superior and inferior facets of apophyseal joints are exactly congruous.

C7/T1 junction must be visualised.

Figure 1 Interpretation of lateral c-spine radiographs in children ≤8 years of age (Based on figure from APLS Manual, 3rd edn).
A 6 yo c/o of neck pain after being thrown into a swimming pool 32 hrs PTA; She was tender along posterior neck and was refusing to move her head much. No paresthesias.

- What do you see that is abnormal?
  - Widened predental space
  - Subluxation of C2 on C3
  - Loss of lordosis

- Subluxation of C2 on C3:
  - Real or Pseudo-subluxation?
Pseudosubluxation C2 on C3
Swischuk line

- Line is drawn from the anterior aspect of the posterior arch of C1 to the anterior aspect of the posterior arch of C3.
- The anterior aspect of the posterior arch of C2 should be within 1 – 2 mm of this line,
- If it is more than 2 mm it is indicative of a true subluxation of C2 on C3, and a possible hangman’s fracture.
Pseudo-subluxation
Absence of Lordosis:
Muscle spasm vs ligamentous injury
Secondary Ossification Centers of the Spinous Process
Mimics an avulsion fracture
Cervical Spine Clearance without Radiography

Prospective multi-center study, NEXUS decision instrument in pediatric trauma population

5 Criteria
1. midline cervical tenderness
2. change in mental status
3. intoxication
4. abnormal neurologic exam
5. painful distracting injury

Results:
- Decision rule correctly identified all pediatric CSI victims (100% sensitivity)
- Could reduce imaging by 20%
- Caution when applying rules to young (preverbal) children

Viccellio et al; Pediatrics 2001
Cervical Spine Clearance

“There is limited evidence to guide clinicians on how to clear the paediatric cervical spine”

Slack & Clancy Emerg Med J 2004

- Possible CSI: 3 groups
  - Alert, asymptomatic (NEXUS criteria clear): no x-ray
  - C-Spine symptoms or signs: 3 view plain film, possible CT scan; MRI if persistent symptoms
  - Impaired LOC, distracting injury, very young < 3 mos:
    • CT immediately (< 3mos if significant trauma)
    • If suspicious, early MRI to exclude ligamentous and SCI
Spinal Cord Injury Without Radiographic Abnormality (SCIWORA)

Definition: Spinal trauma with neurologic injury no vertebral fracture or subluxation seen on plain films (or CT scan)

Background: Pang and Wilberberger 1982

Incidence: 15 – 67% of CSI in children; described as 3.8 – 4.2% prevalence in adults.
## Incidence of SCIWORA

<table>
<thead>
<tr>
<th>Author</th>
<th>Source</th>
<th>Age (years)</th>
<th>n</th>
<th>SCIWORA</th>
</tr>
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<tbody>
<tr>
<td>Hadley et al</td>
<td>J of Neurosurgery '88</td>
<td>0-9</td>
<td>n = 18</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-14</td>
<td>n = 38</td>
<td>16%</td>
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<td></td>
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<td>15-16</td>
<td>n = 66</td>
<td>12%</td>
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<td></td>
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<td>0-16</td>
<td>n = 122</td>
<td>16%</td>
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<tr>
<td>Rekate et al</td>
<td>Child's Nervous Sys. '99</td>
<td>0 - 8</td>
<td>n = 31</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - 16</td>
<td>n = 122</td>
<td>16%</td>
</tr>
<tr>
<td>Pang et al</td>
<td>J of Neurosurgery '82</td>
<td>0.5 - 16</td>
<td>n = 36</td>
<td>67%</td>
</tr>
<tr>
<td>Baker et al</td>
<td>Am J of Emergency Med '99</td>
<td>&lt;18</td>
<td>n = 72</td>
<td>44%</td>
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<tr>
<td>Birney et al</td>
<td>Spine '89</td>
<td>0 - 17</td>
<td>n = 61</td>
<td>21%</td>
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<tr>
<td>Patel et al</td>
<td>J of Pediatric Surg '01</td>
<td>&lt;18</td>
<td>n = 1098</td>
<td>17%</td>
</tr>
<tr>
<td>Kokoska et al</td>
<td>J of Pediatric Surg '01</td>
<td>1 - 10</td>
<td>n = 180</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 - 20</td>
<td>n = 228</td>
<td>15%</td>
</tr>
<tr>
<td>Ruge et al</td>
<td>J of Neurosurgery '88</td>
<td>&lt;12</td>
<td>n = 47</td>
<td>21%</td>
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<td>Brown et al</td>
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<td>0 - 19</td>
<td>n = 103</td>
<td>38%</td>
</tr>
<tr>
<td>Osenbach et al</td>
<td>Ped Neuroscience '89</td>
<td>0 - 8</td>
<td>n = 22</td>
<td>71%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 - 16</td>
<td>n = 9</td>
<td>29%</td>
</tr>
</tbody>
</table>
SCIWORA

- Hallmark is a documented neurologic deficit which may have changed or resolved with time.
- Re-injury may produce permanent disability, so if it is suspected, a thorough neurosurgical evaluation is recommended.
- Maintaining C-spine precautions, serial exams, and MRI
- No steroids used unless ongoing neurologic symptoms
SCIWORA

• Suspect in any child with one of the 6 P’s:
  — Pain, Parasthesia, Paralysis, abnormal Position, Ptosis, and Priapism

• Suspect in any child who describes a focal weakness or paresthesia which has completely resolved.

• Consider in any child with major MVA (-bike–pedestrian-unrestrained) or with decreased GCS

• beware of distracting injuries
Management of CSI
Steroids in Children

- NASCIS from 1990’s recommended high dose steroid use in acute spinal cord injury with neurologic abnormality

- Criticism over design of studies and lack of consensus on possible benefit-to-risk

- Subsequent pediatric studies showing differing results.