Pediatric vs Adult Neurotrauma

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Outline

- Epidemiology / Etiology
- Assessment
- Management
  - Hypothermia
- Outcome
- Concussion / Second Impact Syndrome
- Non-Accidental Head Injury
- SCIWORA
Epidemiology

### Assessment

- **Pediatric Glasgow Coma Scale**

<table>
<thead>
<tr>
<th>Adult scale</th>
<th>Paediatric scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes open</td>
<td>As in adult scale</td>
</tr>
<tr>
<td>Spontaneously</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>None</td>
<td>1</td>
</tr>
<tr>
<td>Best verbal response</td>
<td></td>
</tr>
<tr>
<td>Orientated</td>
<td>5</td>
</tr>
<tr>
<td>Confused</td>
<td>4</td>
</tr>
<tr>
<td>Inappropriate words</td>
<td>3</td>
</tr>
<tr>
<td>Incomprehensible sounds</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td>Best motor response</td>
<td>As in adult scale</td>
</tr>
<tr>
<td>Obey commands</td>
<td>5</td>
</tr>
<tr>
<td>Localises pain</td>
<td>4</td>
</tr>
<tr>
<td>Flexion to pain</td>
<td>3</td>
</tr>
<tr>
<td>Extension to pain</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>Normal milestones</th>
<th>Coma scale norms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>Cries [7]</td>
<td>Cries (0–26 weeks)</td>
</tr>
<tr>
<td>8 weeks</td>
<td>Vocalises (chiefly vowels) [6, 7]</td>
<td>Vocal sounds (26–52 weeks)</td>
</tr>
<tr>
<td>16 weeks</td>
<td>Laughs, uses consonants [7]</td>
<td></td>
</tr>
<tr>
<td>26 weeks</td>
<td>Syllables ha da ke [7]</td>
<td></td>
</tr>
<tr>
<td>48 weeks</td>
<td>One word with meaning [7]</td>
<td>Words (1–5 years)</td>
</tr>
<tr>
<td>52 weeks</td>
<td>Two or three words with meaning [3, 7]</td>
<td></td>
</tr>
<tr>
<td>18 months</td>
<td>Jargon, many intelligible words</td>
<td></td>
</tr>
<tr>
<td>24 months</td>
<td>Spontaneous 2–3 word sentences [7]</td>
<td></td>
</tr>
<tr>
<td>3 years</td>
<td>Asks questions, uses pronouns [7]</td>
<td></td>
</tr>
<tr>
<td>4 years</td>
<td>Talks fluently, often fabricates or fantasizes [6, 7]</td>
<td></td>
</tr>
<tr>
<td>5 years</td>
<td>Gives age [7], answers questions correctly, knows name [6], draws man [6]</td>
<td>Orientated (&gt; 5 years)</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Age</th>
<th>Normal milestones</th>
<th>Coma scale norms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>Spontaneous and reflex first flexion and extension [8]</td>
<td>Flexion (0–26 weeks)</td>
</tr>
<tr>
<td>12 weeks</td>
<td>Selective movement of the pricked limb [1]</td>
<td></td>
</tr>
<tr>
<td>20 weeks</td>
<td>Voluntary grasp [7]</td>
<td></td>
</tr>
<tr>
<td>26 weeks</td>
<td>Voluntary transfer [7]</td>
<td></td>
</tr>
<tr>
<td>32 weeks</td>
<td>Directs gaze at pricked limb [3]</td>
<td></td>
</tr>
<tr>
<td>48 weeks</td>
<td>Gives toy to examiner [7]</td>
<td></td>
</tr>
<tr>
<td>52 weeks</td>
<td>Localises prick exactly [1, 3]</td>
<td>Localizes pain (5 months+ 2 years)</td>
</tr>
<tr>
<td>18 months</td>
<td>Obey simple orders [7]</td>
<td>Obey orders (&gt; 2 years)</td>
</tr>
<tr>
<td>2 years</td>
<td>Points to parts of body [7]</td>
<td></td>
</tr>
</tbody>
</table>

Management

- Guidelines for the Acute Medical Management of Severe Traumatic Brain Injury of Infants, Children, and Adolescents
- Guidelines for the Management of Severe Traumatic Brain Injury (3rd edition)

https://www.braintrauma.org/coma-guidelines/
Management

- Very similar to management of adult traumatic brain injury
- Different physiologic norms
  - Hypotension = SBP < 5\textsuperscript{th} percentile by age or signs of shock
    - 70 mmHg + (2 x age in years)
  - Goal ICP < 20 mmHg
  - Goal Cerebral perfusion pressure (CPP) > 40 mmHg
    - Normal range 40 – 65 mmHg depending on age

Hypothermia

Hypothermia Therapy after Traumatic Brain Injury in Children

Hypothermia

- Multicenter, randomized, controlled trial
- Pediatric patients
- Hypothermia – 32.5 C, started within 8 hours, continued for 24 hours
- Trend toward increased mortality in hypothermia group
- Trend toward worse outcome in hypothermia group

Hypothermia

- Concerns with Hutchison, et al trial
  - Rebound ICP elevation during rewarming
    - Rapid rewarming leads to elevated ICP
  - Inclusion of GCS 3 patients
    - Previous studies suggest these patient have poor outcome despite intervention
  - Late initiation of hypothermia
    - Previous studies suggest that early initiation of hypothermia is beneficial
  - Short duration of hypothermia
    - Previous studies suggest that longer duration of hypothermia is beneficial

Adelson PD. 2009.
Hypothermia

- Cool Kids Trial
  - Multicenter, randomized, controlled trial
  - Funded by NINDS
  - Hypothermia – 32-33°C
    - Started within 6 hours, target temperature within 8 hours
    - Continued for 48 hours
    - Rewarming 1°C every 12-24 hours, stop rewarming for ICP elevations
  - Exclude GCS 3

Adelson PD. 2009.
http://www.coolkidtrial.org
Outcome of TBI

- Once thought that children would recover better than adults from TBI (plasticity)
- Mild TBI
  - No data on children < 3 years
  - Short-term cognitive deficits resolving within 6 months in older children
- Moderate – severe TBI
  - Poorer cognitive outcomes in younger children

Keenan HT and Bratton SL. 2006.
Concussion

- **Ropper and Gorson**
  - “Concussion refers to an immediate and transient loss of consciousness accompanied by a brief period of amnesia after a blow to the head.”

- **Zwienenberg-Lee and Muizelaar**
  - “Concussion is the mildest form of diffuse injury ... A classic cerebral concussion results in a transient loss of consciousness followed by a rapid return to a normal state of alertness.”

- **American Academy of Neurology**
  - “Concussion is a trauma-induced alteration in mental status that may or may not involve loss of consciousness. Confusion and amnesia are the hallmarks of concussion.”

Ropper AH and Gorson KC. 2007.
Concussion

- Increasingly reported in high school athletics

- Boys
  - Football
  - Lacrosse
  - Soccer
  - Wrestling
  - Basketball
  - Baseball

- Girls
  - Soccer
  - Lacrosse
  - Basketball
  - Softball
  - Field hockey
  - Cheerleading

Concussion

• More than just a minor head injury
  • Adults
    • Tend to improve with time
    • Cognitive and executive functioning deficits
    • Motor deficits
  • Children
    • Deficits in executive functioning
    • Deficits in verbal IQ, expressive language
    • Psychiatric effects – hyperactivity/attention deficit, conduct disorder

Concussion

- Is a CT scan necessary?
  - Neurological deficit
  - Age < 16 years
    - Age < 2 years
    - Suspected NAHI
  - Intoxication
  - No reliable post-discharge observation
  - Anticoagulation
  - Bleeding disorder

<table>
<thead>
<tr>
<th>New Orleans Criteria† — Glasgow Coma Scale score of 15</th>
</tr>
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<tbody>
<tr>
<td>Headache</td>
</tr>
<tr>
<td>Vomiting</td>
</tr>
<tr>
<td>Age &gt; 60 yr</td>
</tr>
<tr>
<td>Drug or alcohol intoxication</td>
</tr>
<tr>
<td>Persistent anterograde amnesia (deficits in short-term memory)</td>
</tr>
<tr>
<td>Evidence of traumatic soft-tissue or bone injury above clavicles</td>
</tr>
<tr>
<td>Seizure</td>
</tr>
</tbody>
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<thead>
<tr>
<th>Canadian CT Head Rule‡ — Glasgow Coma Scale score of 13–15 for patients 16 years and older</th>
</tr>
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<tbody>
<tr>
<td>High risk of neurosurgical intervention</td>
</tr>
<tr>
<td>Suspected open or depressed skull fracture</td>
</tr>
<tr>
<td>Two or more episodes of vomiting</td>
</tr>
<tr>
<td>Moderate risk of brain injury detected by CT</td>
</tr>
<tr>
<td>Retrograde amnesia for ≥ 30 min</td>
</tr>
<tr>
<td>Dangerous mechanism†</td>
</tr>
</tbody>
</table>

Greenberg MS. 2006.
Ropper AH and Gorson KC. 2007.
Second Impact Syndrome

- Injury following mild head injury may lead to massive cerebral edema and death
- Thought to be due to catecholamine release from second injury and autoregulatory failure from initial injury
- Incidence unknown
- Duration of risk after first injury unknown
- Existence of second impact syndrome is controversial
- All reports are in children

McCrory P. 2011.
Wetjen NM, Pichelmann MA, Atkinson JLD. 2010.
Non-Accidental Head Injury

- 17.0 per 100,000 person-years (age < 2 years)
  - 29.7 per 100,000 person-years (age 0 – 1 year)
  - 3.8 per 100,000 person-years (age 1 – 2 years)
- NAHI victims have lower GCS on presentation
- NAHI more likely to have SDH
- NAHI more likely to require surgical intervention
- NAHI has worse prognosis

Non-Accidental Head Injury

**The Law**
- An individual listed as a mandatory reporter shall immediately notify the Child Abuse Hotline if he or she:
  - Has reasonable cause to suspect that a child has been subjected to maltreatment or died as a result of maltreatment
  - Observes a child being subjected to conditions or circumstances that would reasonably result in maltreatment
- Any person or agency required to participate and acting in good faith in making notification, taking photographs or radiological tests, or removing a child while exercising protective services, shall be immune to suit and to liability, both civil and criminal.

**My practice**
- Admission to hospital and consultation of Team for Children at Risk for:
  - Any patient with finding of trauma on head CT (skull fracture, hematoma, etc) under the age of 2 years
  - Any other patient for whom I have suspicion of NAHI

http://www.childwelfare.gov/systemwide/laws_policies/state/
SCIWORA

• Spinal cord injury without radiographic abnormality
  • 1982
    • Myelopathy after trauma with no evidence of fracture or subluxation on plain films, CT scan, or myelography (if performed).
    • Excludes electrical injuries, birth injuries, penetrating injuries
  • 2004
    • Also excludes patients with compressive lesions (disk herniation, hematoma, etc) on MRI

SCIWORA

- 5 – 67% (35.8%) of children with traumatic myelopathy
- Most common in children up to age 8 years
- Less common in older children and teenagers
- More severe in younger children
- Tends to occur at a higher spinal level in younger children

SCIWORA

- Due to immaturity of spine
  - Elasticity of ligaments, facet capsules, intervertebral disk
  - Shallow / horizontal orientation of facets
  - Wedging of vertebral bodies
  - Absence of uncinate process
  - Presence of growth zone at endplate
  - Large head relative to weak cervical musculature

SCIWORA

- Onset of symptoms may be immediate or delayed up to days
- Evaluation
  - Clinical history and physical examination
  - Radiographs – X-rays, CT scan, MRI, +/- flexion/extension xrays
  - Somatosensory evoked potentials
- Treatment
  - Immobilization (controversial) with delayed flexion/extension xrays
- Prognosis
  - Depends on initial symptoms

Conclusions

- Etiology – falls → MVA / assault → falls
- Treatment guidelines similar between adults and children
- Ongoing trial of hypothermia for TBI in children
- Children may have worse outcome after head injury than previously thought
- Concussion is more than just a “mild” head injury
- Second impact syndrome is life threatening and unique to children
- Non-accidental head injury must be kept in mind and reported if suspected
- SCIWORA must be considered in younger children
References