

Introduction and Overview of Pediatric Traumatic Brain Injury: Current status and future directions

Richard A. Falcone, Jr, MD, MPH
Director, Trauma Services
Co-director, Comprehensive Children's Injury Center



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Pediatric Traumatic Brain Injury Numbers

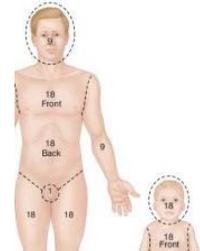
- Nationally
 - Leading cause of death and disability in children
 - >2000 deaths a year
 - > 35,000 hospitalizations
 - > 473,000 ED visits
 - @ 80-90% mild or "concussions"
- In our ED
 - Annual ED volume of ~95,000 visits
 - In 2011, approximately 1,650 children were evaluated with traumatic brain injuries






Kids are Different

- Forces are different
 - Soft pliable skull
 - Head BSA
 - Infant 20%
 - > Child 18%
 - > Adult 9%
 - Cranial –Cervical Axis
 - Elasticity of brain
 - Enlarged subarachnoid spaces
 - Patent sutures






Behavioral Risk Factors for Child Injury

- **Infants**
 - Dependent on caregiver
 - Require constant supervision
 - Unable to verbally communicate
 - Begin to turn over and grasp objects
 - Explores by mouthing objects (spends a lot of time sucking)

- **Toddlers**
 - Curious, exploratory and impulsive
 - Require close supervision
 - Increased motor abilities
 - Oral exploration puts objects in mouth
 - Imitative of adult behavior






Behavioral Risk Factors for Child Injury

- **Elementary School Age**
 - More mature motor skills
 - Increased mobility
 - Increased independence
 - Unable to assess speed and time of oncoming traffic
 - Lack of decision making experience

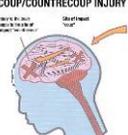
- **Young Adolescent**
 - Curious, experimental, risk taking behavior
 - Increased independence
 - Need for peer approval and influenced by peer pressure
 - Dynamic period of change and transition






Primary Injury

- Occurs at time of impact
 - Direct injury to brain parenchyma
 - Shearing injury to white matter tracts
 - Acceleration → Deceleration







Secondary Injury

- Injury that occurs after the primary event
- Systemic factors
 - Hypotension
 - Hypoxia
 - Hypercapnea
- Intracranial events
 - Inflammatory changes
 - biomolecular changes → microcirculatory disruption + neuronal disintegration
 - Pathophysiological events
 - cerebral edema, increased ICP, hyperemia, and ischemia



Glascow Coma Scale (Revised for Children and Infants)

- Best Motor Response**
- 6 Normal spontaneous movement
 - 5 Withdraws to pain
 - 4 Abnormal flexion
 - 3 Abnormal extension
 - 2 None
 - 1 None
- Best Verbal Response**
- 5 Coos and babbles
 - 4 Irritable cries
 - 3 Cries to pain
 - 2 Moans to pain
 - 1 None
- Eye Opening**
- 4 Spontaneous
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Glascow Coma Scale

- 13-15 Mild
- 9-12 Moderate
- 3-8 Severe



Definition – mTBI/Concussion

- Concussion, mTBI, CHI, minor head trauma
- Concussion is a trauma-induced alteration in mental status that may or may not involve loss of consciousness (AAN)
- Rare imaging abnormalities
- Multiple definitions
 - Ranging severity
 - LOC for seconds to minutes



Primary Prevention Case

- 14 y.o. boy presents for a pre-participation physical for high school football
- What can we do?



Primary Prevention: What can we do?

Education

- Helmet use
 - Proper fitting equipment
 - Football, Hockey, Lacrosse, etc
 - Soccer "headgear"
 - » Mixed results?
 - Bike helmet
 - Decrease hospital admissions
 - decrease serious brain injury by 85%
 - Seat belts/Car seats
- Discuss concussion definition
 - Headache, dazed confused, "Head Rung" possible loss of consciousness
 - No return to play on same day
 - Make coaches and parents aware of symptoms
 - "When in doubt sit it out"

Policy

- Playground equipment
 - no higher than 5 feet
 - Rubber, sand, wood chip surface
- Rule changes to sports
 - No "spearing" in football



Baseline Evaluation - "Objective" Assessments of Concussion

- Sport Concussion Assessment Tool (SCAT2), Standard Assessment of Concussion (SAC)
 - Symptoms score
 - physical exam (balance, coordination)
 - cognitive assessment (memory, concentration)
- Neuropsych Testing
 - Computer Based
 - CogSport
 - Headminders (CRI)
 - ANAM
 - ImPACT



Secondary Prevention

- Case
 - 14 y.o. female collides heads with an opponent while going up for a header in a soccer game
 - Brief loss of consciousness, c/o headache, dizziness, difficulty concentrating, nausea (vomited x 1), poor memory
 - No focal neuro deficits
- What should we do?



Acute Management

- On field assessment
 - Standard emergency procedures
 - C-spine injury
 - Player disposition - ?EMS
 - Stable – sideline concussion eval (SCAT, SAC)
 - Serial monitoring over initial few hours
 - No RTP on day of injury



Symptoms 3 days Post-concussion

- Headache (71%)
 - Feeling slowed down (58%)
 - Difficulty concentrating (57%)
 - Dizziness (55%)
 - "Fogginess" (53%)
 - Fatigue (50%)
 - Visual Blurring or double vision (49%)
 - Light sensitivity (47%)
 - Memory dysfunction (43%)
 - Balance problems (43%)
- Symptoms should be improving overtime
 - Various post-concussion symptom scales available
 - SCAT symptom assessment, Rivermead, Post-concussion Symptom Inventory (PCSI), Health and Behavior Inventory (HBI)



Sub-acute Management

- Cognitive rest
- Graded return to play and other activities
 - Never return to play if symptoms persist
- Most symptoms resolve 7-10 days post injury
 - At least greatly improved
 - Individual management
- Serial evaluation of post-concussion symptoms
 - Repeat SCAT, Neurocognitive testing and compare to baseline



Early Education is Helpful

- **Impact of early intervention on outcome following mild head injury**
- Intervention
 - Information booklet
- Outcome Measure
 - symptoms, cognitive performance, and psychological adjustment three months post-injury.
- Results/Conclusion
 - Those seen at one week and given the information booklet reported fewer symptoms and were significantly less stressed at three months after the injury.
 - An information booklet reduces anxiety and reporting of ongoing problems after mild TBI



Return to play

Rehab Stage	Functional Exercise	Objective
1. No activity	Complete physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming, cycling; < 70% max heart rate	Increase heart rate
3. Sport-specific	Skating drills (ice hockey); running drills (soccer)	Add movement
4. Non-contact training drills	Passing drills, skill drills	Exercise, coordination, and cognitive load
5. Full-contact practice	Normal training activities	Restore confidence and assess functional skills by staff
6. RTP	Normal game play	



Return to School

- Cognitive rest initially
 - No school, no tests
- Graded return
 - Making up double work is not productive
- Communication with teacher, principal, counselors



Post-concussion symptoms

- Participants
 - 130 Children with mild head injury were compared with 96 children having other minor injuries as controls.
- Results
 - 17% of children showed significant ongoing problems 3 months post injury
- Conclusion
 - Persisting problems more common in those with:
 - previous head injury
 - preexisting learning difficulties
 - Preexisting neurological or psychiatric problems
 - Family problems



Multiple Concussions

- Collegiate Football players (Guskiewicz et al 2003)
 - ≥ 3 concussions \rightarrow 3x more likely to have a concussion vs. no h/o concussion
 - Slower recovery – multiple concussions
 - 30% with symptoms > 1 week if multiple concussion
 - ~15% with symptoms > 1 week if 1st concussion
- Decreased memory scores on computerized neuropsych testing (~2days post-injury) in athletes with multiple concussions (≥ 3) vs. athletes with no previous concussion (Iverson et al 2004)
- Retrospective study of collegiate athletes (Covassin et al 2010)- 2 or more concussion associated with graded decrease in neurocognitive measures on ImPACT



Which on-field signs/symptoms predict protracted recovery

- 107 male high school football athletes
- Followed until returned to play
 - Rapid (≤ 7 days, $n = 62$)
 - Protracted (≥ 21 days, $n = 36$)
- Dizziness at the time of injury
 - 6.34 odds ratio (95% CI = 1.34-29.91, $P = .02$) of a protracted recovery from concussion.



Second Impact Syndrome

- Occurs after repeated concussion
- Cerebral blood flow changes 2nd dysregulation
 - Herniation, ischemia, brain death
 - More common in children
- Don't return to play on same day of injury
- Don't return to play if symptoms persistent



Chronic Traumatic Encephalopathy

- Chronic cognitive/neuropsychiatric symptoms
 - 2nd to chronic neurodegeneration
 - Diagnosis with tissue
 - Atrophy, Beta-amyloid plaques, neurofibrillary tangles
 - Single severe TBI vs. Multiple mTBI
- Emotional/Behavioral symptoms may indicate CTE
 - Depression (suicide)
 - Attention problems



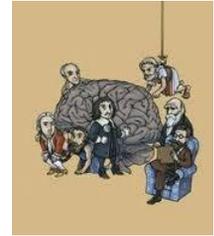
Head Injury Clinic Mission

- Improve access and timeliness of care of children with all types and severities of TBIs
- Improve patient and family satisfaction
- Improve quality of care of children with all severities of TBIs locally, regionally, and nationally
- Provide a foundation for the development of evidence-based clinical care
 - Change the outcome for children with traumatic brain injury
- Improve primary, secondary, and tertiary prevention of head injuries



CCHMC Head Injury Clinic Players

- Emergency Medicine
- Neurology
- Neuropsychology
- Neurosurgery
- Physical Medicine and Rehabilitation
- Sports Medicine
- Therapy: PT/OT/ST
- Trauma
- Behavioral Medicine
- Primary Care Physician



Head Injury Clinic Referral

Follow-Up Appointment

It is recommended that your child follow-up for their head injury, even if they are feeling better.

Please call **513-803-HEAD (4323)** within 1-2 days to make an appointment with the Cincinnati Children's Head Injury Clinic. Leave a message asking for an appointment. A nurse will call back within 1 business day.

The appointment date should be within 5-7 days after your child's initial injury.



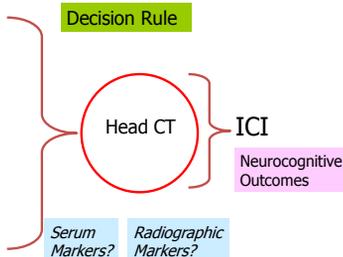
Do we need a CT head?

- Physician practice varies widely
 - 5- 50% of minor head traumas
 - Less than 4-8% of CT Scans show evidence of TBI
 - < 0.5% require neurosurgical intervention
- Multiple decision rules
 - Wide range of inclusion and exclusion criteria
 - None validated prospectively to see if practices change or if they work
 - Studies moving to consider GCS 14-15 as mild



Current Practices to Diagnose TBI

- Mechanism of Injury
- Historical Factors
 - LOC
 - Vomiting
 - Amnesia
 - Seizures
 - Headache
- Physical Exam
 - GCS
 - Neuro exam
 - Scalp hematoma
 - Skull fx



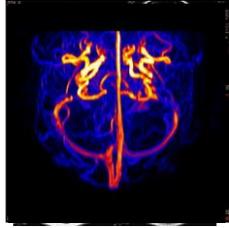
Current Practices to Diagnose TBI

- Intracranial injury (ICI) incidence
 - 3-7% for children
 - 4-48% for infants
- Head CT is the GOLD STANDARD for ICI
 - > 50% of children undergo head CT
 - CT radiation increases cancer risk

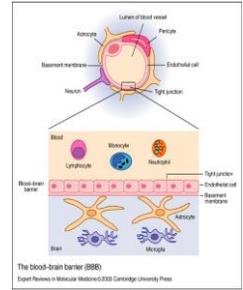
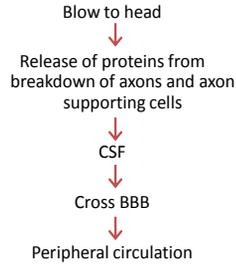


MRI

- No radiation
- May be more sensitive when routine CT scan does not correlate with symptoms
- Diffusion tensor imaging may give more accurate information about disruption of white matter tracts
- MR spectroscopy allows the chemical environment of the brain to be examined
- MR phase contrast angiography



Serum Markers of Brain Injury



Initial Management

- Number 1 goal is to minimize secondary injury!
 - Avoid hypoxia
 - Avoid hypotension
 - Rapid transfer to trauma center
- If necessary treat underlying cause of hypotension before diagnostic evaluation of brain injury



Initial Management

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- Determine the best GCS score after correction of hypotension and hypoxia
- Rapid CT imaging once stable
- Treat underlying mass lesions such as epidural or subdural blood



Intracerebral Pressure and Cerebral Perfusion Pressure

- Tiered treatment of ICP and CPP
 - Normothermic
 - HOB elevated 30°
 - Head midline, no jugular outflow obstruction
 - Adequate sedation*
 - Neuromuscular blockade
 - Adequate MAP* (age appropriate) – fluid and pressors as needed*
 - Drain CSF (when ventricular drain available)
 - 3% HTS bolus (3ml/kg) if Na <160, OSM < 360
 - 3% HTS infusion (0.1 – 1ml/kg/hr) – maintain goal Na of 145-155 mEq/L
 - Pentobarbital (load 10mg/kg over 1 hour, start infusion 1 mg/kg/hr)
 - Decompressive craniotomy
 - Hypothermia (32 - 34° C)



Rehabilitation

- Should begin early after injury
- Involves a broad range of specialist
 - Rehabilitation doctors
 - Physical and Occupational Therapists
 - Speech Therapists
 - Neuropsychologists
 - **FAMILY**



Rehabilitation

- Two key intervention areas
 - Interventions to retrain cognitive processes
 - Intervention to teach compensatory skills
- Transition to home
 - Significant stress on the family
 - One of the most important predictors of outcome may actually be the child's home environment



Rehabilitation

- Two main categories of family burden
 - Objective – child's neuropsychological and cognitive deficits
 - Subjective – level of distress experienced by family members (primarily the mother)
- One of the most important interventions include clear information about the child's injury and predicted recovery



Rehabilitation

- On-line family problem solving groups have been shown to result in less global distress among the recovering children and improved problem solving skills



Rehabilitation

- School re-entry requires careful coordination between home, school and the medical team
 - 70% of children with severe TBI will require some special education services



Rehabilitation

- Transition to adulthood
 - Driving, peer relationships and high school graduation
 - Vocational rehabilitation may be a valuable tool
 - Consider college/universities with understanding and flexibility to support the needs of TBI survivors



Opportunities

- Rapid access to high quality consistent care
- New techniques to identify those at greatest need for ongoing treatment
- Improved transition from in-patient to long term out-patient support including family support
- New approaches to minimize secondary injury

