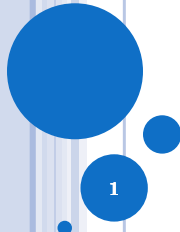




Pediatric Mild Traumatic Head Injury

Illinois Emergency Medical
Services For Children

October 2011



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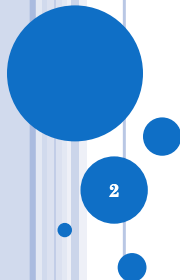


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Illinois Emergency Medical Services for Children

- Illinois EMSC is a collaborative program between the [Illinois Department of Public Health](#) and [Loyola University Health System](#), aimed at improving pediatric emergency care within our state.
- Since 1994, the [Illinois EMSC Advisory Board](#) and several committees, organizations and individuals within EMS and pediatric communities have worked to enhance and integrate:
 - Pediatric education
 - Practice standards
 - Injury prevention
 - Data initiatives
- The goal of Illinois EMSC is to ensure that appropriate emergency medical care is available for ill and injured children at every point along the continuum of care.

This educational activity is being presented without the provision of commercial support and without bias or conflict of interest from the planners and presenters.



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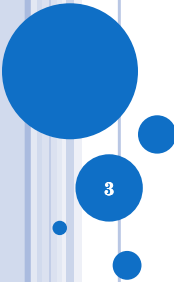
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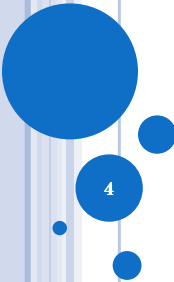


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- ◆ Additional Resources
- ◆ Citations
- ◆ For More Information
- ◆ Appendix A: Abusive Head Trauma
- ◆ Appendix B: Information for Parents/Caregivers/Coaches



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Introduction & Background

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Purpose

The purpose of this educational module is to enhance the care of pediatric patients who present with mild traumatic head injury. It will discuss a number of topics including:

- Assessment
- Management
- Disposition & Patient Education
- Complications

This module was developed by the [Illinois Emergency Medical Services for Children](#) QI Subcommittee and is intended to be utilized by all healthcare professionals serving a pediatric population.

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What Is Mild Traumatic Head Injury?

The term, *mild traumatic head injury* (MTHI) has been applied to patients with certain types of head injuries for many years. However, despite its more widespread use, there is not a standardized definition.

- ❖ MTHI is commonly referred to as concussion or mild traumatic brain injury - the terms are used interchangeably.



Common Features of MTHI

Most definitions of MTHI include the following elements:

- Involves an impact to, or forceful motion of, the head
- Results in a brief alteration of mental status such as:
 - confusion or disorientation
 - memory loss immediately before/after injury
 - brief loss of consciousness (if any) less than 20 minutes
- Glasgow Coma Scale score of 13 – 15
- If hospitalized, admission is brief (e.g., less than 48 hours)
- Possible amnesia – while amnesia does not need to be present, it is a good predictor of brain injury



MTHI vs. Traumatic Brain Injury (TBI)

- ❑ In MTHI, the brain temporarily becomes functionally impaired *without structural damage*.
- ❑ In TBI, there *is structural damage* to the brain.

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Simple and Complex Injury

Brain injury can be classified as simple or complex based on clinical presentation.

- Simple: symptoms resolve in 7-10 days
- Complex:
 - Symptoms persist longer than 10 days
 - Multiple concussions
 - Convulsions, coma or loss of consciousness (LOC) greater than 1 minute
 - Prolonged cognitive impairment

Meehan 2009

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Alarming National Statistics

- o Head injury is a leading cause of morbidity during childhood in the U.S.
- o More than 1.5 million head injuries occur in U.S. children annually, resulting in over 300,000 hospitalizations.
- o Males are twice as likely as females to sustain a head injury.
- o Up to 90% of injury-related deaths among U.S. children are associated with traumatic head injury (is the leading cause of death in traumatically injured infants).
- o Cost of head injury in children living in the U.S. is \$78 million per year (based on 2004 data).

Atabaki 2007; Brener 2004; Berger 2006



Illinois EMSC Statewide QI Project – MTHI

In 2008, over 100 Illinois-area EDs participated in a statewide QI project to improve the assessment, management, and disposition of pediatric patients who presented with MTHI.

Participants responded to a survey of general practice patterns (93% response rate), and completed 3,206 patient record reviews over a 6-month period (July – December 2008).

Illinois EMSC Statewide QI Project – MTHI (cont.)

Examples of record review findings:

- For 0-23 month old patients who received a head CT scan, 68% of the records documented the presence of at least one of the following *prior to CT*:
 - Emesis
 - LOC
 - Focal neurological findings
 - Evidence of skull fracture
 - Evidence of scalp abnormality
- Neurological reassessment was documented in 70% of all records
- Child maltreatment screening was documented in 54% of records

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After enacting quality improvement measures, participants will re-take the Survey and conduct another round of patient record reviews to determine what progress was made. A summary report of both the Survey and Patient Record Review findings are available on the [Illinois EMSC Web site](#).

Objectives

After completing this module, you will be able to:

- Describe the mechanism of mild traumatic head injury in children
- Perform an assessment of a child suspected to have suffered a mild traumatic head injury
- Develop an effective management plan
- Appropriately educate children & parents/caregivers so they can recognize, care for, and prevent mild traumatic head injuries
- Understand common complications

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Key Concepts

- ✦ Mild traumatic head injury can occur as the result of even relatively minor impact to the head.
- ✦ When evaluating a pediatric patient for mild traumatic head injury, the Pediatric Glasgow Coma Scale is an accurate, easily reproducible, and commonly used tool in assessing neurologic status.
- ✦ Computed tomography is a valuable tool in diagnosing mild traumatic head injury, but should be used judiciously.
- ✦ Under appropriate circumstances, mild traumatic head injury can often be managed by observation alone.
- ✦ The effects of recurrent head injuries are cumulative - advise children and caregivers to avoid any situation in which the child may sustain additional blows to the head.
- ✦ Allow time to resolve - a mild traumatic head injury can take days and even weeks or more for the child to return to a normal state.
- ✦ In regards to returning to a normal activity level, *When In Doubt, Sit Them Out.*



Mechanisms of Injury

Biomechanics – Primary Forces

- Impact or direct blow to the head
 - Head can be fixed
 - Head can move in a linear plane
- Inertial forces result in straining of the underlying neural elements
 - Rotational force - when the brain is the center of the rotational axis
 - Angular force - when the neck is the center of the rotational force
- Hypoxic injuries to the brain due to cessation of oxygenation (e.g., suffocation, strangulation, drowning)

Evans 2008; Meehan 2009

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Pathophysiology of Cellular Injury

- Immediate disruption of neuronal membranes results in massive efflux of potassium into extracellular space
- Concentration of potassium triggers neuronal depolarization and neuronal suppression alters blood flow
- Sodium pumps work to restore homeostasis resulting in cerebral blood flow that increases or decreases
- Mitochondrial dysfunction with impaired cerebral glucose metabolism, and, if present, can persist as long as 10 days

Evans 2008; Alexander 1995; Meehan 2009

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Pathophysiology of Cellular Injury

- Predominantly neurometabolic and reversible when force is not significant
- Changes are a multilayer neurometabolic cascade: ionic shifts, abnormal energy metabolism, diminished cerebral blood flow and impaired neurotransmission
- Small number of axons involved; axons recover
- If injury produces LOC, cortex and subcortical white matter will be primarily affected

Evans 2008; Alexander 1995; Meehan 2009



Acceleration/Deceleration

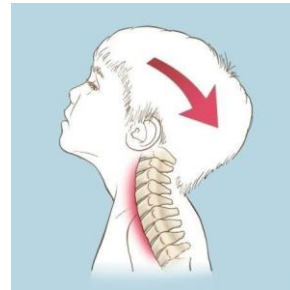
Forces causing abrupt changes in the speed or motion of the brain within the skull are called acceleration or deceleration.

- The movement of the skull through space (acceleration) and the rapid discontinuation of this action when the skull meets a stationary object (deceleration) causes the brain to move at a different rate than the skull.
- Different parts of the brain move at different speeds because of their relative lightness or heaviness.
- The differential movement of the skull and the brain when the head is struck results in direct brain injury.
- Acceleration-Deceleration injuries can be caused by linear as well as rotational impact.

[Traumatic Brain Injury.com](http://TraumaticBrainInjury.com)

Acceleration

- o Direct blow to the head
- o Skull moves away from force
- o Brain rapidly accelerates from stationary to in- motion state causing cellular damage

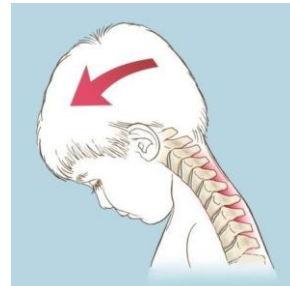


Acceleration

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Deceleration

- o Head impacts a stationary object (e.g., car windshield)
- o Moving skull stops motion almost immediately
- o However, brain, floating in cerebral spinal fluid (CSF), briefly continues moving in skull towards direction of impact, resulting in significant forces that damage cells



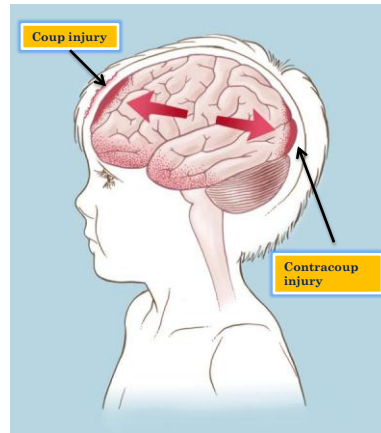
Deceleration

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Coup/Contracoup

Injury resulting from rapid, violent movement of brain is called **coup** and **contracoup**. This action is also referred to as a cerebral contusion.

- **Coup:** an injury occurring directly beneath the skull at the area of impact
- **Contracoup:** injury occurs on the opposite side of the area that was impacted



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Focal/Diffuse Injuries

Brain injuries can be classified as either focal or diffuse

When an injury occurs at a specific location, it is called a *focal* injury (e.g., being struck on the head with a bat). A focal neurologic deficit is a problem in a nerve function that affects a specific location or function. Examples:

- Numbness, decrease in sensation
- Paralysis, weakness, loss of muscle control/tone

In *diffuse* injury, the impact is spread over a wide area, such as being tackled in a game of football that results in a general loss of consciousness.

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Level of Severity: High Risk

Certain conditions present a high risk for serious injury:

- o Motor vehicle collision, particularly with ejection or rollover
- o Pedestrian or unhelmeted bicyclist struck by motorized vehicle
- o Fall from greater than 5 feet/1.5 meters
- o Impact with or struck by an object
- o Contact sports
- o Child maltreatment

[Link to History \(slide 48\)](#)

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Short Vertical Falls: Incidence

Frequently, parents/caregivers bring their young children to the ED for an evaluation with a history of a short vertical fall (defined as 1.5 meters/5 feet in height).

An extensive review of the literature showed that short falls account for **less than 0.48 deaths per 1 million** young children (0-5 years of age) per year.

Remember: Suspect and evaluate for child maltreatment if a short vertical fall history does not match the severity of the injuries.

Chadwick 2008

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Children vs. Adults

Children have greater disposition to head trauma:

- Greater head mass relative to body weight ratio making them top-heavy
 - Neck musculature has not been developed to handle relatively heavier structure
 - Increased head weight results in increased momentum during falls or injuries
- Brain area has more fluid: more susceptible to wave-like forces
- Less myelination
- Thinner cranial bones more easily shattered

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Fuchs 2001

Infants & Toddlers



- Limited head control
- Open fontanels mean less brain protection
- More susceptible to seizures than older children
- Emerging motor and expressive language skills at risk for regression
- Synaptic connections become interrupted resulting in decreased functional processing
- Focal injuries may have better outcome

Common mechanisms include: falls, child maltreatment, and motor vehicle collisions.

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Sellars 1997; National Research Council 2000; Savage 1994

Elementary & Middle School Students



- Functional and developmental risk
- Connections between the two hemispheres of the brain and within each hemisphere may become less efficient
- Brain injury during this time period may interrupt development of critical cognitive and communication skills

Common mechanisms include: falls, sports, child maltreatment, bicycle injuries, motor vehicle collisions, and pedestrian-motor vehicle collisions.

Sellars 1997; National Research Council 2000; Savage 1994

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High School Students



- Functional and developmental risk
- Damage to cellular myelination of the frontal lobes may reduce creation of efficient connections that facilitate development of logical thinking and ability to solve complex problems
- Psychosocial effects of brain injury such as slower response to stimuli threaten adolescent's sense of self

Common causes include: motor vehicle collisions (due to lack of driving experience) and sports injuries (due to increased participation). A marked increase in alcohol and/or substance abuse, predisposition to greater risk-taking behaviors, and greater exposure to violence can lead to more injuries. ***In all age groups, child maltreatment is a potential cause.***

Sellars 1997; National Research Council 2000; Savage 1994

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Test Your Knowledge

1. Which of the following symptoms is an example of a focal neurological deficit?
- A. Loss of consciousness
 - B. Amnesia
 - C. Numbness
 - D. Polydypsia

See slide 95 for the correct response.

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Test Your Knowledge

2. Which of the following is a common mechanism of injury for all developmental levels?
- A. Motor vehicle collisions
 - B. Bicycle riding
 - C. Risk-taking behaviors
 - D. Contact sports

See slide 95 for the correct response.

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Child Maltreatment & Mandated Reporting

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Child Maltreatment

Definition: Mistreatment of a child under the age of 18 by a parent, caretaker, someone living in their home or someone who works with or around children.

- Must lead to injury or put the child at risk of physical injury
- Can be physical (e.g., burns or broken bones), sexual (e.g., fondling or incest) or emotional
- Neglect: When a parent/caregiver fails to provide adequate supervision, food, clothing, shelter or other basics for a child
- ❖ Healthcare providers should always be aware of the signs & symptoms of child maltreatment and cautiously consider it in their assessment of the child
- ❖ Be on the alert to identify children with symptoms of [abusive head trauma](#) (detailed in [Appendix A](#))

Remember: Younger children are very resilient to mild head trauma. It usually takes a significant event to cause serious injury.

↓ [EMSC – Indicators of Potential Pediatric Maltreatment](#) (33 KB)

Illinois Department of Children & Family Services 2009

Mandated Reporting

Reporting suspected abuse is **mandated** by Federal law for personnel in specific professions working with children (e.g., medical, school/child care, law enforcement, clergy, social work, state agency staff dealing with children, etc.). Mandated reporters must make reports if they have reasonable cause to suspect abuse or neglect (even if you are transferring the child).

- Hospitals must report suspected abuse even if transferring patient to another institution.
- Each state is responsible for providing its own definition of maltreatment within civil and criminal contexts (if outside of Illinois, check your state's definition).
- Members of the general public can report, but are not mandated.

In Illinois, the child abuse hotline number is 1-800-25ABUSE

Illinois Department of Children and Family Services 2009

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Mandated Reporting (cont.)

As a healthcare professional, call the hotline ***whenever you suspect*** a person who is caring for the child, who lives with the child, or who works with or around children has caused injury or harm or put the child at risk of physical injury.

Some examples include:

- If a child tells you that he/she has been harmed by someone.
- If you see marks that do not appear to be from developmentally appropriate behavior (e.g., babies with bruises).
- If a child who sustains a serious injury where the history does not fit the sustained injury (esp. a nonambulatory child).
- If a child has not received necessary medical care.
- If a child appears to be undernourished, is dressed inappropriately for the weather, or is young and has been left alone.

Illinois DCFS provides free online training for Mandated Reporters:

**[Recognizing and Reporting Child Abuse:
Training for Mandated Reporters](#)**

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Child Maltreatment Hotlines

For Illinois and its surrounding states, here are reporting hotlines and Web links to the state departments that oversee children's services.

STATE	HOTLINE	WEB SITE
Illinois	1-800-25-ABUSE	Department of Children & Family Services
Indiana	1-800-800-5556	Department of Child Services
Iowa	1-800-362-2178	Department of Human Services
Kentucky	1-877-597-2331	Cabinet for Health and Family Services
Missouri	1-800-392-3738	Department of Social Services
Wisconsin	1-414-220-SAFE (Milwaukee)	Department of Children & Families

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Test Your Knowledge

1. In which of the following situations are mandated reporters legally bound to report?
 - A. History of a one-week-old infant presenting with a femur fracture rolling off a couch on to a carpeted floor.
 - B. During an exam to rule out gastroenteritis, a six-year-old girl reports that her mom's boyfriend hits her when mom is not home.
 - C. History of two-month-old boy presenting for unexplained crying who is noted to have had no weight gain since birth.
 - D. All of the above.

See slide 95 for the correct response.

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Signs & Symptoms

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Physical

- o Headache
- o Nausea/vomiting
- o Problems with balance/walking/crawling
- o Dizziness
- o Visual problems
- o Fatigue or lethargy
- o Sensitivity to light or noise
- o Numbness or tingling
- o Feeling dazed or stunned
- o Any deviation from normal/baseline as per parent/caregiver

[CDC Heads Up: Facts for Physicians](#)



Cognitive

- o Feeling mentally 'foggy'
- o Feeling slowed down
- o Difficulty concentrating
- o Difficulty remembering
- o Forgetful of recent information or conversations
- o Confused about recent events
- o Answers questions slowly
- o Repeats questions
- o Any deviation from normal/baseline as per parent/caregiver

[CDC Heads Up: Facts for Physicians](#)

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Emotional

- o Irritability
- o Sadness
- o Increased demonstration of emotions
- o Nervousness
- o Loss of impulse control
- o Difficult to console
- o Shows lack of interest in favorite toys/activities
- o Any deviation from normal/baseline as per parent/caregiver

[CDC Heads Up: Facts for Physicians](#)

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Sleep

- o Drowsiness
- o Sleeping less than usual
- o Sleeping more than usual
- o Trouble falling asleep
- o Any deviation from normal/baseline as per parent/caregiver

[CDC Heads Up: Facts for Physicians](#)



Conditions With Similar Symptoms

Not every child experiencing these symptoms has a MTHI. A careful history and assessment is necessary to confirm the diagnosis. Similar symptoms can also result from:

- Dehydration
- Heat related
- Overexertion
- Lack of sleep
- Eating disorders
- Reaction to medications
- Learning disabilities
- Depression

Meehan 2009

Test Your Knowledge

1. Which of the following signs and symptoms should alert you to a possible MTHI?
 - A. History of nausea and vomiting
 - B. Having trouble remembering recent events
 - C. Increased irritability
 - D. All of the above

See slide 95 for the correct response.

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Test Your Knowledge

2. True or False:
Similar signs and symptoms of MTHI can also be attributed to a patient with an eating disorder.

See slide 96 for the correct response.

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Assessment

(with a Pediatric GCS Primer)

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History

A detailed history is critical in assessing MTHI. Consider:

- o Age of child; developmental history/ability
- o Medical history:
 - ✓ Medications (prescription, OTC, herbal, etc.)
 - ✓ Past illnesses
 - ✓ Past hospitalizations
 - ✓ Previous head injuries
- o History related to event:
 - ✓ Time of injury
 - ✓ Emesis
 - ✓ Loss of consciousness / Amnesia
- o [Severity and mechanism of injury](#)
- o Was injury witnessed by a reliable person?

Fuchs 2001



Primary Assessment

- Begin your immediate assessment by following the ABCs:
 - ✓ Airway
 - ✓ Breathing
 - ✓ Circulation
- Always consider the possibility of cervical spinal injury.
- Determine the child's orientation to people, place, and time.
- Perform a test of recent memory - does the child remember events just before injury?

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Cervical Spinal Injuries

With any head injury, be alert for cervical spine injuries.

- Most common cause is impact to the top of the head when the neck is held in flexion
- Occurs most frequently during contact sports and in motor vehicle or bicycle collisions

Atabaki 2007

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Loss Of Consciousness (LOC)

- LOC is not a reliable predictor of concussion or length of recovery.
- LOC is not as definitive a predictor of severity as the Pediatric Glasgow Coma Scale.
- Cognitive symptoms such as confusion and disturbance of memory *can* occur without LOC.
- However, when the patient *does* experience LOC, confusion and memory disturbance *always* occur.

Gray 2009; Meehan 2009

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Amnesia

Post traumatic amnesia (PTA) is more accurate than loss of consciousness in predicting functional recovery. Patients suffering from MTHI may have amnesia of events occurring immediately after injury.

Classification of the severity of amnesia is measured by length of time it occurs:

- | | |
|----------------|-----------------------|
| ○ Very mild: | Less than 5 minutes |
| ○ Mild: | Less than 1 hour |
| ○ Moderate: | 1-24 hours |
| ○ Severe: | Greater than 24 hours |
| ○ Very severe: | Greater than 1 week |

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AVPU

AVPU is a quick test used to determine level of consciousness. It measures the reaction of the eyes, voice and motor activity in response to stimuli. In the scale, *Alert* represents the level of least injury and *Unresponsive* the most severe.

Alert: fully conscious; may be *mildly* disoriented

Voice: responds to verbal stimuli

Pain: responds only to pain stimulus

Unresponsive: unconscious

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AVPU is *not* a replacement for the Glasgow Coma Scale.

McNarry 2005



Glasgow Coma Scale (GCS)

An accurate, commonly used, and easily reproducible tool

- Commonly used neurologic assessment tool for trauma patients since its development by *Jennett and Teasdale* in the early 1970s
- Is an accurate measure for trauma care practitioners to document level of consciousness over time
- Commonly used in adults - more recently used in children (Pediatric GCS score)

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Sternbach 2000



The *Pediatric* GCS (PGCS)

- o Developed as an alternative to the original GCS
- o Resulted because there are physiologic differences between adults and children
- o Most adult field triage tools are not applicable to pediatric trauma victims
- o The verbal response component of the Pediatric GCS better addresses the developmental capabilities in the young child than the adult GCS
- o Most applicable to children five years old and younger

Reilly 1988; Holmes 2005



Pediatric GCS: Application

Pediatric GCS (PGCS) is most effective when measured serially over time. Frequent assessment will indicate the progression of illness, helping to determine severity of injury. Actual time between measurements depends on institutional practices and the individual patient.

The PGCS score can be classified as:

Minor: 13-15
Moderate: 9-12
Severe: 3-8

The lower the score, the more severe the injury.

MTHI is typically with a PGCS score of 13 – 15.

Pediatric GCS: Components

The Pediatric Glasgow Coma Scale looks at three components:

- o **Eye Opening**
- o **Motor Response**
- o **Verbal Response**

Add the scores of all three components together to determine the total PGCS score for that interval.

The following slides expand upon each component.

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Eye Opening

Greater Than 1 Year Old	Less than 1 Year Old	Score
Spontaneously	Spontaneously	4
To Verbal Command	To Shout	3
To Pain	To Pain	2
No Response	No Response	1

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Motor Response

Greater Than 1 Year Old	Less than 1 Year Old	Score
Obeys Commands	Spontaneous Movement	6
Localizes Pain	Localizes Pain	5
Flexion-withdrawal	Flexion-withdrawal	4
Flexion-abnormal (decorticate rigidity)	Flexion-abnormal (decorticate rigidity)	3
Extension (decerebrate rigidity)	Extension (decerebrate rigidity)	2
No Response	No Response	1

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Verbal Response

Older Than 5 Years Old	2 to 5 Years Old	0 – 23 Months	Score
Oriented	Appropriate words / Phrases	Smiles/coos appropriately	5
Disoriented / Confused	Inappropriate Words	Cries and is consolable	4
Inappropriate Words	Persistent cries and screams	Persistent inappropriate crying and/or screaming	3
Incomprehensible Sounds	Grunts	Grunts, agitated, and restless	2
No Response	No Response	No Response	1

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Sample PGCS Form  (13 Kb)

Pediatric GCS Score Scenario 1

Brief Presenting History

A 3-month-old female is brought to the emergency department by her father with a history of “not acting right” since falling out of her crib two days ago. You note multiple bruises are on the child’s face and rapidly complete the assessment and treatment in the trauma room.

Eyes: The child’s eyes remain closed during painful stimuli.
Motor: The child withdraws both arms during IV access.
Verbal: The child is grunting.

What PGCS score you would assign for each component for this patient?

See slide 97 to see how we scored the patient.

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Pediatric GCS Score Scenario 2

Brief Presenting History

A 6-year-old male is brought into the emergency department fully immobilized by paramedics who report that he was a restrained front seat passenger. There was intrusion into the driver’s side of the car only. His left forearm is swollen.

Eyes: The child opens eyes to his name being called.
Motor: The child withdraws his right arm when his blood pressure is taken.
Verbal: The child cries when his swollen forearm is touched.

What PGCS score would you assign for each component for this patient?

See slide 97 to see how we scored the patient.

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Pediatric GCS Score Scenario 3

Brief Presenting History

A 3-year-old female is brought to the emergency department by her mother who claims that her child is lethargic after being pushed down by her 5-year-old brother (fighting over a toy). The mother states the red mark on her daughter's forehead is where she landed head first on the tile floor.

Eyes: The child is sitting on her mother's lap curiously looking at you.
Motor: The child accidentally drops her favorite toy so she quickly jumps off her mother's lap crawls under the chair and grabs her toy.
Verbal: The child states "Mine" clutching her favorite toy. She says, "I am this many" as she proudly tries to hold up three fingers.

What PGCS score you would assign for each component for this patient?

See slide 97 to see how we scored the patient.

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Putting It All Together

- ⊕ Take a detailed and complete history
- ⊕ Consider the possibility of structural injuries such as cervical spine damage
- ⊕ The *pediatric* specific GCS is more appropriate and accurate than the *adult* GCS in children
- ⊕ The PGCS is commonly used to assess the severity of MTHI
- ⊕ The PGCS measures three aspects of the patient: eye opening, verbal response, motor response
- ⊕ More useful results are obtained when the PGCS is measured serially over time
- ⊕ MTHI is typically associated with a PGCS score of 13 – 15
- ⊕ The PGCS is especially valuable when testing children aged five years and younger
- ⊕ AVPU can be useful in determining LOC, but is not a substitute for the PGCS score

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Imaging

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Types of Imaging Studies

Many children presenting with a possible MTHI may not require an imaging study. However, if a physician determines the need, the most commonly ordered studies are:

- o Computed Tomography Imaging (CT) - preferred diagnostic tool that comes with benefits and risks; main risk factor - concern for radiation overexposure
- o X-Ray - useful to detect skull fracture, but not recommended in most cases
- o Magnetic Resonance Imaging (MRI) - useful to detect skull fracture, but not recommended in most cases

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CT: Benefits & Risks

There is no consensus regarding the use of CT to diagnose brain injuries

Benefits:

- Can help determine the difference between MTHI and the more serious condition of traumatic brain injury
- Offers definitive results in determining structural damage

Risks:

- Exposes child to ionizing radiation (1 head CT scan can potentially equal over 200 chest x-rays)
- Transporting child to CT suite may take child away from ED skilled supervision and resources
- Pharmacologic sedation is often required in younger children (may increase overall health risk; requires additional monitoring)
- Prolongs time child spends in ED
- Incurs greater cost

[Link to MRI \(slide 73\)](#)

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Increased Use of CT

- The use of CT to evaluate children with head injuries has increased substantially over the past decade, almost doubling during that time and thus increasing the risks associated with radiation.
- 500,000 ED visits each year for children with head injury has resulted in an estimated annual usage of 250,000 CTs used to diagnose potential head injury.

Brenner 2001; NCIPC 2003

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Recommendations of *Image Gently* Campaign

The *Alliance for Radiation Safety in Pediatric Imaging* began a public health campaign in 2006 called *Image Gently*. Its goal is to change CT practice by raising awareness of the opportunities to lower radiation dose in the imaging of children.

Examples of recommended techniques:

- Scan only the area required. Scanning beyond the body regions where there is clinical concern results in needless exposure.
- Reduce tube output (kVp and mAS). Exposure parameters should be reduced for the smaller patient size.
- Perform single phase studies. Most pediatric conditions are readily diagnosable with single phase CT; more phases unnecessarily increases radiation dose without adding substantial data to diagnoses.

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Use of CT: Need for Guidelines

There is considerable debate regarding the value of a head CT to determine MTHI. Internal discussion needs to take place in order to set hospital policy and ensure consistency when CTs are ordered.

Common issues for institutional discussion:

- Are there any institutional guidelines suggesting general criteria for ordering pediatric head CT image in certain situations?
- Do the benefits of ordering a head CT outweigh the potential risks from radiation?
- Do you discuss risks and benefits with parents/caregivers?

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PECARN Study: Future CT Guidelines

In 2009, The Pediatric Emergency Care Applied Research Network (PECARN) completed a large national prospective study of children with TBI to guide when it is appropriate to use head CT in diagnosing.

- ❖ Goal: Draw from the evidence a prediction rule to identify children at very low risk for a clinically-important traumatic head injury, hopefully reducing the number of unnecessary CT scans for this population. Findings were published in *The Lancet* (online Sept. 15, 2009).

[PECARN](#)



X-Rays

- X-rays can detect a skull fracture that may be missed by a CT.
- X-rays *will not* reveal metabolic or soft tissue injuries that may be present in MTHI.
- If imaging is indicated, **CT scanning is most often the imaging of choice to detect brain trauma.**
- The mechanism and history of the injury, and the PGCS score are better indicators of significant head injury in children than x-rays.

Reed 2005

Magnetic Resonance Imaging (MRI)

- MRI is currently not as commonly used to image MTHI as CT. However, it is an evolving technology that may become increasingly utilized in the future.
- MRI may help determine some types of neurological damage when performed several days post injury.
- Since performing an MRI may require the sedation of the child, extra caution needs to be observed.
- MRI is a more costly procedure, and may not be as readily available as CT.
- Risks and benefits of MRI mimic those of [CT](#).

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Test Your Knowledge

1. If imaging is required to detect MTHI, what is the preferred method?
 - A. X-ray
 - B. MRI
 - C. CT scan
 - D. PET scan

See slide 96 for the correct response.

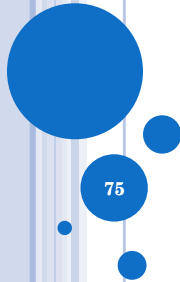
74

Test Your Knowledge

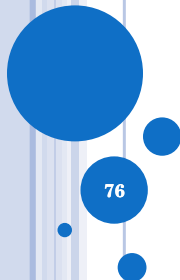
2. True or False:

There is very little one can do to limit a child's exposure to ionizing radiation from a CT scan.

See slide 96 for the correct response.



Management



Emergency Department Management

Children may be managed in the ED through:

- o Neurologic assessment - serially perform neurological assessment with using PGCS during ED admission:

Children who appear neurologically normal (e.g., PGCS score =15) are at lower risk for subsequent deterioration

- o Observation
- o Pain management
- o Imaging studies (if needed)

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Observation At Home

Parents/caregivers require careful discharge instructions if they are to observe the child outside of a medical facility. Some factors to consider include:

- o Healthcare professional must make a careful assessment of the parent/caregiver's anticipated compliance with the instructions
- o Must be without suspicion of maltreatment/neglect
- o Must have ability to seek medical attention if condition worsens (access to telephone, transportation, etc.)
- o Should be capable to assess and manage the child's pain
- o If parent/caregiver is not competent, or unavailable, or suspected of being intoxicated or otherwise incapacitated, other provisions must be made to ensure adequate observation of the child (including hospital admission)

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Fuchs 2001



Discharge Planning

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Discharge Planning

Discharge instructions & parent/caregiver education should include:

- Warning signs & symptoms of [Post Concussive Syndrome](#)
- Signs & symptoms that prompt a return visit to the ED for immediate care
- Emergency phone number to call
- Expected course of recovery
- Pain management measures

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Discharge Planning (cont.)

- Referral to primary care provider for follow up care
- Guidelines regarding when to return to activity
- Safety information (proper helmet use, seatbelt use, etc.)
- Links to additional traumatic head injury resources

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✚ [EMSC - Patient Education Resources](#)

Return To Play Guidelines

- Simple – an injury that progressively resolves without complication for 7-10 days. Management based on a step-wise approach until all symptoms resolve.
- Complex – persistent symptoms, specific sequelae (e.g., prolonged LOC), or prolonged cognitive impairment. Consider formal neuropsychological testing beyond return to play guidelines.

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✚ [EMSC - Return To Play Guidelines Brochure](#)

McCrory 2005

Return To Play: A Step Wise Approach

Athletes should not be returned to play the same day of injury.

Recommended stages of progression:

- Step #1. Rest until asymptomatic (physical and mental rest)
- Step #2. Light aerobic exercise
- Step #3. Sport-specific exercise
- Step #4. Non-contact training drills (start light resistance training)
- Step #5. Full contact training **ONLY AFTER MEDICAL CLEARANCE**
- Step #6. Return to competition (game play)

There should be approximately 24 hours (or longer) for each stage and the athlete should return to previous step if symptoms reoccur.

McCrory 2005

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Discharge: Time For Advocacy

The discharge process is a valuable time to provide information to the parent/caregiver regarding how to prevent future head injuries. Suggested topics may include, but are not limited to:

- o Potentially harmful situations that may result in head injury (such as unsupervised sports, playing without necessary protective sports equipment, eliminating areas within home that could result in falls, etc.).
- o How to recognize MTHI in children and the appropriate steps to take if an injury is suspected.
- o Be alert for signs of child maltreatment.
- o Use and proper fit of bicycle helmets.
- o Importance of wearing seatbelts at all times within a moving vehicle.
- o Appropriate use and fit of car seats.

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Advocacy in Action: The CDC Heads Up Tool Kit

The CDC, working in partnership with noted professional medical, sport, and educational organizations, has created a tool kit called *Heads Up* that is designed to help coaches prevent, recognize, and manage concussion in sports. It contains:

- A concussion guide for coaches;
- A coach's wallet card on concussion for quick reference;
- A coach's clipboard sticker with concussion facts and space for emergency contacts;
- A fact sheet for athletes in English and Spanish;
- A fact sheet for parents in English and Spanish;
- An educational video/DVD for you to show athletes, parents, and other school staff;
- Posters to hang in the gym or locker room; and
- A CD-ROM with additional resources and references.

Coaches can use tool kit materials to educate themselves, athletes, parents, and school officials about sports-related concussion and work with school officials to develop an action plan for dealing with concussion when it occurs. The *Heads Up* tool kit can also be ordered or downloaded free-of-charge at: <http://www.cdc.gov/concussion/HeadsUp/youth.html>.



[Heads Up Online Training Course](#) (free)

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Test Your Knowledge

1. Which of the following elements should not be included in your MTHI discharge instructions?
 - A. Expected course of recovery
 - B. Permission for the child to return to sports the next school day
 - C. Warning signs & symptoms of Post Concussion Syndrome
 - D. Injury prevention & safety information

See slide 96 for the correct response.

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Potential Complications

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Post Concussive Syndrome

One potential complication of MTHI is *Post Concussive Syndrome*. Clinical indications include:

- o Dizziness, trouble concentrating
- o Changes in sleep pattern
- o Any deviation from normal behavior in the days or even weeks following the injury.

Over time, the symptoms *may* eventually lessen. However, parents/caregivers must report any new, continuing, or worsening symptoms to their physician immediately.

It is critical that parents / caregivers are made aware of this complication at time of discharge.

[Link to Discharge Planning \(slide 80\)](#)

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Second Impact Syndrome

The effects of multiple injuries to the head are cumulative and potentially more damaging than a single incident. A second blow is more damaging than the “sum” of the two blows.

Second Impact Syndrome should be suspected in all children involved in high-risk situations (i.e., contact sports) and with a history of previous head injuries.

Patients experiencing Second Impact Syndrome are:

- o More likely to experience post-traumatic amnesia
- o More likely to experience mental status disturbance after each new injury
- o Often score lower on memory tests

Second Impact Syndrome can result in fatal brain swelling.



ESPN video (11:56)

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Conclusion: *The Bottom Line*

- ⊕ MTHI can occur as the result of even relatively minor injuries and should always be suspected during evaluation for head trauma.
- ⊕ When evaluating a pediatric patient for MTHI, the Pediatric Glasgow Coma Scale is an accurate, easily reproducible, and commonly used tool in assessing neurologic status.
- ⊕ CT is a valuable tool in diagnosing MTHI, but should be used judiciously.
- ⊕ MTHI can often be managed by observation alone under appropriate circumstances.
- ⊕ The effects of recurrent head injuries are cumulative - advise the patient to avoid any situation where they may sustain additional blows to the head.
- ⊕ Allow time to resolve - MTHI can take days and even weeks or more to resolve.
- ⊕ In regard to returning to a normal activity level, *When In Doubt, Sit Them Out.*

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Additional Resources

The protocols surrounding the diagnosis, treatment, and prevention of concussions are continually evolving. Keep up-to-date by routinely visiting authoritative resources such as:

- ❖ American Academy of Family Physicians www.aafp.org
- ❖ American Academy of Pediatrics www.aap.org
- ❖ The Brain Injury Association of America www.biausa.org
- ❖ The Brain Injury Recovery Network www.tbirecovery.org/
- ❖ Brain Trauma Foundation www.braintrauma.org
- ❖ The Centers for Disease Control: *CDC Heads Up* www.cdc.gov
- ❖ Center For Neuro Skills www.neuroskills.com
- ❖ The Children's Hospital of Pittsburgh www.chp.edu/CHP/besafe
- ❖ National Center for Injury Prevention and Control
<http://www.cdc.gov/traumaticbraininjury/>
- ❖ National Database of Educational Resources on Traumatic Brain Injury
www.tbicommunity.org/html/tbiresources/b_advancequeryItem.asp

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Answers to Self-Test Questions 1-4

1. Which of the following symptoms is an example of a focal neurological deficit?
 - **C. Numbness** is evidence of a focal rather than a diffuse injury.
2. Which of the following is a common mechanism of injury for all developmental levels?
 - **A. Motor vehicle collisions** are a common mechanism of injury for children of all ages.
3. In which of the following situations are mandated reporters legally bound to report?
 - **D. All of the above** situations must be reported as instances of potential maltreatment or neglect.
4. Which of the following signs and symptoms should alert you to a possible MTHI?
 - **D. All of the above** are signs and symptoms of a possible MTHI.

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Answers to Self-Test Questions 5-8

5. True or False: Similar signs and symptoms of MTHI can also be attributed to a patient with an eating disorder.
 - **True.** An eating disorder is among several diagnoses with similar signs and symptoms to MTHI. A careful history and assessment is necessary to confirm the diagnosis.
6. If imaging is required to detect MTHI, what is the preferred method?
 - **C. CT scan** imaging can help determine the difference between MTHI and the more serious condition of traumatic brain injury, and also offers definitive results in determining structural damage.
7. True or False: There is very little one can do to limit a child's exposure to ionizing radiation from a CT scan.
 - **False.** Strategies to reduce radiation exposure include scanning only the area required, reducing tube output (kVp and mAS), and performing single phase studies.
8. Which of the following elements should not be included in your MTHI discharge instructions?
 - **D. Permission for the child to return to sports the next school day** is not appropriate as a standard discharge instruction. Children need both physical and mental rest to recover. Medical clearance is required prior to returning to sports.

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Answers to Scenario Questions

Scenario 1

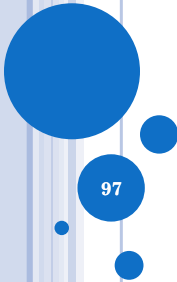
- Eyes: 1
- Motor: 4
- Verbal: 2
- Total: 7

Scenario 2

- Eyes: 3
- Motor: 4
- Verbal: 3
- Total: 10

Scenario 3

- Eyes: 4
- Motor: 6
- Verbal: 5
- Total: 15



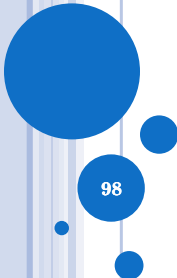
For More Information

For other EMSC educational modules and information:

Illinois EMSC website: <http://www.luhs.org/emsc>

Federal EMSC Program: <http://bolivia.hrsa.gov/emsc/>

Illinois EMSC is a collaborative program between the Illinois Department of Public Health and Loyola University Medical Center



Appendix A: Abusive Head Trauma

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[Link to Child Maltreatment \(slide 34\)](#)

Abusive Head Trauma

Abusive Head Trauma results from the violent shaking (Shaken Baby Syndrome) or intentional blow to the head of an infant or small child. An impact mechanism can occur, but is not necessary to cause irreversible brain injury.

What Happens:

- Brain rotates within the skull cavity resulting in shearing injuries to the brain and blood vessels injuring or destroying brain tissue
- Subarachnoid bleeding (*bleeding in the area between the brain and the thin tissues that cover the brain*) and subdural hemorrhages (*a collection of blood on the surface of the brain*) occur. Subdural hematomas are markers for shearing injury.
- Cerebral edema peaks at 72 hours after injury
- All children are immediately symptomatic
- Associated findings may include:
 - Retinal hemorrhages that involve multiple layers of the retina and extend out to the periphery of the retina either in one or both eyes
 - Skeletal injuries such as rib fractures and metaphysial injuries to the long bones

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[National Center on Shaken Baby Syndrome 2009](#)

Abusive Head Trauma (cont.)

Symptoms of Abusive Head Trauma:

- Lethargy / decreased muscle tone / extreme irritability
- Decreased appetite, poor feeding or vomiting for no apparent reason
- No smiling or vocalization / poor sucking or swallowing
- Rigidity or posturing / difficulty breathing
- Seizures / inability to lift head
- Head or forehead appears larger than usual or fontanel appears to be bulging
- Inability of eyes to focus or track movement or unequal size of pupils

NOTE: External findings are rarely found

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Abusive Head Trauma (cont.)

Work Up:

To make this diagnosis, you must have a strong suspicion of Abusive Head Trauma. Brain injury *is* a necessary finding - eye and skeletal findings *are not* necessary for the diagnosis.

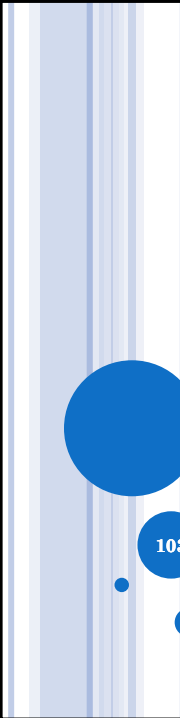
Plan for immediate transfer if your ED is not equipped to complete the work up. If equipped:

- Perform a skeletal survey
- Have an eye exam done by a qualified ophthalmologist aware of the signs/symptoms of Abusive Head Trauma

Note: All children are immediately symptomatic at the time of brain injury. There is *no* lucid period in children that are violently shaken.

J. C. Glick (personal communication, March 19, 2009)

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Appendix B: Information for Parents / Caregivers / Coaches

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Signs of MTHI

Consult a healthcare professional if your child experiences:

- o Headache or “pressure” in head
- o Nausea or vomiting
- o Balance problems or dizziness
- o Double or blurry vision
- o Sensitivity to light
- o Sensitivity to noise
- o Feeling sluggish, hazy, foggy, or groggy
- o Concentration or memory problems
- o Confusion
- o Does not “feel right”

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[CDC Heads-Up](#)



What To Do If MTHI Is Suspected

- o **Seek medical attention right away.** A healthcare professional will decide how serious the injury is and when it is safe to return to normal activities.
- o **If playing a sport, keep the child out of play.** Mild traumatic head injuries take time to heal. Children who return to play too soon risk a greater chance of having a second injury. Second or later injuries can be very serious. They can cause permanent brain damage, affecting your child for a lifetime.

When in doubt, sit them out!



Sports Injuries

Many head injuries often occur during sports activities. This is a time to be particularly vigilant.

- o Football is the most common cause of sports injuries in children. 74% of football related injuries are associated with MTHI.
- o Most children who experience the symptoms of head injury do not seek help: ***Most do not even tell their coach!***
- o Many coaches are not trained to recognize the symptoms of serious head injury.

Atabaki 2007

Resources for Coaches: The CDC Heads Up Tool Kit

The CDC, working in partnership with noted professional medical, sport, and educational organizations, has created a tool kit called *Heads Up* that is designed to help coaches prevent, recognize, and manage concussion in sports. It contains:

- A concussion guide for coaches;
- A coach's wallet card on concussion for quick reference;
- A coach's clipboard sticker with concussion facts and space for emergency contacts;
- A fact sheet for athletes in English and Spanish;
- A fact sheet for parents in English and Spanish;
- An educational video/DVD for you to show athletes, parents, and other school staff;
- Posters to hang in the gym or locker room; and
- A CD-ROM with additional resources and references.

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Coaches can use tool kit materials to educate themselves, athletes, parents, and school officials about sports-related concussion and work with school officials to develop an action plan for dealing with concussion when it occurs. The *Heads Up* tool kit can also be ordered or downloaded free-of-charge at: <http://www.cdc.gov/concussion/HeadsUp/youth.html>.



[Heads Up Online Training Course](#) (free)

For Coaches: Signs of MTHI

Suspect MTHI if the student:

- Appears dazed or stunned
- Is confused about assignment or position
- Forgets sports plays
- Is unsure of game, score, or opponent
- Moves clumsily
- Answers questions slowly
- Loses consciousness (even briefly)
- Shows behavior or personality changes
- Can't recall events prior to or after the hit or fall

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[CDC: Heads-Up](#)

Sport Concussion Assessment Tool 2 (SCAT2)

This tool represents a standardized method of evaluating people after concussion in sports. It is used for patient education as well as for physician assessment of sports concussion.

It was developed by a group of international experts at the *3rd International Consensus Meeting on Concussion in Sport* held in Zurich, Switzerland (November 2008).

Pocket SCAT2  (213 Kb)

SCAT2 for Healthcare Professionals  (268 Kb)

McCrory 2009

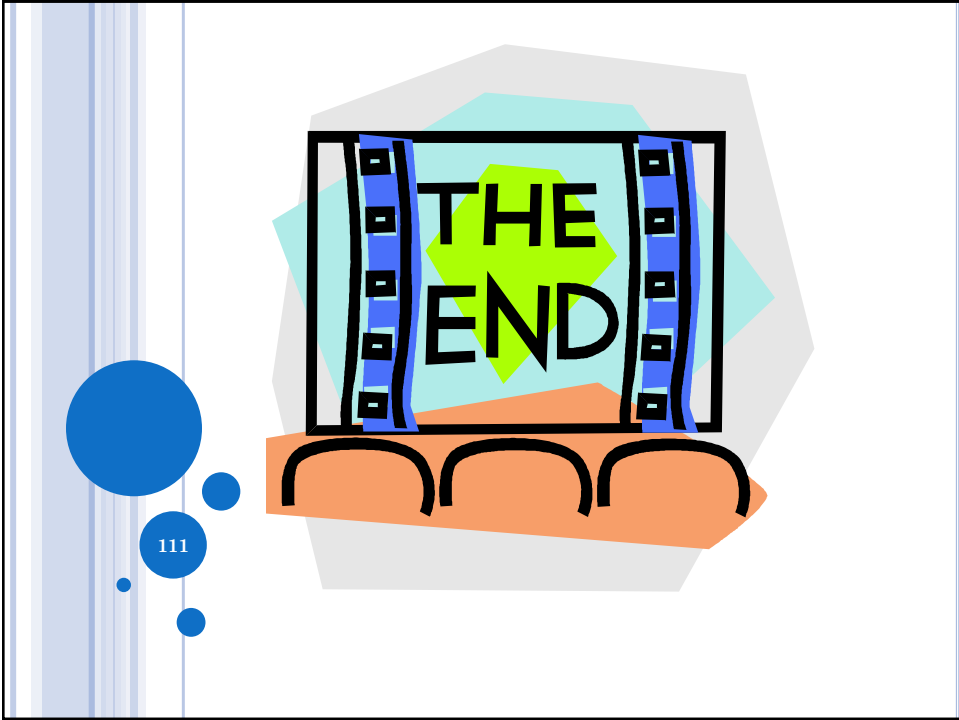
109

Summary: *Sports Guidelines*

- Never return an injured child to active play/sports on the same day.
- After one MTHI, child must be symptom-free and cleared by a healthcare professional before resuming normal activities or participating in sports.

When In Doubt, Sit Them Out

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