POP AND DROP: 
Head Trauma and Concussion

Paul Graham Fisher, M.D.
Professor of Neurology and Pediatrics, and by courtesy, Neurosurgery and Human Biology | The Beirne Family Professor of Pediatric Neuro-Oncology | The Bing Director, Program in Human Biology | Chief, Division of Child Neurology | Director of the Center for Brain and Behavior |

Stanford University and Lucile Packard Children’s Hospital | Palo Alto, CA 94304-1510 | (650) 721-5889 | pfisher@stanford.edu
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I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.
As a result of attending this lecture at the, attendees will make the following change in their practice:

- Diagnose concussion and other types of head trauma
- Employ current concepts of recovery from concussion and return to play
- Know evolving standards required for pediatricians to see children with concussion
- Critique the evidence for and against current thinking regarding concussion
REALITY CHECK

• Most youth sports programs are ill equipped to handle their participants injuries independently, and as a result are more heavily reliant on family physicians and pediatricians, creating a false expectation of unlimited access to medical services.

• Physicians assume that coaches and parents are capable of keeping the injured athlete compliant with required recovery demands, but are the first to be blamed when something goes wrong.

• Most youth sport coaches believe they are qualified to manage an injury that occurs in sport participation, and as a result, many are mismanaged.

• >80% of primary-care pediatricians believe they are the most appropriate follow-up for children with concussions, yet <10% had seen >10 patients with concussion in 6 months and >50% had not participated any CME on concussion

J Trauma 2010;68:1396-40
Pediatric Concussions in United States Emergency Departments in the Years 2002 to 2006

William P. Meehan, III, MD and Rebekah Mannix, MD, MPH

Objectives To estimate the incidence and demographics of concussions in children coming to emergency departments (EDs) in the United States and describe the rates of neuroimaging and follow-up instructions in these patients.

Study design This is a cross-sectional study of children 0 to 19 years old diagnosed with concussion from the National Hospital Ambulatory Medical Care Survey. National Hospital Ambulatory Medical Care Survey collects data on approximately 25,000 visits annually to 600 randomly selected hospital emergency and outpatient departments. We examined visits to United States emergency departments between 2002 and 2006. Simple descriptive statistics were used.

Results Of the 50,835 pediatric visits in the 5-year sample, 230 observations, representing 144,000 visits annually, were for concussions. Sixty-nine percent of concussion visits were by males. Thirty percent were sports-related. Sixty-nine percent of patients diagnosed with a concussion had head imaging. Twenty-eight percent of patients were discharged without specific instructions to follow-up with an outpatient provider for further treatment.

Conclusions Approximately 144,000 pediatric patients present to emergency departments each year with a concussion. Most of these patients undergo computed tomography of the head, and nearly one-third are discharged without specific instructions to follow-up with an outpatient provider for further treatment. (J Pediatr 2010;157:889-93).

- 144,000 pediatric emergency visits each year
- An overabundance of CT scanning
- A lack of follow-up
CONCUSSION

Look on the Bright side. For one brief, glorious moment, you forgot you were on the Cubs.
SPORTS-RELATED HEAD TRAUMA

Factoids

• “At least 50 high school or younger football players in more than 20 states since 1997 have been killed or have sustained serious head injuries on the field.” (The New York Times, September 15, 2007)

• Football, hockey, soccer, and lacrosse are the four NCAA sports leaders for concussion

• In collegiate soccer, girls sustained concussions 68% more often than boys (Journal of Athletic Training). In general, girls are reported to have a higher rate of concussion than boys in soccer and basketball

• 39% of high school and college football players with catastrophic head injuries were playing with residual neurological symptoms from the prior head injury (Am J Sports Med 2007;35:1075-81)
SPORTS-RELATED CONCUSSION

Research Problems with Numerators and Denominators

• Teens don’t know what concussions are
  • “Got my bell rung”
• Perhaps 40% of adolescents do not report head trauma
• Precise definition of concussion
HEAD TRAUMA

Definitions

- Contusion – parenchymal “bruise,” typically hemorrhagic, either directly (coup) or indirectly (contrecoup)
- Nondisplaced skull fracture
- Displaced skull fracture
- Subdural hematoma - crescent hemorrhage, which crosses sutures. Tearing of bridging veins frequent
- Epidural hemorrhage - football-shaped hemorrhage which does not cross sutures. Middle meningeal artery tear frequent
- Closed head trauma (closed head injury, traumatic brain injury) - cerebral hyperemia may be accompanied by diffuse axonal injury; may be synonymous with concussion
BASILAR SKULL FRACTURE

**Signs**

- Mastoid bruising (Battle’s sign)
- Periorbital ecchymosis (raccoon eyes)
- Otorrhea
- Hemotympanum
- CSF rhinorrhea
HEAD TRAUMA
Management

- ABCs
- Neck immobilization
- Elevate head of bed 30 degrees
- Fluids: ¾ - 1x maintenance
- Maintain blood pressure
- Head CT
- Hypertonic saline – 2 ml/kg of 3-7.5% saline
- Mannitol 0.5 - 1.0 g/kg
- Hyperventilation
- Intracranial pressure monitoring if GCS < 8
- Pentobarbital coma - 10-20 mg/kg bolus, then 1-4 mg/kg/hr until burst suppression
MINOR HEAD INJURY
Evaluation Ages 2-20 Years

*Pediatrics* 1999;104:1407-15

- If no loss of consciousness → observation in the office, clinic, emergency department, or home under the care of a competent caregiver
- If loss of consciousness <1 minute → *either* observation in the office, clinic, emergency department, hospital, or home under the care of a competent caregiver, or cranial CT along with observation
“The literature on mild head trauma does not provide a sufficient scientific basis for evidence-based recommendations about most of the key issues in clinical management. More consistent definitions and multisite assessments are needed to clarify this field.”
CONCUSSION
Definition…What Is It?

• Concussion – (Latin *concutere* to strike together) a *violent jarring*, a shock; an injury to an organ, especially the brain, produced by a violent blow and by a temporary or prolonged loss of function (*The American Heritage Dictionary*)

• Trauma-induced (biomechanical) alteration in mental status (typically memory and orientation) that may or may not involve loss of consciousness. Confusion and amnesia are the hallmarks (*Neurology* 1997;48:581-5, and *Neurology* 2013;80:2250)

• Complex pathophysiological process affecting the brain, induced by biomechanical forces (*Br J Sports Med* 2002;36:6-10)

• But tends to be *low-velocity impact*
Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an “impulsive” force transmitted to the head.

Concussion typically results in the rapid onset of short lived impairment of neurological function that resolves spontaneously.

Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury.

Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course.

Concussion is typically associated with grossly normal structural neuroimaging studies.
“…while some existing studies provide useful information, much remains unknown about the extent of concussions in youth; how to diagnose, manage, and prevent concussions; and the short- and long-term consequences of concussions as well as repetitive head impacts that do not result in concussion symptoms.”
CONCUSSION
Pathophysiology

- Immediate disruption of neuronal membranes, resulting in a massive efflux of $K^+$ into the extracellular space $\rightarrow Ca^{+2}$ dependent release of excitatory amino acids, particularly glutamate?
- Acute metabolic dysfunction, with mismatch between glucose demand and supply?
- Length of vulnerable period unknown
- No existing animal or other experimental model accurately reflects a sporting concussive injury.
## CONCUSSION

**Colorado Medical Society Guidelines**


<table>
<thead>
<tr>
<th></th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Confusion</strong></td>
<td>Transient</td>
<td>Transient</td>
<td></td>
</tr>
<tr>
<td><strong>Loss of consciousness</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>&lt;15 minutes</td>
<td>&gt;15 minutes</td>
<td></td>
</tr>
</tbody>
</table>
CONCUSSION

So How Do I Describe It?

- But there are >25 concussion-grading scales!
- Grading has been abandoned
- Concussion severity can only be determined in retrospect
- **Simple concussion**: injury that progressively resolves without complication over 7–10 days
- **Complex concussion**: injury with persistent symptoms (including persistent symptom recurrence with exertion), specific sequelae (such as concussive convulsions), prolonged loss of consciousness (more than one minute), or prolonged cognitive impairment after the injury
- Simple vs. complex distinction abandoned in Zurich 2008 consensus, but 80-90% of concussions are simple
- *In the end, individualized assessment and management is key*
CONCUSSION

Acute Symptoms and Signs

• Confusion
• Amnesia
• Loss of consciousness <10%
• Headache, the most frequently reported symptom
• Dizziness or vertigo
• Nausea, vomiting
• Blurry vision, diplopia

Athletes seldom report concussive symptoms
CONCUSSION
Features Observed by Coaches or Parents

- Vacant stare (befuddled facial expression)
- Delayed verbal and motor responses (slow to answer questions or follow instructions)
- Confusion and inability to focus attention (easily distracted and unable to follow through with normal activities)
- Disorientation (walking in the wrong direction, unaware of time, date, and place)
- Slurred or incoherent speech (making disjointed or incomprehensible statements)
- Gross observable incoordination (stumbling, inability to walk tandem/straight line)
- Emotions out of proportion to circumstances (distraught, crying for no apparent reason)
- Memory deficits (exhibited by athlete repeatedly asking the same question that has already been answered or inability to memorize and recall 3 of 3 objects in 5 minutes)
- Any period of loss of consciousness
MINOR HEAD TRAUMA

Sideline Assessment?

- 522 consecutive Milwaukee high school athletes pre-participation physical exam
- Asked to perform serial 7 subtraction, serial 3 subtraction, or months of year in reverse
- Had to perform seven consecutive correctly, or eleven with one mistake
- 51% serial 7s
- 79% serial 3s
- 89% months of year in reverse

CONCUSSION
Management Day of Injury

- Graded symptom checklists (GSC) or post-concussion symptom scales (PCSS) likely identify concussion
- But sensitivity 64-89% while specificity 91-100%
- SAC (Standardized Assessment of Concussion) and SCAT2 (Sports Concussion Assessment Tool) better
- But BESS (Balance Error Scoring System) … SOT (Sensory Organization Test) not very sensitive
- Diagnosis can/might still be clinical
CONCUSSION
Management Day of Injury

- Should not return to play same day!
- Close observation for first 24-48 hours
  - Rest
  - May eat and sleep
  - Wake every 3-4 hours, assess for worsening symptoms
  - No analgesics
- Physician evaluation required before return to play
CONCUSSION

He’s Good to Go!

42% of coaches believe that a sports-related concussion occurs only when an athlete loses consciousness.

In a study of Minnesota high school football teams, 69% of players who experienced LOC and 81% of players who sustained a concussion without LOC returned to play the same day.

CONCUSSION

Factors Increasing Risk for Post-Concussion Impairment

- Ongoing symptoms
- History of prior concussions
- Younger age
CONCUSSION
Returning to Play…One Older Approach

• Grade 2: one week after being asymptomatic with normal neurological assessment at rest and with exercise
• Grade 3: one – two weeks…
• Multiple Grade 3: one month or longer…based on clinical decision of evaluating physician
CONCUSSION

Return to Play...Current Approaches

- Physical and cognitive rest
  - No sports, no driving, no school, no Tweeting
- No symptoms at rest or with exertion, and off medication
- Follow-up and clearance from primary physician
  - Zackery Lystedt Law, Washington State and 16 other states
- Complete return of memory and concentration
  - ImPACT™
  - HeadMinder™
- Computerized neuropsychological testing used by NHL, NFL, and NCAA
- Scores usually recover in 7 – 10 days
- Yet, the safety of returning an athlete to play based on neuropsychological testing has not been well studied
- Evidence that ongoing symptoms and signs are risk factors for more severe concussion is weak
CONCUSSION

Gradual Return to Play

TABLE 2

<table>
<thead>
<tr>
<th>Step</th>
<th>Level of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No activity, complete rest; proceed to level 2 once symptoms resolve</td>
</tr>
<tr>
<td>2</td>
<td>Light aerobic exercise (eg, walking, stationary cycling)</td>
</tr>
<tr>
<td>3</td>
<td>Sport-specific exercise (eg, skating in hockey, running in soccer); addition of light resistance training</td>
</tr>
<tr>
<td>4</td>
<td>Noncontact training drills; progressively increased resistance training</td>
</tr>
<tr>
<td>5</td>
<td>Full-contact training after medical clearance</td>
</tr>
<tr>
<td>6</td>
<td>Game play</td>
</tr>
</tbody>
</table>

Any occurrence of concussion symptoms should prompt the athlete to drop back to a previous asymptomatic level of activity for at least 24 hours before attempting to progress again.
CONCUSSION Controversies

• Do padded soccer headbands make a difference?
• Have goggles made a difference for women’s lacrosse players?
• Do mouth guards prevent concussions or stingers?
• Does neck muscle conditioning help?
• Should all athletes undergo baseline neurocognitive assessment?
• Is the risk of repeat concussion exponential if the athlete returns too soon?
• Does second impact syndrome exist?
• Do multiple concussions lead to depression and chronic cognitive impairment?
• How many concussions are too many?
CONCUSSION

Heads Up

- Should kids head the ball?
- No well constructed studies have shown neurocognitive changes, symptoms, neurochemical changes, or MRI findings from purposeful heading of the ball
- No recommendations can be made for not heading until a certain age, learning a technique, or developing neck muscles
- Maybe could decrease size and air pressure of ball, or simply enforce the rules, and secure and pad goal posts
- In the end, nothing has been show to prevent concussion
CONCUSSION
Second Impact Syndrome

- Second blow, days or weeks before concussion symptoms have resolved, with diffuse cerebral edema, possibly from loss of cerebrovascular autoregulation
- With this hypothesis, intracranial pressure rises rapidly, and cerebral herniation can occur; surgery does not help and there is little hope for recovery. When not fatal, patient can experience persistent muscle spasms and tenseness, emotional instability, hallucinations, and cognitive problems
- Few reported/proved cases

JAMA 1984;252:538-9
CONCUSSION

How Many Concussions Should End a Career?

• We don’t know
• No two concussions are the same
• No two athletes are the same
HOW MANY HITS ARE TOO MANY?

Cognitive effects of one season of head impacts in a cohort of collegiate contact sport athletes

ABSTRACT

Objective: To determine whether exposure to repetitive head impacts over a single season negatively affects cognitive performance in collegiate contact sport athletes.

Methods: This is a prospective cohort study at 3 Division I National Collegiate Athletic Association athletic programs. Participants were 214 Division I college varsity football and ice hockey players who wore instrumented helmets that recorded the acceleration-time history of the head following impact, and 45 noncontact sport athletes. All athletes were assessed prior to and shortly after the season with a cognitive screening battery (ImPACT) and a subgroup of athletes also were assessed with 7 measures from a neuropsychological test battery.

Results: Few cognitive differences were found between the athlete groups at the preseason or postseason assessments. However, a higher percentage of the contact sport athletes performed more poorly than predicted postseason on a measure of new learning (California Verbal Learning Test) compared to the noncontact athletes (24% vs 3.6%; p < 0.006). On 2 postseason cognitive measures (ImPACT Reaction Time and Trails 4/B), poorer performance was significantly associated with higher scores on several head impact exposure metrics.

Conclusion: Repetitive head impacts over the course of a single season may negatively impact learning in some collegiate athletes. Further work is needed to assess whether such effects are short term or persistent. *Neurology* 2012;78:1777-1784
CONCUSSION

Do Multiple Concussions Lead to Chronic Traumatic Encephalopathy?

Neurosurgery 2006;59:1086-93

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Patient 1</th>
<th>Patient 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at death</td>
<td>50 years</td>
<td>45 years</td>
</tr>
<tr>
<td>Approximate age when decedent was drafted into the NFL</td>
<td>22 years</td>
<td>25 years</td>
</tr>
<tr>
<td>Duration of professional play in the NFL</td>
<td>17 years</td>
<td>8 years</td>
</tr>
<tr>
<td>Approximate duration of play of football in high school, college, and/or in the military</td>
<td>5 years</td>
<td>6 years</td>
</tr>
<tr>
<td>Interval between retirement from the NFL and death</td>
<td>12 years</td>
<td>12 years</td>
</tr>
<tr>
<td>History and diagnosis of major depressive disorder after retirement from the NFL</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Gross atrophy of the brain and hydrocephalus ex vacuo</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Fenestration of the septum pellucidum</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Cavum septi pellucidi</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Presence of diffuse amyloid plaques</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Presence of NFTs and NTs</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>APOE genotype</td>
<td>E3/E3</td>
<td>E3/E4</td>
</tr>
<tr>
<td>Postmortem diagnosis of coronary atherosclerotic disease</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Premortem history of steroid use</td>
<td>Present</td>
<td>Present</td>
</tr>
</tbody>
</table>

* NFL, National Football League; NFTs, neurofibrillary tangles; NTs, neuropil threads; APOE, apolipoprotein-E.
Retired players with three or more reported concussions had a fivefold prevalence of mild cerebral impairment diagnosis and a threefold prevalence of reported significant memory problems compared with retirees without a history of concussion.

- Neurosurgery 2005;57:719-26

Players with three or more concussions did not display statistically significant differences on the 10 individual scores that made up the neuropsychological test battery.

- Neurosurgery 2004;55:1290-1305
# Concussion

**A Must Read for NFL Players**

Let's take brain injuries out of play.

<table>
<thead>
<tr>
<th>Concussion Facts</th>
<th>Concussion Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concussion is a brain injury that alters the way your brain functions.</td>
<td>Different symptoms can occur and may not show up for several hours. Common symptoms include:</td>
</tr>
</tbody>
</table>
| Concussion can occur from a blow to the head/body:  
  - Following helmet to helmet contact, and/or  
  - Contact with the ground, object or another player | - Confusion  
- Headache  
- Amnesia / Difficulty remembering  
- Balance problems  
- Irritability  
- Dizziness  
- Difficulty concentrating  
- Nausea  
*Symptoms may worsen with physical or mental exertion (e.g., lifting, computer use, reading)* |
| Most concussions occur without being knocked unconscious. | - Feeling sluggish, foggy or groggy  
- Sensitivity to noise  
- Sensitivity to light  
- Double / fuzzy vision  
- Slowed reaction time  
- Feeling more emotional  
- Sleep disturbances  
- Loss of consciousness |
| Severity of injury depends on many factors and is not known until symptoms resolve and brain function is back to normal. | All concussions are not created equally. Each player is different, each injury is different and all injuries should be evaluated by your team medical staff. |

### Why Should I Report My Symptoms?

- Practicing or playing while still experiencing symptoms can prolong the time to recover and return to play.
- Unlike other injuries, there may be significant consequences of “playing through” a concussion. Repetitive brain injury, when not treated promptly and properly may cause permanent damage to your brain.

### What Should I Do If I Think I’ve Had a Concussion?

**Report it.** Never ignore symptoms even if they appear mild. Look out for your teammates. Tell your Athletic Trainer or Team Physician if you think you or a teammate may have had a concussion.

**Get Checked Out.** Your team medical staff has your health and well-being as its first priority. They will manage your concussions according to NFL/NFLPA Guidelines which include being fully asymptomatic, both at rest and after exertion, having a normal neurologic examination, normal neuropsychological testing, and clearance to play by both the team medical staff and the independent neurologic consultant.

**Take Care of Your Brain.** According to the CDC, “traumatic brain injury can cause a wide range of short- or long-term changes affecting thinking, sensation, language, or emotions.” These changes may lead to problems with memory and communication, personality changes, as well as depression and the early onset of dementia. Concussions and conditions resulting from repeated brain injury can change your life and your family’s life forever.

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*for more information about traumatic brain injury and concussion, go to [http://www.cdc.gov/concussion](http://www.cdc.gov/concussion)*
CONCUSSION
Genetic Testing?

- ApoE4 genotype
  - Risk factor for adverse outcome following brain injury
  - Risk factor for chronic encephalopathy in boxers
  - But also associated with Alzheimer’s disease and atherosclerosis
  - Significance in sports-related concussion unclear, perhaps associated with chronic cognitive impairment

- S-100-calcium binding protein and neuron-specific enolase also not known to be useful
CONCUSSION
Late Symptoms and Signs (Post-Concussion Syndrome)

- Chronic headaches
- Light-headedness
- Poor attention and concentration
- Memory dysfunction
- Easy fatigability
- Irritability and low frustration tolerance
- Phonophobia, tinnitus
- Photophobia
- Anxiety and/or depressed mood
- Sleep disturbance

Post-concussive syndrome may occur in up to 5% of concussions
CONCUSSION AND HEAD TRAUMA

Late Effects

- Chronic headaches
- CSF leak
- Pneumocephalus
- Communicating hydrocephalus
- Seizures
  - Early <1 week
  - Late >1 week: no role for antiepileptic drug prophylaxis
- Cranial defects
- Inattention
- Cognitive dysfunction
- Behavior and mood disorders
- Sleep disturbance
Heads Up: Brain Injury in Your Practice

DID YOU KNOW?

- Each year, as many as 3.8 million sports- and recreation-related concussions occur in this country.
- Athletes who have had at least one concussion are at increased risk for another concussion.
- A repeat concussion that happens before the brain fully recovers from the first can result in brainswelling, permanent brain damage, and even death. This is called “second impact syndrome.”

The Centers for Disease Control and Prevention (CDC) has created a free tool kit, Heads Up: Concussion in High School Sports, that provides useful tools and information to help coaches, as well as athletic directors and trainers, prevent, recognize, and manage concussions.

The tool kit contains practical, easy-to-use information including:
- A video and DVD;
- A coach’s guide with information about preventing and managing concussion;
- A wallet card and clipboard sticker for coaches;
- Posters to hang in locker rooms;
- Fact sheets in English and Spanish for athletes and their parents; and
- A CD-ROM with downloadable kit materials and additional concussion-related resources.

To order or download this tool kit free of charge, go to: http://www.cdc.gov/ncbtp/tbi/Coaches_Tool_Kit.htm.

For more information or questions on the Heads Up: Concussion in High School Sports tool kit, please contact CDC at 1-800-CDC-INFO (232-4636) or email at cdcinfo@cdc.gov.

It’s better to miss one game than the whole season.

www.cdc.gov/traumaticbraininjury
### Off-Field Mental Status Evaluation

No Return to Play

Any athlete who exhibits signs and symptoms of concussion should be removed from play and should not participate in games or practices until they have been evaluated and given permission by an appropriate health care provider. Research indicates that high school athletes with less than 15 minutes of on-field symptoms exhibited deficits on formal neuropsychological testing and re-emergence of active symptoms, lasting up to one week post-injury.²

**Exertion**

Symptoms will typically worsen or re-emerge with exertion, indicating incomplete recovery. If the athlete is symptom-free, provoking with exertion is recommended (e.g., 5 push-ups, 5 sit-ups, 5 knee bends, 40-yard sprint).

Return to play should occur gradually. Individuals should be monitored by an appropriate health care provider for symptoms and cognitive function carefully during each stage of increased exertion.

**Repeated Evaluation**

On-field follow-up evaluation (e.g., every 5 minutes) is important, as signs and symptoms of concussion may evolve over time.

**Off-Field Management**

The physician should provide information to parents/caregivers regarding the athlete’s condition. For example, the athlete:

- Should not operate a motor vehicle or participate in activities such as sports, PE class, riding a bicycle, riding carnival rides, etc.
- May experience cognitive/behavioral difficulties at home, making it necessary to reduce physical and cognitive exertion (e.g., running, lifting weights, intensive studying) until fully recovered.
- Should receive follow-up medical and neuropsychological evaluation, both for managing injury and determining return to sports.

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### Concussion in Sports

This palm card provides information and tools to help medical staff with the on-field recognition and management of concussion.

<table>
<thead>
<tr>
<th>Concussion Signs and Symptoms¹</th>
<th>Symptoms Reported by Athlete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signs Observed by Medical Staff</td>
<td>Headache or “pressure” in head</td>
</tr>
<tr>
<td>Appears dazed or stunned</td>
<td>Nausea</td>
</tr>
<tr>
<td>Is confused about assignment</td>
<td>Balance problems or dizziness</td>
</tr>
<tr>
<td>Forgets sports, plays</td>
<td>Double or fuzzy vision</td>
</tr>
<tr>
<td>Is unsure of game, score, opponent</td>
<td>Sensitivity to light</td>
</tr>
<tr>
<td>Moves clumsily</td>
<td>Sensitivity to noise</td>
</tr>
<tr>
<td>Answers questions slowly</td>
<td>Feeling sluggish or slowed down</td>
</tr>
<tr>
<td>Loses consciousness (even briefly)</td>
<td>Feeling foggy or groggy</td>
</tr>
<tr>
<td>Shows behavior or personality changes</td>
<td>Does not “feel right”</td>
</tr>
</tbody>
</table>


This palm card is part of the “Heads Up: Brain Injury in Your Practice” tool kit developed by the Centers for Disease Control and Prevention (CDC). For more information, visit: www.cdc.gov/hip.
# Acute Concussion Evaluation (ACE)

**Physician/Clinician Office Version**

**Gerard Gioia, PhD** & **Micky Collins, PhD**

*Children's National Medical Center*

*University of Pittsburgh Medical Center*

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## A. Injury Characteristics

- **Date/Time of Injury:**
- **Reporter:** Patient Parent Spouse Other

1. **Injury Description:**
   - 1a. Is there evidence of a forcible blow to the head (direct or indirect)? Yes No Unknown
   - 1b. Is there evidence of intracranial injury or skull fracture? Yes No Unknown
   - 1c. Location of Impact: Frontal Lift Temporal Rt Temporal Lt Temporal Rt Parietal Lt Parietal Occipital Neck Intracranial Force
   - 2. **Cause:** MVC Pedestrian-MVC Fall Assault Sports (Specify)
   - 3. **Amnesia Retro:** Are there any events just BEFORE the injury that your patient has no memory of (even brief)? Yes No Duration
   - 4. **Amnesia Anter:** Are there any events just AFTER the injury that your patient has no memory of (even brief)? Yes No Duration
   - 5. **Loss of Consciousness:** Did your patient lose consciousness? Yes No Duration
   - 6. **Early Signs:** Appears dazed or stunned Is confused about events Answers questions slowly Repeats questions Forgets recent info
   - 7. **Seizures:** Seizures observed? Yes No Detail

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## B. Symptom Check List

Since the injury, has the patient experienced **any** of these symptoms more than usual today or in the past day? Indicate presence of each symptom (0-No, 1-Yes). *Lowell & Collins, 1996 JHR*

<table>
<thead>
<tr>
<th>Physical (10)</th>
<th>Cognitive (4)</th>
<th>Sleep (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache 0/1</td>
<td>Feeling mentally foggy 0/1</td>
<td>Drowsiness 0/1</td>
</tr>
<tr>
<td>Nausea 0/1</td>
<td>Feeling slowed down 0/1</td>
<td>Sleeping less than usual 0/1</td>
</tr>
<tr>
<td>Vomiting 0/1</td>
<td>Difficulty concentrating 0/1</td>
<td>Sleeping more than usual 0/1</td>
</tr>
<tr>
<td>Balance problems 0/1</td>
<td>Difficulty remembering 0/1</td>
<td>Trouble falling asleep 0/1</td>
</tr>
<tr>
<td>Dizziness 0/1</td>
<td>Cognitive Total (0-4)</td>
<td>Sleep Total (0-4)</td>
</tr>
</tbody>
</table>

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## C. Risk Factors for Protracted Recovery

- Concussion History? Y N
- Headache History? Y N
- Developmental History
- Psychiatric History

- Previous: 1 2 3 4 5 6+
- Longest symptom duration: Days Weeks Months Years
- If multiple concussions, less force caused injury? Yes No

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## D. Red Flags for Acute Emergency Management

Refer to the emergency department with sudden onset of any of the following:
- Headaches that worsen
- Can’t look or move eyes or face
- Nervous system signs
- Amnesia
- Seizures
- Focal neurologic signs
- Slurred speech
- Unusual behavioral changes
- Weakness or numbness
- Change in state of consciousness

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## E. Diagnosis (ICD):

- Concussion w LOC 850.0
- Concussion w LOC 850.1
- Concussion (Unspecified) 850.9
- Other (854)
- No diagnosis

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## F. Follow-Up Action Plan

- Complete ACE Care Plan and provide copy to patient/family.
- No Follow-Up Needed

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**ACE Completed by:**

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*This form is part of the "Head's Up Brain Injury in Your Practice" tool developed by the Centers for Disease Control and Prevention (CDC).*

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*Lucile Packard Children’s Hospital at Stanford*
A concussion (or mild traumatic brain injury [MTBI]) is a complex pathophysiological process affecting the brain. Induced by traumatic biomechanical forces secondary to direct or indirect forces to the head, disturbance of brain function is related to neuremetabolic dysfunction, rather than structural injury, and is typically associated with normal structural neuroimaging findings (i.e., CT scan, MRI). Concussion may or may not involve a loss of consciousness (LOC). Concussion results in a constellation of physical, cognitive, emotional, and sleep-related symptoms. Symptoms may last from several minutes to days, weeks, months or even longer in some cases.

ACE Instructions
The ACE is intended to provide an evidence-based clinical protocol to conduct an initial evaluation and diagnosis of patients (both children and adults) with known or suspected MTBI. The research evidence documenting the importance of these components in the evaluation of an MTBI is provided in the reference list.

A. Injury Characteristics:
1. Obtain description of the injury — How injury occurred, type of force, location on the head or body (if force transmitted to head). Different biomechanics of injury may result in differential symptom patterns (e.g., occipital blow may result in visual changes, balance difficulties).
2. Indicate cause of injury. Greater forces associated with the trauma are likely to result in more severe presentation of symptoms.
3. Amnesia: Amnesia is defined as failure to form new memories. Determine whether amnesia has occurred and attempt to determine length of time of memory dysfunction — amnesia (retrograde) and/or memory loss (anterograde) injury. Event seconds to minutes of memory loss can be predictive of outcome. Recent research has indicated that amnesia may be up to 4-10 times more predictive of symptoms and cognitive deficits following concussion than LOC (less than 1 minute).8
4. Loss of consciousness (LOC) — If occurs, determine length of LOC.
5. Early signs, if present, ask the individuals who know the patient (parent, spouse, friend, etc.) about specific signs of the concussion that may have been observed. These signs are typically observed early after the injury.
6. Inquire whether seizures were observed or not.

B. Symptom Checklist:
1. Ask patient (and/or parent, if child) to report presence of the four categories of symptoms since injury. It is important to assess all listed symptoms as different parts of the brain control different functions. One or all symptoms may be present depending upon mechanisms of injury.9 Record “1” for Yes or “0” for No for their presence or absence, respectively.
2. For all symptoms, indicate presence of symptoms as experienced within the past 24 hours. Since symptoms can present premonitory baseline (e.g., irritability, headaches, sleep, sadness), it is important to assess changes from their usual presentation.
3. Scoring: Sum total number of symptoms present per area, and sum all four areas into Total Symptom Score (score range 0-22). (Note: Most sleep symptoms are only applicable after a night has passed since the injury. Drowsiness may be present on the day of injury.) If symptoms are new and present, there is no lower limit symptom score. Any score > 0 indicates positive symptom history.
4. Exertion: Inquire whether any symptoms worsen with physical (e.g., running, climbing stairs, bike riding) and/or cognitive (e.g., academic studies, multi-tasking at work, reading or other tasks requiring focused concentration) exertion. Clinicians should be aware that symptoms will typically worsen or re-emerge with exertion, indicating incomplete recovery. Over-exertion may protract recovery.
5. Overall Rating: Determine how different the patient is from their usual self. Circle “0” (Normal) to “9” (Very Different).

C. Risk Factors for Protracted Recovery: Assess the following risk factors as possible complicating factors in the recovery process.
1. Concussion history: Assess the number and date(s) of prior concussions, the duration of each symptom for each injury, and whether less biomechanical force resulted in re-injury. Research indicates that cognitive and physical effects of concussion may be cumulative, especially if there is minimal duration of time between injuries and less biomechanical force results in subsequent concussion which may indicate incomplete recovery from initial trauma.44
2. Headache history: Assess personal and/or family history of diagnosis/treatment for headaches. Research indicates headache (migraine in particular) can result in protracted recovery from concussion.41
3. Developmental history: Assess history of learning disabilities, Attention-Deficit/Hyperactivity Disorder or other developmental disorders. Research indicates that there is the possibility of a longer period of recovery with these conditions.44
4. Psychiatric history: Assess for history of depression/mood disorder, anxiety, and/or sleep disorder.15 46

D. Red Flags: The patient should be carefully observed over the first 24-48 hours for these serious signs. Red flags are to be assessed as possible signs of deteriorating neurocognitive functioning. Any positive report should prompt strong consideration of referral for emergency medical evaluation (e.g. C1 scan to rule out intracranial bleed or other structural pathology).17

E. Diagnosis: The following ICD diagnostic codes may be applicable.
850.0 (Concussion, with loss of consciousness) — Positive injury description with evidence of forcible direct/indirect blow to the head (A1a); plus evidence of active symptoms (B) of any type and number related to the trauma (Total Symptom Score >0); no evidence of LOC (A8), skull fracture or intracranial injury (A1b).
850.1 (Concussion, with brief loss of consciousness <1 hour) — Positive injury description with evidence of forcible direct/indirect blow to the head (A1a); plus evidence of active symptoms (B) of any type and number related to the trauma (Total Symptom Score >0); positive evidence of LOC (A8), skull fracture or intracranial injury (A1b).
850.9 (Concussion, unclassified) — Positive injury description with evidence of forcible direct/indirect blow to the head (A1a); plus evidence of active symptoms (B) of any type and number related to the trauma (Total Symptom Score >0); unclear/unknown injury details; unclear evidence of LOC (A8), no skull fracture or intracranial injury.
Other Diagnoses — If the patient presents with a positive injury description and associated symptoms, but additional evidence of intracranial injury (A1b) such as from neuromaging, a moderate TBI and the diagnostic category of 854 (intracranial injury) should be considered.

F. Follow-Up Action Plan: Develop a follow-up plan of action for symptomatic patients. The physician/cyclinician may decide to (1) monitor the patient in the office or (2) refer them to a specialist. Serial evaluation of the concussion is critical as symptoms may resolve; worsen, or ebb and flow depending upon many factors (e.g., cognitive/physical exertion, comorbidities). Referral to a specialist can be particularly valuable to help manage certain aspects of the patient’s condition. (Physician/Cyclinician should also complete the ACE Care Plan included in this tool kit.)
1. Physician/Cyclinician serial monitoring — Particularly appropriate if number and severity of symptoms are steadily decreasing over time and/or fully resolve within 3-5 days. If steady reduction is not evident, referral to a specialist is warranted.
2. Referral to a specialist — Appropriate if symptom reduction is not evident in 3-5 days, or sooner if symptom profile is concerning in terms of severity.
   • Neuropsychological Testing can provide valuable information to help assess a patient’s brain function and impairment and assist with treatment planning, such as return to play decisions.
   • Physician Evaluation is particularly relevant for medical evaluation and management of concussion. It is also critical for evaluating and managing focal neurologic, sensory, vestibular, and motor concerns. It may be useful for medication management (e.g., headaches, sleep disturbance, depression) if post-concussive problems persist.
HEAD TRAUMA AND CONCUSSION
Where to Find More

- www.cdc.gov/concussion/HeadsUp
- www.impacttest.com
- www.headminder.com
- www.cogstate.com/go/sport

Pediatrics 2009;123:114-23
Pediatrics 2010;126:597-615