

Concussion in the Pediatric Patient

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Case Study

A twelve year old boy presents with brief loss of consciousness and vomiting after colliding with another football player during a game.

Per his mother, he struck helmet to helmet with the other player, fell forward to the ground, and was unconscious for less than a minute.

When he woke up, he was confused for about five minutes, vomited twice, and then was fully awake and wanted to return to the game.

Much to his disappointment, the trainer requested that he be transported to an Emergency Department for further evaluation prior to return to play.

Case Study

- His initial vital signs on the field are as follows:

Pulse	80
Respiratory Rate	20
Blood Pressure	100/60
Oxygen Saturation	99% (room air)

- He is fully awake and has a normal physical exam with the exception of a right frontal scalp hematoma that measures 3cm in diameter; there is no evident bony step-off underlying the hematoma.

Case Study Questions

- Do you really need to transport this patient to the Emergency Department?
- What are your patient care priorities in the pre-hospital setting to assure safe transport of the patient?
- Upon arrival in the ER, what are the initial steps in the management of this patient?
- Does this patient need an imaging study to further evaluate his symptoms?
- Can this patient be safely discharged home?
- When can this patient safely return to physical activity?

What is a concussion?

CP Symonds, 1928- *British Medical Journal*

Regarding Cerebral Concussion...

“the patient is completely unconscious and in a state of flaccid paralysis. In a severe case, the respiratory and cardiac functions may hardly continue. In a few minutes recovery begins; the visceral reflexes are the first to return, and vomiting is common at this stage. The other cerebral functions recover more gradually, and there may be complaint of headache, dizziness and giddiness, but at the end of 24 hours, in a typical case of concussion....

... recovery should be complete”

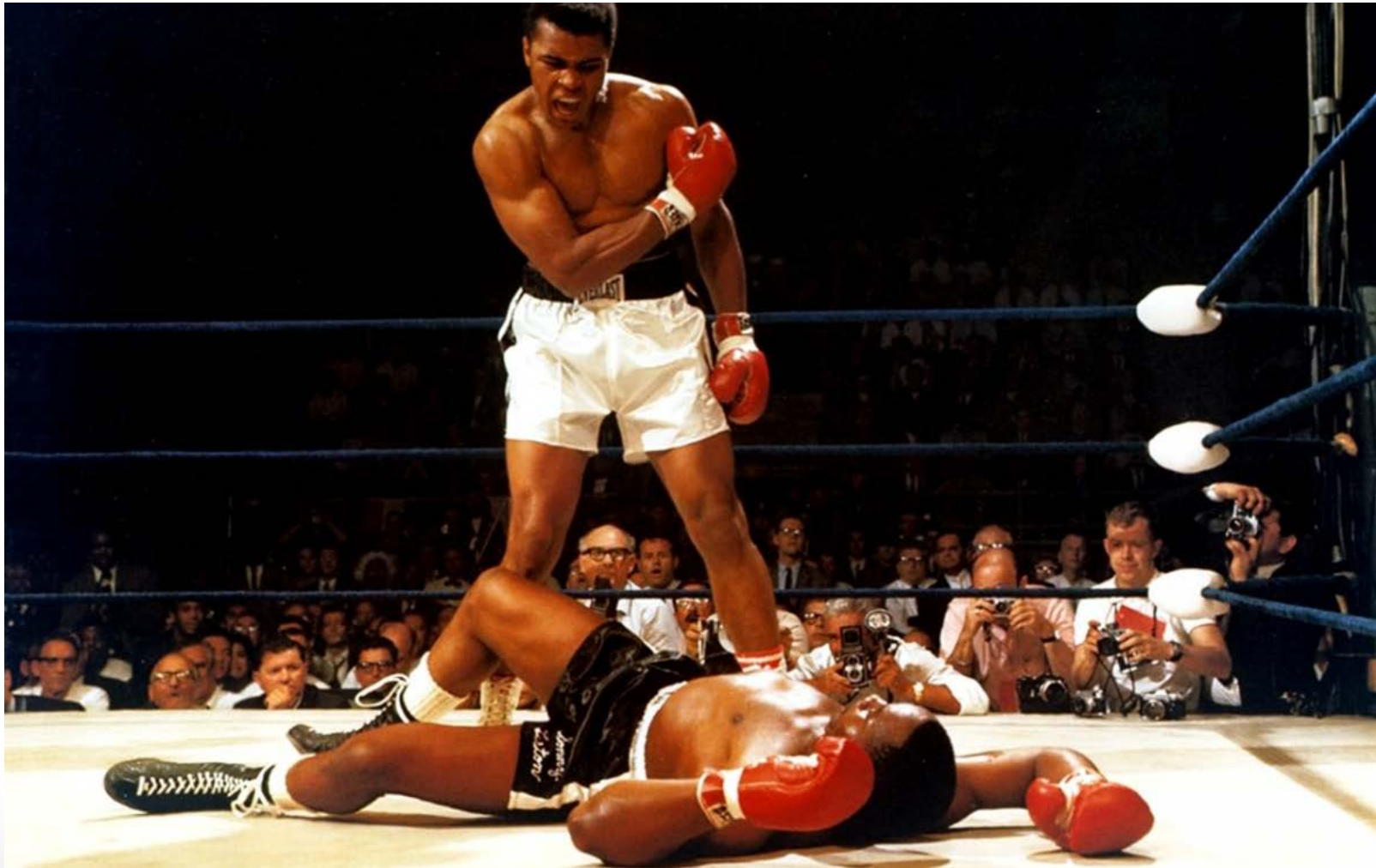
What is a concussion?

- A Traumatic Brain Injury (TBI) is caused by a bump, blow or jolt to the head or a penetrating head injury that disrupts the normal function of the brain.
 - Not all blows or jolts to the head result in a TBI.
- The severity of a TBI may range from “**mild,**” i.e., a brief change in mental status or consciousness to “**severe,**” i.e., an extended period of unconsciousness or amnesia after the injury.
 - The majority of TBIs that occur each year are concussions or other forms of mild TBI.

How common are concussions?

- Each year, an estimated 1.7 million people sustain a TBI
- About 75% of TBIs that occur each year are concussions or other forms of mild TBI
 - Concussions are probably under-reported as many do not seek medical care even though they have classic symptoms
 - Some studies suggest at least 25% of patients with concussion are not properly evaluated by a medical professional
 - Estimated to occur at a rate of 6 per 1000 people/year
- While a mild TBI is usually not life-threatening, this injury can have serious and long-term impact on a person's cognitive, physical and psychological function

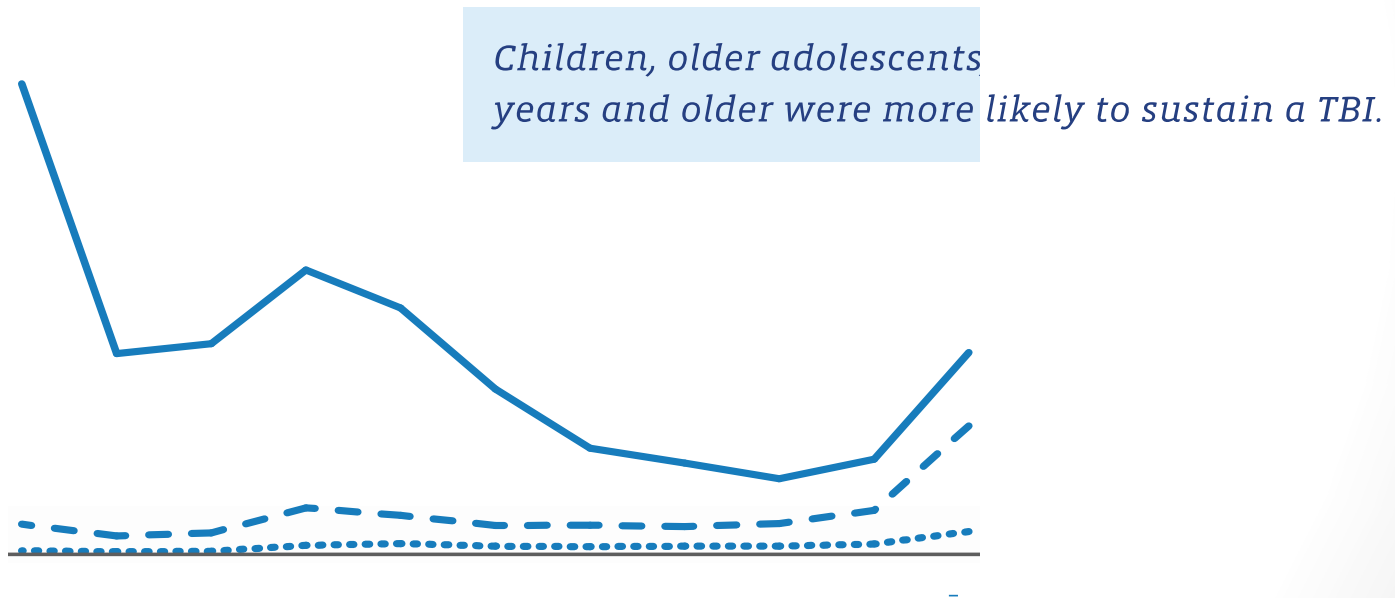
How common are concussions?



How common are concussions?

- Most common in children and young adults
- Males are twice as likely to have a concussion as females
- CDC estimates as many as 300,000 concussions in sports-related events annually in the U.S.
 - Only includes concussions associated with loss of consciousness
 - Likely underestimates the true problem since loss of consciousness likely only occurs in about 10% of patients with concussion
 - More common in football and boxing
 - American Academy of Neurology and the World Medical Association have called for a ban of boxing

How common are concussions?



VA State Code on Concussions

- § 22.1-271.5. Policies on concussions in student-athletes – passed into legislation on July 1, 2010.
- A. The Board of Education shall develop and distribute to each local school division guidelines on policies to inform and educate coaches, student-athletes, and their parents or guardians of the nature and risk of concussions, criteria for removal from and return to play, and risks of not reporting the injury and continuing to play.

VA State Code on Concussions

- B. Each local school division shall develop policies and procedures regarding the identification and handling of suspected concussions in student-athletes. Such policies shall require:
 - 1. In order to participate in any extracurricular physical activity, each student-athlete and the student-athlete's parent or guardian shall review, on an annual basis, information on concussions provided by the local school division. After having reviewed materials describing the short- and long-term health effects of concussions, each student-athlete and the student-athlete's parent or guardian shall sign a statement acknowledging receipt of such information, in a manner approved by the Board of Education; and

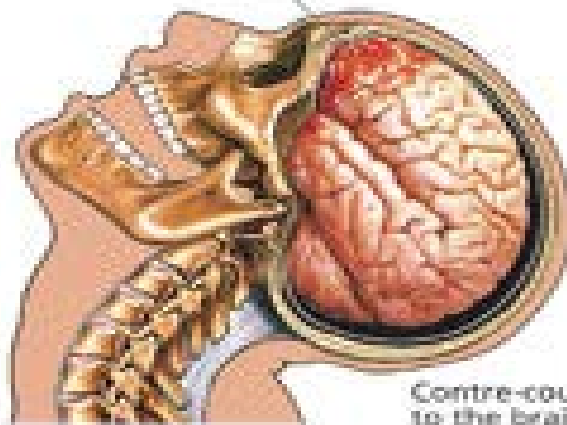
VA State Code on Concussions

- 2. A student-athlete suspected by that student-athlete's coach, athletic trainer, or team physician of sustaining a concussion or brain injury in a practice or game shall be removed from the activity at that time. A student-athlete who has been removed from play, evaluated, and suspected to have a concussion or brain injury shall not return to play that same day nor until (i) evaluated by an appropriate licensed health care provider as determined by the Board of Education and (ii) in receipt of written clearance to return to play from such licensed health care provider.
- The licensed health care provider evaluating student-athletes suspected of having a concussion or brain injury may be a volunteer.

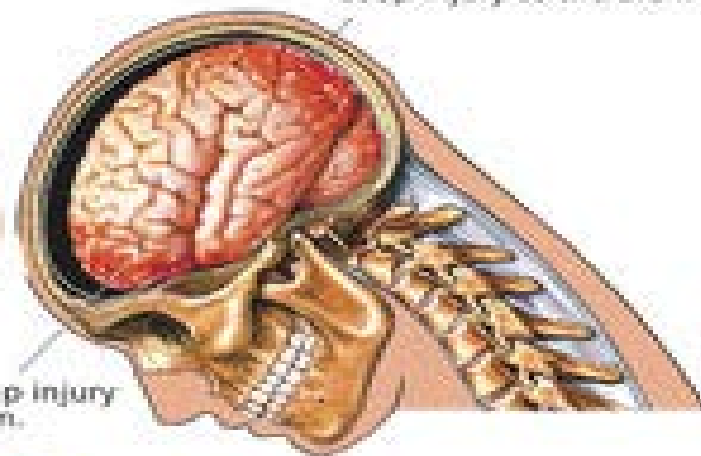
What causes concussions?

- Concussion = Metabolic Crisis!
- During injury: potassium rushes out of cell, (toxic) calcium rushes in → **metabolic dysfunction**
- Leads to an **energy crisis** & massive release of neurotransmitters (leading to interference with cell communication)
- Things to avoid: another blow to head or increasing metabolic demands on brain

Contre-coup injury to the brain.



Coup injury to the brain



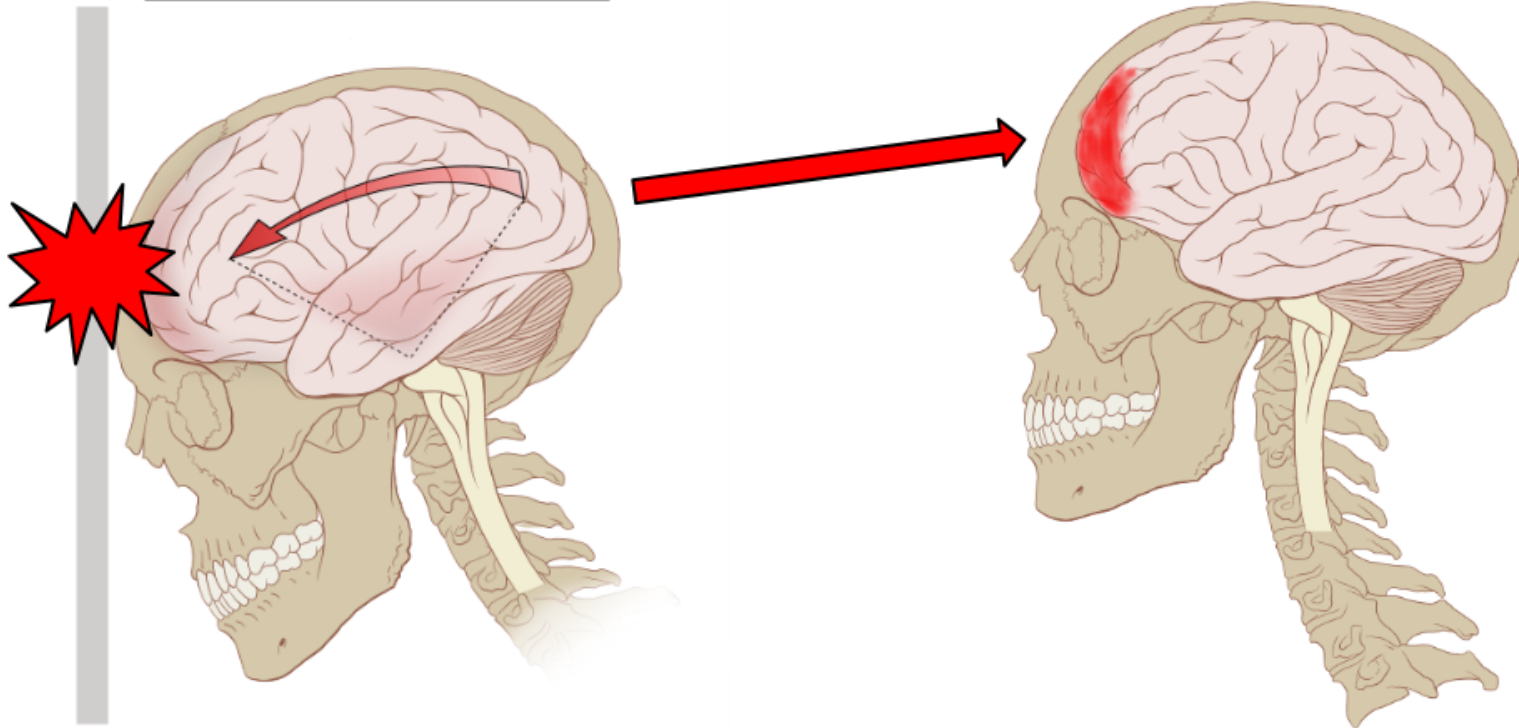
Contre-coup injury to the brain.



Contre-coup Injury to the Brain.

Concussion: A traumatic brain injury that changes the way your brain functions.

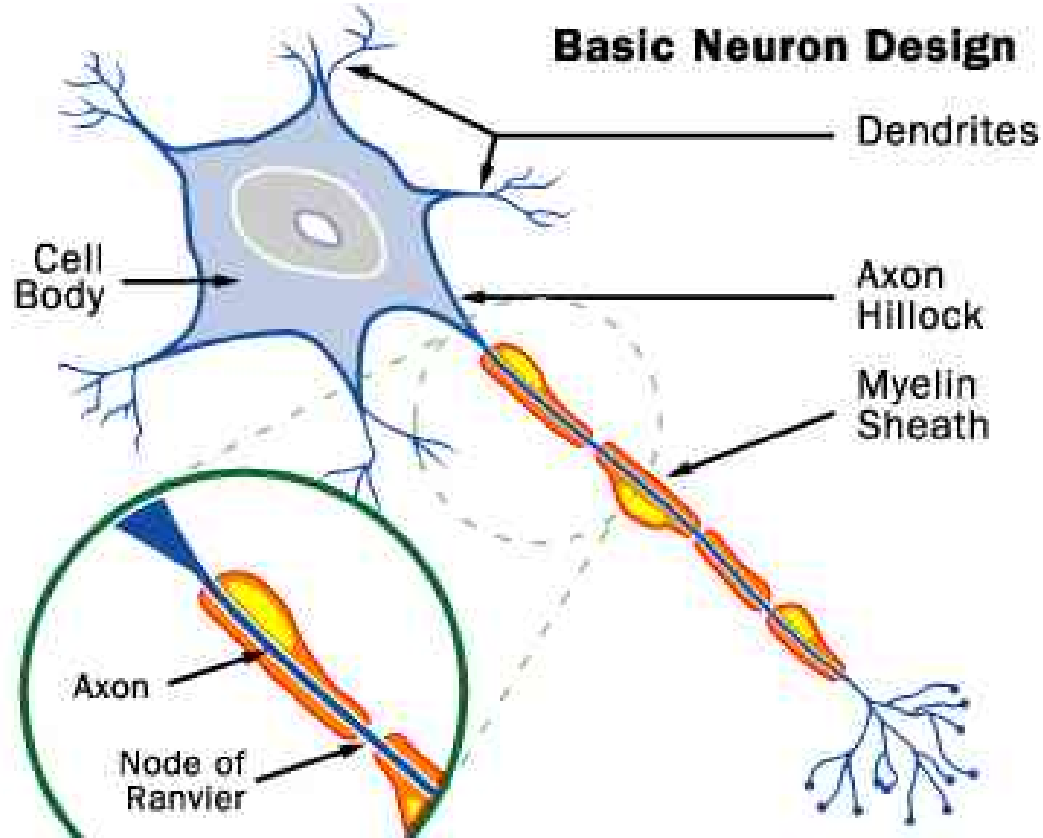
This can lead to bruising and swelling of the brain, tearing of blood vessels and injury to nerves, causing the concussion.



The brain is made up of soft tissue and is protected by blood and spinal fluid. When the skull is jolted too fast or is impacted by something, the brain shifts and hits against the skull.

Most concussions are mild and can be treated with appropriate care. But left untreated, it can be deadly.

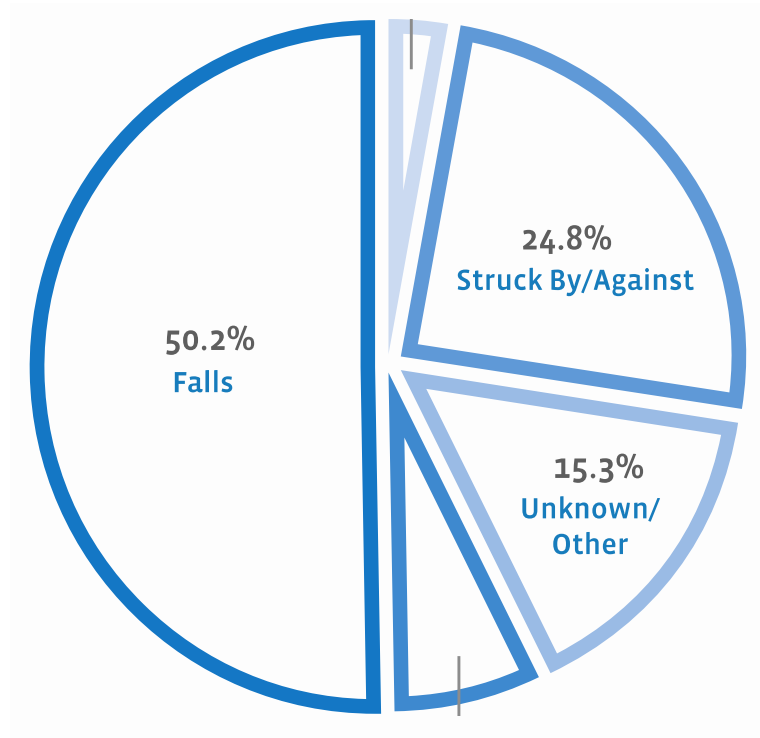
What causes concussions?



What causes concussions?



What causes concussions?



Symptoms of concussion

- **Cognitive Symptoms** Include:
 - Difficulty thinking clearly, slurred speech
 - Feeling slowed down
 - Difficulty concentrating
 - Difficulty remembering new information, amnesia
 - Disoriented
- **Physical Symptoms** Include:
 - Headache
 - Fuzzy or blurry vision
 - Nausea or vomiting (early on)
 - Dizziness
 - Sensitivity to noise or light
 - Balance problems, poor coordination
 - Feeling tired, having no energy

Symptoms of concussion

- **Emotional/Mood Symptoms Include:**
 - Irritability
 - Sadness
 - More emotional/emotionally labile
 - Nervousness or anxiety
- **Disturbances in Sleep Pattern Include:**
 - Sleeping more than usual
 - Sleep less than usual
 - Trouble falling asleep

Diagnosis of Concussion

- The suspected diagnosis of concussion can include one or more of the following clinical domains:
 - **Physical signs:** *loss of consciousness, vomiting, headache*
 - **Behavioral changes:** *irritability, labile emotions*
 - **Cognitive impairment:** *slowed reaction times, feeling like in a fog*
 - **Sleep disturbance:** *drowsiness*
- If any one or more of these components is present, a concussion should be suspected and the appropriate management strategy instituted.
- No longer utilize grading systems to determine treatment

Management of concussions

- Acute Management
 - Rule out more serious intracranial pathology
 - CT, MRI, neurologic examination primary diagnostic test
- Post Injury Management
 - Prevent against Second Impact Syndrome
 - Prevent against cumulative effects of injury
 - Less biomechanical force causing extension of injury
 - Prevent presence of Post-Concussion Syndrome
- Determination of asymptomatic status essential for reducing repetitive and chronic morbidity of injury



Acute Sideline Management

- Medically evaluated onsite using EMT principles
 - Attention to Cervical spine
- SCAT2 (or similar)
 - Sideline evaluation tool
- Should not be left alone, serial assessments for next few hours to evaluate for deterioration
- No Same-Day Return To Play!
- Refer to appropriate medical setting

SCAT-2

- **Sports Concussion Assessment Tool – 2:**
 - Standardized sideline assessment tool that is easy to administer and can be repeated over time to help determine progression of symptoms
- Online access to full SCAT-2:
<http://www.neurosurgery.net.au/SCAT2.html>
- Available as an app for iPhones, iPod, iPad:
<https://itunes.apple.com/us/app/scat2/id434110174?mt=8>

SCAT-2

Pocket SCAT2



FIFA®



Concussion should be suspected in the presence of **any one or more** of the following: symptoms (such as headache), or physical signs (such as unsteadiness), or impaired brain function (e.g. confusion) or abnormal behaviour.

1. Symptoms

Presence of any of the following signs & symptoms may suggest a concussion.

- Loss of consciousness
- Seizure or convulsion
- Amnesia
- Headache
- "Pressure in head"
- Neck Pain
- Nausea or vomiting
- Dizziness
- Blurred vision
- Balance problems
- Sensitivity to light
- Sensitivity to noise
- Feeling slowed down
- Feeling like "in a fog"
- "Don't feel right"
- Difficulty concentrating
- Difficulty remembering
- Fatigue or low energy
- Confusion
- Drowsiness
- More emotional
- Irritability
- Sadness
- Nervous or anxious

2. Memory function

Failure to answer all questions correctly may suggest a concussion.

- "At what venue are we at today?"*
- "Which half is it now?"*
- "Who scored last in this game?"*
- "What team did you play last week / game?"*
- "Did your team win the last game?"*

3. Balance testing

Instructions for tandem stance

*"Now stand heel-to-toe with your **non-dominant** foot in back. Your weight should be evenly distributed across both feet. You should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

Observe the athlete for 20 seconds. If they make more than 5 errors (such as lift their hands off their hips; open their eyes; lift their forefoot or heel; step, stumble, or fall; or remain out of the start position for more than 5 seconds) then this may suggest a concussion.

Any athlete with a suspected concussion should be IMMEDIATELY REMOVED FROM PLAY, urgently assessed medically, should not be left alone and should not drive a motor vehicle.

Transport Considerations

- A, B, C's of trauma management – rapidly use your pediatric assessment triangle and primary survey to determine if the patient is sick or not sick:
 - Airway
 - Breathing
 - Circulation
 - Disability
 - Exposure
- Secondary survey once all primary survey interventions are met – more detailed head to toe physical exam
 - Cervical Spine Immobilization
 - Spinal Immobilization

Quick Neurologic Exam

- Examine pupil size for symmetry and reaction to light
- Determine level of responsiveness by utilizing the AVPU method or completing the Glasgow Coma Score
- Determination of upper and lower motor strength and sensation
- Look for signs of basilar skull fracture:
 - Raccoon eyes
 - Battle sign
 - CSF leak from ears / nose

Pediatric Glasgow Coma Score: Eye Opening

Age > 2yrs	Score	Age < 2 yrs
Spontaneous	4	Spontaneous
To Voice	3	To Speech
To Pain	2	To Pain
None	1	None

Pediatric Glasgow Coma Score: Verbal Response

Age > 2 yrs	Score	Age < 2yrs
Oriented	5	Coos, Babbles
Confused	4	Irritable, Cries
Inappropriate	3	Cries to Pain
Incomprehensible	2	Moans to Pain
None	1	None

Pediatric Glasgow Coma Score: Motor Response

Age > 2yrs	Score	Age < 2yrs
Obeys Commands	6	Normal, Spontaneous
Localizes Pain	5	Withdraws to Touch
Withdraws to Pain	4	Withdraws to Pain
Flexion to Pain	3	Abnormal Flexion
Extension to Pain	2	Abnormal Extension
None	1	None

Raccoon Eyes



Raccoon Eyes



Battle Sign



CSF Leak – Halo Test



Source: Knapp KL, Stack LB, Morrow AB, Thurman RJ. The Atlas

Arrival in Hospital

- Provide overview of patient's presentation to hospital care providers including:
 - Mechanism of the injury
 - Symptoms demonstrated by the patient at the time of injury, upon your arrival, and during transport
 - Physical exam and vital signs
 - Changes in symptoms or physical exam findings over time
 - Pertinent medical history (SAMPLE history is sufficient)
 - Results of any screening tests performed by trainer or EMS providers en route to hospital
- Physician will perform primary and secondary survey to determine further treatment needed

Management of Concussion

- **Indications for CT scan:**
 - Posttraumatic seizure
 - Amnesia
 - Progressive headache
 - Distracting history / exam
 - Intoxicants
 - Other injuries
 - LOC > 5 minutes
 - Signs of basilar skull fracture
 - Repetitive emesis
 - Emesis > 8 hours post injury
 - Instability following multiple traumas

Management of Concussion

- **Indications for Outpatient Care:**
 - Minor head injury (initial GCS 14 – 15)
 - **Reliable** adult caretaker *
 - LOC < 5 minutes
 - Normal neurological exam
 - No ↑ ICP symptoms
 - Normal CT if obtained
 - No signs of basilar skull fracture

Management of Concussion

- **Indications for Admission:**

- Documented LOC > 5 minutes
- Focal neurologic findings
- Persistent altered mental status, amnesia
- Posttraumatic seizures
- Protracted emesis
- Persistent headache
- Intoxication
- Suspected child abuse
- Unreliable caregiver
- Underlying pathology
 - Coagulopathy
 - Hydrocephalus

Follow Up Management

- List of symptoms that would require immediate follow-up:
 - Worsening headache, protracted vomiting
 - Worsening fatigue or alteration in mental status
 - Any seizure
 - Numbness or weakness of any part of the body
- The cornerstone of concussion management is **Physical and Cognitive Rest** until symptoms resolve and then a graded program of exertion prior to medical clearance and return to play.
- **Cognitive Rest** means limiting exertion with activities of daily living and limiting scholastic and other cognitive stressors (e.g. text messaging, videogames, etc.) while symptomatic.
 - School attendance and activities may also need to be modified to avoid provocation of symptoms.

Ideal Management Algorithm



Management of concussions

- Areas of Concern:
 - Grading systems ineffective/ not data based
 - “Little bit pregnant?”
 - CT and MRI usually “normal”
 - Reliance on self-report
 - Variability of clinician recommendations
 - Lack of education and awareness of injury

TBI Clinic at VCU/CHoR

- Follow up services include the following:
 - Medical evaluation
 - History and physical
 - Neurological exam
 - Balance exam
 - ImPACT Testing
 - Psychologist
 - Education Consultant
 - Therapy
 - Case manager
- PROVIDE INDIVIDUALLY BASED MANAGEMENT

ImPACT Test



<http://www.impacttest.com/>

ImPACT Testing

- ImPACT's Test is computerized and takes about 25 minutes to complete.
- ImPACT recommends that it be administered by an ImPACT trained athletic trainer, school nurse, athletic director, team doctor or psychologist.
 - Baseline tests are suggested every two years.
 - If a concussion is suspected, the baseline report will serve as a comparison to a repeat ImPACT test, which professionals can use to assess potential changes or damage caused by a concussion.
- The management of concussions should only be conducted by trained medical professionals.
 - To achieve this, ImPACT is expanding reach to manage concussions through a growing national network of several hundred clinical professionals who are Credentialed ImPACT Consultants

ImPACT Testing

- Measures player symptoms
- Measures verbal and visual memory, processing speed, and reaction time
- Reaction time measured to a 1/100th of second
- Assists clinicians and athletic trainers in making difficult return-to-play decisions
- Provides reliable baseline test information
- Produces a comprehensive report of test results
- Results are presented as a PDF file and can be emailed
- Automatically stores data from repeat testing
- Testing is administered online for individuals or groups
- Compatible with PC and MAC

Return to Play?

- Can't trust a concussed athlete to diagnose their own injury
- Athletes notorious for hiding symptoms
- As many as 50% of athletes experience concussion symptoms per year but only 10% report having an injury

Must be:

Asymptomatic at rest

Asymptomatic with exertion (cognitive and physical)

Normalized ImPACT scores

Meet all three, may begin a graded exertion program to return to play best if under a therapist or trainer guidance

Return to play protocol

- For persons participating in athletics, the 2008 Zurich Consensus Statement on Concussion in Sport recommends persons be symptom free before restarting and then, not all at once, but rather through a series of graded steps
- These steps include: complete physical and cognitive rest, light aerobic activity (less than 70% of maximum heart rate), sport-specific activities such as running drills and skating drills, non-contact training drills (exercise, coordination, and cognitive load), full-contact practice, and full-contact games
- Only if a person is symptom free for 24 hours, should he or she proceed to the next step
 - If symptoms occur, the person should drop back to the previous asymptomatic level for at least another 24 hours

Graduated return to play protocol

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1. No activity	Complete physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity <70 percent MPRH; no resistance training	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer; no head impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, eg, passing drills in football and ice hockey; may start progressive resistance training	Exercise, coordination, and cognitive load
5. Full contact practice	Following medical clearance, participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

Six-day return to play protocol. Each day the athlete makes a stepwise increase in functional activity, is evaluated for symptoms, and is allowed to progress to the next stage each successive day if asymptomatic.

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Medical treatment for persistent symptoms

- Sleep disturbances:
 - Trazodone, melatonin, ambien, behavioral strategies
- Mood symptoms:
 - Psychotherapy, antidepressants (SSRI's, TCAs), anxiolytics (SSRI's, benzo's)
- Somatic symptoms such as headache, dizziness, nausea:
 - Calcium channel blockers, anticonvulsants, beta-blockers, antidepressants, non-sedating anti-emetics
- Cognitive symptoms such as foginess, difficulty concentrating, memory deficits, cognitive fatigue:
 - Neurostimulants (ritalin, amantadine, modafanil)

Memory Impairment

- To help improve recall:
 - Memory practice
 - Use of organizational strategies
 - Mnemonics
 - Using structured teaching techniques to make learning more efficient
 - Backward chaining
 - Making use of compensatory techniques
 - » Memory notebook
 - » Electronic device
 - Avoiding purely verbal
 - Increased repetition

Long Term Effects

- Those who have had one concussion seem more susceptible to another, especially if the new injury occurs before symptoms from the previous concussion have completely resolved.
- There is also a negative progressive process in which smaller impacts cause the same symptom severity.
- Repeated concussions may increase the risk in later life for dementia, Parkinson's disease, and/or depression.

Post-Concussion Syndrome

- In post-concussion syndrome, symptoms do not resolve for weeks, months, or years after a concussion, and may occasionally be permanent
- Symptoms may include headaches, dizziness, fatigue, anxiety, memory and attention problems, sleep problems, and irritability
- There is no scientifically established treatment; rest which is the typical recommendation usually has limited effectiveness
- Symptoms usually resolve after several months
- Debate as to whether the symptoms are due to structural damage or other factors such as psychological issues

Second Impact Syndrome

- Second-impact syndrome, in which the brain swells dangerously after a minor blow, may occur in very rare cases
- The condition may develop in people who receive a second blow days or weeks after an initial concussion, before its symptoms have gone away
- No one is certain of the cause of this often fatal complication, but it is commonly thought that the swelling occurs because the brain's arterioles lose the ability to regulate their size causing a loss of control over cerebral blood flow leading to brain swelling and increased ICP
 - The brain can eventually herniate, and loss of brainstem functions can occur rapidly
- Except in boxing, all cases have occurred in athletes younger than age 20; catastrophic head injuries are three times more likely in high school athletes than in college athletes
 - Debate over whether this is due to two separate hits or just one hit



Chronic Traumatic Encephalopathy (CTE)

- **Chronic traumatic encephalopathy (CTE)** is a progressive degenerative disease which can only be definitively diagnosed postmortem typically seen in individuals with a history of multiple concussions and other forms of head injury
- Individuals with CTE may show symptoms of dementia including memory loss, aggression, confusion and depression that generally appear years or many decades after the trauma
- As of December 2012, 33 former NFL players have had evidence of CTE on post-mortem autopsies
- Autopsies on patients as young as 17 have revealed clinical findings consistent with CTE indicating that early, repeated head trauma requires serious evaluation and management
- Work is being done to identify biomarkers that may indicate presence of CTE in young players

Prevention

An ounce of prevention is worth a pound of cure

- Bike helmets
- Appropriately sized sports gear
- Safety belts/car seats

Bike helmets can be fashionable...



Questions or Comments?

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