



Concussion in Sports

Joaquin Wong, M.D.
LSUHSC-NO/Children's Hospital
New Orleans, LA

Concussion in Sports



- **NFL: 53 concussions by the middle of October 2010**
- **Week 6 of 2010 NFL season: 3 players fined a total of \$175,000**
- **New rules regarding helmet to helmet hits with threat of suspensions**
- **In 2009 the NFL donated \$1 million to Boston U's Center for the Study of Traumatic Encephalopathy**

Concussion in Sports



- 13 of 14 brains of former NFL players studied at Boston Univ were diagnosed with Chronic Traumatic Encephalopathy
- Some had dementia, ALS or severe depression
- CTE has also been found in brains of deceased college and high school football players

Concussion in Sports



- *Biomechanics and pathophysiology of Sport-Related Concussion:*
- Rotational or angular acceleration forces are applied to the brain, resulting in shear strain
- On molecular level: immediate disruption of neuronal membranes, resulting in massive efflux of potassium into the extracellular space.

Concussion in Sports



- Calcium-dependent release of excitatory aminoacids, particularly glutamate, which stimulates further potassium efflux
- Triggering of neuronal depolarization, followed by neuronal suppression
- Na-K pump works to restore homeostasis
- Large amount of energy is expended, which increase glycolysis w/ lactic acid accumulation.

Concussion in Sports



- Decrease in cerebral blood flow
- Mitochondrial dysfunction w/ decrease oxidative metabolism and decreased cerebral glucose metabolism which can be seen within 24 hours, persisting as long as 10 days in experimental models

Concussion in Sports



- **Epidemiology of SRCs**: some numbers
- 20% of TBI resulting in LOC occur during sports activity
- 18% of head injuries reported to the National Head Injury Association are sustained during athletic competition
- 300,000 sport-related TBIs resulting in LOC occur each year

Concussion in Sports



- **Epidemiology cont:**
- Vast majority of SRCs do not involve LOC
- 26% of closed head injuries in children occur during athletics
- 1.5 million Americans participate in American football
- Incidence of SRCs in high school and college football players b/w 4%-5%



Concussion in Sports

- **Epidemiology cont:**
- Athletes do not regularly report concussions
- Much higher rates ranging from 15%-45%
- Concussion accounts for 8%-11% of all injuries in American football
- More likely to occur during games than practices



Concussion in Sports

- **Epidemiology cont:**
- More common in high school athletes than in college players
- Higher incidence in ice hockey accounting for 12% of total injuries
- Concussions are 6 times more likely to occur in organized sports than in leisure physical activity

Concussion in Sports

- **Epidemiology cont:**
- 8.6 % of all game-time injuries in women's soccer (NCAA)
- Due to collision with another player, goal post, ground as opposed to heading the ball.
- Proper skill/technique. Neck musculature.
- Decrease mass/air pressure of ball. Pad goal posts

Concussion in Sports



- *Underreporting:*
- Possible reasons include:
- Personal desire and outside pressure to continue playing
- Failure to recognize the symptoms of concussion
- Jeopardizing future career or financial benefits

Concussion in Sports



- *Underreporting:*
- 28% of athletes report continuing to play after a blow to the head that results in dizziness
- 61% of athletes w/ headache after a blow to the head stay in the game

Concussion in Sports



- Topic of Saturday morning symposium of 39th annual meeting of the Child Neurology Society in October 2010
- Consensus Statement on Concussion in Sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. Published in British Journal of Sports Medicine in 2009

Concussion in Sports



- 1st International Conference on Concussion in Sport, Vienna, Nov 2001
put together by IIHF, FIFA, Medical Commission of IOC
- 2nd Int. Conf on CIS, Prague, Nov 2004.
IRB was added

Concussion in Sports



- Issues studied: epidemiology
- basic and clinical science
- injury grading systems
- cognitive assessment
- new research methods
- protective equipment
- management, prevention and long term outcome



Concussion in Sports

- **1.1 Definition of Concussion:**
- A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.
- 1. Caused either by a direct blow to the head, neck or elsewhere on the body with and ‘impulsive’ force transmitted to the head.

Concussion in Sports



- **Definition cont.**
- 2. Typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously
- 3. May result in neuropathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury

Concussion in Sports



- 4. Results in graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however in a small percentage of cases postconcussive symptoms may be prolonged
- 5. No abnormality on standard structural neuroimaging studies is seen

Concussion in Sports



- **1.2 Classification:**
- To abandon the simple versus complex terminology
- Majority (80-90%) of concussions resolve in a short (7-10 day) period, although the recovery time frame may be longer in children and adolescents

Concussion in Sports



- “Simple”: injury resolves in 7 to 10 days
- “Complex”: Symptoms persist, multiple concussions, LOC > 1 minute, prolonged cognitive impairment

Concussion in Sports

- **2.Evaluation: 2.1 Symptoms and signs of acute concussion.** Clinical symptoms, physical signs, behavior, balance, sleep and cognition.
- A. Symptoms-somatic (e.g. headache), cognitive (e.g. feeling like in a fog), and/or emotional symptoms (e.g. lability)
- B. Physical signs (e.g. loss of consciousness, amnesia)



Concussion in Sports

- **Evaluation cont.**
- C. Behavioral changes (e.g. irritability)
- D. Cognitive impairment (e.g. slowed reaction times)
- E. Sleep disturbance (e.g. drowsiness)

Concussion in Sports

- **Evaluation cont.**
- ***2.2 On-field or sideline evaluation of acute concussion.***
- A. Standard emergency principles with attention to exclude a cervical spine injury
- B. Appropriate disposition of the player by healthcare provider. If none present, remove from play and urgent referral to physician

Concussion in Sports

- *On-field evaluation cont.*
- C. After first aid measures are taken then assess for concussion using SCAT2 or similar tool (Maddocks questions, SAC)
- D. The player should not be left alone. Serial monitoring needs to be done
- E. The player should not be allowed to return to play on the same day





How Do You Feel?

Score yourself on the following symptoms, based on how you feel now.

Symptom	None	Mild	Moderate	Severe			
Headache	<input type="radio"/> 0	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
Pressure in head	<input type="radio"/> 0	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
Neck Pain	<input type="radio"/> 0	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
Nausea or Vomiting	<input type="radio"/> 0	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6

Continue

[← Back](#)

Memory function

[Continue](#)

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?"

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

Concussion in Sports



- *On-field evaluation cont.*
- Considerations: rule change, flow of game,
- Standard orientation questions (e.g. Time, place, person) are unreliable.
- Brief neuropsychological test batteries that assess attention and memory function have been shown to be practical and effective

Concussion in Sports

- 2.3 Evaluation in emergency room or office by medical personnel
- A. History and detailed neurological examination including mental status, cognitive function, gait and balance
- B. Determine if patient's condition is improved or deteriorated
- C. Determine need for neuroimaging to exclude structural abnormality

Concussion in Sports

- **3. Concussion Investigations**
- **3.1 Neuroimaging:** CT or MR whenever suspicion of intracerebral structural lesion exists. Examples of situations include prolonged disturbance of conscious state, focal neurological deficit or worsening of symptoms
- fMRI has shown activation patterns that correlate with symptom severity & recover

Concussion in Sports



- *3.2 Objective balance assessment*
- Postural stability deficits lasting approximately 72 hours have been identified using 'force plate technology', clinical balance tests (e.g. Balance error scoring system (BESS))

Concussion in Sports



- *3.3 Neuropsychological assessment*
- Cognitive recovery may occasionally precede or more commonly follow clinical symptom resolution, suggesting that assessment of cognitive function should be an important component in any return to play protocol

Concussion in Sports



- 3.4 Genetic testing
- Significance of apolipoprotein (Apo) E4, ApoE promotor gene, tau polymerase and other genetic markers in the management is unclear.
- Induction of genetic and cytokines such as IGF-1, IGF binding protein, fibroblast growth factor, SOD, NGF, GFAP, S-100

Concussion in Sports



- *3.5 Experimental concussion assessment modalities*
- Electrophysiology: evoked response potential, cortical magnetic stimulation and EEG have been studied. However can't reliably differentiate from controls
- Biochemical markers in serum and CSF have been proposed. Insufficient evidence

Concussion in Sports



- **4. Concussion management**
- 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.

Concussion in Sports



- *Concussion management cont.*
- Activities that require concentration and attention (e.g. scholastic work, videogames, text messaging, etc) may exacerbate symptoms and possibly delay recovery

Concussion in Sports

- 4.1 Graduated return to play protocol
- Table 1 Graduated return to play protocol
- A. Rehabilitation stage
- B. Functional exercise at each stage of rehabilitation
- C. 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% maximum predicted heart rate. No resistance training /
- Increase heart rate

Concussion in Sports

- Table 1 Graduated return to play protocol cont
- A. Rehabilitation stage
- B. Functional exercise at each stage of rehabilitation
- C. Objective of each stage
- **3. Sport-specific exercise** /Skating drills in ice hockey, running drills in soccer. No head impact activities/
- Add movement

Concussion in Sports



- A. Rehabilitation stage
- B. Functional exercise at each stage of rehabilitation
- C. Objective of each stage
- **4. Non-contact training drills**/ Progression to more complex training drills, e.g. passing drills in football and ice hockey. May start progressive resistance training/
- Exercise, coordination, and
- cognitive load



Concussion in Sports

- A. Rehabilitation stage
- B. Functional exercise at each stage of rehabilitation
- C. Objective of each stage
- **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

Concussion in Sports



- *4.1 Graduated return to play protocol cont.*
- Generally each step should take 24 hours so that an athlete would take approx one week to proceed through the full rehabilitation protocol once they are asymptomatic at rest and with provocative exercise.

Concussion in Sports



- 4.2 Same day RTP
- Adult athletes in some settings i.e. some professional American football players are able to RTP more quickly without risk of recurrence or sequelae
- However, at collegiate and high school level some athletes allowed to RTP on the same day may demonstrate NP deficits post injury not evident on the sidelines

Concussion in Sports



- *Same day RTP cont.*
- The young (<18) athlete should be treated more conservatively
- 4.3 Psychological management and mental health issues
- Need to evaluate the concussed athlete for affective symptoms such as depression

Concussion in Sports

- 4.4 The role of pharmacological therapy
- A. Management of specific prolonged symptoms e.g. sleep disturbance, anxiety, etc
- B. Drug therapy to modify the underlying pathophysiology
- Athlete should not only be symptom free but also not be taking any pharmacological agent that may mask or modify symptoms



Concussion in Sports

- *4.5 The role of pre-participation concussion evaluation*
- Get detailed concussion history
- Identify athletes that fit into a high risk category
- Incl. previous symptoms of a concussion

Concussion in Sports

- **5. Modifying factors in concussion management**
- Table 2 Concussion modifiers
- I. Factors/ II. Modifier
- **A)Symptoms**/ Number, Duration (>10 days), Severity
- **B)Signs**/ Prolonged loss of consciousness (>1 min), amnesia
- **C)Sequelae**/ Concussive convulsions
- **D)Temporal**/ Frequency—repeated concussions over time. Timing—injuries close together in time.
“Recency”—recent concussion or traumatic brain injury

Concussion in Sports

- I. Factors/ II. Modifier
- **E. Threshold**/ Repeated concussions occurring with progressively less impact force or slower recovery after each successive concussion
- **F. Age**/ Child and adolescent/ (<18 years old)
- **G. Co- and pre-morbidities**/ Migraine, depression or other mental health disorders, attention deficit hyperactivity disorder, learning disabilities, sleep disorders

Concussion in Sports



- I. Factors/ II. Modifier
- **H. Medication**/ Psychoactive drugs, anticoagulants
- **I. Behavior**/ Dangerous style of play
- **J. Sport**/ High risk activity, contact and collision sport, high sporting level

Concussion in Sports



- 5.3 Motor and convulsive phenomena
- Immediate motor phenomena (e.g. tonic posturing) or convulsive movements
- 5.4 Depression
- Depression and other mental health issues have been reported as long-term consequence of TBI, incl sports related

Concussion in Sports



- **6. Special populations**
- **6.1 The child and adolescent athlete**
- Recommendations applied to children and adolescents down to 10 years of age.
- NP testing needs to be sensitive to stage of development
- Children should not return to practice or play until clinically completely symptom free

Concussion in Sports



- Concept of ‘cognitive rest’
- Limit exertion with activities of daily living and limit scholastic and other cognitive stressors (e.g. text messaging, videogames, etc.)
- It is not appropriate for a child or adolescent athlete to RTP on the same day regardless of level of athletic performance

Concussion in Sports



- *6.2 Elite versus non-elite athletes*
- All athletes should be managed the same regardless of level of participation
- Formal baseline NP screening is recommended in all organized high risk sports

Concussion in Sports



- *6.3 Chronic traumatic brain injury*
- Epidemiological studies have suggested an assoc b/w repeated sports concussions and late life cognitive impairment
- Neuropathological evidence of chronic traumatic encephalopathy in retired football players

Concussion in Sports



- 7. Injury prevention
- There is no good clinical evidence that currently available protective equipment will prevent concussion although mouthguards have a definite role in preventing dental and orofacial injury
- Biomechanical studies have shown a reduction in impact forces to the brain with the use of head gear and helmets

Concussion in Sports



- 7.2 Rule change
- Consideration of rule change where a clear-cut mechanism is implicated
- E.g. Football/Soccer: upper limb to head contact in heading contest account for approx 50% of concussions

Concussion in Sports



- 7.3 Risk compensation
- Use of protective equipment results in behavioral change, such as more dangerous playing techniques.
- This is a concern in child and adolescent athletes where head injury rates are higher than in adult athletes

Concussion in Sports



- 7.4 Aggression versus violence in sport
- Maintain the competitive/aggressive nature of sport which makes it fun to play and watch
- Sports organizations are encouraged to address violence
- Fair play and respect should be supported

Concussion in Sports



- 8. Knowledge transfer
- Education of colleagues, athletes, referees, coaches, parents, administrators, and general public
- Web-based resources, educational videos, international outreach programs



Concussion in Sports

- 9. Future directions
- Validation of SCAT2
- Gender effects on injury risk, severity and outcome
- Pediatric injury and management paradigms
- Virtual reality tools in the assessment of injury

Concussion in Sports

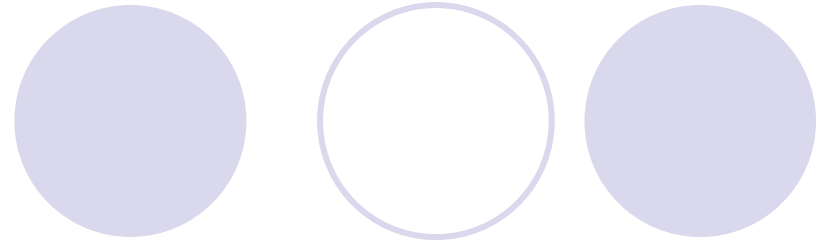
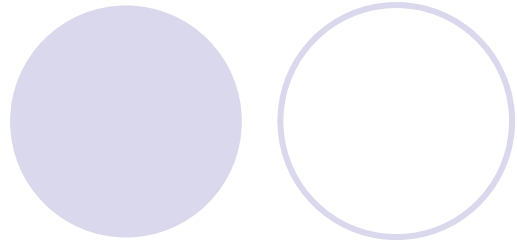


- *Future directions cont.*
- Rehabilitation strategies (e.g. exercise therapy)
- Novel imaging modalities and their role in clinical management
- Concussion surveillance using consistent definitions and outcome measures

Concussion in Sports



- Clinical assessment where no baseline assessment has been performed
- “Best-practice” neuropsychological testing
- Long-term outcomes
- On-field injury severity predictors
- *10. Medico-legal considerations*
- Only a guide, not intended as standard of care



THE END