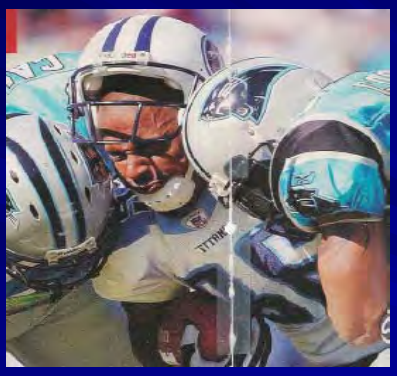
The Management of Concussion in the Pediatric & Adolescent Population



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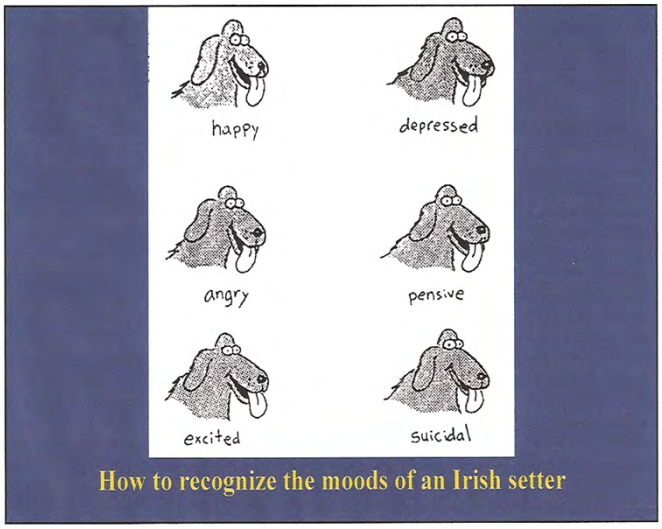
Disclosure

Aaron M. Karlin, MD has no relevant financial disclosures

Overview

- Definition
- Epidemiology
- Historical Management
- Current Concussion Management Guidelines
- Return to Play Criteria
- Concussion Clinic Setting Evaluation
  - Role of ImPACT Neuropsych testing
- Resources for Physicians



Just what is a Concussion (mTBI)?

- "Concussion" – from the Latin *concussus* or *concutere*, meaning "to shake" or "be shaken violently"
- "…a pathophysiological process involving the brain, induced by traumatic biomechanical forces.
- Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness or memory dysfunction.
- Concussion typically results in a functional disturbance with the rapid onset of short-lived impairment of neurological function that resolves spontaneously…"

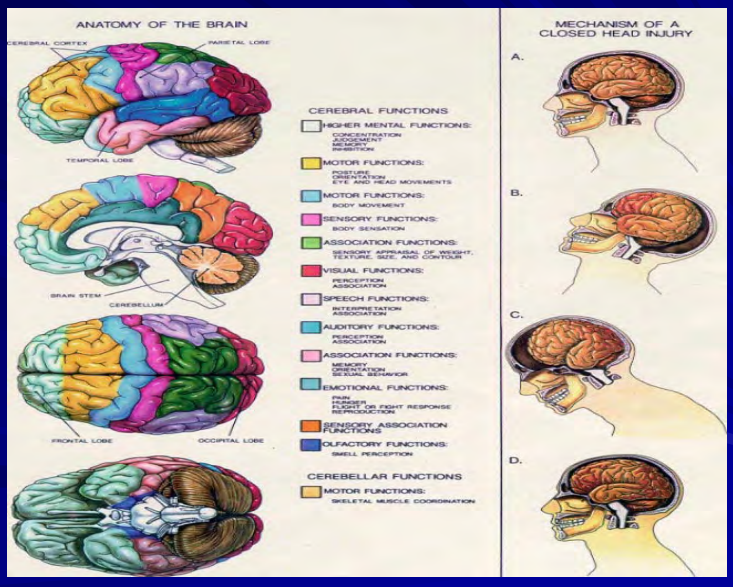
Summary and Agreement Statement of the 1st International Symposium on Concussion in Sport. Clin J Sports Med 12(1): 6-11 , 2002

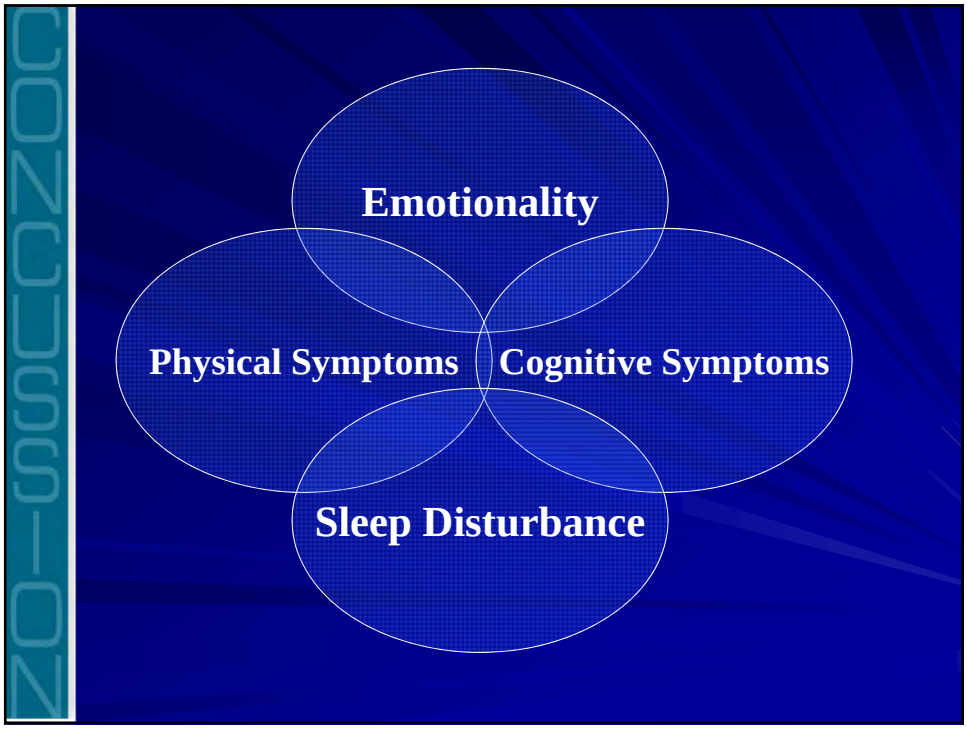
What is a Concussion?

What is a Concussion?

- Concussion can be caused by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head.
- Typically associated with grossly normal structural neuroimaging studies
- Symptoms and signs do not always occur immediately after injury – may evolve over time
- Resolution of the clinical and cognitive symptoms typically follows a sequential course

What is a Concussion?





Signs & Symptoms of Concussion

- Physical
  - Headache
  - Dizziness
  - Nausea
  - Balance problems
  - Feeling “dinged” or “stunned”
  - Visual disturbances
  - Photophobia
  - Tinnitus
  - Diplopia
  - Simply “not feeling right”.

Post Concussion Symptom Scale

	None			Moderate			Severe
Headache	0	1	2	3	4	5	6
“Pressure in head”	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Balance problems/dizzy	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Vision problems	0	1	2	3	4	5	6
Hearing problems/ringing	0	1	2	3	4	5	6
“Don’t feel right”	0	1	2	3	4	5	6
Feeling “dinged”/“dazed”	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like “in a fog”	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
More than emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
(follow up symptoms only)							
Sadness	0	1	2	3	4	5	6
Nervous or anxious	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
Sleeping more than usual	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Other:	0	1	2	3	4	5	6

Signs & Symptoms of Concussion

- Cognitive
  - Confusion
  - Post-traumatic amnesia
  - Disorientation
  - Poor concentration
  - Memory disturbance
  - Feeling mentally "foggy"
  - Slowed reaction times
- Sleep Disturbance
  - Diff falling/staying asleep
  - Excessive fatigue
  - Daytime somnolence
- Emotional Signs & Sx's
  - Sadness
  - Moodiness
  - Emotional lability
  - Nervousness

Commonly reported symptoms

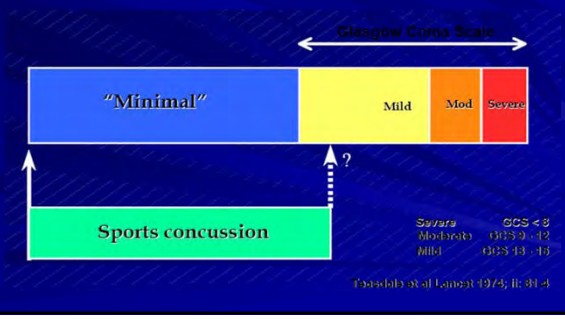
High School and College Athletes:
within 3 days of injury

Headache	71%
Feeling slowed down	58%
Difficulty concentrating	57%
Dizziness	55%
Fogginess	53%
Fatigue	50%
Visual Blurring/double vision	49%
Light Sensitivity	47%
Memory dysfunction	43%
Balance problems	43%

Lovell, Collins et al., 2004; N=215

Epidemiology

- Estimated 1.7 - 1.8 million/year
  - 300,000 sports-related TBI with LOC (Thurman et al., 1999)
- High School athletics (Powell,et al., 2002)
  - 3 year time span, 236 schools surveyed
    - 23,566 total injuries
      - 1,291 concussions (5.5%)

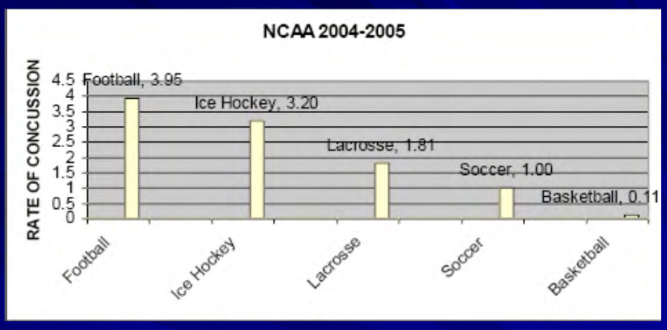


Sports-related Concussion

- 26% of Closed Head Injuries → Athletics
- Children under 5 yrs. suffer relatively few concussions from participating in sports and recreation activities.
- Concussion frequency increases as age increases and peaks between the years of 15-24.
  - 0.8 injuries per 100,000 persons in children under 5
  - 5.1 per 100,000 in youth ages 5-14
  - 6.6 per 100,000 in those aged 15-24.

Epidemiology

- > 10% of all contact sport athletes sustain concussions yearly
- > 50% of all concussions occur in football (>90,000/year)
- Estimated that up to 20% of football players will sustain a concussion per season.
- "Bell ringers" or mild concussions account for > 50% of all concussive injuries
- Concussions resulting in LOC account for only 8% to 19% of injuries (Collins et al., 2003; Schultz et al., 2004).
- Estimated 1.7 million sports-related concussions per year (CDC Toolkit for Physicians, 2007).
  - Majority are sustained by children and adolescents
    - 7.6 million H.S. athletes → 1.1 million in H.S. football



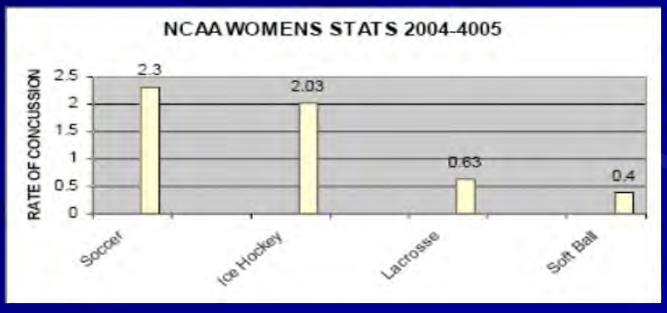
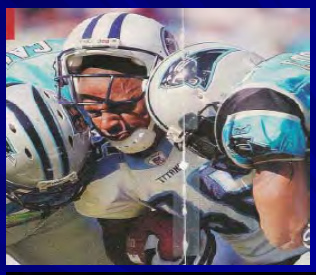


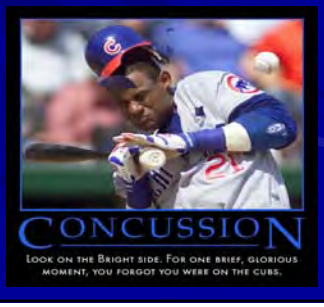
TABLE 1. 1989-1998 NCAA Injury Surveillance System Concussion Data

Sports with head protection	Concussion as a percent of all game injuries
Ice hockey	7.5
Men's lacrosse	5.2
Football	4.5
Softball	3.6
Baseball	2.7
Sports without head protection	
Field hockey	13.0
Women's soccer	11.0
Men's soccer	9.0
Women's lacrosse	8.5
Women's basketball	8.0
Wrestling	4.3
Men's basketball	3.1

Children are Different!

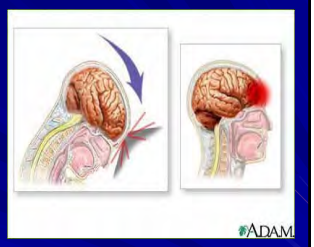
VS.





Children are different…

- Thought most brain growth completed by age of 5 yrs., likely 95% by this time.
- Area of the brain, the prefrontal cortex ("CEO" of function), is growing again before puberty.
- Overproduction of synapses around the age of 11 or 12 then a pruning during adolescence. Loss of 1% of grey matter per year.
- Changes in the corpus callosum and the cerebellum also occur during adolescence.
- "Use or lose it" time period



Children are Different…

- Increased vulnerability due to rapidly emerging neurodevelopmental pathways
- "Plasticity" may not be protective in concussion

Children are different…

- Frontal cortex is not fully myelinated until the early 20s.
- Studies are showing that it takes longer for high school athletes to recover from concussions than adults.

Recovery Rates Vary by Age/Dependent Measure

Authors	*Sample Size*	*Population*	*Tests Utilized*	*Total Days Cognitive Resolution*	*Total Days Symptom Resolution*
Lovell et al. 2005	95	Pro (NFL)	Paper and Pencil	1 day	1 day
Echemendia 2001	29	College	Paper and Pencil	2 days	2 days
McCrea et al. 2003	94	College	Paper and Pencil	5-7 days	7 days
Guskiewicz 2003	94	College	Balance BESS	3-5 Days	7 Days
Bleiberg et al. 2005	64	College	Computer ANAM	3-7 days	Did Not Evaluate
Iverson et al. 2006	30	High School	Computer ImPACT	10 days	7 Days
McClincy 2006	104	High School	Computer ImPACT	14 days	7 Days

Children are different…

- Lack of proper technique
  - Less-refined movement and coordination at earlier ages
- Reduced neck and shoulder strength/stability
- Less frequent practices
- Lack of concussion awareness & education
  - Parents, coaches, athletes

Children are different…

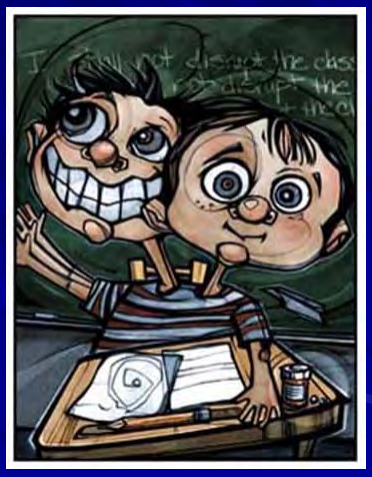
- Barlow, et al. (2010)
  - 670 patients with mTBI
  - Followed 1 year out from injury
  - 13.7% of school-aged children (6-18 yrs.) remained symptomatic 3 months out from injury
  - 2.3% were symptomatic 1 year out

Pre-school mTBI and behavior

- McKinley, et al. (2008)
  - mTBI 0-5 yrs of age
    - GCS > 13
    - LOC < 20 minutes
    - Hosp < 2 days
    - No skull fracture
  - Inpatient vs. outpatient
  - Control group
  - ADD/ADHD & ODD/CD symptoms
    - Rutter and Conners questionaires
    - Assessed each year from 7-13 years

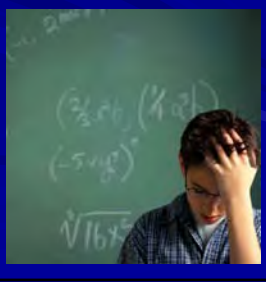
Pre-school mTBI and Behavior

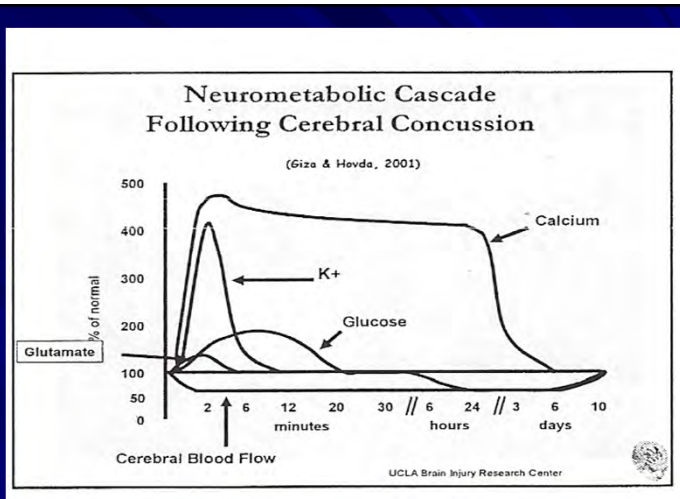
- Increased ADD/ADHD *and* ODD/CD symptoms in the inpatient mTBI group
- No difference in outpatient group compared to control
- Severity of mTBI more important than age?



Children are different…

- Hastening the resolution of symptoms is paramount
- "Use it or lose it" time period for the developing brain
- "Pause button" analogy
- Difficulty acquiring new skills both during and after brain healing





Initially K+ is released from damaged cells and Ca++ flows into the neurons causing swelling and activates proteases which breakdown the integrity of the cell. This results in hyperglycolysis and due to the inability to increase the blood flow, a metabolic crisis results. Glutamate, an excitatory neurotransmitter, likely plays a role as excess in the damaged area surrounding the injury causes degeneration and apoptosis.

Common Concussion "Myths"

- A child must be rendered unconscious to sustain a concussion
- Having your "Bell Rung" is not big deal
- You can "push through" a concussion
- Children will report if they feel "bad" after a hit or fall
- Concussions are ONLY from a head injury
- Concussion symptoms appear immediately
- Concussions ONLY occur in football, boxing, and hockey
- 's experience more concussions than 's in the same sport
- All physician's are well educated on the management guidelines of concussions

Problems in Identification and Management of Concussion

- Lack of awareness in athletes, coaches, parents
- Lack of up-to-date knowledge within the medical community
- Lack of clinical tools to assess and manage concussion
- Lack of appropriate medical care systems
  - Primary vs. Specialty care (concussion clinics)

Sports Concussion (mis)management: Topics of Concern

- Prior guidelines not data driven
  - Over 20 different concussion grading scales based on subjective data
- Self-reporting by athletes is not always accurate and/or honest and are SUBJECTIVE
- CT and MRI are used too often
  - Diagnoses changes in anatomic structure and a concussion is primarily a biochemical/physiological/***FUNCTIONAL*** abnormality
- Inconsistencies in physician recommendations on Return to Play because of inconsistent knowledge and lack of accepted guidelines.

	Mild Grade I	Moderate Grade II	Severe Grade III
Cantu (1986)	No LOC PTA < 30 min	LOC < 5 min PTA 30 min-24 hrs	LOC > 5 min PTA > 24 hrs
Colorado (1991)	Conf; No LOC No amnesia	Conf & amnesia No LOC	LOC
AAN (1997)	No LOC Conf < 15 min	No LOC Conf > 15 min	Any LOC

Grade 1 (Mild)	No LOC*; PTA† <30 minutes; PCSS‡ <24 hours
Grade 2 (Moderate)	LOC <1 minute *or* PTA ≥30 minutes <24 hours *or* PCSS ≥24 hours <7 days
Grade 3 (Severe)	LOC ≥1 minute *or* PTA ≥24 hours *or* PCSS ≥7 days

*Loss of Consciousness
†Post Traumatic amnesia (anterograde/retrograde)
‡Post Concussion signs/symptoms other than amnesia

Cantu R.C., *Journal of Athletic Training*, 2001,Vol. 36(3): 244-248

Changes in Concussion Management: Guideline Evolution

- 1st International Symposium on Concussion in Sport, Vienna, Nov, 2001
  - Organized by International Ice Hockey Federation, FIFA, and International Olympic Committee
  - Concussion defined as "…a pathophysiological process involving the brain, induced by traumatic biomechanical forces."
  - "Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness or memory dysfunction."
  - "Concussion typically results in a functional disturbance with the rapid onset of short-lived impairment of neurological function that resolves spontaneously."

Does loss of consciousness matter?

- Answer: PROBABLY NOT!
- *Does loss of consciousness predict neuropsychological decrements of concussion? (*Lovell, et al.1999)
  - After Concussion, no difference in LOC vs. non-LOC groups of neuropsych testing
  - Study casts doubt on importance of LOC as predictor of neuropsych test performance
  - Does not provide support for guidelines that rely heavily upon using LOC regarding grade and return to play decisions

Summary statement of the 2nd International Conference on Concussion in Sport, Prague, 2004 "Guidelines Redux"


- Concussion severity can only be determined after all signs/symptoms have cleared, neurologic exam wnl, cognitive function returned to baseline.
  - Abandoned previous used grading scales
- LOC is associated with early deficits but not concussion severity
- Data suggests that the nature, burden, and duration of post-concussion symptoms are more important than the presence of post-traumatic amnesia

Summary statement of the 2nd International Conference on Concussion in Sport, Prague, 2004 "Guidelines Redux"

- Pediatric concussion guidelines similar to adults with concept of "cognitive rest" with scholastic and ADL performance while symptomatic
  - Ages 5-18 years
- Classification of Concussion based on duration of symptoms
  - Simple vs. Complex

Simple vs. Complex Concussions

- Simple
  - Symptoms & Signs resolve within 10 days
  - No recurrence with progressive return to play
  - By definition, no risk for post-concussive syndrome
  - LOC transient, "blacked out"
- Complex
  - Symptoms & Signs persist > 10 days
  - LOC > 1 minute
  - Prolonged cognitive impairment
  - Referral to ***sports concussion*** specialist recommended

3rd International Conference on

Concussion in Sport

30 October 2008 | 9:00 – 17:00hrs
hosted by FIFA at the Home of FIFA in Zurich

Zurich, 2008 CIS Consensus Statement

- Abandon the simple vs. 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.
- *SCAT2* form developed (SAC + BESS)
- Sideline: A player with diagnosed concussion should not be allowed to return to play on the day of injury. Occasionally in adult athletes, there may be return to play on the same day as the injury.
  - Recognized delayed onset of symptoms

Zurich, 2008 CIS Consensus Statement

- Concussion Management
  - Reinforced Physical AND Cognitive Rest
  - Graduated RTP: when asymptomatic at rest
    - stepwise progression, proceed to next level if asymp at current.
    - Each step to take a ***minimum*** of 24 hours; would take approximately one week to proceed through the full rehabilitation protocol
- Modifying Factors in Concussion Management
  - A range of 'modifying' factors may influence the investigation and management of concussion and in some cases, may predict the potential for prolonged or persistent symptoms

Zurich, 2008 CIS Consensus Statement: "Modifying Factors"

- Symptoms
  - Number, Duration (>10days), Severity
- Signs
  - Prolonged LOC (> 1 minute)
- Sequelae
  - Concussive Convulsions
- Temporal
  - Frequency, repeat, timing
- Threshold
  - Less impact force required
- Age
  - < 18 years
- Co-morbidities
  - Migraine, Mental illness, ADD/ADHD, LD, Sleep disorders
- Medication
  - Psychoactive drugs
- Behavior
  - Dangerous Style of Play
- Specific Sport Participation
  - Contact/Collision

4th International Consensus Conference on **Concussion in Sport**

Zurich, November, 2012

- Consensus Statement recently published in March: *Br J Sports Med*, 2013;47:250-258.
  - Reinforced 3rd Int'l Conf recommendations
  - Importance of Vestibular Testing
  - Role of Neuropsychological testing
  - More conservative management for < 13 yrs of age
  - Development of SCAT3 and Child-SCAT3

4th International Consensus Conference on **Concussion in Sport**

Pocket CONCUSSION RECOGNITION TOOL

To help identify concussion in children, youth and adults

RECOGNIZE & REMOVE

Concussion should be suspected if one or more of the following visible clues, signs, symptoms or errors in memory questions are present.

1. Visible clues of suspected concussion

Any one or more of the following visual clues can indicate a possible concussion:

Loss of consciousness or responsiveness
Lying motionless on ground/Slow to get up
Unsteady on feet / Balance problems or falling over/Incoordination
Grabbing/Clutching of head
Dazed, blank or vacant look
Confused/Not aware of plays or events

2. Signs and symptoms of suspected concussion

Presence of any one or more of the following signs & symptoms may suggest a concussion:

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

3. Memory function

Failure to answer any of these 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?"

Any athlete with a suspected concussion should be IMMEDIATELY REMOVED FROM PLAY, and should not be returned to activity until they are assessed medically. Athletes with a suspected concussion should not be left alone and should not drive a motor vehicle.

It is recommended that, in all cases of suspected concussion, the player is referred to a medical professional for diagnosis and guidance as well as return to play decisions, even if the symptoms resolve.

RED FLAGS

If ANY of the following are reported then the player should be safely and immediately removed from the field. If no qualified medical professional is available, consider transporting by ambulance for urgent medical assessment:

- Athlete complains of neck pain
- Increasing confusion or irritability
- Repeated vomiting
- Seizure or convulsion
- Weakness or tingling/burning in arms or legs
- Deteriorating conscious state
- Severe or increasing headache
- Unusual behaviour change
- Double vision

Remember:

- In all cases, the basic principles of first aid (danger, response, airway, breathing, circulation) should be followed.
- Do not attempt to move the player (other than required for airway support) unless trained to do so
- Do not remove helmet (if present) unless trained to do so.

From McCrory et. al, Consensus Statement on Concussion in Sport. Br J Sports Med 47 (5), 2013

Sports Concussion (mis)management: Topics of Concern

- Prior guidelines not data driven
  - Over 20 different concussion grading scales based on subjective data
- Self-reporting by athletes is not always accurate and/or honest and is SUBJECTIVE
- CT and MRI are used too often
  - Diagnoses changes in anatomic structure and a concussion is primarily a biochemical/physiological/***FUNCTIONAL*** abnormality
- Inconsistencies in physician recommendations on Return to Play because of inconsistent knowledge and lack of accepted guidelines.

Self-reporting of Concussion

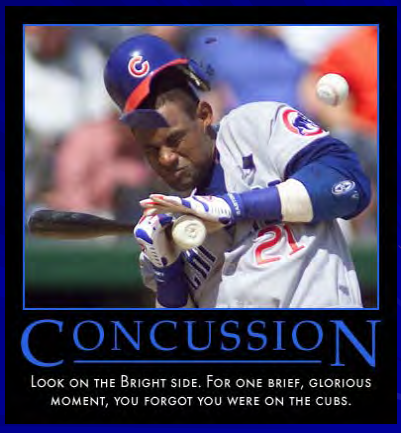
- *Collins and Lovell, 2003*
  - Previous studies show 3.6% in HS Football
  - In this study 30% had a concussion prior to current season
  - During season 15.3 % had concussion and only 47.3% reported the injury.
    - ATC (76.7%)
    - Coach 38.8%
    - Parent (35.9%)
    - Teammate (27.2%)
    - Others (include MDs) 11.7%

Self-reporting of Concussion

- *Kaut KP, et al., 2003*
  - Collegiate athletes
  - RTP same game after blow to head
    - 61% with headache
    - 28% with dizziness, imbalance

Self-reporting of Concussion

- Reasons for not reporting injury
  - Athlete didn't believe it was serious enough to report
  - Not wanting to leave the game or practice
  - Not knowing the injury was a concussion
  - Not wanting to let teammates down
  - Residual belief that it is macho to play hurt!!



McCrea, Hammeke, Olsen et al. *Clin J Sport Med* 2004;14:13-17

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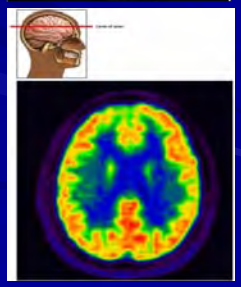
To Image or not to Image…

- When?
  - Acute changes/worsening
  - High risk mech of injury (e.g. MVC)
  - Severe cognitive deficits
  - Prolonged duration of symptoms
  - ? LOC > 1 minute
  - Focal neurologic exam findings
- For the majority of concussions imaging is wnl.
- CT-scan, MRI most common
- Role for fMRI, PET-scan?



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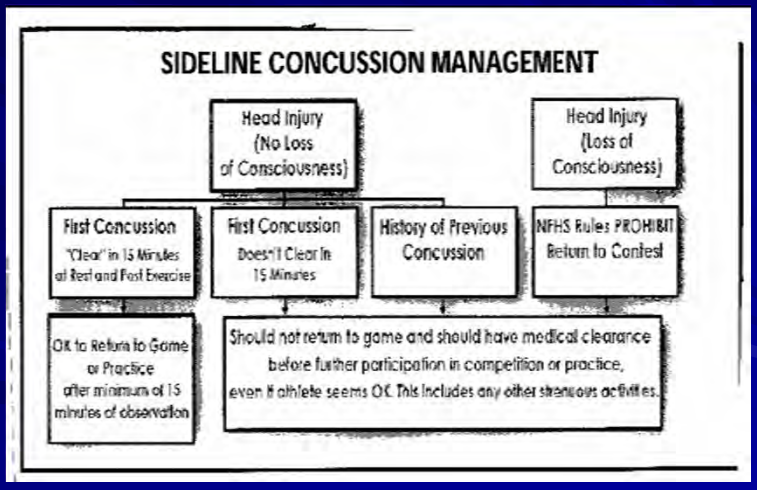
- CT and MRI are used too often
  - Diagnoses changes in anatomic structure and a concussion is primarily a biochemical/physiological/***FUNCTIONAL*** abnormality
- Inconsistency in physician recommendations on Return to Play because of limited knowledge in management and lack of accepted guidelines.

- Prior Return to Play Guidelines Vague
  - Allowed RTP if Sx's cleared < 15 minutes



Current Concussion Management

- The initial cornerstone of concussion management is ***rest until all symptoms resolve***
  - It is unsafe to return to play while symptomatic
- This includes ***both physical and cognitive rest*** and must be emphasized to the patient and parents
  - TV, video games, reading
  - School attendance, homework
  - Physical activity
  - Any "brain stimulation"
- Return to activity ***is graduated*** and the patient should be asymptomatic for 24 hrs ***(min)*** prior to moving to the next level.
  - Asymptomatic = No physical, cognitive, emotional symptoms

Progressive Return to Play Strategy (Prague, 2004)

(1) ***No activity; complete rest***. When asymptomatic proceed to Step 2.

(2) Light aerobic exercise (i.e. walking, stationary cycling). No resistance training.

(3) Sport-specific exercise (i.e. skating in hockey, running in soccer). Progressive addition of resistance training.

(4) Non-contact, sport-specific training drills

(5) Full-contact training ***after*** medical clearance

(6) Return to Game play

Current Concussion Management

- Physical & Cognitive Rest and School
  - ***No P.E. or recess until fully cleared***
  - Academic decline not uncommon
    - Reading comp., memory, slow processing, prolonged test taking
    - Schoolwork, school environment may exacerbate symptoms
  - ***Clinician, school administration communication is key***
    - ATC and school nurse or guidance counselor as liaison
  - Removal from school may be necessary initially
    - Half day attendance is an option
    - Needs to be considered re: allowable absences
  - May need short-term accommodations
    - Open book/untimed tests, pre-printed class notes, tutoring, prolonged deadlines to complete work
    - Postpone standardized testing
    - Role of development of an appropriate 504 Plan or IEP

Return to Play Considerations

- No symptoms is predictive of severity, duration (LOC, PTA, etc.)
  - Prior grading systems based on Sx's not relevant
- Post-concussion Sx's last longer than thought
- Sx's do not recover in linear fashion
  - Sx's may be greatest the day after injury
- Exercise, stress can exacerbate Sx's if not recovered
  - Exercise testing important part of RTP protocol

Return to Play Considerations

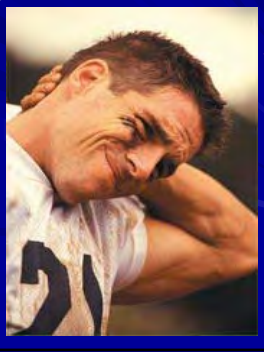
- ***No athlete should RTP even if Sx's clear within 15 minutes***
- Inadequate "brain rest" can…
  - ↑ risk of repeat concussion
  - ↑ risk of more severe post concussive symptoms
    - Cognitive impairments
    - Emotional disturbances
  - Delay recovery
  - ↑ risk of catastrophic event

Concussion-related Emergencies

- "Second Impact" Syndrome
  - Observed primarily in athletes < 21 years of age
  - Rapid brain swelling and herniation following a second head injury sustained before the resolution of post-concussive symptoms of a previous concussion.
    - Second blow often minor
    - Typically, no LOC and athlete remains on feet but initially dazed
    - Within 15 seconds to minutes, athlete collapses
  - Pathophysiology
    - Vasomotor paralysis → cerebral edema → increased ICP → herniation
  - 50% mortality and nearly 100% morbidity

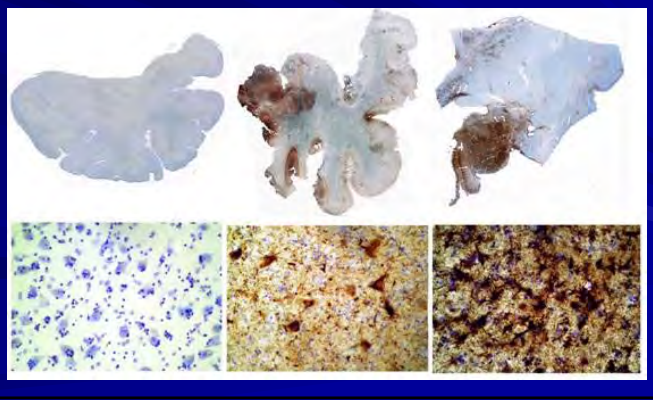
Long Term Effects

- Post-Concussion Syndrome
  - Persistent physical symptoms → headache, dizziness
  - Emotional lability → depression, irritability
  - Cognitive Impairment → academic decline
    - Reduced GPA in athletes with > 2 concussions compared to controls (Moser et al., 2005)
  - Attention and/or memory deficits
  - Sleep cycle disruption
- Chronic Traumatic Encephalopathy



Long Term Effects

- Chronic Traumatic Encephalopathy
  - Brain tissue degeneration
  - Tau protein deposition
  - Dementia, Emotional lability



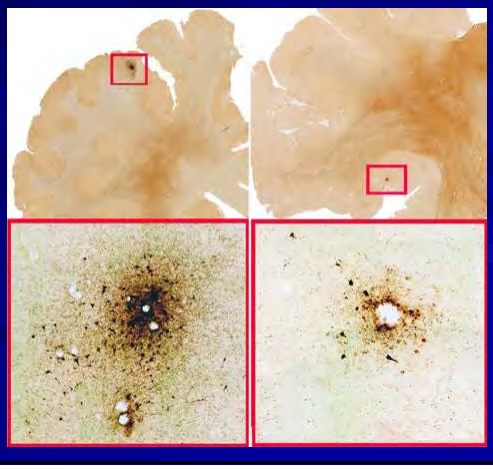
Chronic Traumatic Encephalopathy

- Chris Henry, 26 years old
  - Cincinnati Bengals, WR
    - Previously youngest dx'd with CTE

- Owen Thomas, 21 years old
  - U Penn, Wharton School of Business
  - 2nd team All-Ivy League, lineman
  - ***NO hx of documented concussions***
  - Hx of emotion change, depression

Chronic Traumatic Encephalopathy

- 18 y.o multi-sport athlete
  - +Hx of multiple concussions

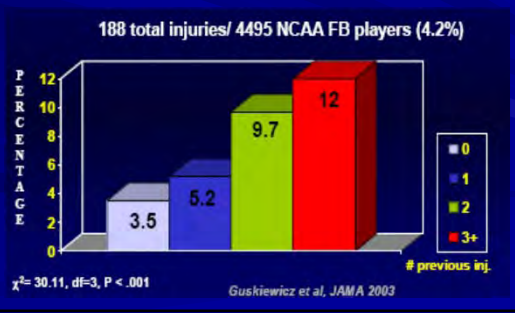


Return to Play

- The final decision regarding when and if a concussed athlete can return to competition is made on an individual basis and will depend on:
  - Athlete's concussion history
  - Severity of the injury
  - Duration of signs and symptoms
  - Time between injuries
  - Severity of blow causing concussion
  - Availability of experienced personnel to conduct repeated assessments and monitoring recovery.

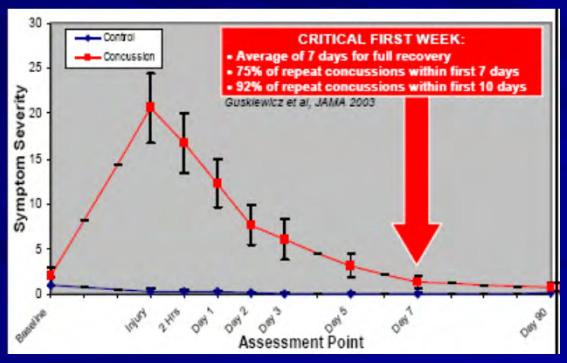
Predisposition for future injury?

- Risk of repeat concussion:
  - Players with 3+ previous concussions → 3.5x more susceptible to incur repeat concussion
  - Players with 2 previous → 2.8x (95%CI: 1.6-4.7) risk
  - Players with 1 previous → 1.5x (95%CI: 1.0-2.1) risk



Recurrent Concussion risk?

- 11/12 (92%) in-season repeat concussions occurred within 10 days of the first injury
- 9/12 (75%) occurred within 7 days of the first injury



Guskiewicz et al, JAMA 2003

Recurrent Concussion risk?

- Why risk may be greatest within 7-10 after injury
  - (1) Pre-disposed due to style of play
  - (2) Are some athletes more susceptible to concussion?
    - Apolipoprotein Eε4 allele
  - (3) Age/level of play may expose certain athletes to greater forces than not sustaining concussion
  - (4) Do players with ↑ # of concussions simply receive more playing time?
  - (5)More susceptible due to inherent changes in the brain after initial concussion
    - Still symptomatic / brain not yet fully healed

Acute Concussion Management on the Sideline

- Remove from game immediately
  - ***NO RETURN SAME DAY***
- Sideline neurologic and mental status evaluation
  - Orientation, memory, balance
- Ensure child is attended by adult at all times
  - Serial sideline reevaluation q10-15 minutes
- No medication unless Physician prescribed
- Physician evaluation next day
  - To ED if acutely worsening N/V, HA, ↓ MS
- **"When in doubt….Sit them out"**

Concussion-related "RED FLAGS" for acute emergency management within first 24-72 hours:

Referral to ED with sudden onset of any of the following:

- Severely worsening HA
- Repeated vomiting
- ↑ drowsiness / difficult to awaken
- Difficulty recognizing people or places
- Neck pain
- Seizures

- Increasing confusion or irritability
- Unusual behavioral change
- Focal neurologic signs
- Slurred speech
- Weakness or numbness in arms/legs
- Change in state of consciousness

Concussion Management in the ED

- Is imaging necessary?
  - Concussion = metabolic, functional disturbance -- not structural
- Meehan, et al, *J Peds*, 2010
  - 69% of peds pt's dx'd with concussion received imaging in ED -- majority was CT
  - Conc child w/ nl MS, no focal neuro abnl, no skull fx
    - As low as 0.02% risk of significant intracranial pathology
- Exposure to radiation
  - Adult vs. pediatric CT settings
  - Malignancy risk is cumulative
    - After one CT-Head → 1:2000 for < 2 yo child and 1:10,000 for 15 yo

Concussion Management in the ED

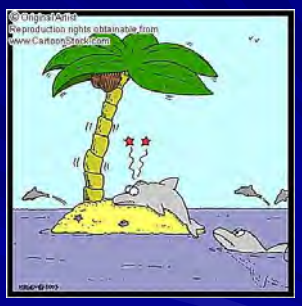
- Clinical Hx
- PEx including full neurologic exam, balance, gait
  - Focality? Asymmetry? Stable over time?
- Gross majority can be discharged home
- ***D/C instructions are key!***
  - Follow-up with medical provider < 72 hrs
    - Lovell, et al., 2004 → 28% of conc peds pt's d/c'd from ED did not receive instruction to f/u w/MD
    - Genuardi et al., 1995 → d/c instructions did not include activity restrictions of physical and cognitive rest

Concussion Management in the ED

- Ponsford, et al., 2001
  - Reduction of post-concussion Sx's and behavioral changes at 3 mos. post-conc if pt & family informed of expected Sx's, varying time course for resolution, and rec'd management strategies
- ED Physician, Nurse should review "red flag" signs/symptoms suggestive of slowly evolving intracranial pathology (e.g. SDH)
- Home from school until MD follow-up ***is appropriate*** in some cases!

Concussion Management in the Office

- Complete evaluation of a Concussion often involves…
  - Clinical History
  - Physical Evaluation
  - Balance Testing
  - Neuropsychological Testing
  - Neuro Imaging
  - Rehabilitation
  - Prevention/Counseling



- The RTP decision should be ***individualized***, and not based on a rigid timeline

Concussion Management in the Office

- Clinical history
  - Immediate post-concussion
  - Changes since injury
  - Current status
  - Always corroborate details
    - Parents, video?
  - 3 Components
    - Characteristics of the injury
    - Types and severity of symptoms
    - Risk factors that can lead to a protracted period of recovery.

Clinical History

- Injury Characteristics
  - Mechanism of Injury
  - Cause
  - Post-traumatic amnesia
    - Retrograde vs. Anterograde
  - Loss of consciousness
  - Seizure
- Post-Concussion Symptom Scale scoring

Post Concussion Symptom Scale

	None			Moderate			Severe
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Balance problems/dizzy	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Vision problems	0	1	2	3	4	5	6
Hearing problems/ringing	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Feeling "dinged"/"dazed"	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
More than emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
(follow up symptoms only)							
Sadness	0	1	2	3	4	5	6
Nervous or anxious	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
Sleeping more than usual	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Other:	0	1	2	3	4	5	6

Clinical History

- Risk Factors for prolonged recovery
  - Concussion history
    - Number, severity, time to recovery
  - Headache History
    - Migraines
  - Developmental History
    - Developmental Delay, MR
  - Psychiatric History
    - ADD/ADHD, Depression/Anxiety

Physical Examination

- HEENT
- Neck
  - C-spine, Sperling's Maneuver
- Musculoskeletal
  - MMT, ROM
- Neurologic
  - Cranial nerves, Heel/toe, Romberg
  - 30 second balance testing +/- aerobic challenge

Cognitive Examination

- Sports Concussion Assessment Tool (SCAT)
  - Recall
  - Numbers/months in reverse
  - Serial 7's
  - Basic MMS questions

The SCAT Card (Sport Concussion Assessment Tool)
Medical Evaluation

Name: _____ Date: _____

Sport/Team: _____ Mouth guard? Y N

1) SIGNS
Was there loss of consciousness/unresponsiveness? Y N
Was there seizure or convulsive activity? Y N
Was there a balance problem / unsteadiness? Y N

2) MEMORY
Modified Maddocks questions (check if athlete answers correctly)
- At what venue are we? ____ Which half is it? ____ Who scored last? ____
- What team did we play last? ____ Did we win last game? ____

3) SYMPTOM SCORE
Total number of positive symptoms (from reverse side of the card) = ____

4) COGNITIVE ASSESSMENT (5 word recall)

	(Examples)	Immediate	Delayed
Word 1	____ car	_____	_____
Word 2	____ pen	_____	_____
Word 3	____ shoe	_____	_____
Word 4	____ book	_____	_____
Word 5	____ car	_____	_____

Months in reverse order:
Jun-May-Apr-Mar-Feb-Jan-Dec-Nov-Oct-Sep-Aug-Jul

Digits Backwards (check correct)

5-2-8	3-9-1	____
6-2-9-4	4-3-7-1	____
8-3-2-7-9	1-4-9-3-6	____
7-3-9-1-4-2	5-1-8-4-6-8	____

Ask delayed 5-word recall now

5) NEUROLOGIC SCREENING

	Pass	Fail
Speech	____	____
Eye Motion and Pupils	____	____
Pronator Drift	____	____
Gait Assessment	____	____

Any neurologic screen abnormality necessitates formal neurologic or hospital assessment

Computerized Neuropsych Testing

- Computer based testing currently available:
  --Cogsport
  --Headminders
  --ANAM
  --ImPACT

- These tests have been found to be as valid as the old pencil/paper tests.
- Mandated use in the NFL (2007), National Hockey League (2007), NASCAR, professional snow sports, Major League Baseball (2008), soccer and rugby leagues around the world, and over 400 NCAA colleges (even the WWF)

Computerized Neuropsychological testing for Concussion Rehabilitation

The Best Approach To Concussion Management

ImPACT: A Tool for Evaluating Concussion

(Immediate Post-Concussion Assessment and Cognitive Testing)

- Computerized test developed by clinical researchers at the University of Pittsburgh Medical Center (UPMC)
- Developed to allow for a more objective assessment of concussion and recovery
- Accounts for individual differences in cognitive ability and symptom reporting through the use of baseline testing
- Provides a common metric which allows for effective collaboration between athletic trainers, coaches, physicians, and neuropsychologists in concussion management
- Utilized throughout professional and amateur sports across the country and internationally

WHAT DOES ImPACT MEASURE?

- Demographic/Concussion History Questionnaire
- Concussion Symptom Scale
  - 21 Item Likert scale (e.g. headache, dizziness, nausea, etc)
- Eight Neurocognitive Measures
  - Memory
  - Working Memory
  - Attention
  - Reaction Time
  - Mental Speed
  - Verbal Memory
  - Visual Memory, Reaction Time
  - Processing Speed
  - Summary Scores

ImPACT Testing

- Detailed Clinical Report
  - Automatically computer scored
  - Outlines demographic, symptom, neurocognitive data
- Repeat testing used to follow recovery from concussion
  - Return to baseline signals time to begin progressive return to play
  - Allows for safer – and possibly earlier -- return to play based upon each individual's rate of recovery, not generalized grading scales

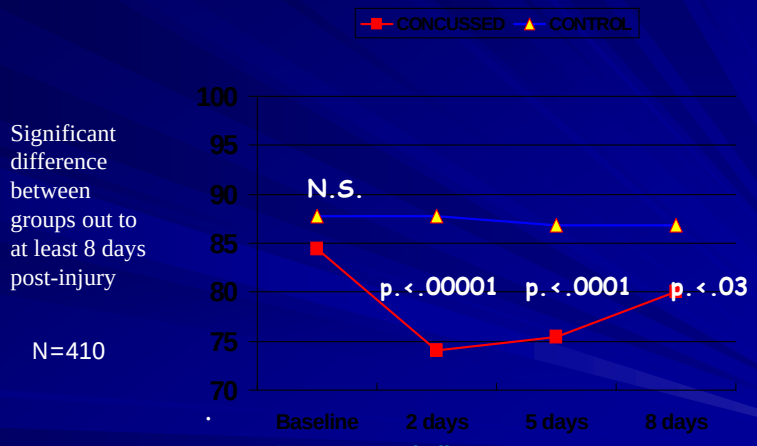
How Long Does It Take The Athlete To Recover from Concussion?

Lovell MR, Collins MW, Maroon et al. Medicine and Science in Sports Exercise, 34:5;2002

ImPACT
Overall Injury Sample 2000-2002

- Over 4,500 athletes in baseline sample
- 410 athletes suffered concussion during season
  - Evaluated within 2 days of injury
  - Re-evaluated at days 5 and 8 post-injury
  - 243 high school, 141 college, 26 other athletes
- 272 male concussions, 138 female concussions
- Compared to 100 HS and College controls

ImPACT MEMORY COMPOSITE
Control vs. Concussed Athletes



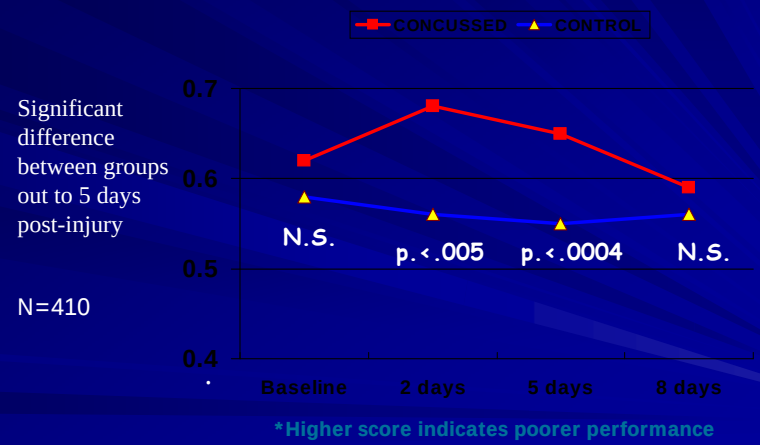
Significant difference between groups out to at least 8 days post-injury

N=410

*Lower score indicates poorer performance

Collins MW, Lovell MR, Maroon et al. Medicine and Science in Sports Exercise, 34:5;2002

ImPACT REACTION TIME COMPOSITE
Control vs. Concussed Athletes



Significant difference between groups out to 5 days post-injury

N=410

*Higher score indicates poorer performance

Lovell MR, Collins MW, Maroon et al. Medicine and Science in Sports Exercise, 34:5;2002

Ochsner Concussion Management Program

- Focus is upon patients aged 21 years and under
- Complete evaluation/management of a Concussion
  - Clinical History
  - Physical Evaluation
    - Balance Testing
  - ImPACT testing
  - ***Individualized***, Progressive RTP
    - RTP based upon persistence of symptoms
      - Physical, cognitive emotional, sleep, etc.
    - Not a "cookie-cutter" approach using older, no longer accepted grading scales
  - Prevention/Counseling/Education
    - Communication with coaches, athletic trainers, parents, etc.

It's not just "Return to Play"

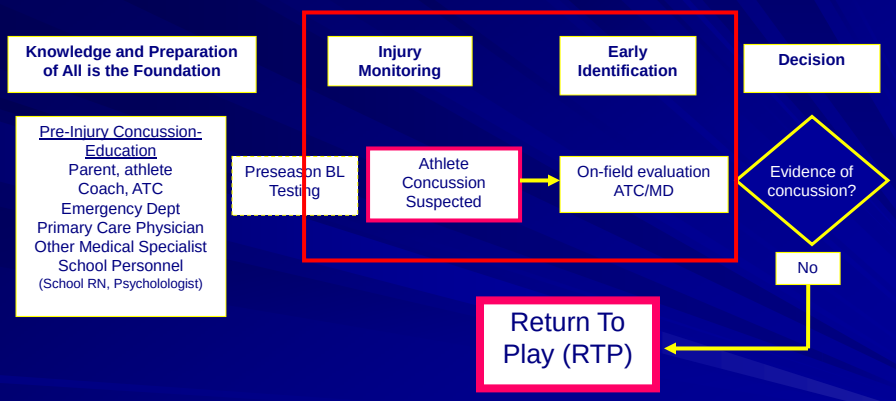
(2) Academics

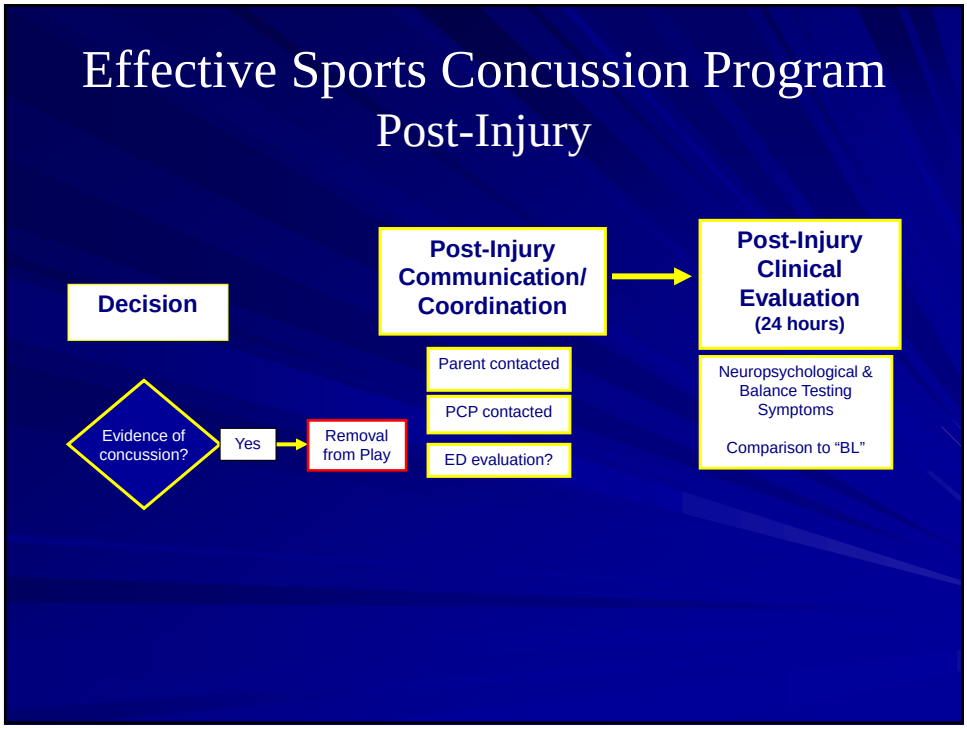
- Accommodations
  - Open book/untimed tests
  - Pre-printed class notes
  - Tutoring (Teacher or Peer)
  - Reduced workload, no double-work
  - Preferential seating
  - Reduced visual/auditory stimuli
  - Extended time for projects/assignments
- Attendance
  - Absences, Half day attendance

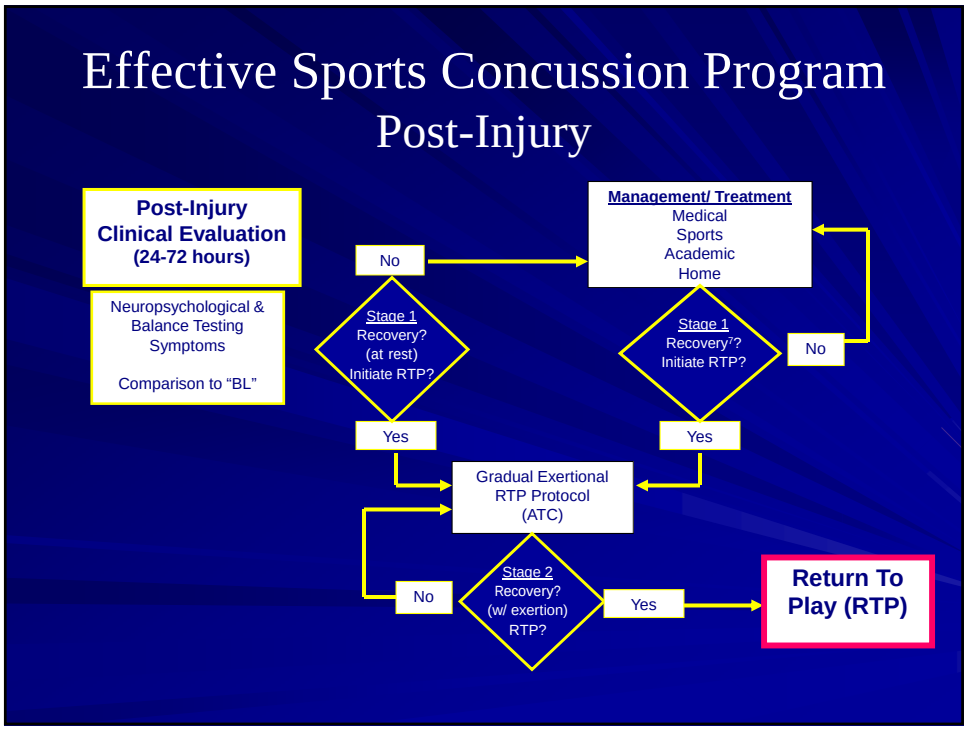
Ochsner Concussion Management Program

Effective Sports Concussion Program

Pre-Injury




Effective Sports Concussion Program
Post-Injury
Decision
Evidence of concussion?
Yes
Removal from Play
Post-Injury Communication/ Coordination
Parent contacted
PCP contacted
ED evaluation?
Post-Injury Clinical Evaluation (24 hours)
Neuropsychological & Balance Testing
Symptoms
Comparison to "BL"


Effective Sports Concussion Program
Post-Injury
Post-Injury Clinical Evaluation (24-72 hours)
Neuropsychological & Balance Testing
Symptoms
Comparison to "BL"
No
Stage 1 Recovery? (at rest) Initiate RTP?
Yes
Management/ Treatment
Medical
Sports
Academic
Home
Stage 1 Recovery? Initiate RTP?
No
Yes
Gradual Exertional RTP Protocol (ATC)
Stage 2 Recovery? (w/ exertion) RTP?
No
Yes
Return To Play (RTP)

Ochsner Concussion Management Program

- **2010-11 Academic Year**
  - Baseline ImPACT testing for all St. Tammany Parish H.S. student-athletes
    - Coordinated by M.D. and each H.S. team's athletic trainer
    - Part of pre-season practices
  - Web-based testing allows for mass testing in school's computer labs
- **2011-2012 Academic Year**
  - Jefferson Parish High Schools

Why Schools Should Use Neurocognitive Testing:

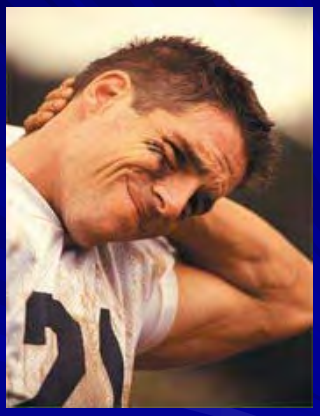
- Concussions are one of the most serious medical problems at the High School level
- Proper management of concussion is the best form of prevention of serious injury
- An increasing number of schools are being sued each year for concussion mismanagement
- Parents appreciate the information provided by ImPACT about their injured child

If used correctly…

- Neurocognitive testing will…
  - Help determine severity of concussion
  - Provide valuable information to the athlete, parents, athletic trainers, physicians
  - Provide information on academic deficits associated with concussion
  - Promote safe return to play
  - Reduce liability for school districts
- Will Not …
  - Prevent a concussion
  - Eliminate the risk of concussion

Pharmacology

- Cognitive Sx's
  - 1st line: Amantadine
    - Onset of action 5-7 days
  - 2nd line: Methylphenidate, Straterra
    - Lower than normal doses
- Sleep Disturbances
  - 1st line: Melatonin
  - 2nd line: Trazadone, Rozarem
  - 3rd line: Ambien
- Emotional Lability
  - SSRI's
  - Psychotherapy
- Somatic Sx's (e.g. HA)
  - PT, Modalities, Trigger point injections
  - NSAID's – limited use 2° to rebound
  - Elavil, Verapamil, Beta-Blockers (propanolol)
  - Topamax, Keppra



EFFORTS TO IMPROVE MANAGEMENT OF CONCUSSIONS

- Research scientific data on head injuries
  - Incidence
  - Causes
  - Opportunities for reeducation
- ***Educate coaches, athletes, & parents***
- ***Educate the medical community***
- Focus on safe Return to Play decisions
- Research new techniques to prevent, evaluate, and manage concussions

Future Endeavors in the Management of Sports-Related Concussion

- Gender studies
- More pediatric-specific injury/management paradigms
- Virtual Reality tools for assessment/rehab
- Rehabilitation strategies (role for exercise therapy?)
- New imaging modalities (fMRI?)
- Prospective/retrospective studies (ImPACT database)
  - On-field injury severity predictors
  - Long-term outcomes
  - “Best practices” Neuropsychological testing
- State legislation for Concussion Management

Louisiana Youth Concussion Act

- LA Senate bill 189 → passed June 29, 2011
  - Sponsored by Sen. Sheri Cheeks, Shreveport, LA
- 25th State with Concussion Law on the books
  - 1st in the Deep South
- Louisiana Youth Concussion Coalition
  - Work began on bill ***early April, 2011***
  - 3 Physicians
    - 2 PM&R, 1 NSurg
  - LSU MPH grad student
  - New Orleans Saints
    - Michael Lewis, Fred McAfee
  - NFL
    - Provided counsel, legal aide
  - LSU Football
  - BIALA

Louisiana Youth Concussion Act, 2011

(1) Any player suspected of a concussion removed from game or practice

(2) Player required to have written medical clearance from a medical professional, preferably trained in the management of concussion

- MD, DO, NP, PA, or Neuropsychologist

(3) Annual education requirement for public/private schools ***and*** recreational sports leagues/clubs

- Annual concussion course completion (e.g.. CDC "Head's Up" course)
  - Coaches, volunteers, officials

Louisiana Youth Concussion Act

Summary

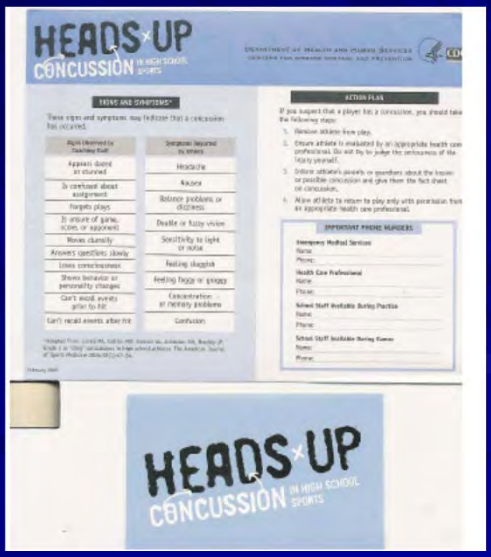
- Concussion is a functional injury to the brain
  - LOC is not required to have a concussion
- Children ARE different!
- Initial, prompt recognition is key
- Rest, Rest, Rest – Physical AND Cognitive
  - It is unsafe to return to play while symptomatic
  - Serial exams until asymptomatic
- Progressive RTP is key
- Role for computerized neuropsych testing aids RTP
- "When in doubt, sit them out."

Concussion Resources

- www.headinjury.com
- www.hockeycanada.ca
- www.impacttest.com
- www.cogsport.com
- Summary and Agreement Statement of the 1st, 2nd and 3rd International Conferences on Concussion in Sport,2001, 2004, 2008
- ***Br J Sports Med***, 2013;47:250-258.
  - Summary Statement of the 4th International Conference on Concussion in Sport held in Zurich, November, 2012

CDC "Heads Up: Concussion" program

www.cdc.gov/concussion/HeadsUp



Concussion Resources

- www.thinkfirst.ca ; Concussion management package available online for primary care providers
  - New Concussion Management Guidelines: Concussion Question and Answer Document For Physicians.
  - Heads Up, Facts for physicians about mild traumatic brain injury (MTBI).
  - Acute Concussion Evaluation (ACE) Physician/Clinician Office Version.
  - Acute Concussion Evaluation (ACE) Care Plan – Work Version
  - Acute Concussion Evaluation (ACE) Care Plan – School Version

Questions?

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