THE “WHAT”, “WHO”, “WHEN”, “HOW” AND “WHAT COULD BE” WITH CONCUSSION INJURIES

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Financial Relationships

- I have no financial relationships to disclose

DEFINITION

“…a biomechanically induced neurological injury resulting in an alteration in mental status such as confusion or amnesia which may or may not involve a loss of consciousness.”

AAN, 1997
DEFINITION

“Cerebral concussion is essentially a reversible syndrome without detectable pathology.”

Denny-Brown, 1941

THE CONFLICT BETWEEN DEFINITION AND PERCEPTION

- A concussion is a brain injury that occurs in sports
- It is contrary in every way to any other type of “sports injury”
- Most people look at it only as a “sports injury”

PREVALENCE

The Center for Disease Control (CDC) reports that an estimated 1.8 to 3.6 million concussion injuries occur in sports and recreational activities annually in the USA.
### CONCUSSION RATES

<table>
<thead>
<tr>
<th>Sport</th>
<th>Rate</th>
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<tbody>
<tr>
<td>Boys soccer</td>
<td>22.68</td>
</tr>
<tr>
<td>Girls soccer</td>
<td>12.92</td>
</tr>
<tr>
<td>Boys basketball</td>
<td>9.72</td>
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<tr>
<td>Girls basketball</td>
<td>17.21</td>
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<tr>
<td>Baseball</td>
<td>11.90</td>
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<tr>
<td>Softball</td>
<td>10.03</td>
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<tr>
<td>Wrestling</td>
<td>9.27</td>
</tr>
<tr>
<td>Cheerleading</td>
<td>9.26</td>
</tr>
<tr>
<td>Football</td>
<td>31.37</td>
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</tbody>
</table>

*(per 100,000 athlete-exposures)*

### CONCUSSION RATES BY GENDER

<table>
<thead>
<tr>
<th>Gender</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>19.91</td>
</tr>
<tr>
<td>Females</td>
<td>10.91</td>
</tr>
</tbody>
</table>

*(per 100,000 athlete-exposures)*

### OTHER FACTOIDS

- Game v. practice
- Position in game v. practice per sport
- Mechanism or play that caused concussion
MECHANISM OF INJURY

PATTERNS OF FORCE
- Rotational
- Linear
- Impact deceleration
- Vertical

ROTATIONAL FORCES
- Dynamic loading (<200 msec)
- Caused by direct impact or indirect impulse which creates increased inertial loading by sudden changes in motion
- Damage occurs at surface and at zones where there is a change in density
- Increased force/shear strain = deeper penetration of injury
TRANSLATIONAL FORCES

- Static loading (> 200 msec)
- Less common cause of injury
- Site of impact is important for focal component of injury and clinical signs/symptoms

IMPACT DECELERATION

- Falls or head impact to ground
- More common than linear/translational pattern
- Coup-contrecoup pattern of injury

HYPOTHESIS FOR CEREBRAL CONCUSSION

“graded set of clinical syndromes following head injury wherein the increased severity of disturbance caused by mechanically induced strains affecting the brain in a centripetal sequence of disruptive effect on function and structure”

Ommaya & Gennarelli, Brain, 1974.
**GRADES OF CEREBRAL CONCUSSION**

- Grade I: Confusion without amnesia
- Grade II: Confusion with PTA
- Grade III: Confusion with PTA + RA
- Grade IV: Coma (loss of consciousness)
- Grade V: Coma (PVS)
- Grade VI: Coma leading to death

Ommaya and Gennarelli, 1974.

**THE “HOW”**

**PATHOPHYSIOLOGY OF CONCUSSION**

**BASIC RESEARCH**

- Experimental models with mice and rats
- Mechanism of injury
  - Closed-skull weight drop
  - Closed-skull controlled impact
  - Lateral fluid percussion injury (FPI)
OBSERVED CHANGES

- Molecular alterations
- Ionic and neurotransmitter disturbances
- Synaptic perturbations
- Structural changes

NEUROMETABOLIC CASCADE

- Disruption of neuronal cell membrane + axonal stretching
- Indiscriminate flux of ions through previously regulated ion channels and membrane defects
- Release of excitatory amino acids
- Increases ionic flux further
- Na/K pump works at maximum capacity to restore ionic balance
- Energy stores become depleted—“metabolic crisis”

IONIC FLUX

- Neuronal cell membrane deformity as a result of trauma
- Deformity allows K+ eflux and glutamate (EAA) release
- Glutamate binds to and activates NMDA receptors which causes depolarization of the neuron and also allows for an influx of Ca++
- Depolarization also results in neuronal suppression similar to the mechanism in migraine
CELLULAR RESPONSE

- Restore ionic balance through activation of Na/K pumps
- Pumps require higher levels of glucose metabolism to restore balance due to operating at maximum capacity
- Intracellular energy stores are depleted which demands more rapid but inefficient glycolysis
- Mitochondrial function subsequently is diminished which leads to an increase in lactate production
- Lactate contributes to local acidosis, increased membrane permeability and cerebral edema

GLUCOSE METABOLISM

- Initial response to injury is hyperglycolysis
- 30 minutes after a lateral FPI there is a 30-40% increase in glucose metabolism
- At 6 hours there is a reduction to 50% of normal
- Reduction is due to oxidative dysfunction of mitochondria who cannot keep up with energy demands
- There is also production of superoxide free radicals which can create further intracellular injury

MORE ABOUT MITOCHONDRIA

- Activation of the NMDA receptor by glutamate allows for Ca++ influx
- Ca++ accumulates in the mitochondria creating the glycolytic abnormalities and oxidative dysfunction
- Mitochondria are down-regulated after a lateral FPI for at least 10 days
RESULT OF METABOLIC CRISIS

- Cerebral hypofunction or permanent damage
- Single mTBI = self-limited, transient changes
- Multiple mTBI = more lasting derangement

YOU MAKE THE CALL

VASCULAR RESPONSE

- Triphasic response to concussion based on severe TBI models
- Day 0 = Cerebral hypoperfusion
- Day 1-3 = Cerebral hyperemia
- Day 4-15 = Cerebral vasospasm
- Mild TBI is similar but to a lesser extent
**AXONAL INJURY**

- Axonal injury is felt to be reversible in mild TBI
- Decreased axonal transport noted in the inferior and superior frontal regions as well as in the supracallosal region
- Correlates with changes in motor speed, executive function and behavior

**VULNERABILITY**

- Related to:
  - Metabolic perturbations
  - Altered blood flow dynamics
  - Axonal injury
  - Abnormal neural activation
  - Reduced cerebral perfusion
- Exacerbated by:
  - Repeated mild injuries
  - Concussive or sub-concussive injuries within window of impairment

**RECOVERY TIMELINES**

- Study using MRS looking at altered metabolism in 13 concussed adult athletes (>18 years old) at 3, 15, 22 and 30 days post-injury
- Metabolism reduced at 3 and 15 days and normalized by 30 days
- 3 athletes suffered a “repeat” injury in the 3-15 day window and took 45 days to normalize
- Single concussion group reported being symptom free at 3 days and double concussion group at 30 days

Vagnnizzi et al., Brain 2010
SECOND IMPACT SYNDROME

- Potential catastrophic outcome as a result of a repeat concussion injury while recovering from the initial injury
- Cellular, metabolic, axonal and vascular disturbances are amplified
- Profound cerebral edema develops which may lead to coma and severe neurological disability or death
- Primary rationale for delayed RTP
- Is there a spectrum for Second Impact Syndrome???

LONG TERM OUTCOMES

- Genetic predisposition
  - Apo E-4 allele
  - Amyloid and tau deposition
- Number of concussions
  - 3 or more
- Length of career
  - Longevity = Exposures

CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE)

- Associated with memory disturbances, behavioral and personality changes, Parkinsonism and speech and gait abnormalities
- Neuropathologically characterized by atrophy of the cerebral hemispheres, medial temporal lobe, thalamus, mammillary bodies and brainstem
- Microscopically there is extensive tau protein deposition
TAU PROTEIN

- Protein that invades cortical nerve cells and disables them effectively shutting them down
- Unlike Alzheimer’s disease and the neurofibrillary tangles associated with that disease, the build up of tau protein is related to environmental factors such as trauma or injury.

CHRONIC TRAUMATIC ENCEPHALOPHY

- NFL Survey—
  - >50 = 5x risk
  - 30-49 = 19x risk
- Comparative data from the Framingham heart study
- Concept of subconcussive trauma
- Sports Legacy Institute

HOW CAN WE PREVENT MORE STORIES LIKE GENE ATKINS?
THANK YOU
KEYS TO CLINICAL INTERPRETATION OF SPORTS CONCUSSION INJURIES

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Financial Relationships

- I have no financial relationships to disclose

CONCUSSION CLASSIFICATION

- Colorado Guidelines (1991)
  - Grades 1-3 based on symptoms and LOC
- AAN Guidelines (1997)
  - Grades 1-3 based on symptom recovery and LOC
- Cantu Guidelines (1998)
  - Grades 1-3 based on symptoms, LOC and PTA
- Prague Guidelines (2005)
  - Simple v. complicated
  - No classification system
IS THE RECOVERY TIMELINE PREDICTABLE???

“We hold these truths to be self-evident, that all men are created equal, …”

CONCUSSION MODIFIERS

- Symptoms—Number, duration and severity
- Signs—Amnesia and prolonged LOC
- Sequelae—Concussive convulsions
- Timing—Frequency of concussions and when was most recent concussion

CONCUSSION MODIFIERS

- Threshold—Repeat concussions occurring with less force or with slower recovery timelines
- Age
- Co-morbidities—Migraine, depression or other mental health disorders, ADHD, learning disabilities and sleep disorders
- Medication use—Psychoactive drugs
- Behavior—Style of play
- Sport—Contact or collision sport, high-risk
**CLINICAL CHALLENGES**

- Complex injury with many variables to consider for proper management
- Most people (i.e. parents, coaches) have some personal experience with a concussion injury
- Transition from the “subjective” (symptoms) to the “objective” (performance)

**PERFORMANCE EVALUATION**

**COGNITIVE TESTING**

- Baseline Testing
  - Establishes personal benchmarks
  - Enhances post-injury management
- Post-Injury Testing
  - Gives the concussion an objective measure
  - Aids in academic recommendations

**SPORTS CONCUSSIONS IN NORTH CAROLINA**

- Fall 2008—3 deaths in NC HS football
- Fall 2008—NCHSAA Rule requiring MD release (not ATC, PA, NP, or 1st responder) for return to play following a concussion injury
- April 6, 2011—Gfeller-Waller Concussion Awareness Act filed
CONCUSSION CASE STUDY

SPORTS CONCUSSION CLINIC INSIGHTS & SURPRISES

- How “healthy” are our kids?
- Is there an injury selection bias?
- Longer recovery timelines for females
- Adaptability of athletes—no disclosure=no evaluation=no missed games
- Sports culture barriers—athletes, coaches, and parents
- A general lack of respect for the brain

THANK YOU
SPORTS CONCUSSION
PHYSICAL EXAMINATION

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Financial Relationships

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DEFINITION

“...transient neurological disturbance with evidence of functional and not structural abnormalities...”
KEY ELEMENTS

- Understand the mechanism of injury
- Review the post-concussion symptom profile
- View the imaging results—X-ray, CT, MRI

PHYSICAL EXAMINATION

- Musculoskeletal
- Neurological
- Functional
- Cognitive

MUSCULOSKELETAL CERVICAL SPINE

- Palpation
  - Bony elements
  - Soft tissues
- Range of Motion
  - Active only, pain as endpoint
  - Flexion/Extension/Lateral rotation and flexion
NEUROLOGICAL CRANIAL NERVES

- Optic Nerve + Oculomotor Nerve
  - Papillary response
  - Funduscopic examination
  - Visual fields (extinction)
  - Extra-ocular movements (C.N. IV, VI)

- Vestibulo-Cochlear Nerve
  - Nystagmus
  - VOR provocation
  - Finger rub
  - Hallpike-Dix maneuver

MOTOR + REFLEXES

- Motor
  - Upper and lower extremity strength
  - Pronator drift

- Reflexes
  - Muscle stretch reflexes
  - Hoffman
  - Babinski

CEREBELLAR

- Finger to nose (eyes closed)
- Finger-nose-finger (eyes open/eyes closed)
- Heel to shin
- Tandem gait
FUNCTIONAL BALANCE SKILLS

- Integration of multiple systems
- More sensitive with multiple concussions
- “Modified” BESS

PERFORMANCE SKILLS

- Motor sequencing
- Language errors (observational)

COGNITIVE EVALUATION

- Computerized testing format
- Separate cognitive battery if < 10 years old
TREATMENT PLAN

- Observation/Rest
- Therapy—PT, Cognitive, Psychology
- Medication management options
- Additional diagnostic testing (Imaging, EMG)
- Specialty consultation
  - Ophthalmology
  - ENT
  - Psychiatry

SUMMARY

- The PE is almost always normal in concussion evaluations.
- Abnormalities are more likely to be functional and not neurological.
- Cognitive testing helps define the concussion injury objectively.
- Don’t forget about the neck.
- Don’t get lulled into a false sense of security—the PE is a window into other clinical issues.
McLeod Sports Medicine
Prevention
Adam Ploeg MS, ATC
Head Athletic Trainer
Wilson High School

School Case Study

<table>
<thead>
<tr>
<th>School</th>
<th># Concussions in 2010</th>
<th>Helmet Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>School 1</td>
<td>9</td>
<td>Newest helmet was 5 years old, most approaching 10 years old.</td>
</tr>
<tr>
<td>School 2</td>
<td>1</td>
<td>90% brand new with concussion technology.</td>
</tr>
</tbody>
</table>

Observations or Implications:
- Is it lack of strength and conditioning?
- Is it tackling technique?
- Is it equipment related?

Preventative Exercises

1. Guide off-season workouts to increase atlanto-axial stability.
   - In a recent article reported on FoxNews, Dr. Robert Cantu, had this to say regarding neck strengthening exercises, “It's just straight physics,” Cantu said. "If you see the blow coming and you have a very strong neck... you have a much greater chance to have significantly reduced the forces the brain will see.”
Neck Strengthening

1. Isometric Exercises
   - Perform in all four directions
     - Flexion, Extension, Lateral Flexion (Abduction)
   - Benefits are ease of use (portability) and exercises are timely.

Neck Strengthening

1. Resistance Training
   - Same four directions as Isometric exercises: Flexion, Extension, Lateral Flexion (Abduction).
   - Use neck harness or partner resistance training
   - Trapezius strengthening
     - Shoulder shrugs – upper trap
     - Upright row – middle trap

Tackling Technique

1. The mantra, “See what you hit” will help limit both spinal injuries and concussions.
2. Do NOT lead with the helmet when making tackles.
3. Teach athletes to slide their helmet across an opponent’s chest, rather than through it.
Helmets 101

Before Fitting
• Make sure helmet has a NOCSAE warning label.
• NOCSAE – National Operating Committee on Standards for Athletic Equipment
• Helmets should be reconditioned and re-certified each year after use.
• Always follow manufactures guidelines when fitting helmets.
• Inspect helmet before issuing for cracks, proper interior padding and that face mask has no imperfections.
• **Meet with your helmet rep. They are a wealth of information when it comes to fitting and replacing helmets.

Fitting Helmets

Can Vary Based on Helmet Manufacturer and Design
1. Make sure that hair style will be similar to one worn in season and is wet to simulate sweating during a game.
2. Measure Circumference of Head to get approximate helmet size. (Generally 19-20.5-5, -22-M, -23.5-L, -25-XL)
3. Once athlete has put helmet on, make sure that all padding is in firm contact with the head. (Front/Back Sizers, Jaw Pads)
4. Chinstrap should be equally tight on all clips.

Checking Proper Fit

• Helmet should:
  • be 1” (About 1-2 finger widths) above eyebrows.
  • Cover the base of the Occipital, but not impede neck extension.
  • Ear holes should line up with ears.
  • Facemask should allow for a complete field of vision and be no closer than 1” to the nose.
  • Facemask should be appropriate for position being played
  • Helmet should not move when pushed in any direction
  • Try to rotate helmet while athlete holds head still. Skin should slightly wrinkle and all padding should remain in contact at all times.
Helmet Technology

Below is the inside of a 9 year old large helmet.
Below is the inside of a 2 year old medium helmet.

Notice the differences between the two helmets:
- Padding
- Helmet Design
- Air Cells
Helmet Technology

9 Year Old Helmet
2 Year Old Helmet

Helmet Technology
Cross Section

9 Year Old Helmet
2 Year Old Helmet

Final Thought

Chris Nowinski is the director at the Center for the Study of Traumatic Encephalopathy. He was quoted in an article on May 3rd stating, "It's amazing to me that we have pitch counts in youth baseball to protect children's elbow ligaments, but we do not count how often they get hit in the head to protect their brains."
References


Fox Sports (2010). Concussions can be fought from the neck up. Retrieved April 11 from http://www.foxnews.com/sports/2010/05/21/concussions-fought-neck/#1IgAdyM8m

Legislation and Litigation

Financial Relationships

- I do not have any financial relationships to disclose.

Youth Sport Concussion Legislation

20 states have youth sport concussion related laws:
2011: AK, AR, AZ, CO, IA, ND, NE, NM, SD, UT, WY
2010: CT, ID, MA, NJ, OK, RI, VA
2009: OR, WA

Many states have legislation pending
WA was the first state to pass legislation, the (Zackery) Lystedt Law

As of April 27, 2011, SC has 2 brain injury bills introduced
House Bill, H 3768
Senate Bill, S 668
Athlete Safety Laws - Concussion

Potential Provisions
1. Coach training
2. Parent / Athlete Education
   - Acknowledge reading prior to play.
   - Suggested baseline testing at parents expense.
3. Return to Play
   - Removal from practice.
   - Release to return to practice.
   - Multi-disciplinary approach (teachers, coaches, parents, ATC, MD, RN).
4. Injury reporting structure
5. Immunity for volunteers

The Legislative Landscape

South Dakota
- Requires state high school association to develop guidelines for concussion education among parents, coaches and students.
- Requires removal from athletic activity for students with suspected concussion.

Utah
- Requires parental informed consent.
- Removal from play without medical clearance after concussion.

Wyoming
- Required training for coaches.
- Education of students, parents and guardians regarding concussions.

Colorado “Did it for the Children”

Colorado Senate Bill 40, Jake Snakenberg Youth Concussion Act

History: Young high school athlete who died in 2004 after being hit in a football game. It is suspected to be a second impact where a previous concussion was never diagnosed.

What does it do?
- Ensures coaches of youth sports for kids age 11-18 get training in how to recognize signs of a concussion.
- Athlete removed from play and cannot return same day.
- Athlete can not return to play until evaluated by a healthcare provider and receive a written clearance.
- Affected entities: Public and Private schools, private clubs, and recreational facilities.
- Return to play only with medical clearance by MD, DO, NP, PA or psychologist. ATC for graduated return to play.
South Carolina Senate Bill, S 668

A BILL TO AMEND THE CODE OF LAWS OF SOUTH CAROLINA
1. REQUIRE EACH LOCAL SCHOOL DISTRICT OF THIS STATE TO DEVELOP POLICIES AND PROCEDURES REGARDING THE IDENTIFICATION OF SUSPECTED CONCUSSIONS IN STUDENT ATHLETES.
2. AND THEIR SUSPENSION FROM PLAY UNTIL CLEARED BY A LICENSED HEALTH CARE PROFESSIONAL.
3. TO REQUIRE STUDENT ATHLETES AND THEIR PARENTS OR LEGAL GUARDIANS TO READ AND SIGN THE POLICIES.
4. TO PROVIDE THAT THE HEALTH CARE PROFESSIONAL MAY SERVE AS A VOLUNTEER.
5. AND TO LIMIT HIS LIABILITY

South Carolina House Bill, H 3768

A BILL TO AMEND THE CODE OF LAWS OF SOUTH CAROLINA
1. TO REQUIRE THE DEPARTMENT OF EDUCATION TO DEVELOP AND DISTRIBUTE MODEL POLICIES CONCERNING THE NATURE AND RISK OF CONCUSSIONS SUSTAINED BY STUDENT ATHLETES.
2. TO REQUIRE EACH LOCAL SCHOOL DISTRICT TO DEVELOP ITS OWN POLICY.
3. TO REQUIRE THE REVIEW OF THE POLICY BY STUDENT ATHLETES AND THEIR PARENTS OR GUARDIANS.
4. TO REQUIRE THE REMOVAL FROM PLAY.
5. AND MEDICAL EVALUATION OF A STUDENT ATHLETE BELIEVED TO HAVE SUSTAINED A CONCUSSION DURING PLAY.
6. TO ALLOW FOR THE EVALUATION TO BE UNDERTAKEN BY A VOLUNTEER HEALTH CARE PROVIDER.
7. AND TO PROVIDE THAT LOCAL SCHOOL DISTRICTS ARE NOT REQUIRED TO ENFORCE THE PROVISIONS OF THIS SECTION.

Federal Legislation - 112th CONGRESS

H.R. 469 – Introduced
Protecting Student Athletes from Concussion Act of 2011

To promote minimum state requirements for the prevention and treatment of concussions caused by participation in school sports, and for other purposes.

Requires each state educational agency, in order to be eligible to receive funds under the Elementary and Secondary Education Act of 1965 in fiscal 2013 or subsequent years, to issue regulations establishing the following minimum requirement for the prevention and treatment of concussion.
Federal Legislation - H.R. 469

Requires local educational agency concussion safety and management plan:
1. Education of students, parents, and school personnel about concussions.
2. Support for students recovering from a concussion.
3. Best practice designed to ensure uniformity of safety standards.

Requires posting of information on concussions:
1. Based on peer-reviewed scientific evidence (such as info from CDC).

Requires response to concussion:
1. Removed from participation.
2. Prohibited from same day return.
3. Report to parents / guardian of date, time, extent of injury, and action taken to treat.

The Coming Wave of Concussion Litigation

“As awareness and the list of injuries tied to concussion grows, so too will the number of related lawsuits.”

“Wherever significant injuries appear, plaintiff’s lawyers will follow.”

William A. Starr, Litigation Sports Law

11/2009, LaSalle was settled for 7.5 million

The Coming Wave of Concussion Litigation

The number of concussions reported in all sports are on the rise
- CDC reports 1.8 to 3.6 million sports and recreation-related concussions occur in US per year.
- Each year, U.S. emergency departments treat an estimated 195,000 sports and recreation-related TBIs, including concussions, among children ages 5 to 18. (MMWR July 2007)

Any entity appearing to cause or failing to prevent a brain injury suffered by an athlete is a potential defendant.

Targets are: manufactures of athletic helmets, school systems and universities, physicians, coaches, and athletic trainers.
The Coming Wave of Concussion Litigation

Four types of sports-related brain injury that defense attorneys are likely to encounter are:

1. Concussion
2. Post-Concussion Syndrome
3. Second Impact Syndrome
4. Long-term Brain Damage

Exacerbating Factors

Many athletes do not understand what constitutes a concussion and, thus, when they experience a concussion, do not report it:

1. Ignorance: lack of knowledge.
2. Warrior Culture: players expected to do anything necessary.
4. Insufficient Funds: lack of funds for newest equipment, reconditioning, ATC on staff.
5. Rule Changes: NFL - prohibit same day return, reducing contact during practice, penalties.
6. Research: NFL players may experience Alzheimer’s and other brain deficits at a much higher rate than normal.
7. Helmet Technology: development of technology to reduce frequency and severity of concussion.

Where’s The Liability?

Athletes suffering serious long term neurological injuries after multiple concussions have a high value personal injury case. All the required elements are there:

1. Breach of duty of reasonable care on the part of the coach or team,
2. That causes a player’s injury,
3. With severe, permanent damage.

Professional athletes start young and can have significant earning potential, all factors that exponentially raise the potential liability exposure.
### Implications for the Defense Practitioner

1. Physicians will face claims they failed to dx and properly treat.
2. Allied health professionals will face claims they failed to properly manage.
3. Coaches and school systems will be accused of teaching improper technique and ignoring evidence of potential concussion.

Entities with the financial means to protect players from concussion but choose NOT to do so, will expose themselves to negligence claims.

### PA: HS football player received a concussion on 11/9/07

- Athlete continued to play even tough he was behaving strangely.
- Claims of previous concussions 10/12/07, 11/2/07.
- Claims that the coach ignored visible signs of concussion and put the athlete back into the game.
- Lawsuit against the school district, principal, assistant principal, and athletic trainer for deliberate disregard for his welfare in allowing him to be injured repeatedly.
- Lawsuit claims the district failed to accommodate the learning disabilities his injuries created, and “passed” him along.
- Lawsuit says the district should have used ImPACT, district began use in 2009.

### NJ: 16 year old HS football player suffered a brain hemorrhage, never regaining consciousness and taken off life support 10/15/08.

- Previous concussions 9/10/07, 9/19/08.
- ImPACT baseline test 10/2/08.
- ImPACT results “objectively normal”, but results were deemed invalid by the high school because a disruptive student in the testing room compromised all of the test-takers' results.
- MD exam 10/3/08 cleared to resume FB participation on 10/6/08.
- Family is suing the physician, physicians practice, and the high school for clearing him to return to play.
- Lawsuit names the township and school board for being “negligent in their conduct by permitting return to play in light of PMHx and ImPACT results.”
The Gap

Concussion research and treatment have evolved rapidly, but actual care provided to athletes has lagged.

That this gap has muddied the “standard of care” from a legal basis for determining whether there has been negligence in treating an athlete.

Lack of clarity, combined with society’s litigious streak can make sports medicine staff vulnerable to litigation.

Final Thought

Sports medicine personnel should err on the side of caution and follow the most conservative concussion protocol for determining athlete return to play.

Thank You

Paul John, MPT, ATC
Director, McLeod Sports Medicine
Balance & Vestibular Abnormalities following A Mild Traumatic Brain Injury (mTBI)

Heidi R. Mehlman, ATC, LMT
McLeod Sports Medicine
Darlington High School
Lamar High School

Financial Relationships
I have no financial relationships to disclose as it pertains to this CME.

Early Symptoms Following Sports Related mTBI
1. Headache (71%)
2. Feeling slowed down (58%)
3. Difficulty concentrating (57%)
4. Dizziness (55%)
5. Fogginess (53%)
6. Fatigue (50%)
7. Visual blurring/ double vision (49%)
8. Light sensitivity (47%)
9. Memory dysfunction (43%)
10. Balance problems (43%)

Lovell et al, 2004
**Vestibular System Overview**

**Anatomy**
- Peripheral Vestibular System
  - Semicircular canals
  - Otoliths: Utricle and Saccule
  - Vestibular ganglia
  - Vestibular nerve
- Central Vestibular Projections
  - Vestibular nuclei
  - Cerebellum
  - Autonomic nervous system
  - Thalamus
  - Cerebral cortex

**Function of Vestibular System**

**Vestibulo Ocular Reflex (VOR)**
- STABILIZE VISION WHILE HEAD MOVES

**Vestibulo Spinal Reflex (VSR)**
- BALANCE CONTROL
  - Most active when vision & somatosensation is reduced

**Subjective Complaints Pointing to Vestibular Dysfunction**
- Dizziness
- Impaired balance (particularly in the dark)*
- Blurry vision, difficulty focusing
- Motion discomfort, height phobia
- Difficulty in busy visual environments
Why is Vestibular Dysfunction Important to Recognize?

Patients with protracted recovery from mTBI's frequently have dysfunction involving the vestibular system. Possible causes:
- Post-traumatic Benign Paroxysmal Positional Vertigo
- Co-existing Labyrinthine Concussion
- Post-traumatic Migraine–Related Dizziness
- Central Vestibular dysfunction/ Brainstem Concussion

*These issues can be improved when treated by a qualified Vestibular Physical Therapist

Sensory Organization in Maintaining Balance

- Vision
- Somatosensation (i.e., proprioception)
- Vestibular

*All must work together

Screening – Interview/ Self Reports

Balance:
- Falls since mTBI?
- Staggering, veering, near falls?
- Imbalance in the dark?
Balance Screening

1. Eyes Open
2. Eyes Closed
3. Abnormal if cannot maintain for 30 seconds

Feet Together – Solid Surface

Feet Together – Foam Surface

Balance Screening (cont.)

Tandem Stance
1. Eyes Open/Arms out on stable floor and foam pad
   - Abnormal if < 30 sec or unsteady
2. Eyes Closed/Arms out on stable floor and foam pad
   - Abnormal if < 30 sec or unsteady

Tandem Walk
- Abnormal if unsteady or unable to perform

Screening for Vestibular Abnormalities Interview/ Self Report (cont.)

Is Dizziness Present?

Useful tool: Dizziness Handicap Inventory (DHI)
- Jacobson and Newman, 1990
- 25- item subjective self-rating
- Each item answered “yes” “no” or “sometimes”
- Scoring: yes – 4 points; sometimes – 2 points; no- 0 points
- Range 0-100; higher scores reflect higher disability
Vestibular Screening – Interview/ Self Report (cont.)

Movement-specific dizziness:
- Looking up
- Getting out of bed
- Quick head motions
- Turning over in bed
- Bending over
- Lying down

Positive responses to any may indicate a possible vestibular system problem

Vestibular Screening – Interview/ Self Report (cont.)

- Walking in a supermarket
- Do you avoid heights due to dizziness?
- Do you get dizzy in wide open spaces?

- Positive responses indicate probable space and motion discomfort and/or height phobia

Space and Motion Discomfort

Space and motion discomfort (SMD)
- Jacob et al, 1993
- Uneasiness created by situational stimuli, i.e.: moving crowds, supermarkets, busy patterns, spiral staircases, heights, etc
- Heightened awareness of normal motion

Other Similar terms:
- “Visual Vertigo” (Bronstein 1995)
- “Chronic Subjective Dizziness” (Staab 2004)
Space and Motion Discomfort (cont.)

- Coexists frequently with migraine and/or anxiety
  * Migraine-Related Dizziness (MRD)
  * Migraine-Anxiety Related Dizziness (MARD)

- Appears to be responsive to combined approach using medication, Vestibular Physical Therapy, & behavioral therapy. (Whitney et al, 2005; Jacob et al, 2001)

Screening – Interview/ Self Reports

Aural Symptoms:

- May identify labyrinthine injury
  * Changes in hearing
  * Tinnitus, particularly lateralizing
  * Pressure/fullness in ear(s)

- Significance: patients with mixed central and peripheral vestibular dysfunction recover more slowly and incompletely
- Warrants referral to Otology or Oto-neurology

Screening – Physical Exam

Ocular Motor:

- Smooth Pursuits
- Saccades
- Convergence
- Any observable nystagmus?
Screening – Physical exam

Vestibulo-Ocular Reflex:
VOR (focus on stationary object while moving head side to side and up and down)
- Blurriness?
- Dizziness?

Vestibulo-Ocular Reflex (VOR)

Management of Vestibular Dysfunction

BPPV (benign paroxysmal positional vertigo)
- Canalith repositioning maneuver
Visually Conflicting Environments

Thank you
Return to Play

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Financial Relationships
I have no financial relationships to disclose as it pertains to this CME.

Five Stages of Progression
• Progressing from very light to full practice
• Progress to next stage as long as symptom free
• If symptoms occur during activity, stop and wait 24 hours before testing again. Do not move on to next stage
Stage 1: Basic Movement

- Walking - track for 10 - 15 minutes
- Stretching
- Balancing – feet together

Stage 2: Advanced Movement

- Active stretching – lunge walk, side to side groin stretch, band squats
- Walk bleachers for 20 - 25 minutes
- No running/jogging yet
  - Can use bike, elliptical, UBE

Stage 3: Active Movements

- Active stretching – same as Stage 2
- Agility Drills – Zig zag runs, side shuffle
- Reactionary/balance drills – plyo balls, Bosu ball
- Strength training (80% max)
- Jogging/running can begin
- Helmet can be added for football
Stage 4: Non Contact

- Sport specific drills
  - Plyometric drills
- Non-contact practice
  - Full pads, no hitting

Stage 5: Full Exertion

- Resume full contact
- Cleared to practice, monitor as needed

Thank You