Closed Head Injury and Concussion

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Voluntary / non-paid Committee work:
- Chair, US Lacrosse Sports Science & Safety Committee
- CDC Consultant
- NFL Head, Neck & Spine Committee
- Korey Stringer Institute Medical Advisory Board
- NCAA Concussion Task Force member
- Ivy League Concussion Core Group
- Ivy League – Big Ten Concussion Core Group
- USA Football Medical Advisory Board

Objectives
- Presentation of concussion
- Presentation of more serious brain injury
- Sideline evaluation of the injured athlete
- Management and Return to Play (RTP)

Overview – Big Picture
- Head injuries and concussion common & important injury in sport
- Consider focal, vascular and associated injuries (e.g. e-spine, skull fx, bleed) when evaluating head injured athlete

Overview – Big Picture
- Concussion is an elusive injury
- Variability in presentation, can be very subtle
- No clear marker, no definitive test
- Management & RTP decisions challenging
Concussion Guidelines

Overview – Big Picture
Concussion

- Most common head injury
- Most recent Guidelines;
  - No same day Return to Play
  - No grading or “cookbook” approach
  - Consider “modifiers”
- Individualized management & Return to Play decisions

Focal Brain Injury
Subdural Hematoma

- Low pressure venous bleed into space (subdural) b/wn arachnoid & dura mater
- Classified; time to clinical presentation
  - Acute; w/in 24 hrs
  - Sub-acute; 24 hrs to 2 wks
  - Chronic; > 2 wks
- Leading cause of death; overall mortality 35-50%; LOC implies poor prognosis
- Elderly & alcoholics at greatest risk b/o increased space b/wn brain & dura

Focal Brain Injury
Subdural Hematoma

- Presentation; decreased /altered level of consciousness, lucid interval followed by declining mental status, headache, may see anisocoria, motor deficits (e.g. unilateral weakness or paralysis) or other findings of brain swelling
- Rx; referral to facility w/ neurosurgical capabilities, prompt surgical evacuation
Focal Brain Injury

Subdural Hematoma

- High pressure arterial bleed between inner table of skull and dural mater
- Middle or other meningeal arteries disrupted; 80% assoc w/ skull fx in temporoparietal region; occasionally caused by tear of underlying dural sinus
- Other assoc intracranial pathology common
- Mortality rate low if diagnosed acutely; coma assoc w/ highest mortality rate (20%), higher w/ assoc injuries

Epidural Hematoma

- Presentation; decreased level of consciousness followed by lucid interval, deteriorating mental status w/ eventual LOC, HA, confusion, sleepiness, nausea & vomiting
- Only 1/3 present classically
- Late signs; ipsilateral dilated pupil, contralateral muscle weakness, coma
- Lucid interval may last for several hrs
- Rx; craniotomy / evacuation

Intracerebral Hemorrhage / Hematoma

- Bleeding from small caliber arterioles w/in brain parenchyma; most common frontal & temporal lobes
- Mortality rate low if pt conscious before intervention; close to 45% if unconscious
- Presentation; varies w/ size & location as well as assoc pathology
  - LOC in ~50%, HA, confusion, nausea / vomiting, focal deficits
  - Symptoms may develop over hrs - days
- Rx; may require emergent intervention to lower ICP and/or stop bleeding
Case #1

- 20 yo rower, slips and falls while out at a party, small laceration forehead, slurring words, headache
- Sent by squad to ER
- BAC high
- CT scan
- MRI scan

Ax grad FE
Ax T1 post

Case #2

- Junior lax player returns from summer and reports on interim PPE: “small bleed in brain, cleared to return to play, just need to monitor it”. 5/2010
- Acute onset of subtle HA and mild confusion. No prior headaches
- ER after worsening HA, confusion
- Hx of head trauma 1/2010, cleared 3/10
- Records requested

Obtained second opinion from local neurosurgeon as well as two additional neurosurgical opinions
- D/Q from play for one year, w/ repeat cerebral angiogram p/t clearance

Case #1; repeat MR 2 wks later

- R frontoparietal occult cerebrovascular malformation (cavernous angioma)
- Well circumscribed 13 mm cortical/subcortical focus of intermediate to bright signal on T1 images, predominate bright on T2 w/ a rim of low signal better shown on T2 weighted images. No surrounding edema.
- Findings c/w occult cerebrovascular malformation (cavernous angioma) w/ thin margin of hemosiderin formation around it. Stability c/w ocm vs hemorrhagic contusion
- Gradient echo images demonstrate no foci of additional chronic or acute hemorrhage. DW images; no acute or ischemic change

Ax Flair T2
DW Images Ax Flair T2

Case #2

- Obtained second opinion from local neurosurgeon as well as two additional neurosurgical opinions
- D/Q from play for one year, w/ repeat cerebral angiogram p/t clearance

Concussion; Definition

- Pathophysiologic process affecting the brain induced by direct or indirect biomechanical forces
- Common features
  - Rapid onset of short lived impairment, resolves spontaneously
  - Functional disturbance more than structural
  - Graded set of clinical symptoms +/- LOC, sequential resolution
  - Typically normal neuroimaging
What occurs during Concussion?

- Neurometabolic cascade; ionic fluxes, hyperglycolysis
- Concussed brain in energy / metabolic crisis w/ potential loss for microstructural neuronal / axonal integrity
- With more severe injury; shear injury & diffuse axonal injury (DAI)
- Recovery metabolically appears to lag behind symptom resolution

Concussion Basics

- Concussion incidence increasing in all sports
  - ATC’s / MD’s better at detecting
  - Athletes stronger, bigger, hit harder, more aggressive
  - Increased media attention

Neurometabolic Cascade Following Experimental Concussion: Time Course & Recovery

Adapted from Giza CC and Hovda DA. J Athletic Training 36:229, 2001

Rate of Competition Concussion Injury

Summary Data
High School & College
Epidemiology of Concussions in High School and Collegiate Sports

- Data from the HS Reporting Information Online System and the NCAA ISS
  - 5.9% of all collegiate athletic injuries
  - 8.9% of all high school athletic injuries
  - Concussion rates were higher in college, but concussions were a higher proportion of all high school athletic injuries (Gessel JAT '07)
- 11.6% of concussions (HS) were recurrent (Swenson AJSM '99)

Gender Differences?

- Women have an increased incidence of concussion vs men in sports with same rules
  - Reporting bias
  - Hormonal influence
  - Head size / neck strength

Concussion; Signs & Symptoms

<table>
<thead>
<tr>
<th>Cognitive</th>
<th>Somatic</th>
<th>Affective</th>
<th>Sleep Disturbances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confusion</td>
<td>Headache</td>
<td>Dizziness</td>
<td>Emotional lability</td>
</tr>
<tr>
<td>Anterograde amnesia</td>
<td></td>
<td>Balance disruption</td>
<td>Irritability</td>
</tr>
<tr>
<td>Retrograde amnesia</td>
<td></td>
<td>Nausea/vomiting</td>
<td>Fatigue</td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td></td>
<td>Visual disturbances</td>
<td>Anxiety</td>
</tr>
<tr>
<td>Disorientation</td>
<td></td>
<td>(photophobia, blurry/double vision)</td>
<td>Sadness</td>
</tr>
<tr>
<td>Feeling “in a fog”, “zoned out”</td>
<td></td>
<td></td>
<td>Trouble falling asleep</td>
</tr>
<tr>
<td>Vacant stare</td>
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<td></td>
<td></td>
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<tr>
<td>Inability to focus</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Delayed verbal &amp; motor responses</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Slurred/incoherent speech</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Excessive drowsiness</td>
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</table>

Concussion Programs

- Identify high risk sports
- Education / Emergency Plans
- Recognition of injury
- Assessment
- Management Issues
  - Treatment
  - Disposition / Follow Up planning
  - Return to Learn / Return to Play

Emergency Action Plan

- Concussion Plan
- EDUCATION
  - Baseline evaluation; standardized assessment including questions re: modifiers; prolong or complicate recovery
  - Emergency protocols
  - Trauma center w/ neurosurgical capabilities

Education

- Poster for NFL Players
Education

Recognizing a Concussion

Signs and Symptoms

- Appears dazed or stunned
- Is confused about assignment
- Forgets plays
- Is unsure of game, score, or opponent
- Moves clumsily
- Answers questions slowly
- Loses consciousness
- Shows behavior or personality changes
- Can’t recall events prior to hit
- Can’t recall events after hit

Symptoms reported by athlete include:
- Headache
- Nausea
- Balance problems or dizziness
- Double or fuzzy vision
- Sensitivity to light or noise
- Feeling sluggish
- Feeling foggy or sluggish
- Concentration or memory problems
- Confusion

Diagnosis of Concussion

- Evaluation by ATC/MD staff of obviously symptomatic athlete
- Self-report by athlete
- Report by others / remote notification
- Delayed presentation several minutes, hours or days later

Diagnosis / Recognition

- Sometimes easy, but not always
- Hallmark confusion
- Differential dx:
  - Trauma-induced headache
  - Head injury w/ resultant HA
  - Intracranial bleed

Spectrum of Presentations

- Don’t miss the 2 extremes

Clinical Presentation

- “Tools” to evaluate injury may vary
  - Sideline v office/TR
  - Immediate v Delayed
- Tools evolving; spectrum
  - Symptoms
  - Cognitive evaluation
  - Balance
  - Neuroimaging
  - Other...
**Baseline Assessment**

**Modified Sideline Concussion Assessment Tool**

**Components of BLSCAT3**

- Symptoms
- PHQ-9, GAD-7
- "Modifiers"
- Cognitive Evaluation (SAC)
- Cranial nerves, visual tracking
- Finger to nose
- Balance (BESS)

**Sideline / On Field**

- Recognition and evaluation of athlete w/concussion is essential role of healthcare provider covering practice/games
- No same day return to play for athlete suspected of or diagnosed with concussion, even if sx resolve as athletic event evolves

**Sideline Assessment**

- More Serious Injury
- Glasgow Coma Scale

**Sideline Evaluation**

- ABC’s
- Neurologic & mental status
- R/O c-spine, skull fracture, bleed
- Spine board & transport to appropriate facility if indicated
- Remove from play; close observation

**Sideline Evaluation SCAT3, BJSM ’03**

- Is the athlete acting differently?
- Was there loss of consciousness?, If so, for how long?
- Was there problems with balance or unsteadiness?
- What mo, date, day, year, time is it?
Sideline Evaluation
Modified BESS (Guskiewicz) in SCAT3, BJSM '13

- Eyes Closed, hands on hips
- Error scoring
- 3 Stances; 20 sec each
  - Double leg stance
  - Single leg stance; stand on non-dominant leg
  - Tandem stance; non-dominant foot in back

Disposition
- Athlete should be improving & monitored
- If any deterioration, consider transport for emergency evaluation / exclude more serious brain injury
- Post Injury Care

When to Refer to ER
SCAT3, BJSM '13

- Worsening headache
- Very drowsy or can't be awoken
- Can't recognize people or places
- Develop nausea/vomiting
- Behave unusually, more confused or irritable
- Develop seizures, slurred speech, weakness, or unsteady gait

Post Injury Care
- Plan for f/u care
- Home care;
  - When to go to ER
  - Avoid aspirin, alcohol
  - No exertion / lifting
  - Avoid cognitive work
- Follow up care
- Consider neuropsychological testing

Neuropsychological Testing
- Provides reliable assessment & quantification of brain functioning by examining brain-behavior relationships

Neuropsychological (NP) Testing

Types of tests
- Computerized
- Paper / pencil
- Hybrid

Measure broad range of cognitive function:
- Speed of information processing
- Memory recall
- Attention & concentration
- Reaction Time
- Scanning & visual tracking ability
- Problem solving abilities
Princeton NP Battery
- ImPACT &
- Additional Tests:
  - Hopkins
  - BVMT
  - Digit Span
  - Trails A & B
  - PSU Cancellation
  - DSMT
  - Stroop

Neuropsychological Testing
- Many factors to consider in NP testing
- Not uncommon to see deficits in cognitive function by NP testing persist after symptoms have abated
- Opposite also true
- Can’t be used alone to make diagnosis or “clear” athlete. “One tool in the toolbox”
- Neuropsychologists best position to interpret

New Concerns re: NP?
- Determine severity of injury once all sx have cleared, neurologic exam & cognitive eval
- Nature, burden, duration of sx may be more indicative of severity

Concussion Management; RTP
- **Table 1. Graduated return to play protocol**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Functional exercise at each stage of rehabilitation</th>
<th>Objectives of each stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No activity</td>
<td>Symptoms limited physical and cognitive rest</td>
<td>Recovery</td>
</tr>
<tr>
<td>2. Light aerobic exercise</td>
<td>Walking, swimming or stationary cycling keeping intensity ≤70% maximum permitted heart rate for resistance training</td>
<td></td>
</tr>
<tr>
<td>3. Sport-specific exercise</td>
<td>Sliding skills in low, ground level, non-head impact activities</td>
<td>Add movement</td>
</tr>
<tr>
<td>4. Non-contact training skills</td>
<td>Progress to more complex training skills in football and/or hockey; May start progressive resistance training</td>
<td></td>
</tr>
<tr>
<td>5. Full-contact practice</td>
<td>For non-contact athletes participate in normal training activities; Restores confidence and access functional skills by creating task</td>
<td></td>
</tr>
<tr>
<td>6. Return to play</td>
<td>Normal game play</td>
<td></td>
</tr>
</tbody>
</table>

Severity of Injury
- Determine severity of injury once all sx have cleared, neurologic exam & cognitive eval
- Nature, burden, duration of sx may be more indicative of severity

TPCC Concussion Update Modifiers (Herring et al ’11)

<p>| TABLE 1. RISK FACTORS THAT MAY PROLONG OR COMPLICATE RECOVERY FROM CONCUSSION |</p>
<table>
<thead>
<tr>
<th>FACTORS</th>
<th>MODIFIER</th>
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</thead>
<tbody>
<tr>
<td>Concussion History</td>
<td>Total number, proximity, severity (duration)</td>
</tr>
<tr>
<td>Symptoms</td>
<td>Total number, severity (intensity and especially duration)</td>
</tr>
<tr>
<td>Signs</td>
<td>Prolonged LOC (&gt;1 min)</td>
</tr>
<tr>
<td>Susceptibility</td>
<td>Concussions occurring with lower impact magnitude and/or requiring longer recovery.</td>
</tr>
<tr>
<td>Age</td>
<td>Youth and adolescent athletes may recover more slowly.</td>
</tr>
<tr>
<td>Pre-existing conditions</td>
<td>Migraine, depression, anxiety/panic attacks, attention deficit hyperactivity disorder (ADHD), learning disabilities (LD)</td>
</tr>
</tbody>
</table>
Modifiers of Injury

- Gender
- Genetics

Revisiting the modifiers: how should the evaluation and management of acute concussions differ in specific groups?

Predicting Recovery

- Cognitive rest important in school aged athlete
- Emotional readiness often not evaluated
- Risk factors for athletes with delayed recovery unknown
- More sophisticated tools (fMRI, DTI, MR-spectroscopy) may provide answers

Complications / Long Term Concerns

- Psychological response to Injury: athletes at risk
- Persistent / Prolonged Symptoms
- Post Concussion Syndrome
- Depression
- Chronic Traumatic Encephalopathy

Psychological Response to Injury

- Not uncommon in all injuries
- Concussion is particularly challenging injury
  - Can’t tell you how long you will be out
  - Can’t exercise...
  - Student-Athlete
- Watch for problematic responses to injury; know resources

Complications/Concerns

What every athlete is concerned about...

"I'm right there in the room and no one even acknowledges me."
Challenges / Future Directions

- Education / awareness
- Technique
- Strength & Conditioning
- Changing the Culture of the game
- Rule Changes / Enforcement
- Decreasing exposures

Policy Changes

- NFL 12/09 Press release
- NCAA follows suit; creates mandates & “best practices”
- NHFS; no same day RTP
- Zack Lystedt Law
- Legislative efforts across the country
- Rule changes in sports; change the culture, ↓ exposures

The New York Times  Published: July 19, 2011

Ivy League to Limit Full-Contact Football Practices
By KEN BELSON

The Ivy League will announce on Wednesday that, in an effort to minimize head injuries among its football players, it will sharply reduce the number of allowable full-contact practices teams can hold.

Yale linebacker Jesse Reising suffered a concussion against Harvard in 2010. In an effort to sharply reduce head injuries, the Ivy League will sharply reduce the number of allowable full-contact practices. The changes, to be implemented this season, go well beyond the rules set by the NCAA and are believed to be more stringent than those of any other conference. The league will also review the rules governing men’s and women’s hockey, lacrosse and soccer to determine if there are ways to reduce hits to the head and concussions in those sports.

Equipment

Helmets; Facts

- Rugby athletes feel more confident in their tackling & feel they can tackle harder w/ headgear Finch BJSM ’01
- False sense of protection; ? greater risk
- Recent review of literature re: equipment

Helmets in Sport

Conclusions;

- Studies evaluating injury data & mechanisms important in determining potential interventions to decrease / prevent injury
- Putting a helmet on an athlete, though appealing, may not always ↓ concussion
- Unintended consequences?
Equipment

Rules & Culture

- Rules / Enforcement
  - NCAA Point of Emphasis
  - NFL rule changes
  - Hockey
  - Lacrosse (NCAA & US Lacrosse Youth Rules)

- EDUCATION
  - High risk sports
  - Coaches / Parents/ Administrators
  - “teachable moments”

Changing the culture of sport

- NFL
- Fair Play Hockey
- USA Football: “Heads Up”
- US Lacrosse: “Honor the Game, Play with Class”

New Imaging Modalities

- fMRI
- DTI
- MR Spectroscopy

Big Picture: What We Know

- LOC does not predict severity
- No athlete should participate when symptomatic
- No same day RTP
- Modifiers important
- Physical and mental rest important
- Individualized management
- Gradual RTP

Big Picture: What We Don’t Know

- How many is too many?
- Genetic, gender & other factors (migraine, LD…)
- NP testing
- Role of neuroimaging?
- Protective equipment?
- Depression & suicide??
- Role of omega 3’s?
Conclusions

- Head injury, including concussions important injury
- Thorough evaluation; consider c-spine & other more serious brain injury
- Concussion Plan as part of EAP
- Understand limitations to sideline eval; injuries evolve
- Err on the side of caution

Thank You!!