CONCUSSION MANAGEMENT IN THE ADOLESCENT ATHLETE
Anne Mucha, DPT, MS, NCS
Sean Learish, MPT
Centers for Rehab Services, University of Pittsburgh Medical Center
Sports Concussion Program
Combined Section Meeting 2012

Objectives
- Describe the pathophysiology, signs and symptoms of concussion
- Recognize factors contributing to prognosis and outcome following concussion in young athletes
- Describe negative outcomes related to concussion
- Identify management principles for rehabilitation of the concussed adolescent athlete
- Recognize the role of physical therapy in the multidisciplinary management of concussion
- Apply the principles of exertional rehabilitation to concussion management in adolescents

Concussion: Spotlight on the Professional Athlete

The Reality:

The Concussion “Epidemic”
- Estimated 1.6-3.8 million sports and recreation concussive injuries occur annually in US (CDC Toolkit for Physicians, 2008)
- Between 1997-2007 the number of ED visits for 14-19 year olds for concussion TRIPLED!
- > 40% of Concussions dx’d in ED occur in children/adolescents between 5-19 yo.
- 30-58% of ED-dx’d concussions due to SPORTS
  (Bakhos 2010) (Meehan 2010)

Which sports have highest risk?
Incidence Rates for High School Sports
(based on 1000 athletic exposures)

Highest:
- Football (.47-.6)
- Girls’ soccer (.32-.35)
- Boys’ Lacrosse (.3)
- Girls’ Lacrosse (.2)

Lowest:
- Baseball (.05 - .06)
- Cheerleading (.06)

Trends:
- Concussion rate has steadily increased over time
- Girls – nearly 2x risk in similar sports
  (Lincoln 2011; Gessel 2007)
Concussion Management in the Adolescent Athlete

Participation Rates (non contact sports omitted)

1. Football (3X)
2. Boys' Basketball
3. Girls' Basketball
4. Baseball
5. Softball
6. Boys' Soccer
7. Boys' Wrestling
8. Girls' Volleyball
9. Girls' Soccer
10. Girls' Field Hockey

Sports w/ Highest Incidence Rates
- Football
- Girls' soccer
- Boys' Lacrosse
- Girls' Lacrosse

What Causes a Concussion?

Mechanism of Injury
- Blow to head or body, direct impact not necessary
- Acceleration/Deceleration
- Rotational Forces
- Frequently no LOC

Concussion: CDC Definition
- A complex pathophysiologic process affecting the brain, induced by traumatic biomechanical forces secondary to direct or indirect forces to the head.
- Caused by a jolt to the head or body that disrupts the function of the brain.
- Typically associated with normal structural neuroimaging findings (ie CT scan, MRI).
- Results in a constellation of physical, cognitive, emotional or sleep-related symptoms that may or may not involve a loss of consciousness (LOC).
- Duration of symptoms is highly variable and may last from several minutes to days, weeks, months, or longer in some cases.

Centers for Disease Control, 2007

Pathophysiology


↑ ENERGY DEMAND + ↓ BLOOD SUPPLY = METABOLIC CRISIS

Concussion is a metabolic, rather than structural, brain injury
Post-Injury Differences

- Differences in glutamate receptor expression
- Differences in dopaminergic activity
- Vascular responses to injury
- Susceptibility of glutamate receptors

Susceptibility to Repeat TBI in Young?

- Pre-adolescent rats subjected to 2 concussions one day apart. Repeat TBI rats had:
  - More axonal damage
  - More memory impairment in novel task
  - Higher mortality

Findings after Concussion:

- Smaller head size compared w/ body
- Brain water content
- Myelination
- Vascular responses
- Clinical presentations

What about kids?

- Pediatric concussion studies support this model of functional, rather than structural, injury
- Post Concussion CBF regulation may be more variable in pediatrics
- Certain pathology seen only in pediatrics: eg. Second Impact Syndrome
- Children are not Small Adults!!
ER Management of Children w/ mTBI
- 69% of children presenting to ED w/ concussions receive scans
- < 10% have abnormalities
- Radiation exposure: ↑d risk of leukemia/solid organ tumors in pediatric vs adult pts exposed to CT
- Clinical prediction rules based on:
  - GCS < 14
  - Altered mental status
  - Signs of skull fx
  - Severe mechanism of injury
  - LOC or vomiting
  - Severe HA
  - Abnormal behavior
  - Short sequence MRI may be better alternative

Symptom Clusters following Sports Concussion

Symptom Checklists in Pediatric Concussion
- Post-Concussion Scale (Lovell 2006)
- Post-Concussion Symptom Inventory (Gioia 2008)
- Graded Symptom Checklist (Guskiewicz 2004)
- Rivermead Post-Concussion Symptoms Questionnaire (King 1995)

The problem with Symptom Checklists:
Under-reporting & magnification are common
(McCrea 2004, Williamson 2006)

Symptom Reporting in Children
- Psychometric evidence for the use of concussion symptom scales is stronger for adolescents (ages 13-22 years) than for younger athletes (ages 5-12 years) (Gioia 2009)
- Children (< 10 yo) may report concussion symptoms differently from adults
- Age-appropriate symptom checklists are recommended after a suspected concussion
(McCrory 2009)

Neurocognitive Assessment
- Traditional: paper-pencil testing
- Computerized models often used
- Most useful when patient has baseline testing for comparison post concussion
- Not recommended as “stand alone” measure, however (Randolph 2005)
Computerized Assessment Measures

**Sports/General Population:**
- ImPACT (Immediate Post-Concussion Assessment and Cognitive Testing)
  - [http://www.impacttest.com/](http://www.impacttest.com/)
- CogState Sport
  - [www.cogstate.com](http://www.cogstate.com) provides normative data, descriptions
- Headminders CRI (Concussion Resolution Index)
  - [www.headminder.com/site/cri](http://www.headminder.com/site/cri)

**Military:**
- Automated Neuropsychological Assessment Metrics (ANAM)

Concussion Assessment:
**Balance, Vestibular & Visual System Findings**

Impaired Postural Control

- Very common acutely and sub-acute following concussion (Gesu'ts 1996; Guskiewicz 1997; Guskiewicz 2000)
- Often related to abnormalities in Sensory Organization
- It appears that, in particular, the ability to utilize and process *vestibular* information needed for postural control may be affected in concussed athletes (Peterson 2003; Guskiewicz 2001)

Dynamic Posturography

Sensory Organization Test (Nashner, 1982)

Clinical Test for Sensory Interaction in Balance

**CTSIB**
- 6 Conditions
- Firm / Foam Surface
  - Eyes Open
  - Eyes Closed
  - Dome
- 30 seconds
- 2 or more falls/3 trials

Balance Error Scoring System

**BESS Test** (6 items)
- 3 Postures
  - Standing feet together
  - Single-limb Stance
  - Tandem Stance
- Firm / Foam Surface
- Eyes Closed
- 20 seconds
- Scored by number of errors committed

This information is the property of Anne Mucha & Sean Learish and should not be copied or otherwise used without express written permission.
Concussion Management in the Adolescent Athlete

**Balance Measures**

- **Self Report (subjective)**
  - Activity-Specific Balance Confidence Scale (ABC)
  - Falls Efficacy Scale (FES)
- **Functional Outcome Measures**
  - Dynamic Gait Index
  - Functional Gait Assessment
  - HiMAT
  - **Dual Cognitive Task paradigms**
  - Five Time Sit to Stand
  - TUG

**Post Concussive Dizziness:**

- Present in 23% to 81% of cases in the first days after injury (Griffiths 1979; Kislevski 2001; Maskell 2006; Maskell 2007, Terrio 2009)
- In blast-related mTBI, most common post-injury symptom (Hoffer 2010)
- Dizziness was the sole ON FIELD factor predictive of protracted (> 21 days) time to recovery (Lau 2011)
- Common symptom in persistent post-concussion syndrome, with prevalence as high as 32.5% at 5 years (Masson 1996)

**Etiology of Dizziness in Concussion**

- **Inner Ear**
  - Benign Paroxysmal Positional Vertigo (BPPV)
  - Labyrinthine Concussion
  - Perilymphatic Fistula
- **Central/Brain**
  - Post traumatic migraine
  - Brainstem concussion
  - Autonomic dysregulation/postural hypotension
  - Oculomotor abnormalities
  - Seizures (rare with mTBI)

**Cervicogenic Dizziness**

**Visual/Ocular Motor Abnormalities often seen in:**

- Pursuits
- Saccades
- Vergence/Accommodation
- Alignment
- Gaze Holding
- Visual Fields

(Kapoor 2002; Ciuffreda 2007)

**Oculomotor Disturbances – subjective complaints:**

- Blurred vision
- Double vision
- Jumping images (oscillopsia)
- Eye strain
- Dizziness

*Intervention is often helpful!*

(Ciuffreda 2008)

**Management of the Post Concussive Patient: Multidisciplinary Team**

- **Core Medical Team**
  - Neuropsychology
  - MD (with concussion background/training)
  - Physical Therapy (Vestibular and/or Exertional)
  - Athletic Trainer
- **Academic Team:**
  - School Nurse
  - Guidance Counselors
  - Teachers
  - Coaches
  - Athletic Director
  - Parents/family

*WHEN NEEDED:*

- Neuro-Otolgy
- Neuro-Ophthalmology/Optometry
- Psychology/Psychiatry
- Cognitive Therapy
Individual Recovery From Sports MTBI: How Long Does it Take?

Factors Related to Outcome:

Constitutional Factors:

Age
Professional athletes - 1 day
College athletes - 2-7 days
High school athletes - 7-14 days

Gender
Females have higher risk of sustaining concussion
Longer recovery time


Migraines:

Athletes with post traumatic migraines had significantly lower cognitive performance compared with those with no headache or even those with non migraineous headaches

Mhaik et al., 2005

Sometimes, you gotta dig!

Repetitive Injury:
History of 3 or more concussions is associated with subjective symptoms, and poorer cognitive test performance
Athletes with ≥ 3 concussions may be at greater risk for future concussion
Iverson et al., 2004; Guskiewicz et al., 2003

Other Constitutional Factors:
- Learning disabilities (Collins 1999)
- Pre-existing mood disorders?
Amnesia:
- Predictive of ability to detect quick recovery (≤ 3 d)
- Retrograde vs Anterograde (post traumatic)
- Presence of amnesia was most predictive of postinjury difficulties at 3d after injury
- Those athletes with high degree of symptoms and cognitive deficits
  - 10x more likely to have had any degree of retrograde amnesia
  - 4x more likely to have had any degree of anterograde amnesia
- Brief LOC was NOT related to quick recovery (Collins et al., 2003)

Determining Which On-Field Signs/Symptoms Were Most Predictive of Protracted Recovery

Direct LR with 3 predictors: \( \chi^2 (3, 94) = 11.77, p = .008 \)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Wald</th>
<th>OR</th>
<th>p</th>
<th>95% CI for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dizziness</td>
<td>5.44</td>
<td>6.34</td>
<td>0.02</td>
<td>1.34–29.91</td>
</tr>
<tr>
<td>LOC</td>
<td>2.53</td>
<td>0.27</td>
<td>0.11</td>
<td>0.54–1.35</td>
</tr>
<tr>
<td>Vomiting</td>
<td>1.45</td>
<td>0.42</td>
<td>0.23</td>
<td>0.10–1.72</td>
</tr>
</tbody>
</table>

Lau et al 2011

FACTORS RELATED TO OUTCOME:
Post Injury Factors

Fogginess:
- May be associated with a more severe course and protracted recovery
- "Foggy" athletes vs non-foggy athletes:
  - Slower reaction time
  - Attenuated memory performance
  - Slower processing speed
  - Significantly higher number of other post-concussion symptoms

(Iverson 2004)

NeuroCognitive Testing:
- Early (< 3 d) deficits in reaction time and visual memory (on ImPACT test) predictive of > 10 day recovery course
- Athletes w/ deficits in 3 out of 4 global areas of ImPACT test: 94.6% likely to require at least 10 days until recover

(Iverson 2007)

N =114 High School Football Players
Concussion Management in the Adolescent Athlete

Exertion:

- Student athletes who engaged in **high levels of activity** in the weeks following concussion had **increased symptoms** and **worsened neurocognitive data**
- They also had significantly longer recovery time

Majerske et al., 2008

Cognitive Symptoms

- "Fogginess"
- Difficulty concentrating
- Memory deficits
- Cognitive Fatigue

Mood Disturbance

- Irritability
- Feeling sad
- Anxiety

Somatic Symptoms

- Headaches
- Dizziness
- Nausea
- Light/Sound Sensitivity

Sleep Alterations

- Difficulty falling asleep
- Fragmented sleep
- Too much/too little sleep

Majerske et al., 2008

What happens when symptoms don’t go away with rest alone?

Management of Concussion

- Medications
- Activity
- School
- Rehab

Headache Management:

- Most common post concussive symptom (71% in sports-related concussion)

Types based on etiology:

- Cognitive-Fatigue
- Migraine
- Musculoskeletal/Cervicogenic
- Medication Induced (Bigal 2004)
  - Combination OTC meds
  - Opiods
  - Triptans

Cognitive Fatigue Headaches

**Scenarios:**

- High school junior sustains concussion. Returns to school asymptomatic, but routinely experiences headaches by mid-morning. Cannot eat lunch in cafeteria. Frequently in nurse’s office and often leaves school early due to headaches.

- 15 year old student experiences concussion. Has no symptoms at rest, but notices headaches with climbing stairs and physical activity.

Potential Treatments:

- Rest
- Neurostimulants (amantadine, ritalin, etc)

Migraine Headache

- Neuro-Vascular (trigeminovascular system)
- Genetic predisposition
- Associated symptoms:
  - Visual (aura)
  - Photophobia/phonophobia
    - ie, light/noise sensitivity
  - Dizziness
  - Nausea

This information is the property of Anne Mucha & Sean Learish and should not be copied or otherwise used without express written permission.
Migraine Management:

<table>
<thead>
<tr>
<th>Education/Control of Triggers</th>
<th>Medications:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Regular Sleep Schedule</td>
<td>Abortive:</td>
</tr>
<tr>
<td>• Caffeine</td>
<td>OTC:</td>
</tr>
<tr>
<td>• Chocolate</td>
<td>• ibuprofen</td>
</tr>
<tr>
<td>• Stress reduction</td>
<td>• Aleve</td>
</tr>
<tr>
<td></td>
<td>• Excedrin migraine</td>
</tr>
<tr>
<td></td>
<td>• etc.</td>
</tr>
</tbody>
</table>

Preventative:

• Triggers:
  - zolmitriptan
  - sumatriptan (Imitrex)
  - rizatriptan (Maxalt)

• Anticonvulsants:
  - valproic acid (Depakote)
  - gabapentin
  - topiramate (Topamax)
  • etc

• Beta blockers
• Calcium channel blockers

Medical Intervention – other areas:

Sleep Alterations

Sleep hygiene education
• Trazodone,
• melatonin agonists,
• nonbenzodiazepine hypnotics

Cognitive Issues

• Neurostimulants*
  • amantadine, Ritalin, etc

Mood Disruption

• Psychotherapy
• Antidepressants
  • SSRI’s
• Tricyclics (eg, amitriptyline, imipramine)

PT MANAGEMENT IN CONCUSSION

Vestibulo-Ocular Reflex Training
(Gaze Stability Training)

- Maintain visual fixation during head movement
  - Direction of head movement
  - Speed of head movement
  - Posture
  - Target size

BPPV

- Canalith repositioning maneuver
- Incidence of BPPV in Concussion may be low (<5%) (Alsalaheen 2011)
Sensory Integration Exercises & Balance Training

Oculomotor Training
Voluntary eye movements; Vergence eye movements

Training of Eye/Head Coordination

Visual Motion Sensitivity training
Gradual exposure to provocative stimuli
- Light/Dark
- Use of fixation point
- Posture
- Surface

Management of Cervicogenic Issues:
- Cervical Spine Management
  - Manual Therapy
  - Targeted strength training/ROM
  - Injection
  - Acupuncture (Michels 2007, Heikkilä 2000)
  - Surgery
- Balance retraining
- Cervical sensory retraining
- Ocular motor retraining
  (Revel 1994; Juli 2007; Kristjansson 2008)

Return to School following Concussion
- Homebound instruction
- Partial attendance
- Late starts/Early dismissals
- Rest periods during day
- Extra time for assignment completion
- Excuse from non-essential assignments
- Postpone or stagger testing
- Excuse from standardized testing
- Extra time and/or open book testing
- Exams in small/quiet rooms
- Tutor
- Excuse from gym & attending sport practices
- Excuse from assemblies, band/orchestra, woodshop
- Lunch in quiet area
- Preferential classroom seating
- Accommodations for light/noise sensitivity (earplugs, ball cap, sunglasses, dimmer lights)
- Books on tape
- Audiolized lectures
- Provide note-taker or scribe
- Provide classroom notes/powerpoint prior to class

McGrath 2010

This information is the property of Anne Mucha & Sean Learish and should not be copied or otherwise used without express written permission.
Facilitating Safe Return to Activity

PURPOSE OF PRESENTATION

- Review risks of returning to physical exertion after concussion
- Review practical approaches to physical examination prior to return to physical exertion
- Review 5 stage exertion protocol and screening process for concussion patients
- To give practical ideas for a safe progression of exercises after concussion
- To give clinical insights as it relates to physical exertion after concussion in adolescents

Concussion Rehab at UPMC

UPMC Center for Sports Medicine

UPMC Concussion Program
- Neuro-Cognitive testing (ImPACT)

Exertion Based Program

CONCUSSION MANAGEMENT: Why?
SERIOUS RISKS OF RETURN TO PLAY

- Second Impact Syndrome (SIS)
  - adolescent at higher risk?

- Post Concussion Syndrome (PCS)
  - adolescent at higher risk?

- Chronic Traumatic Encephalopathy (CTE)
  - long term concern/problem

Second Impact Syndrome (SIS)

- Defined/described as “when an athlete sustains an initial head injury and then suffers a second head injury before the symptoms associated with the first impact have cleared”
- “second-impact dysautoregulation” vs. subdural hematoma (SDH)
- Similarities with non-accidental head trauma (shaken-baby syndrome)
- Questionable whether significant collision/impact to head is necessary?

(Cantu and Gean)

Post Concussion Syndrome (PCS)

- Defined (by World Health Organization): persistence of 3 or more of the following after head injury:
  - headache, dizziness, fatigue, irritability, insomnia, concentration difficulty, memory difficulty
- Other physiological effects:
  - Heart and Autonomic Nervous system dysfunction
  - HR elevated and exaggerated sympathetic responses
  - Cerebral Blood Flow auto-regulation disrupted

Chronic Traumatic Encephalopathy (CTE)

- Defined: a progressive degenerative disease of the brain found in athletes (and others) with a history of repetitive brain trauma, including symptomatic concussions as well as asymptomatic sub-concussive hits to the head. (AKA: Dementia pugilistica)
- Degeneration of the brain tissue, build-up of an abnormal protein called tau.
- Clinical symptoms: memory loss, confusion, impaired judgment, impulse control problems, aggression, depression, and, eventually, progressive dementia.

McKee, et al and Guskiewicz, et al

Management Following Concussion

- Typical Management
  - On Field Management
  - Acute Management
  - Sub-Acute (2-3 wks)
  - Chronic/PCS (>6wks)
- International Conference on Concussion in Sport
  - RECOMMENDATIONS
- Persistent symptoms/PCS

Exertion Testing

- Testing vs. Rehab
  - Progressive
  - Incorporate vestibular challenges
- When Symptom Free
  - Testing for RTP decision
  - Testing for clearance of activity
- If Symptomatic
  - Test for symptom exacerbation
  - Establish thresholds
  - Consultation
Concussion Management in the Adolescent Athlete

GRADED REHAB PROGRAM

Sub-Symptom Threshold Exercise Training (SSTET)
- Leddy, et al

Traditional Target Heart Rate approach
- Karvonen’s Formula with gradual progression
  \[(220 - \text{Age}) - \text{Resting H.R.}] \times \text{Target \%} + \text{Resting H.R}\]

Comprehensive Program
- Graded approach
- Integrate vestibular challenges
- Individualized

Target Heart Rate: 5 Stage Approach

- Minimal Exertion: Target heart rate 30-40%
- Light-Moderate Exertion: Target heart rate 40-60%
- Moderately Aggressive: Target heart rate 60-80%
- Sports Performance: Target heart rate 80-90%
- Sports Performance: Full Exertion with contact

Stages 1-4: Physical Therapy
Stages 5: Sports Performance

Evaluation

- History
  - Current and previous history
  - Review Neuro-cognitive info (ImPACT data)
  - Headache/migraine history
  - Goals and expectations
  - Current Symptoms
  - Medications
  - Daily concussion data

  *** very important ***

Evaluation (cont.)

- Vitals
  - BP, Resting Heart Rate
- Cervical Screen
  - ROM, strength, special testing
- Musculoskeletal Screen
  - ROM, strength
- Balance/Vestibular Screen
  - BESS test
- Exertion Test
  - GRADUATED TREADMILL TEST (SSTET)
- Conditioning tests
  - FIT test, 6 minute Walk test

STAGE 1

Minimal Exertion

POPULATION: Symptomatic, chronic problem, or very acute injury.

EXERTION: 30-40% of MAX
- 10-15 minutes
- Low Impact: Bike, Upper Body Ergometer, Treadmill (walk)

THERAPEUTIC EXERCISE
- Light stretching
- Light strengthening

BALANCE
- Low Level Tasks
- Romberg Activities
*Specialized Balance/Vestibular treatment (as appropriate)
Concussion Management in the Adolescent Athlete

STAGE 1: Exertion Activities

- STAGE 1: Exertion Activities
- STAGE 2: Exertion Activities
- STAGE 3: Exertion Activities
- STAGE 4: Exertion Activities

STAGE 1: Exertion Activities

- **POPULATION**: Less symptomatic, finding threshold for exercise, or acute injury attempting to progress.
- **EXERTION**: 40-60% of max
  - 20-25 minutes
  - Low impact: Elliptical, Treadmill (incline), step exercise
- **THERAPEUTIC EXERCISE**
  - Some active stretching
  - Moderate strength exercise
- **BALANCE**
  - Moderate level tasks
  - Work on movement and position changes
  - Swiss Ball, VOR activities, Ball tossing

STAGE 2: Exertion Activities

- **POPULATION**: Mildly symptomatic, chronic patient attempting to progress, or acute injury attempting return to normal range of exercise.
- **EXERTION**: 60-80% of MAX
  - 25-30 minutes
  - Impact activities: jogging, agility
- **THERAPEUTIC EXERCISE**
  - Active stretching, more aggressive strength exercise
  - Training exercise with position change and head movement
  - Integrate cognitive challenges (concentration)
- **BALANCE**
  - Dynamic Balance tasks
  - Integrate exertion, strength, and dynamic balance activities

STAGE 3: Exertion Activities

- **POPULATION**: No symptoms or infrequent/episodic symptoms only, patient attempting to resume specific activities, functional training phase.
- **EXERTION**: 80% of MAX
  - 40-50 minutes
  - Aggressive cardio, including intervals
- **THERAPEUTIC EXERCISE**
  - Dynamic stretching and other activities to maintain consistent elevation of heart rate
  - Training exercise with position change and head movement
- **BALANCE**
  - Dynamic Balance tasks
  - Integrate exertion and vestibular rehab into work or sport specific activities

This information is the property of Anne Mucha & Sean Learish and should not be copied or otherwise used without express written permission.
**STAGE 4**: Functional Exertion Activities

**STAGE 5** (Sports Performance Training)

- **POPULATION**: symptom free, individuals attempting to return to competitive sports
- **EXERTION**: 80-100% of MAX
  - Sport specific endurance activities, interval training
- **EXERCISE**: Aggressive sport specific flexibility and strength training
- **BALANCE**: Aggressive sport specific dynamic balance activities
  * prepares for practice and game intensity

**Dynamic Balance Exercises**

**Subjective and Objective Assessment**

**Data Before Exertion**
- a) Symptoms reports
- b) Vitals (heart rate, BP)
- c) Medication confirmation
- d) Assessment of activities prior to exertion
- e) Balance check (modified BESS)

**Data After Exertion**
- a) Symptom reports
- b) Vitals
- c) Balance check (modified BESS)

**CRITERIA FOR PROGRESSION OF STAGES**:
1. No exacerbation of symptoms with all activities (Cardio, Therapeutic Exercise, and Balance).
2. Post exertion data/testing normal.
3. If baseline symptoms persist prior to exercise, need to report no exacerbation of symptoms for multiple treatments.
4. Patient and patients family need to express a clear desire and comfort level with plans to progress.
5. Need to be certain that patient is being honest about reporting of symptoms.

**Rate of Progression**

- Variable
  - according to history and symptoms
  - according to type of activity/exercise
  - age
- Dependent on patient’s goals
  - in season of sport
  - time line for return
- Dependent on response to exercise
  - increase, decrease, no change

This information is the property of Anne Mucha & Sean Learish and should not be copied or otherwise used without express written permission.
Physical Exertion: Variables of Interest

- Activity Level prior to rehab session (cognitive/physical)
- Maximum Heart Rate and/or Sustained Heart Rate
- Symptoms severity and symptom exacerbation
- Medications
- Sensitivity to head movement and position change (vestibular)
- Age: Adolescent at more risk?

COMPONENTS of EXERTION

Therapeutic Exercise (Cardio, Strength, Flexibility)

Cognitive (Concentration, focus)

Dynamic Balance Activities (proprioception, vestibular)

KEY POINTS OF CLINICAL OBSERVATION

- Graded return to exertion
- Individualized care with Multi-Discipline involvement
- Patient/ Family Education
- ULTIMATE GOAL: Compliment Neuro-Cognitive and Medical Management
- Safe Return to physical activities/sport
- Unique factors of adolescent patients
  - Parental involvement
  - Behavioral factors
  - More conservative approach

Effects of Exertion Rehab Program

- POSITIVE:
  - Physiologic effect of SSTET on brain (autonomic balance and cerebral autoregulation?)
  - Structure allows return to activity safely... potentially quicker
  - Education of patient/family
  - Avoid deconditioning and depression
- NEGATIVE:
  - challenges of limited access/ supervision
  - exacerbation of concussion symptoms

Adolescent Case Presentation
HPI
- 15 yo male
- 9/17/11 – helmet to helmet blow during football game
- No LOC; immediately dazed, neck pain, blurred vision, photophobia
- Removed from game; taken to Children’s Hospital ED
- C-Spine Radiographs Neg
- 3 hrs retrograde amnesia; 30 min post-traumatic amnesia

PMH

Prior Concussions:
- Aug 2011 – concussion during football practice (sx’s: HA’s, dizziness, phonophobia, bradyphrenia) Managed by ATC; returned to play 1 wk later
- 8th grade

Social/Academic:
- Entering 10th grade: Average/above average student; Plays football, baseball, skier
- Parents divorced; father lives in Florida

Presenting Sx’s - 1 wk post injury:
- Attending school ½ days; no other exertion
- HA’s 8-10 daily
- Phono/photo sensitivity
- Dizziness
- Blurred Vision
- Fogginess
- Fatigue
- Near-syncope w/ sit-stand (2x)
- Memory difficulty

Neurocognitive Data (ImPACT™)

<table>
<thead>
<tr>
<th>Test</th>
<th>9/23/10</th>
<th>Pre-Season Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Memory Composite</td>
<td>37 (&lt;1%)</td>
<td>83 (53%)</td>
</tr>
<tr>
<td>Visual Memory Composite</td>
<td>32 (&lt;1%)</td>
<td>96 (98%)</td>
</tr>
<tr>
<td>Visual Motor Speed Composite</td>
<td>20.45 (&lt;1%)</td>
<td>36.55 (52%)</td>
</tr>
<tr>
<td>Reaction Time Composite</td>
<td>1.20 (&lt;1%)</td>
<td>0.6 (51%)</td>
</tr>
<tr>
<td>Symptom Score (range 0-138)</td>
<td>73</td>
<td>1</td>
</tr>
</tbody>
</table>

Initial Interventions:
- Recommend removed from school
- MRI/MRA of brain (neg)
- F/U 2 wks

F/U Visit – 4 wks post injury
- Attending school ½ days
- HA’s continue; worse @ end of school. Aggravated by environments with lot of sound and stimulation
- Mental fogginess, trouble concentrating, difficulty focusing, and difficulty with short term memory.
- Dizziness and impaired balance

Interventions:
- Placed on amantadine (neurostimulant)
- Referred to Vestibular PT

This information is the property of Anne Mucha & Sean Learish and should not be copied or otherwise used without express written permission.
Vestibular PT Eval – 5 wks post injury
- Constant HA’s (2-9/10)
  - worse w/ reading, riding in car/motion, noise, bright lights, busy environments
- Dizziness
  - Near syncopal episodes w/ sit-stand
- Quick head movements
- Riding in car
- Poor balance
- Sleep dysregulation – initiating
- Fatigue
- Irritability
- Neck pain- resolved

Vestibular PT Referral:
- Impaired Postural Control:
  - mCTSIB – increased sway with eyes open and closed on compliant foam
- Ocular motor: slowed saccades, abnormal convergence
- Blurry/dizzy w/ slow VOR

Initial Vestibular PT Data

<table>
<thead>
<tr>
<th></th>
<th>10/27/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC</td>
<td>77%</td>
</tr>
<tr>
<td>DHI</td>
<td>58/100</td>
</tr>
<tr>
<td>DGI</td>
<td>21/24</td>
</tr>
<tr>
<td>FGA</td>
<td>25/30</td>
</tr>
</tbody>
</table>

Vestibular PT Interventions:
- Home based ex: (1-2x/day)
  - Ocular Motor training: versions (saccades & vergence
  - Gaze stability training
  - Balance training: sensory organization and dynamic ex
- Clinic program 1x/wk

8 Week f/u: Neurocognitive Data (ImPACT)

<table>
<thead>
<tr>
<th></th>
<th>9/23/11</th>
<th>11/10/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Memory Composite</td>
<td>37 (&lt;1%)</td>
<td>61 (2%)</td>
</tr>
<tr>
<td>Visual Memory Composite</td>
<td>32 (&lt;1%)</td>
<td>45 (&lt;1%)</td>
</tr>
<tr>
<td>Visual Motor Speed Composite</td>
<td>20.45 (&lt;1%)</td>
<td>26.1 (3%)</td>
</tr>
<tr>
<td>Reaction Time Composite</td>
<td>1.20 (&lt;1%)</td>
<td>1.06 (&lt;1%)</td>
</tr>
<tr>
<td>Symptom Score</td>
<td>73</td>
<td>18</td>
</tr>
</tbody>
</table>

Management – 8 wk f/u
- Removed from school; homebound instruction 1hr/day, 5d/wk
- Instructed to take amantadine as prescribed 2x/day
- Initiate amitriptyline
- Continue Vestibular PT 1x/wk
- Initiated VisionTherapy
Vestibular PT Data

<table>
<thead>
<tr>
<th></th>
<th>10/27/11</th>
<th>12/1/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC</td>
<td>77%</td>
<td>98%</td>
</tr>
<tr>
<td>DHI</td>
<td>58/100</td>
<td>28/100</td>
</tr>
<tr>
<td>Ocular Motor</td>
<td>Convergence insufficiency, slowed saccades</td>
<td>Saccades WNL; mild convergence insufficiency (started vision therapy)</td>
</tr>
<tr>
<td>mCTSIB</td>
<td>↓'d sway on foam w/ eyes open &amp; closed</td>
<td>WNL all conditions w/ head turns</td>
</tr>
<tr>
<td>DGI</td>
<td>21/24</td>
<td>24/24</td>
</tr>
<tr>
<td>FGA</td>
<td>25/30</td>
<td>30/30</td>
</tr>
<tr>
<td>DVA</td>
<td>3 line loss with clinical exam, severe sx's</td>
<td>Less symptomatic</td>
</tr>
</tbody>
</table>

Neurocognitive Data (ImPACT™)

<table>
<thead>
<tr>
<th></th>
<th>9/23/11</th>
<th>11/10/11</th>
<th>12/01/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Memory Composite</td>
<td>37 (&lt;1%)</td>
<td>61 (2%)</td>
<td>67 (0%)</td>
</tr>
<tr>
<td>Visual Memory Composite</td>
<td>32 (&lt;1%)</td>
<td>45 (&lt;1%)</td>
<td>82 (72%)</td>
</tr>
<tr>
<td>Visual Motor Speed Composite</td>
<td>20.45 (&lt;1%)</td>
<td>26.1 (3%)</td>
<td>42.55 (86%)</td>
</tr>
<tr>
<td>Reaction Time Composite</td>
<td>1.20 (&lt;1%)</td>
<td>1.06 (&lt;1%)</td>
<td>0.67 (25%)</td>
</tr>
<tr>
<td>Symptom Score</td>
<td>73</td>
<td>18</td>
<td>21</td>
</tr>
</tbody>
</table>

12/1/11 –
- Improving
- Continue homebound education thru end of calendar year
- Continue amantadine & amitriptyline
12/8/11
- Referred for Exertional PT
12/22/11
- D/C from Vestibular PT

Exertional PT Evaluation:
- Patient History
- Evaluation
- Symptoms
- Deficits

Exertional Training:
- Established threshold
- Graded program
- Symptom reporting
- Mild symptom exacerbation

Factors Influencing Outcome
- Age
- Prior concussion?
- Amnesia
- Cluster of sx's combined w/ early neurocognitive data
Questions?

“Vollal... Concussion-proof!”

Exertional References


References: Concussion Management in the Adolescent Athlete


