

Pediatric Concussion: A Multidisciplinary Approach

Laura Van Dusseldorp, PT, DPT, ITPT, CBIS
Ashley Jobe, OTR/L, ITOT
Olivia Wolf MA, CF-SLP



Presentation Objectives

- Define concussion
- Understand the symptoms and evaluation of symptoms typically seen throughout the recovery process
- Outline the systematic approach to active management of concussions including tests and treatment
- Understand the components of Return-to-learn and Return-to-play protocols



2

Concussion

**Concussion is a
traumatic brain
injury!**



The pathophysiological definition of a concussion is:
“A complex process that affects the brain, which is induced by traumatic biomechanical forces, that includes major features such as the sodium and potassium pump imbalance.”



3

Pathophysiology of Concussions

- **Neuron:** electrically excitable cell that processes and transmits information through electrical and chemical signals
- **Axon:** slender projection of a nerve that conducts electrical impulses away from a neuron
- **Synapse:** junction at which neurons communicate

Information flow through neurons

Dendrites
Collect electrical signals

Cell body
Integrates incoming signals and generates outgoing signal to axon

Axon
Passes electrical signals to dendrites of another cell or to an effector cell

Figure 02-06: Biological Science, 7th © 2004 Pearson Education, Inc.

4

Pathophysiology Continued

- Linear and rotational forces acting on brain
- Deformation of tissues occurs where white and grey matter move at different rates
- Axonal shearing occurs which causes abnormal firing and leaves neurons weak and swollen
- Damage can continue over a matter of days

5

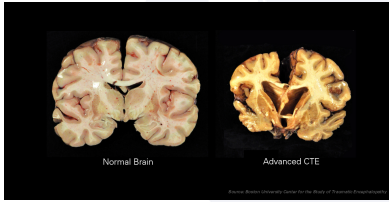
Pathophysiology Continued

- Resulting in **disruption of neuronal membranes** resulting in **potassium efflux and release of glutamate**
- Resulting in **depolarization and suppression of neuronal activity**
- Associated **impaired Na-K pump activity** resulting in **excessive ATP consumption and glucose utilization**, resulting in **lactate accumulation and cerebral blood flow decrease**, resulting in an "energy crisis," **accumulation of cellular calcium and death**
- Subsequent **hypometabolic state** persisting up to 4 weeks

6

Chronic Traumatic Encephalopathy (CTE)

- Diagnosis can only be made post-mortem
- Characterized by abnormal accumulation of tau proteins in the brain



7

CTE

- Clinical symptoms:
 - Behavioral: Emotionally explosive, impulsivity, paranoia
 - Mood: Overly sad/depressed, anxiety, apathy
 - Cognitive: Impaired neuropsych testing
 - Motor: Tremor, headache, unsteady gait, bradykinesia
- Cause and effect relationship between CTE and concussions has not yet been demonstrated
 - CTE Hope Foundation is currently researching biomarkers
- The extent of other contributors to CTE has not yet been determined in published literature
 - Age-related changes, co-existing medical illness, alcohol/drug use, psychiatric or mental illness



8

Clinical Features of Concussions


Signs and Symptoms

| PHYSICAL | COGNITIVE | EMOTIONAL | SLEEP |
|----------------------|----------------------------|----------------|---------------------------|
| Headache | Feeling Mentally Foggy | Irritability | Drowsiness |
| Nausea | Feeling Slowed Down | Sadness | Sleeping More than Usual |
| Vomiting | Difficulty Concentrating | More Emotional | Sleeping Less than Usual |
| Balance Problems | Difficulty Remembering | Nervousness | Difficulty Falling Asleep |
| Visual Problems | Forgetful of Information | | |
| Fatigue | Confused About Events | | |
| Sensitivity to Light | Answering Questions Slowly | | |
| Sensitivity to Noise | Repeating Questions | | |
| Dazed | | | |
| Stunned | | | |

9

Symptom Resolution


- Average day of symptom resolution:
 - 15 days - 25%
 - 26 days - 50%
 - 45 days - 75%
 - 92 days - 90%
- Symptom resolution does not directly correlate with performance on neuro-cognitive testing and vice versa



10

Recognition of Concussions

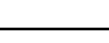
- **Factors that may complicate the recognition of concussions**
 - Athlete may not recognize he/she has concussive signs and symptoms
 - Symptoms may not appear until several hours or even days after concussive episode
 - Athlete may not be forthcoming he/she is experiencing concussive symptoms
 - Does not need to be a loss of consciousness to be a concussion



11

Rates in High School Sports

| SPORT | INJURY RATE/ 1000 ATHLETE EXPOSURES |
|---------------------------|--|
| Football | 0.47-1.03 |
| Girls' Soccer | 0.36 |
| Boys' Lacrosse | 0.28 – 0.34 |
| Boys' Soccer | 0.22 |
| Girls' Basketball | 0.21 |
| Wrestling | 0.18 |
| Girls' Lacrosse | 0.10 – 0.21 |
| Softball | 0.07 |
| Boys' Basketball | 0.07 |
| Boys' & Girls' Volleyball | 0.05 |
| Baseball | 0.05 |



12

Iowa Law 280.13C

- Iowa Law regarding concussion management pertains to school sports only
 - Does not include club teams
- All schools must distribute concussion information to athletes and parents prior to any participation
- All coaches, officials, athletes, parents, health care providers must receive education about concussions
 - IHSAA and IGHSAA websites include materials
- Student athletes must be immediately removed from play if exhibiting concussion symptoms
 - Cannot return until "evaluated and cleared to play by a licensed health care provider trained in the evaluation and management in concussions and other brain injuries"
 - If suspected concussion, child should not return to competition/practice that day



13

Leading Cause of Non-fatal TBI

- Youth under age 19
 - Bicycling
 - Football
 - Playground
 - Basketball
 - Soccer
 - Baseball
 - ATV



14

Systematic Management

- 1. Field/Sidelines**
 - Removal from play
 - Field Assessment
 - Emergency management
- 2. Acute**
 - Physician Monitoring
 - CT Scan
- 3. Post-Injury**
 - Home rest
 - Limited mental and physical activity
 - Neurocognitive Testing
 - Referral to concussion clinic
 - SLP/PT/OT



15

On the Field/Sideline

1. Medically stabilize the child and rule out a spinal cord injury
2. Perform a sideline concussion assessment tool and medical examination to assess whether a concussion is suspected
3. Remove from play immediately if there are any suspicion of injury and continue to monitor on the sideline
4. Triage child for follow-up management
 - Emergency department or primary care provider



16

Indications for Urgent Care/ED

- Repeat vomiting
- Unilateral Pupil diameter change
- Severe or progressive worsening headache
- Seizure activity
- Unsteady gait or slurred speech
- Weakness or numbness in extremities
- Unusual behavior
- Altered mental status resulting in GCS < 15



17

Second Impact Syndrome

- Rare condition in which a second concussion occurs before a first concussion has properly healed
 - Impact needs to be severe for second impact syndrome to occur
- Can be within a matter of days or weeks or it can occur in the same day if individual is not properly treated after the first concussion
- Brain loses the ability to auto regulate intracranial and cerebral perfusion pressure
 - Resulting in:
 - Cerebral edema and possible brain herniation.
 - Loss of consciousness after the concussive event followed by secondary brain damage which creates ionic fluxes, acute metabolic changes, and cerebral blood flow alterations.
- All of these characteristics enhance the vulnerability of the brain and greatly increase the risk of death.



18

Second Impact Syndrome

- Symptoms:
 - Dilated pupils
 - Loss of eye movement
 - Unconsciousness
 - Respiratory failure
 - Death
- Symptoms usually occur immediately following the second impact and progress rapidly
- Populations at Risk for Second Impact Syndrome
 - Anyone who has suffered an initial concussion
 - Athletes especially in sports such as boxing, baseball, football, hockey, and skiing.

19



Second Impact Syndrome

- Prognosis
 - In many cases it is often fatal
 - True second impact syndrome involves brain herniation and death usually within minutes
 - A patient suspected of suffering from second impact syndrome should immediately be:
 - Stabilized with special emphasis on airway management
 - Consultation with neurosurgery
 - When not fatal, long-term effects will likely be similar to those of severe traumatic brain injury

20



Second Impact Syndrome

If there are any doubts about whether the person is suffering from the effects of the concussion or are demonstrating concussion like symptoms, it's crucial to keep them out of situations that could lead to another concussion resulting in second impact syndrome

21



Systematic Management

1. Field/Sidelines

- Removal from play
- Field Assessment
- Emergency management

2. Acute

- Physician Monitoring
- CT Scan

3. Post-Injury

- Home rest
- Limited mental and physical activity
- Neurocognitive Testing
- Referral to concussion clinic
- SLP/PT/OT



22

Acute Care

• Triage to Emergency Department

- CT Scan
- Neurological examination
- Hydration
- Monitor for emesis
- Monitor for seizures



23

Indications for Imaging

Suspicion of intracranial structural injury

- Severe headache
- Seizures
- Focal neurological findings
- Repeat vomiting
- Significant drowsiness or difficulty awakening
- Slurred speech
- Poor orientation to person, place, or time
- Significant irritability
- Neck pain
- LOC greater than 30 seconds



24

Systematic Management

1. Field/Sidelines

- Removal from play
- Field Assessment
- Emergency management



2. Acute

- Physician Monitoring
- CT Scan

3. Post-Injury

- Refer on to appropriate healthcare professionals
- Home rest
- Light mental and physical activity



25

Why Refer?

- Manage symptoms
- Prevent acute and chronic complications
- Monitor medications
- Reassurance and guidance of family/caregivers, school, teachers, coaches, and peers.
- Reintegration into academics, work, physical activity, driving, and sports.



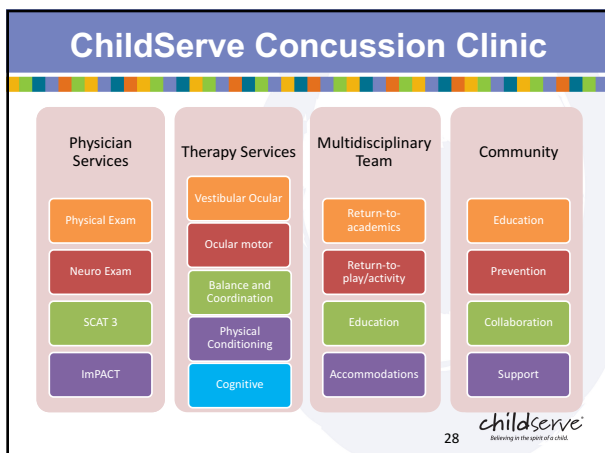
26

Where to Initially Refer?

- Healthcare professionals trained in concussion management
 - I.E. specialized concussion program
- Physical Therapy for balance, coordination, vestibular assessment.
- Occupational Therapy for vestibular and ocular evaluation.
- Speech and Language Therapy for executive functioning tasks and compensatory techniques



27



ChildServe Concussion Clinic

- <http://www.kcci.com/news/nfl-to-review-concussion-protocol/37874090>

29 Believing in the spirit of a child.

Evaluation and Ongoing Treatment

- Individualized goals dependent on observed deficits impacting return to learn and return to play/activity
- Generally recommend 1-2 times per week
- 30- 60 minute sessions
- Neurocognitive testing for comparison with baseline (ImPACT)
- Vestibular ocular assessment
- Physical conditioning
 - Heart rate max progression
 - Head below heart activity
 - Sports or activity specific training
- Referral back to physician services for clearance back to full return

30 Believing in the spirit of a child.

Ongoing Treatment and Therapy

- Ocular Motor Assessment
 - Smooth Pursuits
 - Horizontal and Vertical Saccades
 - Convergence
 - Divergence
 - Horizontal Visual Ocular Reflex (VOR)
 - Vertical Visual Ocular Reflex (VOR)
 - Visual Motion Sensitivity (VMS)
 - Visual Scanning
 - Anti-saccades

31



Ongoing Treatment and Therapy

- Vestibular Ocular Assessment
 - Using ocular system separate from vestibular system
 - Peripheral vision
 - Central vision
 - Use ocular system with vestibular system
 - Maintain visual fixation while moving head
 - Coordinate eye and head movement together
 - Vestibular assessment

32



Ongoing Treatment and Therapy

- Balance and Coordination
 - Static balance
 - Eyes open/eyes closed
 - Dynamic balance
 - Eyes open/eyes closed
 - Crossing midline
 - Vestibular system activation

33



Ongoing Treatment and Therapy

- Physical Conditioning
 - Progressing heart rate to maximal exertion
 - Head below heart activity
 - Impact related endurance training
 - Jogging/running
 - Jumping
 - Resistance training
 - Sport or activity specific training
 - Strengthening
 - Speed
 - Agility

34



Ongoing Treatment and Therapy

- Cognitive Linguistic Assessment
 - Orientation
 - Immediate recall
 - Concentration
 - Executive functioning
 - Short term memory
 - Long term memory
 - Cognitive strategies for functional use

35



Additional Referrals


- Vision
 - Optometrist
 - Developmental Optometrist
 - Ophthalmologist
- Manual Intervention
 - Osteopathic manual medicine (OMM)
 - Chiropractic care
 - Craniosacral
 - Massage
 - Physical Therapy
- Nutrition coaching
- Neuropsychology or psychology
- Neurology
- Cardiology

36



Return-to-Academics


The objective of return-to-academics is to provide the child, family, school, and teachers with progressive academic guidance and recommendations.



37

Graduated Return-to-Academics

Recommended by The Zurich Consensus Statement on Concussion in Sports*




Communication among the student, parents, coaches, and healthcare provider is crucial. Students should return to academics with support and guidance from the community medical provider in collaboration with the others involved with the student. Symptoms of concussion will often create learning difficulties for students. An individualized plan for learning adjustments should be started immediately after diagnosis with a gradual, monitored return to full academics as symptoms clear. Although most symptoms clear within 3-4 weeks, in some cases, symptoms may not clear for months. In rare cases, disability may be permanent. For students with prolonged symptoms, formal procedures for learning supports will be recommended.

| STAGE | PLACE | PROGRESSION | DESCRIPTION |
|-------|--------------------|---|--|
| 1 | HOME | Cognitive Rest | Light mental and physical activity. No driving. Limited mental exertion (computer, texting, video games, social media, homework). No prolonged concentration. 15-minute intervals of on/off schedule. |
| 2 | SCHOOL (Part Time) | Moderate accommodations, shortened day/schedule, built-in breaks | Provide quiet place for scheduled mental rest. No significant classroom or standardized testing. Modify rather than postpone academics. Provide extra time, help, and modified assignments (see attached recommendations). |
| 3 | SCHOOL (Part Time) | Minimal accommodations, shortened day/schedule, built-in breaks as needed | No standardized testing. Modified classroom testing. Continue to provide extra time, help, and modification of assignments (see attached recommendations). |
| 4 | SCHOOL (Full Time) | Moderate accommodations, built-in breaks as needed | No standardized testing. Modified classroom testing. Continue to provide extra time, help, and modification of assignments (see attached recommendations). |
| 5 | SCHOOL (Full Time) | Minimal accommodations | No standardized testing. Modified comprehensive testing (mid-terms, finals). Routine tests OK. Gradual decrease of extra time, help, and modification of assignments. May require more support in academically challenging subjects. |
| 6 | SCHOOL (Full Time) | Full academics, no accommodations. | Attend all classes. Full homework and testing. Continue to observe for any concerns. |

Return-to-Play/Activity

The objective of return-to-play is to provide the child, family, school, and coaches with progressive activity guidance and recommendations.




39

| Graduated Return-to-Play/Activity | | Recommended by The Zurich Consensus Statement on Concussion in Sports* | |
|--|---|---|--|
| | | childserve Believing in the power of a child. | |
| Communication among the student, parents, coaches, and healthcare provider is crucial. Students should return to play/activity with support and guidance from a community medical provider in collaboration with the others involved with the student. | | | |
| STAGE | ACTIVITY | FUNCTIONAL EXERCISE AT EACH STAGE OF REHABILITATION | OBJECTIVE |
| 1 | Physical Rest Notes: | Limited physical activity ex: walking and stairs as tolerated | Recovery |
| 2 | Light Aerobic Exercise Notes: | No impact-related activities like running or jumping. Do not move head below heart. No resistance training. No sports practice. No trampoline. ex: walk longer distances, walk at an incline, ride a stationary bike. | Get moving. |
| 3 | Sport-Specific/ Moderate Aerobic Exercise Notes: | Modified practice, gym and recess. Simple training drills, ex: jogging, running, jumping. Begin activities that move head below heart. No resistive training. | Increase heart rate up to 60%. |
| 4 | Light Contact Practice Notes: | Progression to more complex training drills. May start progressive resistance training. Initiate dummy contact or person to person contact. | Increase heart rate up to 80%, coordination and cognitive load. |
| 5 | Full Contact Practice Notes: | Following medical clearance, participate in normal training activities, including dummy contact and/or person to person contact. ex: scrimmaging | Restore confidence and assess functional skills by coaching staff. |
| 6 | Return to Play | Normal game play | No restrictions |

Post-Concussion Syndrome


- 3-month duration or more of concussion related symptoms
- **Causes**
 - Symptoms are caused by structural damage to the brain or disruption of neurotransmitter systems
 - Symptoms are related to psychological factors, especially since the most common symptoms — headache, dizziness and sleep problems — are similar to those often experienced by people diagnosed with depression, anxiety or post-traumatic stress disorder.
- **Diagnosis**
 - No tests available
 - Made by prolonged presence of symptoms and the affects on daily functioning



41

Post-Concussion Syndrome

- **Treatment**
 - Continue with therapies as recommended
 - Initiate discussions for long term accommodations
 - 504 Plan
 - IEP
 - Work
- **Other referrals if necessary**
 - Psychologist
 - Psychiatrist
 - Counselor
 - Neurology
 - Neuropsychology testing
 - Cardiology
 - Nutrition counseling



42

How many is too many?


- No evidenced-based guidelines
- Each situation needs to be evaluated on an individual basis
- Modifying factors to consider:
 - Multiple lifetime concussions
 - Structural abnormality on imaging
 - Persistent decreased academic or workplace performance
 - History of prolonged recovery with past concussions
 - Post-concussive syndrome



43 *childserve*
Believing in the quest of a child.

Prevention


- Equipment will NOT prevent a concussion
- Safe techniques
- Enforcement of rules or rule changes/Legislation
- Preseason baseline testing
- Education!



44 *childserve*
Believing in the quest of a child.

Presentation Objectives

- Define concussion
- Understand the symptoms and evaluation of symptoms typically seen throughout the recovery process
- Outline the systematic approach to active management of concussions including tests and treatment
- Understand the components of Return-to-learn and Return-to-play protocols



45 *childserve*
Believing in the quest of a child.

Resources

- http://www.cdc.gov/traumaticbraininjury/get_the_facts.html
- <http://www.brainandspinalcord.org/traumatic-brain-injury-types/second-impact-syndrome/index.html>
- <http://www.mayoclinic.org/diseases-conditions/post-concussion-syndrome/basics/prevention/con-20032705>
- CDC HEADS UP <http://www.cdc.gov/headsup/youthsports/>
- American Academy of Pediatrics, Clinical Reports on Sports Concussion in Children; Sept, 2010
- Consensus statement in British Journal of Medicine <http://bjsm.bmj.com/content/47/5/250.full.pdf+html>
- <http://sportsconcussion.bianj.org/>
- <http://momsteam.com/>
- REAP program developed at Rocky Mountain Hospital in Colorado <http://rockymountainhospitalforchildren.com/service/concussion-management-reap-guidelines>

46



References

- Burns, T., Ono, K.E. *Impact Research Report: Sex Based Differences as a Predictor of Recovery Trajectories Using ImPACT*. Volume 3 (2015).
- Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. Report to Congress on mild traumatic brain injury in the United States: steps to prevent a serious public health problem. Atlanta (GA): Centers for Disease Control and Prevention; 2003.
- Centers for Disease Control and Prevention. Nonfatal Traumatic Brain Injuries Related to Sports and Recreation Activities Among Persons Aged ≤19 Years — United States, 2001–2009. *MMWR* 2011; 60(39):1337–1342.
- Comstock, D. R., Currie, D. H., Pierpoint, L., Grubenhöf, J., Fields, S. K. An evidence-based discussion of heading the ball and concussions in high-school soccer. *JAMA Pediatr* (2015) 169:830.
- Faul M, Xu L, Wald MM, Coronado VG. Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2010.

47



References con't

- Halstead, M., Walter, K., The Council on Sports Medicine and Fitness. Sport-related concussion in children and adolescents. *Pediatrics*.126(3). September 2010. p. 597-615.
- Harmon, KG et al. American Medical Society for Sports Medicine position statement: concussion in sport. *Br J Sports Med* 2013;47:1 15-26 doi:10.1136/bjsports-2012-091941.
- Giza CC, Hovda DA. The Neurometabolic Cascade of Concussion. *Journal of Athletic Training*. 2001;36(3):228-235.
- McCrory, P., Meeuwisse WH, Aubry M, et al. Consensus Statement on concussion in sport: the 4th international conference on Concussion in Sport held in Zurich, November 2012. *The Journal of Sports Medicine*; 2013: 47: 250-258
- Meehan III, William P., Medical Therapies for Concussion. *Clinical Sports Medicine*.30. (2011). 115-124.
- Clay MB, Glover KL, Lowe DT. Epidemiology of concussion in sport: a literature review. *Journal of Chiropractic Medicine*. 2013;12(4):230-251. doi:10.1016/j.jcm.2012.11.005.

48