Everyday Concussion and Physical Therapy: Who Knew?

Susan W. Halloran, PT, DPT
Highlands Ranch, Colorado
“I’m right there in the room, and no one even acknowledges me.”

The New Yorker, 9/18/06
Objectives

1. Discuss latest theories related to the definition, mechanism of injury and pathophysiology of concussion.

2. Verbalize 5 overlapping symptoms and 3 diagnoses that could co-occur with concussion.

3. Understand the sequella of concussion from medical, cognitive, and functional points of view, using the ICF model.

4. List 3 “cross specialty” issues to consider for physical therapist collaboration and detection, treatment, and modification when concussion co-occurs.

5. Identify a synthesis of perspectives that suggest concussion might be detectable by physical therapists, and ponder how that would affect current treatment paradigms.
Outline

• 1. Introduction and development of theory
• 2. Overview of concussion Now and Then
• 3. Consequences of concussion
• 4. Symptoms/management of everyday concussion
• 5. Concussion by any other name?
• 6. Holistic collaboration
Concussion science:
Rapidly evolving, related to sports, PT scope of practice?...

Who knew?
Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012

Paul McCrory, Willem H Meeuwisse, Mark Aubry, et al.

• 70 to 80% better within 10 days
• >90% of individuals with concussion fully normal within one yr. or less
• 20% of people with symptoms after 10 days have more complicated recovery, but still recover if managed appropriately

hope
Terminology and abbreviations

mTBI: Mild traumatic brain injury
Concussion vs. mild TBI: used synonymously
LOC: loss of consciousness
SCI: spinal cord injury
mTBI/SCI: co-occurring injury
PCS: Post concussion syndrome
ICF Model: International Classification of Functioning
Scope of Impact
Greater concussion awareness
PT and concussion?

Development of theory

SCI/TBI Physical Therapist

Concussion Advocate

Colorado legislation

Daughter’s concussion

Feedback
Craig Hospital
TBI/SCI/Combined injuries
Evidence: MTBI

- Even though recorded history is consistent with MTBI it is not translated as diagnosis at discharge from ED
- MTBI is severely underdiagnosed in admitted multitrauma patients
- Improved accuracy and communication may enhance treatment of post concussion syndrome and predict those at risk for prolonged recovery from primary diagnosis
- TBI is a common co-occurring injury with traumatic SCI
- Acute medical documentation for TBI/SCI is incomplete; education and algorithms indicated
- SCI + TBI has clinical and economic consequences and has potential to affect community re-entry and quality of life

Daughter’s Concussion
“No one knew”
Factors

• “Ding” culture
  – Mom who denied access to ATC in favor of keeping up with other vehicles
  – Athlete woke up surrounded by teammates, refs, coaches: no concussion?

• Warrior soccer player
  – Aware but plays on
  – Divulged little to parents until the end

• Lack of Awareness
  – “the only thing that could have made this different was education”
Clinical Presentation
Outcome for Katie
Parent Outcome: Advocacy
Advocacy

Promoting Concussion Awareness in Competitive Youth Soccer Coaches

Susan W. Halloran, PT
Sargent College of Health and Rehabilitation Medicine
Boston University

Networking
Outline

1. Introduction and development of theory

2. Concussion Now and Then:

3. Consequences of concussion

4. Concussion symptoms by any other name?

5. Symptoms and modified management of everyday concussion

6. Holistic collaboration
Concussion is an alteration of brain function caused by a direct or indirect impulsive force to the body or skull with or without loss of consciousness.

The Now: Definition

The 4th International Consensus Statement on Concussion in Sport, Zurich 2012, American Academy of Neurology 2013, Centers for Disease Control and prevention 2013.)
The “Then”: prior to

The 1st International Conference on Concussion in Sport, Zurich 2000: Consensus Statement

- Loss of consciousness
- Blow to head
- Structural damage with imaging
- Skull fracture
- Graded severity
- Minimal return to play regulations:
  - “got his bell rung…”
  - “shaken up on the play”
Relation between neuropsychological and neuroimaging findings in patients with late whiplash syndrome.

- Despite the use of advanced imaging techniques (SPECT, PET, MRI and CT), consistent structural or functional aberrations could not be detected in patients with WAD in which cognitive impairment had been diagnosed by means of neuropsychological testing.

- No evidence of brain damage for cognitive impairment in WAD
  - Instead: Pain, anxiety, medication, malingering, psychological mechanisms (e.g. PTSD, depression, lack of adequate coping strategies) may affect cognition after whiplash
Impaired cognitive functioning after whiplash injury of the cervical spine
Radonov, Dvorak (1995)

Exclusion Criteria:

“A traumatic brain injury resulting from a blow to the head is characterized not only by detectable lesions to the brain tissue but essentially by loss of consciousness, resulting in post-traumatic amnesia.”

Assertion:

“For many medical professionals cognitive impairment indicates the existence of organic brain damage. This is a major mistake.”
Mild Traumatic Brain Injury
Concussion Video Clip
Relevant new theories

Altered level of consciousness for less than 30 minutes with/without LOC

“Whiplash”
accel/decel
Rotation
Direct or indirect force

Metabolic cascade of events over time.
Diffuse.
Functional not structural injury.

Altered level of consciousness for less than 30 minutes with/without LOC

Relevant new theories
Altered period of consciousness <30 minutes

- As few as 10% of people with concussion lose consciousness
- Presentation of altered consciousness:
  - “Fogginess”
  - Amnesia for event
  - Anxiety
  - Confusion
  - Short term memory loss
  - Glasgow Score 13 to 15
Impulsive force
Forces acting for very short times are called impulsive forces.
Diagnostic Implications of Concussion Now Science vs. Concussion Then

• No loss of consciousness vs. older means of classifying concussion (e.g. Grades I, II, and III)
• No blow to the head
• Functional not structural = normal MRI and CT with concussion
• Severity now judged retrospectively according to symptomology
Science of Concussion Today
Injury occurs in two phases

1. Biophysics of impact
2. Secondary pathophysiology

Dashnaw ML, et al 2012
Biophysics of head impact

Moment of Impact: Force vector to brain from translation of kinetic energy; linear and/or rotational
Brain within skull
Concussions can occur at lower impact magnitudes than previously thought.

Measures of linear acceleration appear equally important to cause concussion as angular acceleration.

Athletes can sustain a high number of head impacts in a season (many exceeding 80g-90g) and never sustain a diagnosed concussion.

Threshold is elusive and should not be used to predict clinical outcome.
- Damage temporal in nature
- Ion and glutamate flux
- Decreased efficiency of axonal function
- Energy crisis and mitochondrial impairment
- Blood Brain Barrier Disruption
Relevant Anatomy: Diffuse Injury vs. focal
Cascade of Metabolic Events
Concussion Pathophysiology: Rationale for Physical and Cognitive Rest
Matthew F. Grady, MD; Christina L. Master, MD; Gerard A. Gioia, PhD (2012)

• “Constellation of physical, cognitive, emotional, and sleep symptoms ensues”

• Infrequent loss of consciousness (less than 10% to 20%)

• Metabolic problem and energy crisis
  – Metabolism of neurons and axons is high: mitochondria up-regulate production of adenosine triphosphate (ATP) to meet metabolic demands.
  – Concussion causes impaired mitochondrial function.

• Fuel sources less bioavailable.
  – glucose and to a lesser amount selected amino acidsc that generate ATP

• Decreased cerebral blood flow=diminished fuel sources.
Concussion Pathophysiology: Rationale for Physical and Cognitive Rest
Grady, Master, Gioia, (2012)

Ion Channels

1. Widespread depolarization and neurotransmitter release

2. Potassium efflux

3. Calcium in the cell impairs ATP production in mitochondria, worsening energy crisis

4. Calcium influx also causes axonal swelling and decreased axonal function

- Glut: Glutamate
- Ca2+: Calcium
Relevant cellular anatomy: axonal shearing
Glutamate Release and Ionic Flux

- Membrane deformation leads to potassium efflux and release of excitatory amino acids, especially glutamate.
- Glutamate binds NMDA and AMPA ionic channels.
  - Calcium influx and further depolarization.
  - Depolarization leads to neuron suppression resembling spreading depression.
- ATP-dependent Na+/K+ pumps work to restore ionic balance.
  - High levels of glucose metabolism due to high energy needs (lasts from .5 – 4 hours in rat TBI experiments).
  - Lactate production is increased, leading to local acidosis, increased membrane permeability, and cerebral edema.

Pathophysiology

Figure 5. Neurometabolic Cascade Following Traumatic Brain Injury

Hovda, Giza (2001)
www.ncaa.org
Blood Brain Barrier Disruption (BBBD)

1. Force related traction of vessels
2. Increased permeability of vessel walls
3. Neutrophil escape = autoimmune + toxins
BBBD

• Creates inflammatory process with destructive substrates created
• Related to multiple sub-concussive blows = long term effects?
• Hope to determine biomarkers for concussion?
• Potential pharmacological therapy: leukotriene inhibitors
  – (similar to action of Singulaire for asthma)
Theoretical Complications

Post Concussion Syndrome (PCS), “Subconcussive blows": accumulation, Chronic Traumatic Encephalopathy (CTE), Second Impact Syndrome
Diagnostic Implications of Concussion Now Science vs. Concussion Then

• No loss of consciousness vs. the past (previous was “Grades I, II, and III”)
• Not necessarily a blow to the head
• Functional not structural = normal MRI and CT with concussion
• Severity now judged retrospectively according to symptomology over time
Concussion Assessment
“.....Susy, it’s messy”
360 degree assessment

Best assessment results from use of multiple tools
Concussion Assessment
• Scat 2 plus
• History
• Cognitive Assessment (SAC)
• Symptom Checklist (Rivermead)
• Maddocks
• Glasgow Coma Scale
• **Neck:** ROM, UE and LE sensation and strength
• BESS
• Coordination
• Signs of worsening
• Return to Play
Behavioral confounders for concussion assessment.....and for whiplash?

- Anxiety
- Pre existing psychological disorders
- Pain
- PTSD
- ETOH
- Previous brain trauma or pathology
- Catastrophizing (iatrogenic?)
- Malingering
Current Physical Therapy Neuroscreening: Sensitive for concussion?
Outline

• 1. Introduction and development of theory
• 2. Concussion Now and Then
• 3. Symptoms/modified management of everyday concussion
• 4. Consequences of concussion
• 5. Concussion symptoms by any other name?
• 6. Holistic collaboration
ICF view of Katie

**Impairments**
- Dizziness x 8 mo.
- Headache and migraine
- Sleep
- Anxiety
- Nausea and vomiting
- Irritability
- Cognition
  - Memory, processing, attention
- Fatigue
- Sensory hypersensitivity
- Musculoskeletal symptoms

**Activity**
- Unable to run without provoking dizziness
- Difficulty with stimulating environments, light, noise, challenging family
- In bed most of day due to fatigue (missed 33 days of fall semester)
- Unable to tolerate physical and cognitive activities at former levels
- Difficulty with “screens”
Participation

• Unable to play soccer or maintain fitness
• Limited participation in school
• Unable to socialize with soccer/school friends
• Unable to maintain previous self image as warrior-well liked-happy-go-lucky smart girl
• Family interactions challenging
Remediation

• Liberal cognitive and physical rest
• Extensive work with school counselor and teachers to modify school schedule, homework, and status of AP courses. Graduated return to classes.
• Education
• Referral to “Concussion Clinic”
• Physical Therapy
• Psychotherapy
• Migraine medication
• Changed sport to rowing
ICF: Independently preventing medical complications: TBI/SCI

Participation

Activity

Impairments

Successful skin care

Remember and properly execute weight shifts in w/c

Avoid bumping skin during transfer

Memory

Impulsivity

Attention to Detail
ICF
Successful Coping Skills
variables: appropriate medical support behavioral history
ICF model of concussion
Work and School

**Participation**

- Return to Work

**Activity**

- Learning a new computer program
- Ability to work full time

**Impairments**

- Poor Working Memory and Attention
- Visual Deficits
- Anxiety, Irritability, fatigue
ICF
Healthy Relationship at Home

Participation

Activity
- Endurance home tasks
- Successful social interaction

Impairment
- Cognitive and physical fatigue
- Pain due to co-occurring MSK injury
- Irritability

Maintaining home responsibility
ICF Driving

Participation

Activity

Impairment

Independent Driving

Quick decisions and judgment in traffic

Determining proximity of moving vehicles

Slower speed of processing

Decreased attention to detail

Faulty Visual – Ocular Reflex (VOR)

Decreased attention to detail
Physical Therapy

- Physical
  - Vestibular treatment
  - Balance
  - Reaction time
  - Endurance
- Treatment for musculoskeletal involvement
- Education
- Guide graded progression of activity
- Referral and advocacy
Outline

1. Introduction and development of theory
2. Overview of concussion Now and Then
3. Consequences of concussion
4. Symptoms/management of everyday concussion
5. Concussion by any other name?
6. Holistic collaboration
Concussion by any other name?
Practitioner Point of View?
Whiplash of Neck vs. Brain

Neck: No Brain

Brain: Just a Fuzzy Spine

MECHANISM OF WHIPLASH INJURY OF THE BRAIN

A. As Head is Thrown Backward, Brain Collides with Front of Skull
B. As Head is Thrown Forward, Brain Collides with Rear of Skull

As Brain Collides with Front of Skull, Frontal & Temporal Lobes are Injured
As Brain Collides with Rear of Skull, Occipital Lobes & Cerebellum are Injured
# Symptoms of concussion usually fall into four categories:

<table>
<thead>
<tr>
<th>Thinking/Remembering</th>
<th>Physical</th>
<th>Emotional/Mood</th>
<th>Sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty thinking clearly</td>
<td>Headache</td>
<td>Irritability</td>
<td>Sleeping more than usual</td>
</tr>
<tr>
<td></td>
<td>Fuzzy or blurry vision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>Nausea or vomiting (early on)</td>
<td>Sadness</td>
<td>Sleep less than usual</td>
</tr>
<tr>
<td></td>
<td>Dizziness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>Sensitivity to noise or light</td>
<td>More emotional</td>
<td>Trouble falling asleep</td>
</tr>
<tr>
<td></td>
<td>Balance problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>Feeling tired, having no energy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Symptom Overlap

- Mechanism of injury
- Symptoms
- Time to Resolve
- Concussion vs. whiplash
- Functional consequences
- Prognosis
- Anatomy
Cervicogenic dizziness via vestibular system
- Tonic neck reflexes
- Cervical proprioception
- Whiplash Associated Disorders
- Sympathetic response
- Cervical somatosensory disorder
- Malingering?
Concussion by any other name: Review of Literature

Exclusion of Concussion by:

- Loss of Consciousness
- Findings on MRI/CT
- Blow to the head
- Moderate to Severe Brain Injury

Current Concussion Theory: no longer includes these criteria
How to explain concussion like symptoms?
Cervicogenic dizziness:
Theoretical interest or practical relevance?
Brandt and Bronstein, (2001)

Sample of exclusion criteria:

• Loss of Consciousness

• Other types of dizziness and nerve root symptoms
  – Reid, et al. (2012)

• Fracture of skull or spine, paralysis, significant brain injury
Cognitive deficits after whiplash

Sample exclusion criteria:
• Loss of consciousness

• Blow to head

• Structural abnormality on medical imaging

• LOC, post-traumatic amnesia, or history of direct head trauma
Dynamic and functional balance tasks in subjects with persistent whiplash: A pilot trial
Stokel, Yu, Williams, Treleaven (2011)

Exclusion criteria:

- cervical fracture or dislocation
- period of unconsciousness
- post-traumatic amnesia or concurrent head injury with the whiplash injury
- known or suspected vestibular pathology such as BPPV
- history dizziness prior to the whiplash injury
- neurological deficits
- lower limb problems
- medical problems that might affect performance.
Cervical pain, headache, MSK with concussion

Prevalence of chronic pain after mild traumatic brain injury

Malingering

Exclusion LOC:
Whiplash injuries and associated disorders: new insights into an old problem
“Sometimes the questions are complicated and the answers are simple.” — Dr. Seuss

Are there distinctively isolated syndromes?
Concussion Assessment

“.....Susy, it’s messy”
Concussion Assessment
• History
• Cognitive Assessment (SAC)
• Symptom Checklist
• Maddocks
• Glasgow Coma Scale
• **Neck:** ROM, UE and LE sensation and strength
• BESS
• Coordination
• Signs of worsening
• Return to Play
New Recipe for PT Neuro-screening?

Ingredients:
- Physical Signs
- Musculoskeletal Symptoms
- Balance
- VOR
- Headache
- Diffuse nature of injury
Referral

Suggestions

• Immediately if symptoms worsen: MD or ED (e.g.: seizures, SDH or other neuro emergency)

• No symptom resolution after 10 days

• Use a “360 degree” approach to determine need to refer; symptom checklist is not enough
Management

Note: special approach for pediatric population
Prevention
- NO contact sports
- Education
- What to expect...
- What to avoid

- Symptom Management
- Referral where needed
- Sequential return to physical and cognitive activity
Remediation

Keystones

- Rest
- Support
- Education
- Time
- Graduated return to activity and life
Consensus Zurich 2012: Management 10 days and beyond

After the initial period of physical and cognitive rest

• Cognitive
• Vestibular
• Physical and psychological therapy
• Consideration of assessment of other causes of prolonged symptoms
• Consider a “graded exercise programme” at a level that does not exacerbate symptoms.
Outline

1. Introduction and development of theory
2. Concussion Now and Then:
3. Consequences of concussion
4. Symptoms and modified management of everyday concussion
5. Concussion symptoms by any other name?
6. Holistic collaboration
Round up all of the symptoms....
Dizziness and Unsteadiness following whiplash injury: characteristic features and relationship with cervical joint position
Treleaven, Jull, Sterling (2003)

Exclusion Criteria

• **Loss of consciousness**

Salient comments

• With no traumatic brain injury, abnormal cervical afferent input from damaged or functionally impaired neck joint and muscle receptors is considered the likely cause of dizziness but specific diagnostic criteria or measures to confirm the presence of a cervical cause of dizziness are limited.

• After pain, dizziness and unsteadiness are the next most frequent complaints after whiplash and between 40 to 70% of those suffering from persistent WAD have these symptoms, often associated with reports of loss of balance and falls
Cross specialty Possibilities

"That's amazing—I was just thinking the same thing."
Holistic Approach
Implications

New York Subway station unused since 1945
Outline

1. Introduction and development of theory
2. Concussion Now and Then:
3. Consequences of concussion
4. Symptoms and modified management of everyday concussion
5. Concussion symptoms by any other name?
6. Holistic collaboration
Thank You!

Susan W. Halloran, DPT
susyhalloran@msn.com
Acknowledgements

• Katie Halloran

• Donald Gerber, PsyD. Craig Hospital, Englewood CO

• Traumatic Brain Injury SIG/Neurology Section

• Colleagues, friends, and family members who have inspired, reflected, and supported this idea
Questions?

“Mr. Osborne, may I be excused? My brain is full.”
References:
Comprehensive Information

Best Practice:


Comprehensive and very user friendly:

- Centers for Disease Control and Prevention. [www.cdc.gov/concussion](http://www.cdc.gov/concussion)
References:

- Centers for Disease Control and Prevention: Traumatic Brain Injury; Concussion www.cdc.gov/TBI
References

References


• Radanov et al. Relation between neuropsychological and neuroimaging findings in patients with late whiplash syndrome --. 66 (4)  485 -- Journal of Neurology, Neurosurgery & Psychiatry_files


• Haldorsen T, Waterloo K, Dahl A, Mellgren SI. Symptoms and cognitive dysfunction in patients with the late whiplash syndrome. App NeuroPsy 2003. 10(3); 170-175

References

• Prevalence of chronic pain after mild traumatic brain injury
  • Giorgio A, De Stefano N. Clinical use of brain volumetry. J MRI Jan 2013. 37:1 1–14
  • Sturzenegger, M. "MRI-based brain volumetry in chronic whiplash patients: no evidence for traumatic brain injury". Acta neurologica Scandinavica