A Systematic Approach to the Assessment and Management of the Complicated Concussion Patient

From Research to Recovery

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DISCLOSURES

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PUCCS Foundation
NFL Charities
Ralph and Mary Wilson Fund
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At the conclusion of this activity, the participant will be able to:

• Describe an approach to assessment of the complicated concussion patient based upon:
  • Evaluation of exercise intolerance
  • Physical examination findings of neurologic and cervical subsystems

• Describe the active approach to concussion treatment with respect to:
  • Subthreshold aerobic exercise
  • Vestibular and vision therapy
  • Cervical physical therapy
Individual Recovery From Sports Concussion: High School

- All Athletes
- No Previous Concussions
- 1 or More Previous Concussions

WEEK 1: 40% RECOVERED
WEEK 2: 60% RECOVERED
WEEK 3: 80% RECOVERED

High School Male Football Athletes

Collins et al., 2006, Neurosurgery
Symptoms From The Time of Injury College
Guskiewicz et al., JAMA 2003

**Figure 2.** Mean Reported Graded Symptom Checklist Total Scores for Players With Concussion (n=196) Across Repeated Assessments
When does Concussion become PCS?

- **DSM IV**: cognitive deficits in attention or memory and ≥ 3 symptoms for > 3 months.
- **World Health Organization**: three or more of:
  - headache, dizziness, fatigue, irritability, insomnia, concentration difficulty, or memory difficulty.
- **No specific timeframe**
Predictors of PCS

• Headache  Apslund et al 2004
• Amnesia   Apslund et al 2004
• Memory    Lovell et al 2003
• Processing speed  Lau et al 2011
• History of concussions  Guskiewicz et al 2003
• Age       Field et al 2003; Sim et al; 2008  Pellman et al 2006
• Gender    Barnes et al 1998
Summary of Research on Prognostic Factors

- Different studies find different predictors of developing PCS
- However, combined, the predictors do not explain much of the variance
- A big problem with research on prognostic factors is the lack of agreement of what constitutes “PCS”
- “PCS” is not a single syndrome.
The pathophysiology of SRC is much better understood than that of PCS.
Neurometabolic Cascade Following Cerebral Concussion/MTBI

(Giza & Hovda, 2001)
Recovered? Looks like it is on fMRI  
(Leddy et al 2013)

- PCS
- Recovered
Recovered? Looks like it ain’t on DTI

(Polak P et al. in press)
When does Sport-Related Concussion (SRC) become Post Concussion Syndrome (PCS)?

• **Zurich 2012:** Persistent symptoms (>10 days) in 10–15% of concussions.
  - In general, symptoms are not specific to concussion and it is important to consider other pathologies.

• **Athletes:** symptoms > weeks-months (Harmon. AMSSM Position Statement).

• **Youth (13-16 yrs.):** >4 weeks (Zuckerman et al. Surg Neurol Int. 2012)
  - In SRC, 90% athletes recover 4 wks.
  - 13-16 years old take longer to return to neurocognitive and symptom baselines than athletes 18-22 years old.
  - When recommended "comprehensive" approach used for concussion assessment, recovery time for SRC is 3 to 4 weeks (Henry LC et al Neurosurgery 2015).
To diagnose PCS, best to have a test

- Neuropsychological testing?
  - **Meta-analysis:** most cognitive deficits resolve after 7 days in SRC. (Belanger et al J Int Neuropsychol Soc 2005)

- Advanced Imaging (fMRI, DTI)?
  - Not specific and not ready for clinical use.
To treat “PCS”, need a diagnosis

Do prolonged symptoms reflect a prolonged version of the concussion pathophysiology or a different process?
What are you looking for in PCS?

- Treatable Disorders (PCDs)
  - Cervical dysfunction
  - Vestibular dysfunction
  - Oculomotor dysfunction
  - Cognitive dysfunction
  - Migraine
  - Affective disorders
Cannot use Symptoms to Diagnose Concussion
N=128
(Leddy et al. 2014)

• P-PCD (n=36)
  • Headache
  • Dizziness
  • Foggy
  • Can’t concentrate

• Cervical/vestibular injury (n=92)
  • Headache
  • Dizziness
  • Foggy
  • Can’t concentrate

No significant separation of symptoms
Can we define PCS more systematically?

Physiological Approach

- **Physical examination**
  - focus on physiology/autonomic nervous system
    - e.g., cranial nerves, orthostatic vital signs.
  - Cervical, vestibular, ocular examinations

- **Response to exertion** (Leddy et al 2010, 2013)
  - Symptom-limited submaximal threshold = persistently abnormal concussion physiology (a dysautonomia of control of cerebral blood flow) = “Physiological Post-Concussion Disorder”
  - Exercise to exhaustion without a threshold = look for an alternative diagnosis.
How do we diagnose Cervicogenic/Vestibular/Ocular PCD?

- Exercise to exhaustion without a threshold on the treadmill.
- Abnormalities on physical exam
  - Signs and symptoms during visual tracking maneuvers.
  - Cervical tenderness, spasm, reduced proprioception.
  - Altered balance.
Alternative Diagnoses
(N = 181)

Post-Concussion Syndrome
Distribution of Patients Assessed for Post-concussion Syndrome According to their Primary Diagnosis
Leddy et al PM&R 2016
Common Treatments For PCS
(Leddy et al. Sports Health 2012)

• (Radical) Rest
  • Information, counseling
    • Some evidence of efficacy
  • Anti-Depressants
    • Little evidence of efficacy
• Compensatory strategies
  • Particularly for students returning to class.
  • Needs further study.
Cervical and Vestibular Rehabilitation

• A case series and an RCT reported benefit of a combined approach of orthopedic and vestibular PT following concussion. (Schneider K et al. CJSN 2009 and 2012)

• If persistent headache after concussion suggests a cervicogenic etiology, cervical spine manual therapy is effective. (Jull G et al. Spine 2002)
Abnormal Accommodation
Normal is 6-10 cm

- **Eye push-ups**
  - Scheiman et al. Optom Vis Sci 2011
  - Borsting et al. Optom Vis Sci 2012
  - * has not been evaluated in concussion

- Goal is to move the pencil to within 2 to 3 cm of the brow, just above the nose on each push up while trying to keep the target single and clear.
- Perform the pencil push-ups procedure 15 min per day, 5 d per week.
A proactive approach to treating Cervicogenic/Vestibular/Ocular PCD

- Cervical and vestibular/ocular rehabilitation.
- Aerobic exercise (can’t hurt!).
- Outcome (Baker JG et al. Rehabilitation research and practice. 2012)
  - 64% returned to full function
  - Subgroup that doesn’t respond fully
    - Why? Prolonged symptoms (>6 months) before evaluation...
Combined PCDs

• Response to exertion
  • Symptom threshold +

• Physical Exam
  • autonomic, cervical and/or vestibular and/or ocular findings

• Management Options
  • cervical and vestibular/ocular rehabilitation plus
  • Sub-symptom threshold aerobic exercise
Exercise as a Treatment for Prolonged Recovery from Concussion
A proactive approach to treating Physiological PCD

- Establish the diagnosis by systematic evaluation of exercise tolerance
  - symptom-limited threshold on the treadmill (or other exercise modality, e.g., bike).

- Sub-threshold exercise prescription (“Exercise is Medicine”)
  - 80-90% of achieved HR = target HR.
    - HR monitor is **KEY** to prevent athlete from over-exertion.
  - 20 min/day at target HR with 5 min warmup and cool down.
  - Bike first, then running. 6-7 d/wk.
  - Increase target HR 5-10 bpm q1-2 weeks.
A proactive approach to treating Physiological PCD

- ≥ 85% age-predicted max HR x 20 min without symptoms- “Physiological Recovery”
- May need additional Rx for cervical, vestibular and/or ocular dysfunction before RTP.
- Advice on RTP based on history (e.g. number of prior concussions) and other signs and symptoms.
Exercise Treatment Outcomes in P-PCD

- 12/12 subjects returned to full sport or work (Leddy et al. CJSM 2010)

- 4/4 exercise treated subjects had symptom resolution v. stretching placebo control (Leddy et al. J Head Trauma Rehabil 2013)

- 77% of P-PCD (n=65) treated with aerobic exercise returned to full sport or work (Baker et al. Rehabilitation Research and Practice. 2012)
  - *5 of 6 who refused to exercise did not return to full function
Aerobic Exercise for Adolescents With Prolonged Symptoms After Mild Traumatic Brain Injury: An Exploratory RCT
Kurowski et al J Head Trauma Rehabil 2016

- 30 mTBI adolescents (12-17 years) with 4-16 weeks of persistent symptoms.
- **Design:** Partially blinded, pilot RCT of sub-symptom exacerbation aerobic training compared with full-body stretching.
- To be eligible, had to have exercise-exacerbation of symptoms on 30 minute bike test and cervical injury not the primary symptom generator.
- 22% of eligible participants enrolled in the trial.
  - 18/30 injured in sport.
Aerobic Exercise for Adolescents With Prolonged Symptoms After Mild Traumatic Brain Injury: An Exploratory RCT

Kurowski et al J Head Trauma Rehabil 2016

“Potential benefit of active rehabilitation programs for adolescents with persistent symptoms after mTBI”...

> rate of improvement in the sub-symptom threshold aerobic training group than in stretching group ($P = .044$).
CASE
SK
History

- 16 year old Caucasian male who was referred to the clinic for treatment and management of his 2nd concussion.
- Injury occurred during football practice – helmet-to-helmet collision. He did not experience loss of consciousness; however, he immediately stopped playing due to headache, feeling dizzy, nauseous, and foggy. Was attended to by the team AT.
- SK arrived at the clinic 3 days after this event, accompanied by his mother. Since the concussion, he has had a persistent headache, dizziness, sensitivity to light, and fatigue.
SK
History

• This is SK’s 2\textsuperscript{nd} concussion.
• He sustained his first concussion two years ago, from a helmet-to-helmet hit during a football game.
• SK experienced a prolonged recovery, with many of the same issues SK is experiencing currently.
SK
Physical Examination

• Good short term recall.
• Blood pressure supine 119/75 with a pulse of 76. Blood pressure standing 127/81 with a pulse of 94. He was a little lightheaded.
• Cranial nerves II through XII intact. Extraocular motion full without nystagmus. Pupils equal round and reactive to light. Funduscopic examination normal.
SK
Physical Examination

• He became symptomatic with visual tracking and convergence was abnormal at 12 cm from the forehead.
• Tandem gait was abnormal.
• Cervical tenderness and abnormal cervical proprioception.
Cervical Relocation Test

Proprioception (trainable!)

BCTT

• SK completed an exercise/treadmill test to determine his heart rate threshold.

• Information from the test
  • Level of exercise tolerance
  • Symptom pattern may yield clues to other diagnoses
    • Vestibular dysfunction
    • Cervical injury
    • Oculomotor dysfunction
Treatment

- Due to persistent symptoms, the patient was prescribed prednisone for 5 days to manage headaches.
- MRI was ordered
- Referred to vestibular rehabilitation.
- Over the ensuing 6 ½ months, SK presented at the clinic for a total of 15 visits.
### VISIT 1

**Symptoms at rest:** headache, dizziness

**Resting Likert Score:** 6

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<th>RPE</th>
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**Test Stopped**
Outcome

• Meeting at his school and his teachers made changes
  • he was taking breaks when needed, was given additional time to complete assignments, took tests on paper rather than on the computer, and more.

• SK was also given an “exercise prescription” to ride a stationary bike, monitoring his HR so it did not go above his threshold.

• He pushed over the recommended HR once or twice—which caused him to have increased symptoms (headache).
**FOLLOW-UP 5**

**Symptoms at rest:** Headache

**Resting Likert Score:** 1

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<td>145</td>
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Outcome

• SK began to show significant improvement and reduction in symptoms –
• Fully recovered - cleared to go back to gym, and attend full-days of school – 6 months after his injury.
Why could sub-threshold exercise improve CBF regulation?

- Exercise training increases parasympathetic activity at rest and may have restored ANS balance. (Carter et al. Med Sci Sports Exerc 2003)

- Progressive stepwise aerobic training may improve CA by conditioning the brain to gradually adapt to repetitive mild elevations of systolic BP. (Brys et al. Am J Physiol Heart Circ Physiol 2003)

- Physical deconditioning is associated with reduced CA (Zhang et al. J Appl Physiol 1997) whereas regular exercise improves control of CBF. (Guiney et al. Neuropsychology 2014)

- A controlled progressive breathing training program can increase CO₂ sensitivity in subjects with low CO₂ sensitivity to begin with. (Pendergast et al. Undersea and Hyperbaric Medicine 2006)
What Athletes do

This? Or This?
The Principle of Exercise tolerance
Using pre-determined stopping criteria

- Diagnose concussion.
- Establish accurate short-term prognosis.
- Establish physiological recovery and readiness to RTP.
- Develop a sub-threshold aerobic “exercise is medicine” program to treat physiological post-concussion disorder.
Activity After Concussion

- Old view
  - Rest until symptoms resolve
Activity After Concussion
New view

• Rest for a couple of days.
• Get back into activity gradually staying below cognitive and physical symptom thresholds.
Take Homes

• The physiology of concussion can inform an evidence-based approach to concussion diagnosis, determination of prognosis and recovery, and management of those with PCS.

• Patients with prolonged symptoms who have exercise intolerance have a physiological component to their symptoms. Get them active.

• Exercise after concussion must be used wisely, i.e., controlled. Athletes should not push through symptoms.
Take Homes

• For those of you not accustomed to systematic assessment of exercise tolerance, consider partnering with a practitioner who is (Sports MD, PT, ATC…).

• Consider Rx approaches that improve autonomic function
  • Individualized sub-threshold aerobic exercise treatment.
  • Breathing exercise (Dr. Jon Silver) at NYU
    • Slow, deep breathing increases HRV.
    • Rates between 4.5 and 6.5 breaths/min produce greatest improvement in HRV in most persons. (Conder and Conder. Heart rate variability interventions for concussion and rehabilitation. Frontiers in Psychology 2014)
Research Evidence

• Reduced CO$_2$ sensitivity.
• Reduced CBF at rest.
• Increased CBF during exercise.
• Increased difficulty switching ANS at appropriate time.

Signs

• Exercise intolerance.
• Orthostatic imbalance.
• Oculomotor difficulties.
• Balance problems.
Thank you for your attention

Concussion.ubmd.com
leddy@buffalo.edu