

**Treatable Concussion Complications**



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March 2, 2017



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**Objectives**

- ✦ Review the presentation of common concussion complications
- ✦ Identify common concussion complications
- ✦ Discuss potential therapies for the complicated concussion

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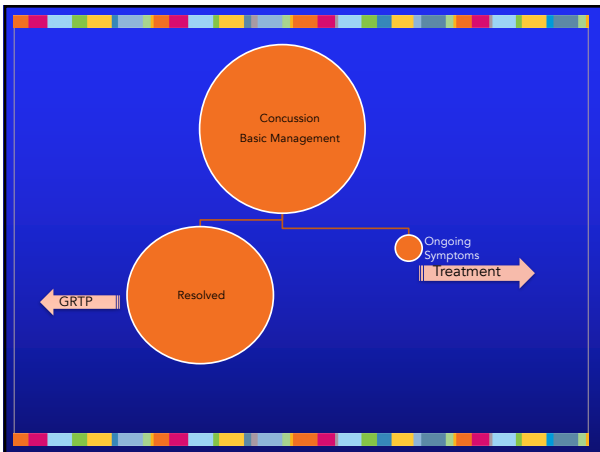
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### What else could it be?

Physical		Cognitive	
Headache/Pressure	Nausea	Feel in a "fog"	
Blurred vision	Vomiting	Feel "slowed down"	
Numbness/Tingling	Dizziness	Difficulty remembering	
Sensitive to light	Poor balance	Difficulty concentrating/easily distracted	
Ringing in ears	Noise sensitive	Slowed speech	
Seeing "stars"	Disorientated	Easily confused	
Glassy eyed	Neck Pain		
Emotional		Sleep/Energy	
Inappropriate emotions	Irritability	Fatigue	Drowsiness
Personality change	Sadness	Excess sleep	
Nervousness/Anxiety		Sleeping less than usual	
Lack of motivation		Trouble falling asleep	
Feeling more "emotional"			

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### Concussion Differential Diagnosis

- ✦ Malingering / School Avoidance
- ✦ Migraine
- ✦ Munchhausen / by proxy
- ✦ Benign Intracranial Hypertension (Pseudotumor cerebri)
- ✦ Atrial Septal Defect
- ✦ Cerebellar Tumor
- ✦ Drug Seeking
- ✦ Substance Abuse

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### Ontario Guidelines

- "The assessment and management of an individual with persistent mTBI-related symptoms should be directed toward the specific symptoms regardless of their etiology or elapsed time from injury"
- " Careful and thorough differential diagnoses should be considered as similar symptoms are common in chronic pain, depression, anxiety disorders, and other medical and psychiatric disorders"

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National Center for Injury Prevention and Control, Report from the Pediatric mTBI Guideline Workgroup, 2016

- ✦ "No current evidence based guidelines exist on the best practices for the diagnosis and management of pediatric mTBI in the United States"
- ✦ Review of last 25 years of literature
  - 21 workgroup members
  - 21 ad hoc members (Dr. McAvoy)
  - 6 federal representatives
- ✦ Recommended levels of obligation
  - Level A: must do
  - Level B: should do
  - Level C: may do
  - Level U: no recommendation can be made
  - Level R: Do only in a research study

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### Treatment of Prolonged Concussive Symptoms

- ✦ Physiologic post-concussive syndrome
- ✦ Headache
- ✦ Vestibular / Oculomotor Dysfunction
- ✦ Convergence / Accommodation Problems
- ✦ Sleep Dysfunction
- ✦ Neck Strain / Cervicogenic HA
- ✦ Dysautonomia
- ✦ Fatigue
- ✦ Cognitive decline / School challenges
- ✦ Anxiety / Depression
- ✦ ? Endocrine
- ✦ ? GI

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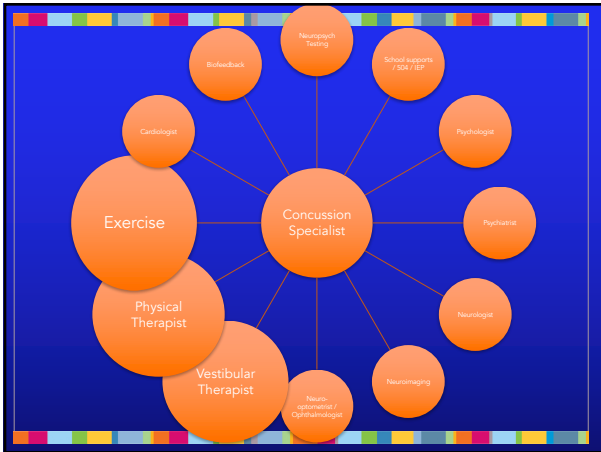
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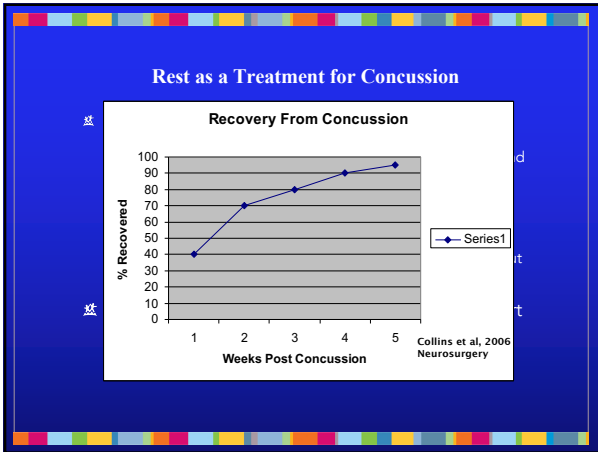
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- ### Rest as a Treatment for Concussion
- "Cocoon Therapy"
    - 2009, Dr. Michael Lee
    - Not scientifically validated
  - Leddy, et al 2012
    - 564 studies on brain injury reviewed
    - 119 fit criteria for concussion
    - "rest" primary treatment for acute symptoms of concussion
  - What is rest?

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- ### Social / Emotional Toll
- Historically ample rest was recommended in light of contrary scientific information
    - Low back pain
    - Whiplash
    - Stroke
  - Being sedentary after an injury or illness is one of the most consistent risk factors for depression (McLean et al, 2004)
 
  - Slow to recover children and adolescents due to ongoing symptoms
  - Keeping involved in social activities helps reduce depression and anxiety:
    - Social isolation
    - Loss of identity
    - Stress from "make-up" work and slipping grades

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### How much rest?

- ✦ Griesbach GS, et al, 2004
- ✦ Rats with experimental TBI
  - Early exercise
    - vs. injured rats without exercise and non-injured rats
    - More poorly on memory and learning acquisition tasks
    - Reduction in plasticity-related proteins
  - Delayed volunteer exercise
    - Increased neurotrophins
    - Better on cognitive tasks



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### How much rest?

- ✦ Majerske, CW, et al, 2008: *Concussion in Sports: Postconcussive Activity Levels, Symptoms, and Neurocognitive Performance*
  - Looked at post injury activity levels retrospectively
  - Ages 12-18
  - Athletes with intermediate levels of activity did best on neurocognitive tests and reported lowest symptom scores vs. lowest and highest levels of activity

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### Active Rehab

Gagnon, 2010: *Active rehabilitation for children who are slow to recover following sport-related concussion*

- ✦ 16 children/adolescents at 1+ month post-injury, no control group
- ✦ Multi-faceted intervention: Aerobic exercises, home program, coordination exercises and visualization (sports related)
- ✦ Results: all patients recovered to prior level of functioning

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**Active Rehab**

Leddy, 2010 *A Preliminary study of subsymptom threshold exercise training for refractory post-concussion syndrome*

- ✦ Adult patients with ongoing symptoms 6 to 52 weeks after injury
- ✦ Regulated exercise program at subsymptom threshold
- ✦ Improved PCS symptoms compared to baseline
- ✦ Exercise was felt to improve altered physiology

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**Physiologic Post Concussive Disorder**

✦ Leddy, et al 2016

- Persistence of biochemical, autonomic and cerebrovascular alterations
- Symptoms
  - Headache
  - Dizziness
  - Fatigue
  - Light sensitivity
  - Worse with activity
- Physical exam
  - Normal
  - Perhaps increased resting HR

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**Diagnosis of Physiologic PCD**

✦ Graded aerobic treadmill testing

- Buffalo Concussion Treadmill Test, Modified Balke Protocol (Leddy, et al)
  - 3.0-3.3 MPH 0% grade
  - ↑ grade by 1% per minute x 15 minutes
  - Then ↑ speed by 0.2 – 0.4 mph per minute
  - Rate sx (Likert scale) and perceived exertion (Borg scale) every minute + HR monitor
  - Stop when sx increased 3 pts over baseline or exhausted
- With Physiologic PCD
  - Escalation of symptoms within 5-15 minutes

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**Treatment of Physiologic PCD**

- ❖ Submaximal aerobic exercise prescription
  - Treadmill test to determine HR achieved with escalation of symptoms
  - 80-90% of HR achieved with test, 5-6 days per week x 20 minutes
  - Retest and adjust q 1-3 weeks
  - Transition to sports specific exercise
  - Results in improved resting cerebral blood flow, improvement of CO2 sensitivity and cerebral vascular reactivity

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**Benefits of Correctly Timed Exercise**

- ❖ Increased parasympathetic activity
- ❖ Reduced sympathetic activation
- ❖ Improved cerebral blood flow
- ❖ Promotes neuroplasticity (animal studies)
- ❖ Positive effects mood, self esteem
- ❖ Promotes general sense of well being

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**Why theory is difficult to translate into practice?**

- ❖ Current guidelines recommend rest until symptom free
- ❖ Risk of re-injury
- ❖ Aggressive exercise may worsen symptoms and increase potential for prolonged recovery
- ❖ No guidelines on when to start or how to progress
- ❖ You can't get some patients off the couch

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# PACER

Progressive  
Acute  
Concussion  
Exertional  
Rehabilitation



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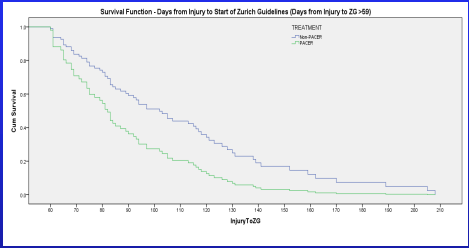
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"Slow to Recover" = 59+ days without resolution of concussion  
67 patients: 36 PACER vs. 31 Non-PACER

Survival Function - Days from Injury to Start of Zurich Guidelines (Days from Injury to ZG-68)



Days from Injury to ZG-68	PACER (%)	Non-PACER (%)
0	100	100
25	85	95
50	65	85
75	45	75
100	25	65
125	15	55
150	10	45
175	8	35
200	7	25

167 patients total first year  
Ages 7yrs - 18 yrs

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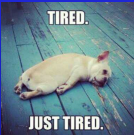
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### Sleep Disturbance

- ❖ Teens biologically driven to stay up late and sleep late
  - 59% of middle school students and 87% high school students get less than recommended 8.5-9.5 hours of sleep
- ❖ Lack of sleep
  - ↑ overweight
  - ↑ depression
  - ↑ risk of MVA
  - ↓ school performance
  - Poor mood
- ❖ 8/25/14
  - AAP Policy Statement
    - Delay start of middle and high school to 8:30am or later



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### Sleep Disturbance

- ❖ Eisenberg et al 2013
  - 36% of teens with sleep disturbance after concussion
- ❖ Guskiewicz et al 2011
  - 26% of colleges aged athletes with concussion had sleep disturbance within 72 hours of injury
- ❖ Chan et al 2015
  - Persistent sleep disturbance predicts poor function and social outcomes 1 year after mTBI

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### Sleep Dysfunction

- ❖ Sleep Hygiene Measures
  - Regular sleep time
  - Avoid electronics / lit screens
  - Avoid caffeine
  - Good sleep environment
  - Eliminate naps
  - Exercise (safe)
- ❖ Melatonin
- ❖ Relaxation / Biofeedback
- ❖ Amitriptyline
- ❖ Sleep Neurology



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### Cervicogenic PCD

- ✦ Most mobile segment of spine is cervical
- ✦ High risk of whiplash injury with head injury
- ✦ Neurologically complex
  - Cervicocollic reflex
  - Vestibulocollic reflex
  - Cervico-oculoar reflex
  - Mediate head, gaze and neck position sense
  - Stabilize during rapid head movements
  - Mechano, proprio, and nociceptive fibers



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### Cervicogenic PCD

- ✦ Symptoms
  - Neck pain
  - Neck stiffness
  - Fogginess
  - Fatigue
  - Dizziness with movement
  - Headache
  - Occipital neuralgia
  - Typically no early sx with graded exertional testing

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### C-spine evaluation

- ✦ Examination
  - Muscular tenderness
  - Muscle spasm
  - Decreased cervical ROM
  - Dizziness with cervical testing
  - (Pain with palpation of occipital nerves)
- ✦ X-ray
- ✦ MRI/MRA



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### Cervicogenic PCD Treatment

- ✦ Schneider KJ, et al. Cervicovestibular rehabilitation in sport-related concussion (RCT)
  - Ages 12-30
  - Treatment group 73% (11/15) cleared within 8 weeks
  - Control group 7% (1/14) cleared within 8 weeks

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- ✦ Physical Therapy
  - Manual PT
  - Low velocity mobilization
  - Passive / active ROM
  - Proprioceptive training
  - Strengthening exercises
- ✦ Dry Needling
  - Kietrys et al, 2013
  - Meta analysis: Grade 1A evidence for myofascial pain
- ✦ Headache neurologist / occipital nerve block

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### Dysautonomia

The diagram illustrates the autonomic nervous system (ANS) and its effects on various organs. It is divided into two main branches: Parasympathetic and Sympathetic.

- Parasympathetic:**
  - Stimulates flow of saliva
  - Stimulates heart rate
  - Constricts bronchi
  - Stimulates peristalsis and secretion
  - Stimulates release of bile
  - Contracts bladder
- Sympathetic:**
  - Dilates pupil
  - Inhibits flow of saliva
  - Dilates bronchi
  - Stimulates heart rate
  - Inhibits peristalsis and secretion
  - Conversion of glycogen to glucose
  - Secretion of adrenaline and noradrenaline
  - Inhibits bladder contraction

The diagram also shows the central nervous system (brain and spinal cord) and the peripheral nervous system (nerves) connecting these branches to the organs.

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### Dysautonomia

- ✦ Evidence for dysautonomia during acute concussion
  - Decreased HR variability
  - Altered cerebral blood flow regulation
  - Altered pulmonary ventilation especially during exercise
- ✦ Heyer GL, et al: studied 34 teens with persistent PCS (>= 3 weeks) with tilt table testing
  - 76% of cohort female
  - 70% with abnormal results
  - Retested when PCS sx resolved, testing normalized

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### Dysautonomia: Symptoms

- ✦ Fatigue
- ✦ Exercise intolerance
- ✦ Brain Fog
- ✦ Nausea / GI discomfort
- ✦ Sleep disturbance
- ✦ Dizziness
- ✦ Postural intolerance / POTS
  - Blurred or tunnel vision
  - Head rush / lightheaded with position change
  - Palpitations
  - Tremulousness
  - HA




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### Treatment of Dysautonomia and POTS

- ✦ Fluids
  - 80-120 ounces / day
- ✦ Increase salt intake
  - 5 gram salt diet
  - Salt supplements (2 gram /day)
- ✦ Avoid caffeine
- ✦ Cardiac rehab
- ✦ Core and lower extremity strengthening
- ✦ Cardiology consultation
  - Medications




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## Dysautonomia

- ✦ Specialty Consult
  - Medications (off label)
    - Fludrocortisone
      - Mineralocorticoid, water retention
    - Midodrine
      - Alpha 1 agonist
      - Vasoconstriction
    - Amphetamines (Adderall XR)
      - Flood alpha receptors, vasoconstriction
      - Increased energy, cognitive
    - Beta Blockers
      - Not well tolerated in pediatric patients

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MAYO CLINIC
 Page 1 of 32 mc6122 Teens - Autonomic Dysfunction

PATIENT EDUCATION  

# Teens + Autonomic Dysfunction

✦ [https://med.uth.edu/pediatrics/files/2014/02/MAYO\\_Clinic\\_Teens\\_Dysautonomia\\_copy.pdf](https://med.uth.edu/pediatrics/files/2014/02/MAYO_Clinic_Teens_Dysautonomia_copy.pdf)

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## Cognitive Decline

✦ <http://www.getschoolledonconcussions.com>

HOME ABOUT US TESTS AND PROCEDURES SERVICES CONTACT

### Get Schooled On Concussions Return to Learn (RTL)

The results of research in brain neurophysiology following a concussion are mixed by healthcare professionals and athletes. There are several studies regarding concussion and learning. Learn more here.

An individual's ability to learn may be affected in a variety of ways. For example, the brain may not be able to process information as quickly as it normally does. This may lead to a variety of learning difficulties. Concussions may also affect the brain's ability to process information. This may lead to a variety of learning difficulties. Concussions may also affect the brain's ability to process information. This may lead to a variety of learning difficulties.

We make concussions treatable in your classrooms.

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**School Supports**

- ✦ Academic Adjustments
  - General education interventions applied flexibly and generously
  - Adequate for vast majority of concussion patients
- ✦ 504
  - Roadmap that outlines a more individualized and formalized plan
  - Consider for those with a protracted or especially difficult recovery
- ✦ IEP (Individualized Education Plan)
  - A written document that is developed for each public school child who is eligible for special education.
- ✦ Homebound education
  - Not recommended

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**Cognitive Decline**

- ✦ Medications
  - Amantadine
    - Reddy CC, et al 2013
  - Stimulants?
- ✦ Neuropsychiatric testing




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**Post-Traumatic Headaches**

- ✦ Definition of Post Traumatic Headache (PTHA)
  - ✦ Onset within 7 days after injury to head or regaining consciousness
    - ✦ Acute < 3 months
    - ✦ Persistent (chronic >3 months)
  - ✦ Appendix criteria per ICHD-3 > 7 days, delayed-onset headache attributed to traumatic injury to the head
- ✦ Up to 90% have headache after concussive injury
- ✦ More common after mTBI than moderate or severe TBI
- ✦ Increased risk with past h/o headache/migraine, FH migraine, female

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- ✦ Blume HK, Headache after Pediatric TBI: A cohort study
  - ED and inpatients ages 5-17
  - 43% of mTBI patients had HA at 90 days compared to 23% of ortho controls
- ✦ Adult studies
  - HA phenotypes often overlapping features and non-classifiable
  - Migraine, tension-type, cervicogenic, cluster, occipital neuralgia, MOH (medication overuse headaches) and hemicrania continua have all been described

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### Post-traumatic Headache

- ✦ Pathophysiology not well understood
  - Given varied presentation, may have varied pathophysiology
- ✦ Some research suggest similar pathophysiology to migraine
  - Both have increased extracellular K+, intracellular sodium, calcium and chloride
  - Activation of Trigeminal nociception resulting in cortical spreading depression
- ✦ Often associated with dizziness, sleep disturbances, anxiety and depression

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### Post-traumatic Headache

- ✦ Evaluation
  - Good history
    - Headache phenotype
    - Provoking factors, lifestyle, substance abuse
    - Medications, diet, sleep, stress, exercise
  - Neurologic exam
  - Musculoskeletal exam including c-spine exam
    - Consider PT evaluation for painful upper cervical joint restrictions

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### Post-traumatic HA / Differential Dx

- ❖ Rule out other diagnoses
- ❖ Consider medication overuse headaches
  - Caffeine and opioids high potential
  - ASA, acetaminophen, triptans significant potential
  - NSAIDs less likely
  - DHE and dopamine agonists low potential
- ❖ Evaluate for comorbidities
  - Vestibular and oculomotor dysfunction
  - Cervicogenic headache
  - Psychological and social factors

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### Acute Post-Traumatic Headaches

- ❖ No RCT's on treatment
  - Educating on expected clinic course may improve outcome in concussion
- ❖ Lifestyle measures
  - Rest / Avoid triggers
  - Paced return to school
  - Sunglasses
  - Colored glasses
  - Headphones
  - Good eating habits and hydration
- ❖ Supplements
  - Magnesium citrate
  - B2 (Riboflavin)
  - Butterbur (Pedadolex)
  - Melatonin



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- ❖ Alternative treatments
  - Biofeedback
  - CBT
  - Stress management / relaxation
  - Acupuncture
  - Occipital Nerve Block
- ❖ Sub-symptom Threshold Exercise with PT

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**Post-Traumatic Headaches (PTHA)**

- ❖ Medications
  - Expert opinion: treat headache subtype
  - Ibuprofen / naproxen / acetaminophen
    - Risk of medication overuse HA
  - Triptans (5HT-1B/D agonist)
    - Reports of success – no RCTs, all off label for PTHA
    - Rizatriptan approved for migraine ages 6 and older
    - Almotriptan approved for treatment of migraine 13 and older
    - Sumatriptan: approved ages >18 years, evidence for use > 12 years
    - None FDA approved for PTHA
    - Theoretical risk in first 72 hours due to vasoconstriction
  - Ondansetron for nausea
- ❖ Avoid opioids unless needed to treat other injury

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**Emergency Department Treatment of Acute PTHA**

- ❖ Antiemetic +/- Ketorolac
  - Prochlorperazine
  - Metoclopramide
- ❖ Brousseau D, et al.
  - Treatment of pediatric migraine HA: a randomized, double-blind trial of prochlorperazine vs. ketorolac
  - Relief at 1 hour
    - 84% with prochlorperazine
    - 55.2% with ketorolac
- ❖ Valproate
- ❖ (Propofol)
- ❖ (Short course of IV or oral corticosteroids)
- ❖ IV hydration

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**Post-Traumatic Headaches (PTHA)**

- ❖ Preventive medications
  - Consider for persistent HA causing disability and/or affecting quality of life
  - Goal: decrease severity, duration and frequency of HA
  - No RCTs
- ❖ Kuczynski and Barlow
  - Treatment of PTHA in peds TBI clinic >3months
  - Improvement with amitriptyline (68%), melatonin (75%), 64% for all meds including: topiramate, nortriptyline, indomethacin
- ❖ Amitriptyline and topiramate most commonly prescribed
- ❖ Consider neurology referral

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### Vestibulo-ocular Dysfunction

- ✦ Managing the complex visual-spatial environment depends on integration of vestibular, oculomotor and somatosensory systems
  - Retina, semi-circular canals, otolithic organs and joint mechanoreceptors
  - Integrated by neurons within the spinal cord, ANS, brainstem nuclei, cerebellum, thalamus, basal ganglia and cerebral cortex
  - VOR: gaze stability with movement
  - VSR: coordinates head, neck and trunk positioning during body movements

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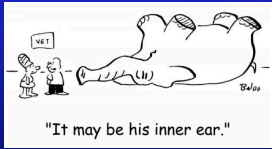
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### Vestibular Dysfunction

- ✦ Corwin, et al, Vestibular deficits following youth concussion.
  - Longer return to school and resolution of symptoms
  - With 3 or more prior concussions more likely to have vestibular deficits and took longer to resolve
- ✦ Incidence unclear



"It may be his inner ear."

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### Symptoms

<ul style="list-style-type: none"> <li>✦ Vestibular           <ul style="list-style-type: none"> <li>■ Motion sickness</li> <li>■ Balance disturbance at rest and with movement</li> <li>■ Dizziness with movement</li> <li>■ Difficulty in busy visual environments</li> <li>■ Hearing loss/ringing in ears</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>✦ Ocular motor           <ul style="list-style-type: none"> <li>■ Difficulty focusing eyes</li> <li>■ Photophobia</li> <li>■ Double vision</li> <li>■ Burry vision</li> <li>■ Difficulty tracking objects</li> <li>■ Headaches with reading</li> <li>■ Avoidance of reading</li> <li>■ Near to far accommodation causes symptoms</li> <li>■ Difficulty taking notes</li> <li>■ Visual motion sensitivity</li> </ul> </li> </ul>
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### Physical Exam

- ❖ Vestibular
  - Abnormal gaze stability
  - Dynamic Balance
    - Heel to toe walk forwards and backwards
  - Static Balance
    - Romberg eye open and closed
    - Modified BESS
  - Coordination
- ❖ Ocular motor
  - Pupil reaction
  - Smooth pursuit testing / EOM
  - Saccade testing
  - Vergence testing
- ❖ Exertional testing
  - Typically no early symptom limited threshold

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### Treatment

- ✦ Vestibular Therapy
  - Subspecialty within physical therapy
  - Vestibular therapist skilled with peds rare
  - Use postural, gait and gaze stability tasks
  - Canalith repositioning if indicated
  - Home exercises very important
- ✦ Neuro-optometry
  - Corrective lenses
  - Prism
  - Inform rehab team
- ✦ Vision Therapy
- ✦ Ellis / Leddy 2016 "moderately strong clinical evidence to support vestibular rehabilitation. No prospective studies to support vision therapy in concussion patients"

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### Depression / Psychological

- ✦ Psychology evaluation
- ✦ Psychiatric evaluation
- ✦ Medications
- ✦ CBT (Cognitive Behavioral Therapy)
- ✦ Exercise



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### Hypothalamic - Pituitary Deficiency

- ✦ Theory of injury in mTBI
  - Direct injury due to acceleration/deceleration or rotational forces
  - Secondary injury due to changes in blood flow, inflammation, autoimmune response
  - Cell death resulting in hypothalamic-pituitary deficiencies

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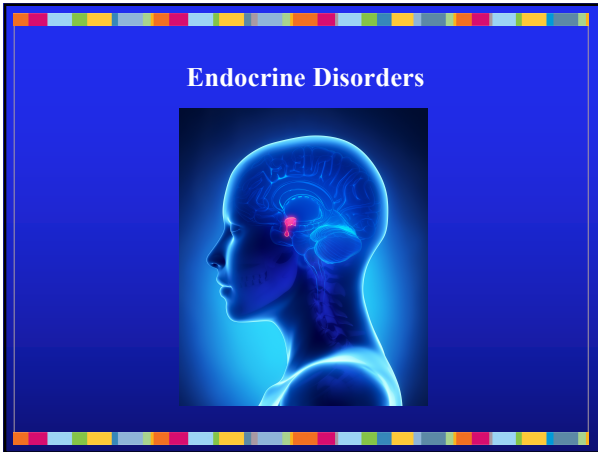
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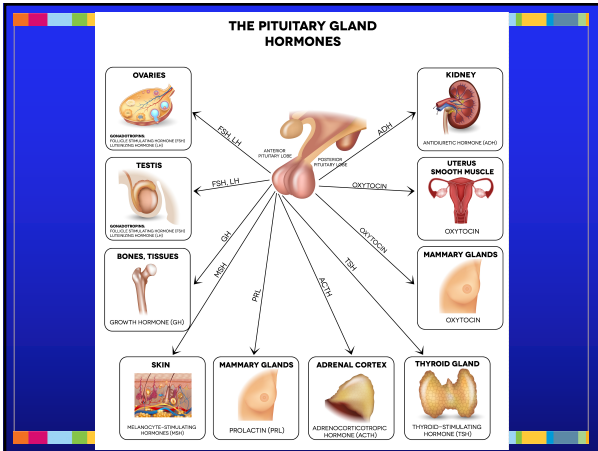
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- ☛ Soliman AT, et all 2015
- Review of pituitary deficiency after tbi in early childhood
  - 11 pediatric studies, variable timing of testing and severity of tbi
  - GH 6-48%
  - TSH 2-33%
  - LD/FSH 6-16%
  - ACTD 2-43%

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- ✦ Small studies suggest risk of pituitary dysfunction after mTBI
- ✦ Clinical features are not clear
- ✦ Risk factors are not clear
- ✦ Screening can be costly, some of the testing is controversial
- ✦ May be early, late, transient or long term
- ✦ No guidelines on who or when to screen
- ✦ Reifschneider, et al 2015
  - Consider in children with "fatigue, cold intolerance, poor growth, altered puberty, mood disturbance or altered appetite control after TBI"

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### Summary

- ✦ Detailed history and specific physical exam can be helpful in determining the etiology of a delayed concussion recovery
- ✦ Treating specific complications can help recovery
- ✦ Prolonged rest and inactivity may be counterproductive in concussion recovery

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### Questions?



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