

# Diagnostic and Treatment Challenges in mTBI (Concussion)

**David Elias**

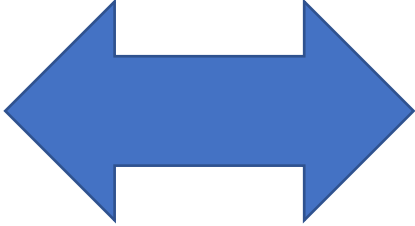
BSC (Pharm), MD, CCFP-EM, CIME, CCBOM

# Conflict of Interest Disclosure

- CHS
- MMRI
- CIRC
- CCI
- WSNB, WCB PEI, WCB NS
- Dalhousie University
- Government of Canada
- Crown Corporations
- No Public and Private Corporations.



# Learning Objectives

- Epidemiology of Traumatic Brain Injury
  - Review the pathophysiology of **TBI Spectrum**
  - Criteria for Diagnosis
  - Natural History of mTBI vs PCS
- 
- Diagnostics
  - Management Principles
  - Occupational Medicine Perspective

# HELP!!!!



CANADIAN CONCUSSION INSTITUTE

# Epidemiology of Traumatic Brain Injury

- **Distribution of TBI** \$7.3Billion in 2011

—Severe and Moderate **TBI** are 10%

\$



**mTBI 90%**

---

But Total Costs (Healthcare and Disability) are equal of mTBI = (Severe + ModerateTBI)

- mTBI Incidence
- 500 to 600 / 100,000 annual incidence in Canada
- 3% reported as work-related

# Incidence – 2010 Ontario Study

5

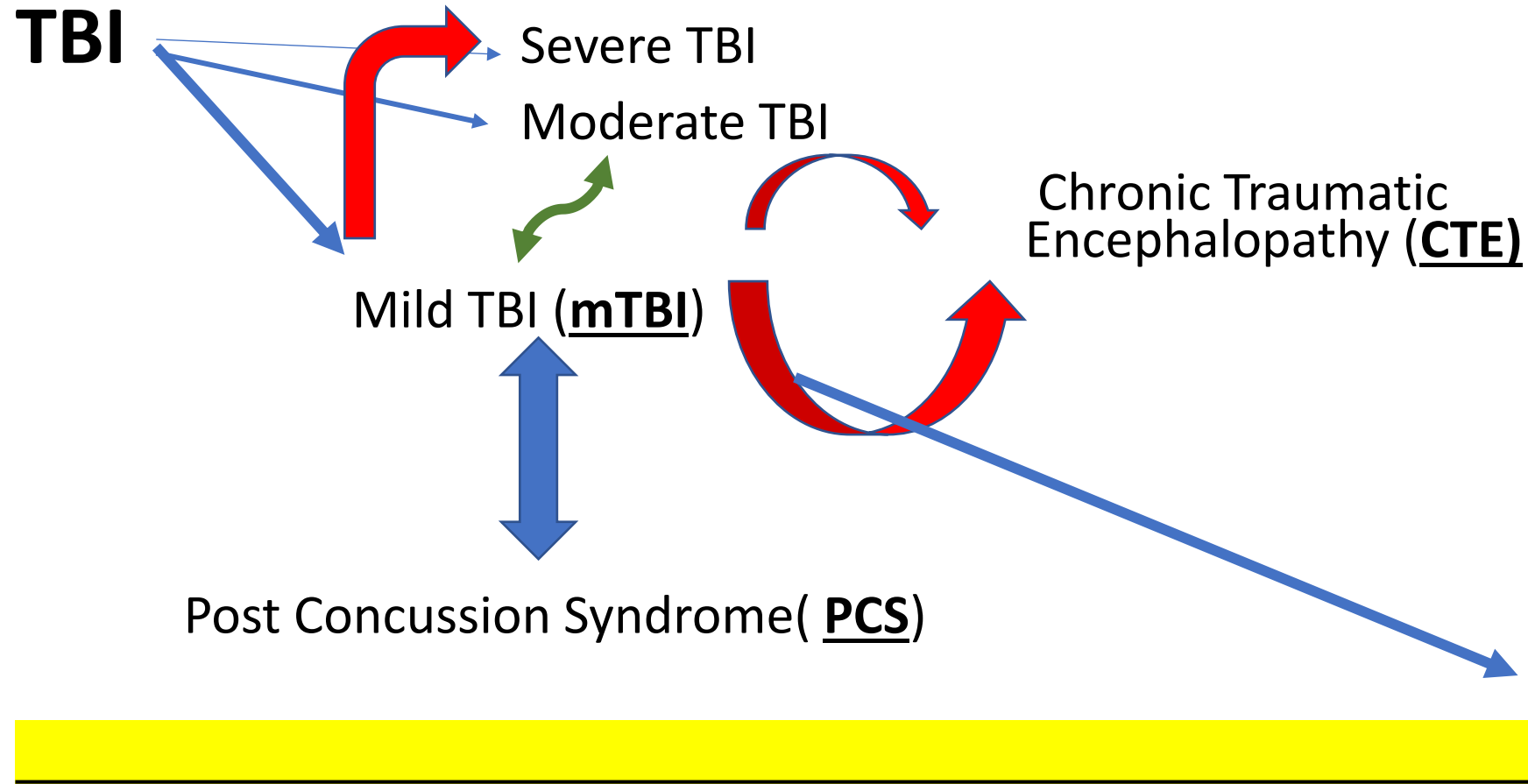
## *The Burden of Work Disability Associated with Mild Traumatic Brain Injury in Ontario Compensated Workers: A Prospective Cohort Study (2010)*

Vicki L. Kristman\*,<sup>1,2,3</sup>, Pierre Côté<sup>1,2,3,4</sup>, Sheilah Hogg-Johnson<sup>3,4,5</sup>, J. David Cassidy<sup>1,2,4,5</sup>,  
Dwayne

Van Eerd<sup>3,4</sup>, Marjan Vidmar<sup>3</sup>, Mana Rezai<sup>1,4</sup> and Richard A. Wennberg<sup>6</sup>

- Annual incidence was 1.5 (95% CI: 1.3, 1.7) per 10,000 full-time equivalents.
- 87% of claimants had a single episode of benefits with median duration of 11 days (95% CI: 10, 12). 50% were off benefits after 17 days and **75% by 72 days.**
- Conclusions: mTBI is disabling in the working population. Most work disability is short-term, but a small proportion of claimants become chronically disabled and unable to work.

# Pathophysiology of TBI Spectrum



# Chronic Traumatic Encephalopathy CTE

- The condition known as *chronic traumatic encephalopathy* (CTE) was formerly believed to exist primarily among boxers, and was referred to as [dementia pugilistica](#). It is a progressive degenerative disease which afflicts the brain of people who have suffered **repeated concussions and traumatic brain injuries**, such as athletes who take part in contact sports, members of the military and others.
- Chronic traumatic encephalopathy is a condition of brain damage which persists over a **period of years or decades** and which is the result of traumatic impacts to the cranium.
- The brain of an individual who suffers from chronic traumatic encephalopathy gradually deteriorates and will over time **end up losing mass**. Certain areas of the brain are particularly liable to atrophy, though other areas are prone to becoming enlarged. Another aspect of CTE is that some areas of the brain experience an **accumulation of tau protein**, a substance which serves to stabilize cellular structure in the neurons but which may become defective and subsequently may cause major interference with the function of the neurons.
- <http://www.protectthebrain.org/Brain-Injury-Research/What-is-CTE-.aspx>

# Diagnosis of mTBI

- Various Definitions and Criteria:
  - GCS 13-15
  - Multiple Severity Indicators of Traumatic Brain Injury
  - Expanded Head Injury Severity Scale
  - CDC mTBI Work Group
  - WHO
  - Defense and Veterans
  - AAN American Association of Neurology
  - Concussion in Sport Group
  - ACRM American Congress of Rehabilitation Medicine
  - Gradings, Sub-Severities, Complex vs Simple, Uncomplicated



In North America, the commonly accepted diagnostic criteria for *mild* traumatic brain injury are those from the American Congress of Rehabilitation Medicine (ACRM) and as such will be used in the subsequent recommendations and assessments. These criteria are listed in Table 1.

**Table 1- ACRM Diagnostic Criteria for mTBI**

<p><b>Traumatically induced physiological disruption of brain function, as manifested by one or more of:</b></p> <p>LOC up to 30 minutes</p> <p>Loss of memory for events immediately before or after for up to 24 hours</p> <p>Any alteration of mental status at the time of the accident that may or may not be traumatic</p> <p><b>But when the severity of the injury <u>does not</u> exceed the following:</b></p> <p>LOC&gt;30 minutes</p> <p>PTA&gt;24 hours</p> <p>GCS&lt;13 after 30 minutes</p>
<p>PTA= post traumatic amnesia; GCS= Glasgow Coma Scale; LOC= loss of consciousness</p>

# Diagnostic Criteria for mTBI

- American Congress of Rehabilitation Medicine (ACRM) Diagnostic Criteria for mTBI:

**Traumatically induced physiological disruption of brain function, as manifested by one or more of:**

1. LOC up to 30 minutes
2. Loss of memory for events immediately before or after for up to 24 hours
3. Any alteration of mental status at the time of the accident that may or may not be traumatic

**But when the severity of the injury does not exceed the following:**

1. LOC>30 minutes
2. PTA>24 hours
3. GCS<13 after 30 minutes

- The severity of traumatic brain injuries are defined using three primary criteria: **Glasgow Coma Scale (GCS), length of post traumatic amnesia (PTA), and duration of loss of conscious (LOC) (ABIEBR, 2013).**

# Common Symptoms of mTBI

11

Physical	Behavioural/Emotional	Cognitive
Headache Nausea Vomiting Blurred or double vision Seeing stars or lights Balance problems Dizziness Sensitivity to light or noise Tinnitus	Drowsiness Fatigue/lethargy Irritability Depression Anxiety Sleeping more than usual Difficulty falling asleep	Feeling “slowed down” Feeling “in a fog” or “dazed” Difficulty concentrating Difficulty remembering

*Guidelines for Concussion/mTBI and Persistent Symptoms: Second Edition. (2013). Ontario Neurotrauma Foundation.*

*Adapted from Willer B, Leddy JJ. Management of concussion and post-concussion syndrome. Current Treatment Options in Neurology. 2006;8:415-426; with kind permission from Springer Science and Business Media.*

# mTBI vs. PCS

- mTBI refers **only to the initial injury** severity
- Post Concussion Syndrome (PCS) denotes a constellation of signs and symptoms that may be reported after a traumatic brain injury, **persistent 3 months post mTBI**
- In most cases, patients who experience mTBI will recover fully, typically within days to months
- 1% to 15% of patients diagnosed with mTBI will continue to experience symptoms beyond 3 months
- Reduced functional ability, heightened emotional distress, and delayed return to work or school
- When symptoms persist beyond the typical recovery period of 3 months, the term **post-concussion syndrome or disorder** may be applied.
- **Importance of proper label at the right time – has implications**

# Natural History of mTBI vs PCS

- Pattern of Symptom Decrescendo Pattern
- Temporal Pattern
- Symptoms
- Grade of mTBI , Complicated vs Uncomplicated, Previous Concussions
- Neurocognitive Impairments after 3 months

# Risk Factors Influencing Recovery Post mTBI

14

<b><u>Medical Factors (red flags):</u></b> Pre-existing medical conditions or post-injury symptoms that are associated with poor outcomes post mTBI	<ul style="list-style-type: none"><li>• Post-traumatic amnesia (PTA)</li><li>• History of previous traumatic brain injury</li><li>• History of previous physical limitations</li><li>• History of previous neurological or psychiatric problems</li><li>• High number of symptoms reported early after injury</li><li>• Skull fracture</li><li>• Early onset of pain and in particular headache within 24 hours after injury</li><li>• Reduced balance or dizziness during acute stage</li><li>• Confounding effects of other health-related issues, e.g., pain medications, disabling effects of associated injuries, emotional distress</li><li>• Presence of nausea after injury</li><li>• Presence of memory problems after injury</li></ul>
<b><u>Contextual Factors (yellow flags):</u></b> Personal, psychosocial, or environmental factors that may negatively influence recovery post mTBI	<ul style="list-style-type: none"><li>• Injury sustained in a motor vehicle accident</li><li>• Potential influence of secondary gain issues related to litigation and compensation</li><li>• Not returning to work or significant delays in returning to work following the injury</li><li>• Being a student</li><li>• Presence of life stressors at the time of the injury</li><li>• Higher levels of symptom reporting is associated with mood symptoms and heightened self-awareness of deficits</li><li>• Older age</li><li>• Lack of social supports</li><li>• Less education/lower social economic status</li></ul>

*Guidelines on Concussion/mTBI and Persistent Symptoms: Second Edition. (2013). Ontario Neurotrauma Foundation.*

*Adapted from the Motor Accidents Authority of NSW, Guidelines for Mild Traumatic Brain Injury following a Closed Head Injury (MAA NSW, 2008).*

# Differential Diagnoses

15

- There is controversy regarding the diagnosis of PCS because of significant symptom overlap with other diagnoses

**Table 4.1. Differential Diagnoses Related to mTBI.**

Major depressive disorder
Generalized anxiety disorder
Post-traumatic stress disorder (PTSD)
Chronic pain syndrome
Cervical strain/whiplash associated disorder
Substance abuse or polypharmacy
Somatoform disorder/factitious disorder
Malingering
Post-traumatic headache
Fibromyalgia syndrome (secondary)
Primary sleep disorder: e.g., obstructive sleep apnea

*Guidelines on Concussion/mTBI and Persistent Symptoms: Second Edition. (2013).  
Ontario Neurotrauma Foundation.*



## 4.8 Controversy

Mild traumatic brain injury and/or post concussion syndrome can be challenging to diagnose, as described above, and to treat. Many of the symptoms are subjective, and are presenting complaints in other diagnoses. A 2003 study examined 63 patients with chronic pain and 32 patients with mTBI, all of whom completed the Rivermead Post Concussion Questionnaire. There were no differences between groups for total scores, and most people with chronic pain endorsed symptoms consistent with PCS (Smith-Seemiller et al, 2003). This overlap can be seen in patients with other diagnoses including depression and post traumatic stress disorder (Ontario Neurotrauma Foundation). Comparable symptoms can also be seen in healthy patients (Ontario Neurotrauma Foundation; VA/DoD).



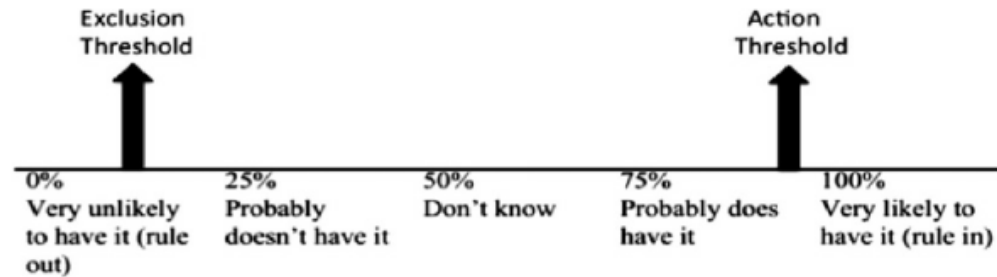
# Diagnostic Considerations

- IF PCS how to evaluate?
- Advanced Imaging
- NeuroCognitive Testing
- Validity Testing
- HR variability
- Occulo-Vestibular and Pupillary

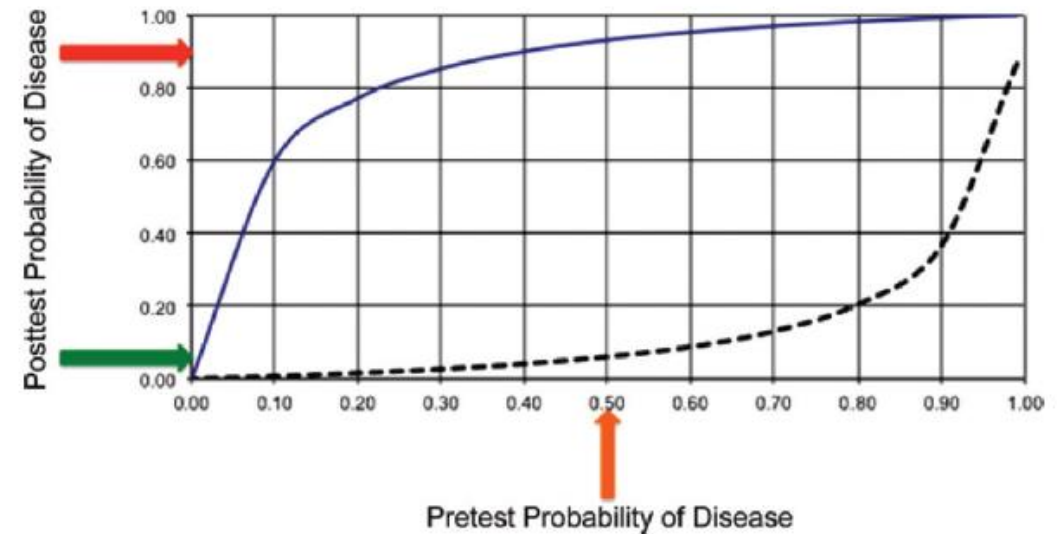
### **3.7 Health Care Provider Assessment of Persistent Symptoms Three Months Post mTBI**

Persistent symptoms following mTBI can often be seen in other conditions, namely psychiatric, chronic pain, and certain medical conditions (Ontario Neurotrauma Foundation). Complete differential diagnoses should be considered and investigated as necessary. Health care providers should consider magnetic resonance imaging (MRI) include susceptibility-weighted imaging (SWI) and diffusion tensor imaging (DTI), to help further clarify the diagnosis of mTBI (Benson et al, 2012).

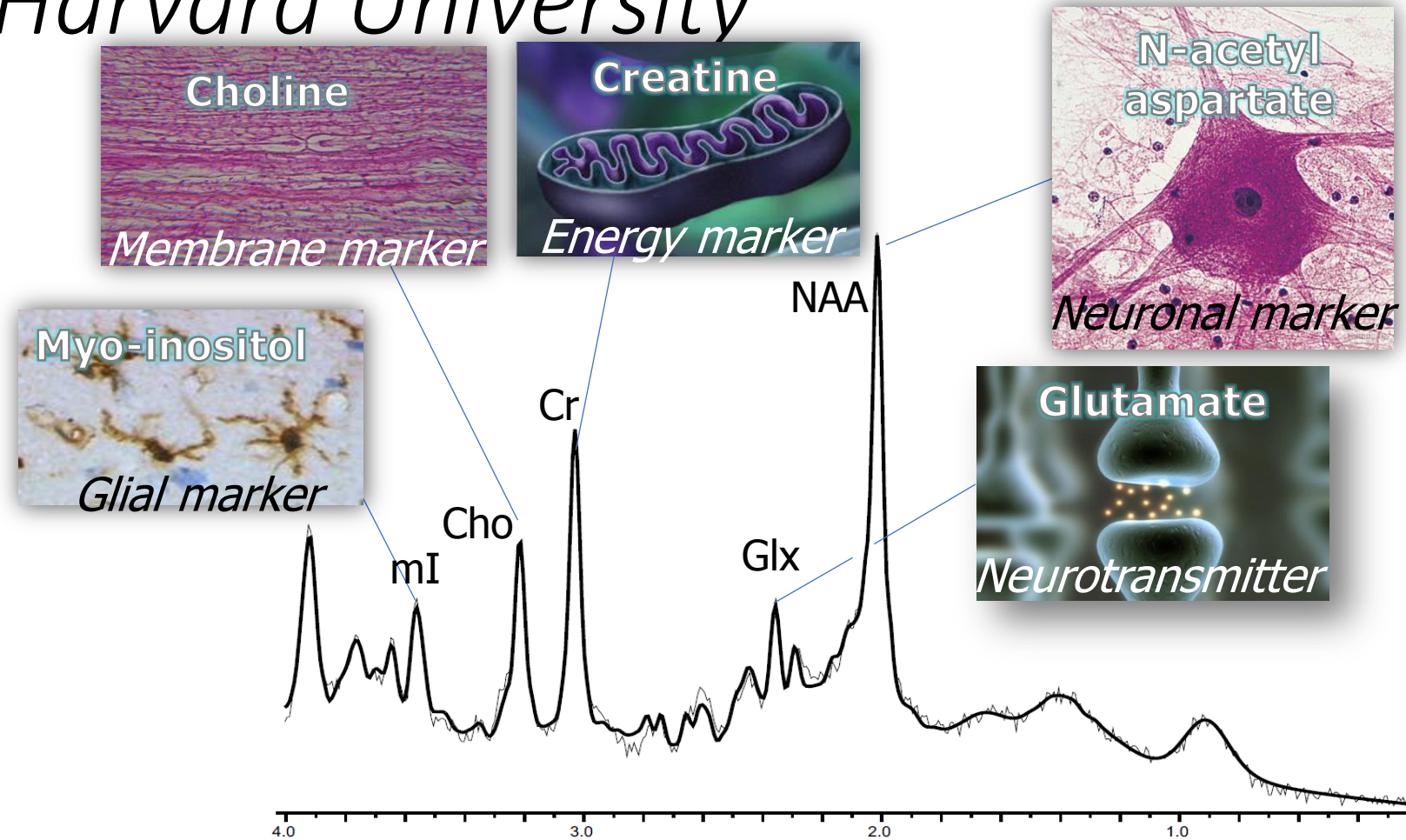
# mTBI 3T Spectroscopy Negative Predictive Value



**Figure 1.** Spectrum of pretest probabilities for a given disease. If the pretest probability is close to 0%, the patient is unlikely to have the disease; no further action is necessary because the probability is below the exclusion threshold. As the pretest probability nears 100%, the patient is increasingly likely to have the disease, and treatment is justified because the probability is above the action threshold. Alternatively, if the clinician is absolutely uncertain of the diagnosis, the pretest probability is 50%. Clinicians assess their patients in broad terms (low, intermediate, or high pretest probability). The aim of imaging is to push the posttest probability either below the exclusion threshold or above the action threshold.



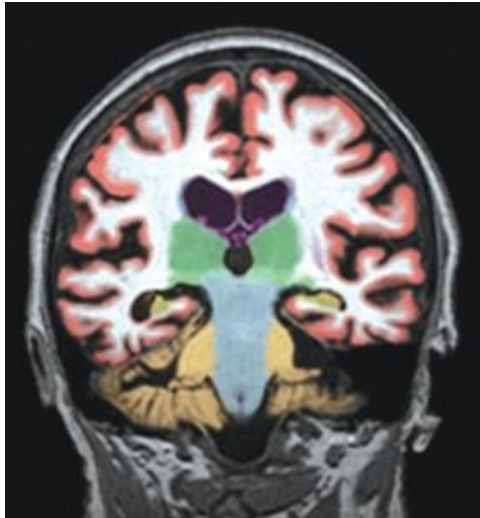
# MR Spectroscopy: *The Virtual Biopsy* - Dr Alex Lin Harvard University



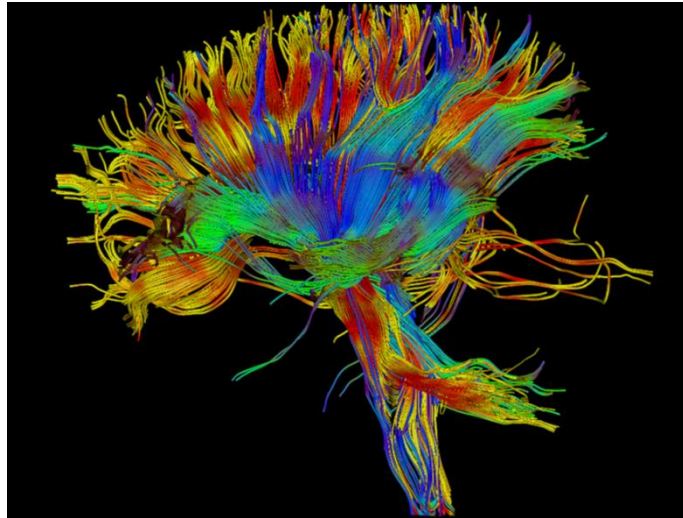


# Multimodal & Multidisciplinary

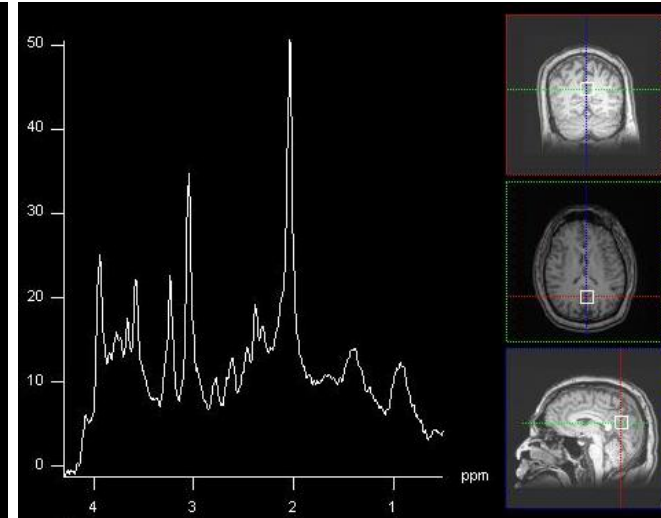
Brain Morphology



Diffusion Tensor Imaging



Neurospectroscopy



- Clinical History
- TBI Assessments
- Neuropsychological evaluation

## *Susceptibility-Weighted Imaging*

---

Improvements in gradient echo imaging methods have increased our ability to detect the susceptibility-related effects of shear-related hemorrhagic injury. Susceptibility-weighted imaging (SWI) uses the paramagnetic property of blood products and increases visibility of microhemorrhages by accentuating signal dropout by rapid spin dephasing. SWI is extremely sensitive to iron and blood products and detects microhemorrhages where conventional MRI fails (**Fig. 1**). Similar to gradient echo images, SWI detects hemorrhage at all stages, because iron remains even after the fluid from blood is reabsorbed.

The technical aspects and clinical applications of SWI have been elaborated in detail by various investigators.<sup>4,5</sup> SWI is best used at higher field strengths, as the TE (time to echo) is much longer at low fields and acquisitions need to be longer. In addition, at higher field strengths, isotropic in-plane resolution can be obtained and the signal-to-noise ratio (SNR) is higher. The use of even higher field strengths can increase the resolution and SNR significantly. Another advantage of SWI over conventional gradient echo sequences is the ability to differentiate between hemorrhage and calcium and visualize vessel connectivity and microbleed location in relation to the vasculature and other structures in the brain. SWI is routinely used in the author's

# Medical Symptom Testing

23

- Consequently, symptom validity measures can help ensure patients are properly diagnosed and treated.
- Where there are prolonged and substantial complaints after mTBI, primary care providers should rule out other contributing or confounding factors (red/yellow flags). (Grade A)



SVA is especially important in the context of secondary gain when external incentives may be associated with poor effort or exaggeration of cognitive deficits and symptoms, yielding worse performance on neuropsychological testing

...

... it has been estimated that about 40% of MTBI cases in litigation or seeking compensation fail effort tests, producing neuropsychological test findings that are invalid and suspicious for malingering (Flaro, Green & Robertson 2007; Larrabee, 2005; Mittenberg, Patton, Canyock, & Condit, 2002).



# Management Principles

- Only Impactful Tx is education and Counselling
- Visual Therapy???????
- Return to Activity
- RTW
- Therapeutics
- Follow Up and Structure
- **Congruency Analysis with Predictive Value Algorithm**
- **RE: Archives of Clinical Neuropsychology - Manuscript ID ACNP-2018-046-**  
**- "Exaggerated Functional Impairment due to Malingered Neurocognitive Dysfunction Following Mild Traumatic Brain Injury"**

# Initial Management Guidelines

26

- ❑ **Education and reassurance** should be provided at the initial assessment or at minimum within 1 week from injury/assessment.
- ❑ Patients should be given advice on **stress management**, and advised to avoid use of **alcohol and recreational drugs** until symptom resolution.
- ❑ Evidence supports the use of written information and education, and patients should be provided with a **brain injury advice card**.
- ❑ **Early symptom management** should be provided for minor problems - headache, sleep
- ❑ Premorbid psychiatric difficulties should be provided with **multidisciplinary treatment**, as this is a known risk factor for poor long-term prognosis.
- ❑ Workers should be given advice about gradual **reintegration** to regular activities including work, driving, and leisure.
- ❑ Patients who continue to demonstrate symptoms require follow up **every two to four weeks** from time of initial assessment until they are asymptomatic.

## The First 4 Weeks After Injury

You may have some common effects from the brain injury which usually resolve in several weeks to three months. These are called **post concussion symptoms** (see below). Tiredness can exaggerate the symptoms. Return to your normal activities gradually (not all at once) during the first weeks or months. **You can help yourself get better by:**

- Rest/Sleeping: Your brain needs time to recover. It is important to get adequate amounts of sleep as you may feel more tired than normal and you need to get adequate amounts of both physical and mental rest.
- Driving: Do not drive or operate machinery until you feel much better and can concentrate properly. Talk to your doctor.
- Drinking/Drugs: Do not drink alcohol or use recreational drugs until you are fully recovered. They will make you feel much worse. Do not take medication unless advised by your doctor.
- Work/Study: You may need to take time off work or study until you can concentrate better. Most people need a day or two off work but are back full time in less than 2 weeks. How much time you need off work or study will depend on the type of job you do. See your doctor and let your employer or teachers know if you are having problems at work or with study. You may need to return to study or work gradually.
- Sport/Lifestyle: It is dangerous for the brain to be injured again if it has not recovered from the first injury. Talk to your doctor about the steps you need to take to gradually increase sports activity and return to play. If in doubt, sit out.
- Relationships: Sometimes your symptoms will affect your relationship with family and friends. You may suffer irritability and mood swings. See your doctor if you or your family are worried.

## Recovery

- You should start to feel better within a few days and be 'back to normal' within about 4 weeks. See your local doctor if you are not starting to feel better.
- Your doctor will monitor these symptoms and may refer you to a specialist if you do not improve over 4 weeks up to 3 months.

# Occupational Medicine Perspective

- Increased reporting/incidence since 2007 – coincides with increased public awareness
- Based on subjective symptom reporting
- Symptom and mechanism of injury escalation
- Higher-than-expected conversion to LTD
- Workers' Compensation Board claims in BC 1987-2001 showed that mTBI were 0.3% of claims, however 1-2% of costs.
- Frustrated CM
- Lack of standards for Diagnosis, Treatment, Documentation
- Early or mislabelled Diagnosis
- Multiple factors affect return to function - 1% to 30%
- Only effectively managed if use evidence and science

# Health Care Provider Assessment of Persistent Symptoms Three Months Post mTBI

29

- Health care providers should consider **MRI** include susceptibility-weighted imaging (SWI) and diffusion tensor imaging (DTI) to help further clarify the diagnosis of mTBI. (Benson et al, 2012)
- Patients with **persistent symptoms** should undergo **post concussive symptom monitoring** for somatic, cognitive, and emotional symptoms using the Rivermead Post Concussion Questionnaire. (Ontario Neurotrauma Foundation)
- **At 3 months**, if there are concerns about **cognitive deficits**, patients should be assessed with a **screening tool**, such as the Montreal Cognitive Assessment. If concerns are documented, then a **formal assessment** should be considered and a referral should be made to a neuropsychologist as well as a brain injury specialist (Ontario Neurotrauma Foundation, New South Wales). Neuropsychology testing should include **symptom validity testing** (Ontario Neurotrauma Foundation).
- For patients with **valid and persistent cognitive deficits**, cognitive rehabilitation is recommended. For patients with persistent symptoms post mTBI, or who have difficulty once back at work, a return to work program should be implemented, with the assistance of an occupational therapist.

# Who We Are

## GOALS Canadian Concussion Institute

- Improvement of clinical outcomes
- Standards on assessment and Management
- Research focused on validations of MTBI institute programs
- Contribution to Public Policy
- Education of Public
- CME for Medical Community
- Prevention objectives
- Partnership and Collaboration with other leaders
- Strong Communication Goals
- Empowerment of Members
- Governance Model

