Pathophysiology of traumatic brain injury

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Disclosures

- Neurologist and physician scientist at Ohio State Medical Center
- I split my time between clinical care of patients with traumatic brain injuries (TBI) and research in a lab and clinic exploring the immune response to TBI and long term effects of TBI.
- I have no financial relationships or conflicts of interest
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Traumatic Brain Injury (TBI)

- TBI accounts for approximately 2.5 million emergency department visits in the United States
- Approximately 2.2 million were treated in and released from EDs, 300,000 admissions, and 50,000 deaths
- Children and young adults ages 0 to 19 years are at the highest risk for TBIs.
- Elderly over the age of 70 are at highest risk of death from TBI.
- Most common causes of TBI
  - Falls: 40-50%
  - MVA: 20-25%
  - Blunt Trauma: 10-15%
- 3.2 million–5.3 million persons in the United States are living with a TBI-related disability

CDC TBI in the US; epidemiology and rehabilitation Congressional Report 2015

Glasgow Coma Scale

Glasgow Coma Scale,

Eye opening	
Spontaneous	4
To loud voice	3
To pain	2
None	1
Verbal response	
Oriented	5
Confused, disoriented	4
Inappropriate words	3
Incomprehensible sounds	2
None	1
Best motor response	
Obeys	6
Localizes	5
Withdraws (flexion)	4
Abnormal flexion posturing	3
Extension posturing	2
None	1

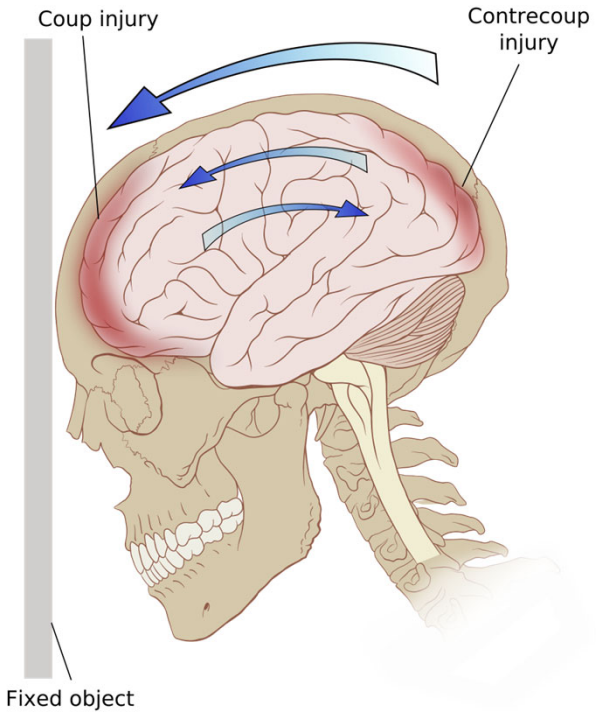
Grading TBI severity

	Mild	Moderate	Severe
Glasgow Coma Scale	13-15	9-12	3-8
Structural Imaging	Normal	Normal or abnormal	Normal or abnormal
Loss of Consciousness	<30 min	30 min – 24 h	>24 h
Post Traumatic Amnesia	0-3 day	1-7 days	>7 days

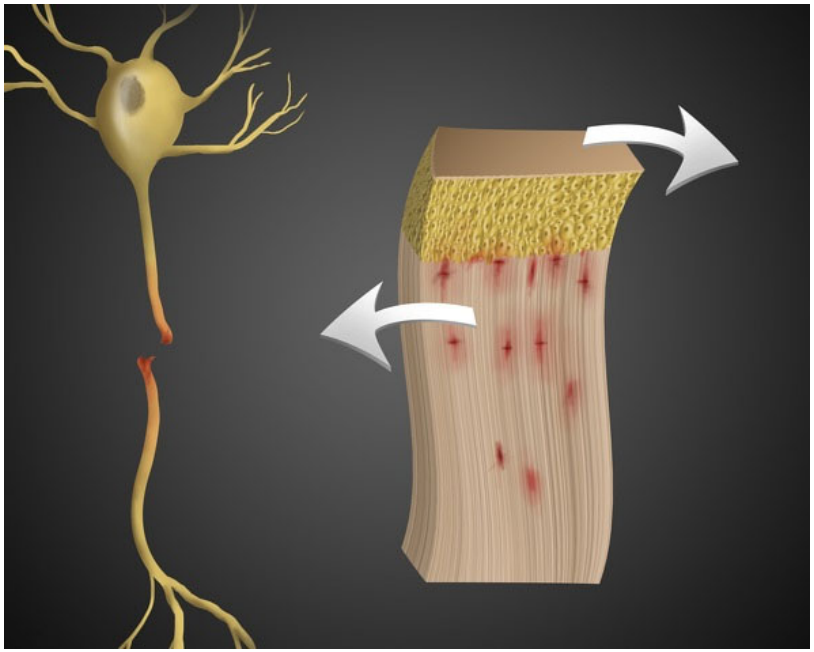
Mena et al. J Trauma: 2011

Pathologic injuries of TBI

Coup-countercoup injury



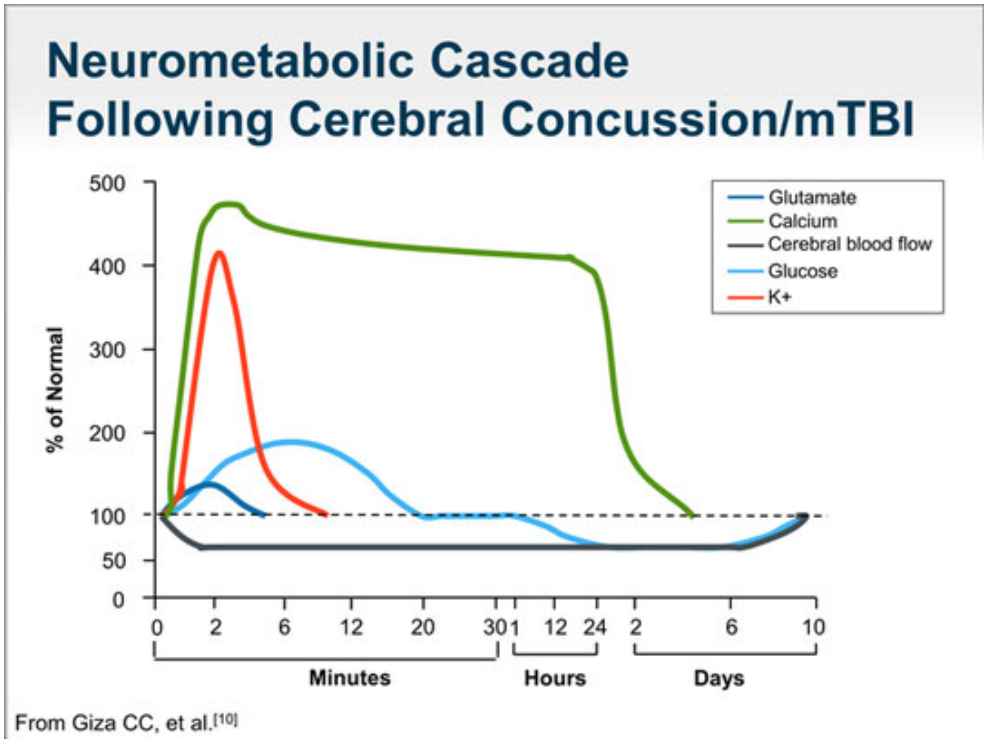
Axon shearing



Knipe et al. Radiopedia.org

Pathophysiology

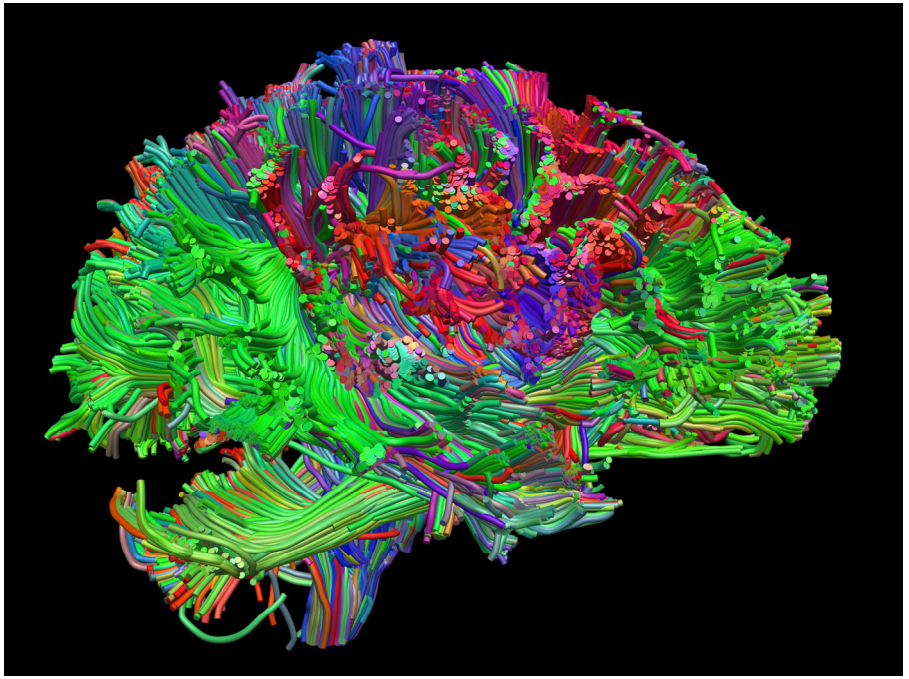
- Metabolic cascade that starts with electrolyte abnormalities (K+ and Ca2+).
- Depletion of glucose in an attempt to re-establish cell homeostasis.
- The rapid use of glucose leads to a prolonged hypo-metabolic state.
- Prolonged hypoperfusion, excitatoxicity, and axonal injury.



Giza CC and Kutcher JS. An introduction to sports concussions Continuum. 2014 Dec;20(6 Sports Neurology):1545-51.

TBI leads to a network injury

- 100 billion+ neurons in the central nervous system (CNS)
- Each region must communicate efficiently and synchronously
- Metabolic disequilibrium leads to dys-synchronous neuronal communication



Common TBI Symptoms

Somatic:
Headache
Dizziness
Balance problems
Visual disturbances
Photo/Phonophobia

Cognitive:
Confusion/Disorientation
Retro/anterograde Amnesia
Foggy thinking
Inattention
Delayed verbal response
Slurred speech
LOC

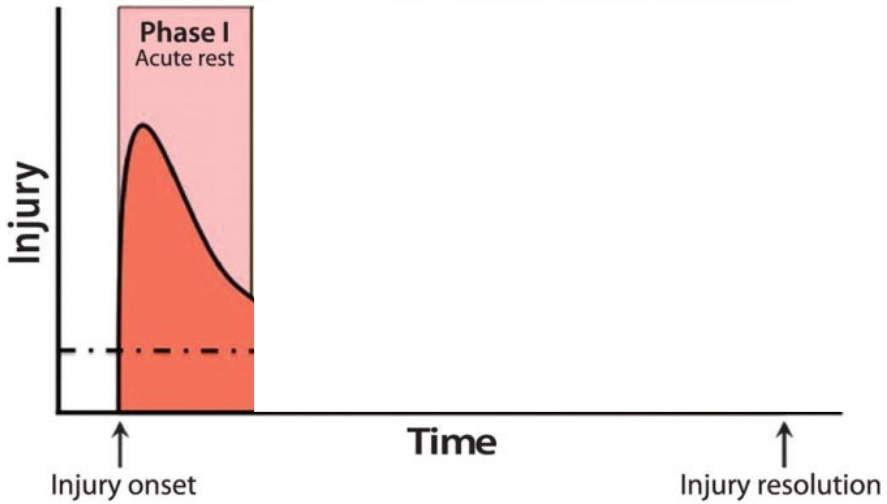
Sleep:
Trouble falling asleep
Sleeping more
Sleeping less

Affective:
Emotional Lability
Anxiety
Fatigue
Irritability
Sadness

Moderate/Severe:
Seizure
Weakness
Loss of sensation

http://www.cdc.gov/TraumaticBrainInjury/

Mild TBI Normal Recovery



<u>Conceptually can be applied to moderate and severe injury</u>

- Phase I: Acute Rest
- Phase II: Relative Return to life
- Phase III: Return to life/Graduated exertion

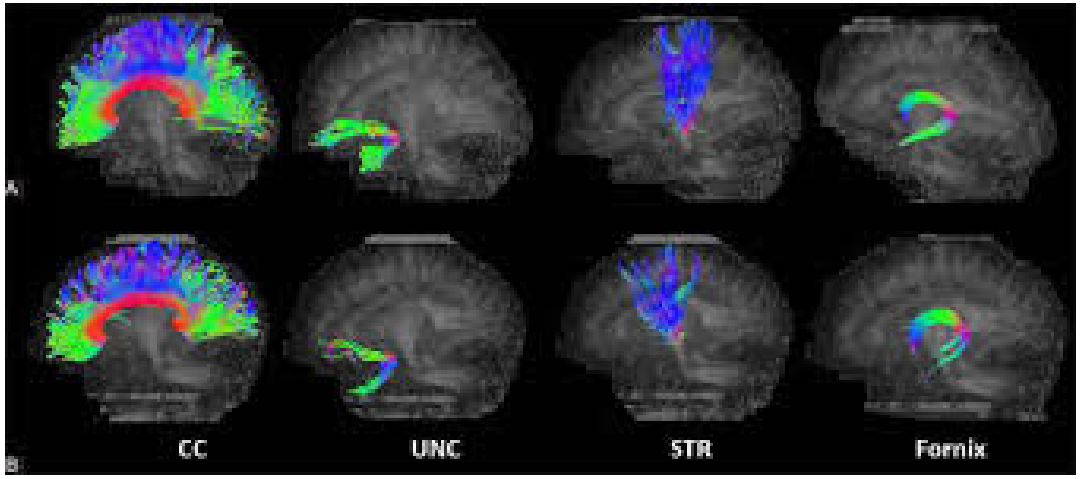
Adapted from: Giza CC and Kutcher JS.
Sports Concussion Diagnosis and Management

Chronic brain injury symptoms are associated with changes in brain connectivity

- Research studies show that chronic TBI patients have changes in regions of their brain after mTBI.
- The brain is constantly changing. Memories, growth, maturity, age, and injuries.
- The brain is plastic, in TBI connectivity changes do not have to be permanent

Normal

TBI



Khong et al. 2016

Long term TBI symptoms are treatable

- Therapies
  - Physical therapy
  - Vestibular therapy
  - Vision therapy
- Symptomatic medications
  - Mood changes
  - Headache
  - Foggy thinking
  - Poor sleep
- Neuropsychology evaluation
  - Cognitive behavioral therapy
- Exercise and Sleep

The brain is trainable, teachable, and can learn again. Symptoms and deficits can improve with time.

Grool et al 2017
Seifert 2016
Ellis et al 2015

Conclusions

What we do know

- TBI causes direct injury to brain at the time of injury
- Your brain can also suffer for long term signaling changes in the ways your neurons talk to each other
- Your brain is plastic: It has the ability to be trained to be better or worse depending on the situation
- You should talk with your physician about if you are getting the right types of therapy to help your recovery

What can you do at home:

- How is your sleep?
  - Do you have a calm environment, TV off and phone away? Do you sleep through the night? Do you feel rested when you get up in the morning?
- Sleep is when you body restores your neuron energy supply
- Do you exercise?
- Exercise produces growth factors that are good for your brain and stimulates new neuron connections
- Do you use your phone too much?
  - Phones are great to stay connected, keep calendars, schedules and information stored
  - They are also distractors
- Put your phone away when need to focus and turn off the reminders so it does not ping you. Microdistractions can make people feel like their focus is worse than it actually is

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