Rehabilitation Challenges After Mild TBI

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Objectives

- Understand the physical, cognitive, and emotional complications of a mild brain injury
- Identify appropriate management strategies to maximize outcomes in those who have suffered a mild TBI
- Appreciate the rehabilitation process and resources available to facilitate return to pre-morbid state

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Introduction

According to the CDC, an estimated 1.7 million people sustain a traumatic brain injury (TBI) each year. Of them:

- 52,000 die
- 275,000 are hospitalized
- 1.365 million, nearly 80%, are treated and released from an emergency department
- 80,000 of these survivors will live with significant disability

- **About 75% of TBIs that occur each year are non-sports related concussions or other forms of mild TBI**

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TBI Introduction

- 5.3 million have TBI-related disabilities (2% of population)
- 90% are mild TBI's (GCS>13)
- Economic Impact:
  - $9.2 Billion in lifetime medical costs ($4.2 million/survivor)
  - $51.2 Billion in productivity losses

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TBI Introduction

- 50% of hospitalized TBI's are from transportation accidents (most common cause <75yo)
- Incidence has decreased by 38% between 1980 and 1994
- 50% of people sustaining TBI are intoxicated at time of injury

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TBI Introduction

- Most common cause >75yo: falls
- Fall prevention: address polypharmacy, balance impairments, orthostatic hypotension, minimize sedating medications

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Introduction

- **1.6 to 3.8 MILLION** sports-related mild TBI's/concussions occur annually
  - Most (90%) recover in 7-10 days
  - Prolonged recovery may be due to:
    - Non-physiologic Post-Concussive Syndrome (PCS)
    - Prolonged Concussion (Physiologic PCS)
  - Non-sports related concussions
    - Most recover in 3 months
    - 33% may have prolonged symptoms
  - Soldiers in Combat
    - 5-10% had LOC or altered consciousness
    - Caused by blasts, falls, MVA's, wounds

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Introduction

Definition of a mild TBI/concussion:

- A traumatic injury to tissues of the brain as a result of a violent blow, shaking, spinning, or acceleration/deceleration forces that results in a complex pathophysiological process affecting the brain
- Glasgow Coma Scale (GCS) Score of 13-15
- May or may not have loss of consciousness (LOC)

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Severity- Glasgow Coma Scale

Glasgow coma scale

		Score
Eye opening	spontaneously	4
	to speech	3
	to pain	2
	none	1
Verbal response	orientated	5
	confused	4
	inappropriate	3
	incomprehensible	2
	none	1
Motor response	obeys commands	6
	localises to pain	5
	withdraws from pain	4
	flexion to pain	3
	extension to pain	2
	none	1
Maximum score		15

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Risk Factors for TBI

- Males:Females = 2:1 (except in sports)
- 15-34 years old → less than 5 years old/ greater than 60 year old
- Low socioeconomic status
- Low cognitive function
- History of hospital admissions for intoxication

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Sports with Highest Incidence of Concussions

- Football
- Wrestling
- Soccer - girls
- Soccer – boys
- Girls basketball – 3 times higher incidence than boys basketball
- Overall, females are 2-3 times more likely to get a concussion than males
- Children and teens are more likely to get a concussion and take longer to recover than adults.

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Mild TBI/Concussions: How Do They Occur?

- Primary Injury
  - Shifting of the brain
  - Results in contusions or bruising of the brain

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Mild TBI/Concussions: How Do They Occur?

- Secondary Injury "Neurometabolic Cascade"
  - Series of ionic, metabolic, and pathophysiological events accompanied by axonal injury
  - Increased energy required to recover + decreased cerebral blood flow/mitochondrial dysfunction = ENERGY MISMATCH and thus post-traumatic vulnerability
  - More pronounced in youth

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Diffuse Axonal Injury

- Focal damage and diffuse damage to axons
- Effects tend to be broad (diffuse)

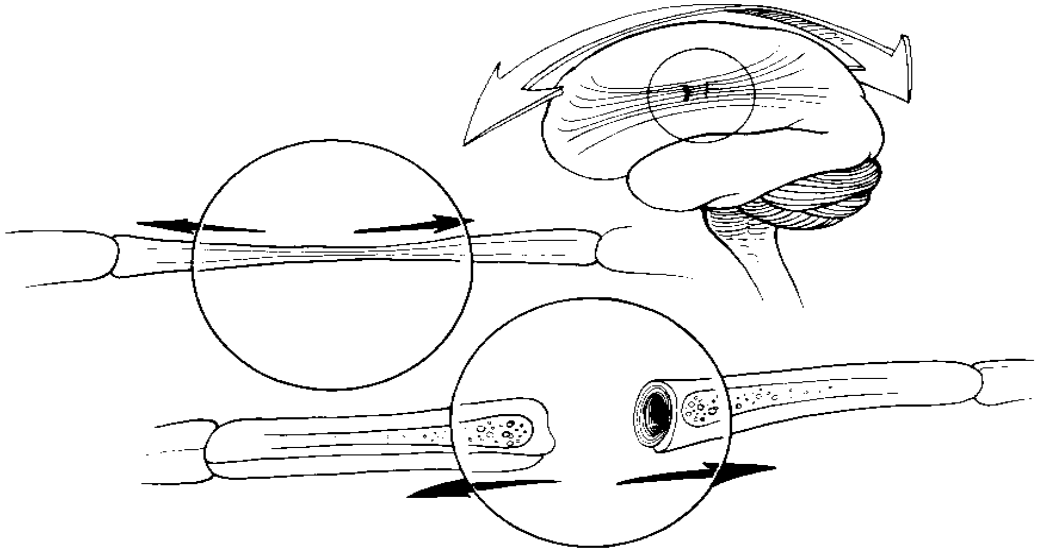

Figure 1-16. Axonal shearing may occur in acceleration as well as deceleration injuries. The nerve fiber may be stretched or completely severed, producing the manifestations of diffuse head injury.

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Diffuse Axonal Injury

- Leading cause of morbidity (cognitive, behavioral, and arousal deficits) in TBI
- Occurs during acceleration/deceleration events (MVA's) exposing the brain to stretch and torque forces → pathophysiologic process lasting days → axonal swelling and detachment
- CT/MRI often unremarkable except for some petechial hemorrhages

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Diffuse Axonal Injury

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Physical Symptoms

- Headache- most common complaint
- Nausea/vomiting
- Balance problems
- Dizziness
- Visual Problems
- Fatigue
- Sensitivity to light and/or noise
- Numbness/tingling
- Dazed/stunned

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Emotional Symptoms

- Irritable
- Sadness
- Labile
- Nervousness

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Sleep Symptoms

- Drowsiness
- Sleep more than usual
- Sleep less than usual
- Difficulty falling asleep

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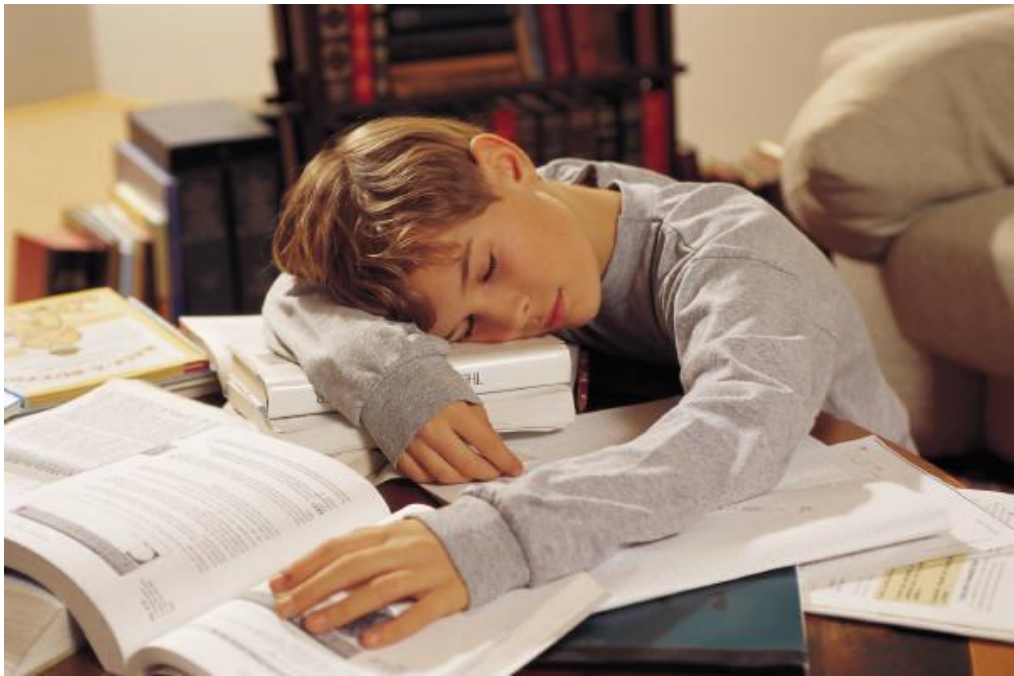
Cognitive Symptoms

- Difficulty concentrating
- Memory problems
- Forgetting information or conversations
- Confusion
- Repeats questions
- Feeling sluggish
- Feeling “foggy”
- Answers questions slowly



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Mild TBI/Concussion Assessment

- Assess "A,B,C's"
- Exclude cervical spine injury and more serious brain injury (send to ED)
- Mild TBI's typically are NOT associated with obvious structural damage to the brain → CT or MRI scans usually are normal
- When to order imaging:
  - Deteriorating mental status
  - Focal neurological findings
  - Worsening symptoms
  - GCS< 15
  - Suspected Skull Fracture
  - >2 Vomiting episodes
  - > 30min Pre-traumatic amnesia
  - Bleeding risk
  - Intoxication

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Concussion Sideline Assessment

The Standardized Assessment of Concussion

Obtain Pre-Season Baseline Score; Compare with Post-Concussion Score

NAME OF ATHLETE:		
Age:	Sex:	Examiner:
Nature of Injury:		
Date of Exam:		Time:

I. ORIENTATION		
Month	0	1
Date	0	1
Day of Week	0	1
Year	0	1
Time	0	1
Orientation Total Score:		/5

II. IMMEDIATE MEMORY						
All 3 trials are completed regardless of score on trial 1 & 2; score equals sum across all 3 trials.						
List	**Trial 1**		**Trial 2**		**Trial 3**	
Elbow	0	1	0	1	0	1
Apple	0	1	0	1	0	1
Carpet	0	1	0	1	0	1
Saddle	0	1	0	1	0	1
Bubble	0	1	0	1	0	1
Total Immediate Memory Recall:						/15
Note: Do not inform the subject that delayed recall will be tested.						

III. NEUROLOGICAL SCREENING
Recollection of injury (pre- or post-traumatic amnesia):
Strength:
Sensation:
Coordination:

IV. CONCENTRATION			
Digits Backwards: If correct, go to the next string length. If incorrect, read second trail. Stop after incorrect on both trails.			
4-9-3	6-2-9	0	1
3-8-1-4	3-2-7-9	0	1
6-2-9-7-1	1-5-2-8-6	0	1
7-1-8-4-6-2	5-3-9-1-4-8	0	1
Months of the Year in Reverse Order: Athlete must recite entire reverse sequence correct.			
Dec-Nov-Oct-Sep-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan		0	1
Total Concentration Score:			/5

VI. DELAYED MEMORY RECALL						
List	**Trial 1**		**Trial 2**		**Trial 3**	
Elbow	0	1	0	1	0	1
Apple	0	1	0	1	0	1
Carpet	0	1	0	1	0	1
Saddle	0	1	0	1	0	1
Bubble	0	1	0	1	0	1
Total Delayed Memory Recall:						/15

V. EXERTIONAL MANEUVERS			
5 Jumping Jacks	5 Sit-ups	5 Push-ups	5 Knee-bends

SUMMARY OF TOTAL SCORES	
Orientation	/5
Immediate Memory	/15
Concentration	/5
Delayed Memory Recall	/15
Overall Total Score	/40
*If score is below baseline, DO **NOT** return to play.*	

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SCAT2

Sport Concussion Assessment Tool 2

Name

Sport/team

Date/time of injury

Date/time of assessment

Age Gender M F

Years of education completed

Examiner

What is the SCAT2?[1]

This tool represents a standardized method of evaluating injured athletes for concussion and can be used in athletes aged from 10 years and older. It supersedes the original SCAT published in 2005[2]. This tool also enables the calculation of the Standardized Assessment of Concussion (SAC)[3,4] score and the Maddocks questions[5] for sideline concussion assessment.

Instructions for using the SCAT2

The SCAT2 is designed for the use of medical and health professionals. Preseason baseline testing with the SCAT2 can be helpful for interpreting post-injury test scores. Words in italics throughout the SCAT2 are the instructions given to the athlete by the tester.

This tool may be freely copied for distribtion to individuals, teams, groups and organizations.

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific symptoms (like those listed below) and often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (such as headache), or
- Physical signs (such as unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour.

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle.

Symptom Evaluation

How do you feel?

You should score yourself on the following symptoms, based on how you feel now.

	none	mild		moderate		severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep (if applicable)	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22)

Symptom severity score

(Add all scores in table, maximum possible: 22 x 6 = 132)

Do the symptoms get worse with physical activity? Y N

Do the symptoms get worse with mental activity? Y N

Overall rating

If you know the athlete well prior to the injury, how different is the athlete acting compared to his / her usual self? Please circle one response.

no different | very different | unsure

SCAT2 SPORT CONCUSSION ASSESMENT TOOL 2 | PAGE 1

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Disadvantages to “Quick” Assessments

- Reduced sensitivity to complexity of mild concussions
- Overemphasis on loss of consciousness
- Lack of emphasis on neurocognitive dysfunction
- Not adequately sensitive to the individualized nature of a concussion

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Comprehensive Neuropsychological Assessments

- Verbal and non-verbal intellectual functions
- Attention/concentration
- Processing speed
- Memory & new learning capacity
- Language processing
- Visual Spatial Processing
- Sensory & Motor Functions
- Executive Functions
  - Mental Flexibility
  - Fluency
  - Adaptive Problem Solving
- Emotional & Personality Functioning

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Neurocognitive Assessments

- Comprehensive testing takes 6-8 hours
- Costly
- Relatively more vulnerable to practice effects with repeated use
- Turn around on results can be several days to a week

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Importance of Neurocognitive Assessment

- Testing reveals the presence of cognitive deficits in patients who may otherwise be symptom-free
- Increased accuracy of diagnosis
- Increased likelihood of appropriate early intervention
- Increased quality of return to play decision

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Computer Administered Screening Tools

- Takes approximately 30 minutes to complete
- Baseline tests are relatively inexpensive
- Reports generated immediately
- Tests designed to have multiple forms since each is comprised of randomly generated test (reduces the problem of practice effects)
- Validity checks are included

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Computer Administered Screening Tools

- Pre-injury baseline data can be used for comparison purposes with post-injury testing
- Athlete can be compared to themselves
- Normative comparisons are available
- Data can be integrated with assessment of signs and symptoms

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ImPACT Testing

- ImPACT Testing
  - Useful screening tool
  - Not a substitute for comprehensive neuropsychological testing
  - Can be administered to athletes 11 to 59 years of age
  - Has established validity
  - Sensitive and specific for concussions

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ImPACT Testing

- ImPACT is the most widely used neurocognitive screening tool for concussions
- Used by the NFL, NHL, MLB, NCAA, Professional Soccer
- Military is investigating possibility of implementation
- Available in 13 different languages

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ImPACT Testing

- Verbal memory
- Visual memory
- Visual motor speed
- Reaction time
- Impulse control
- Symptom score

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Management of Concussions

- Early diagnosis
- Rule out more serious brain injury
- Prevent long-term cumulative and chronic sequelae- PCS, 2nd Impact Syndrome, CTE
- Rest the Brain!
  - Restriction of BOTH physical and cognitive activities such as exercise, rigorous classes, homework, videogames—and even driving!

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Post-Concussion Syndrome Introduction

- **1.6 to 3.8 MILLION** sports-related mild TBI's/concussions occur annually
  - Most (90%) recover in 7-10 days
  - Prolonged recovery may be due to:
    - Non-physiologic Post-Concussive Syndrome (PCS)
    - Prolonged Concussion (Physiologic PCS)
  - Non-sports related concussions
    - Most recover in 3 months
    - 33% may have prolonged symptoms
  - Soldiers in Combat
    - 5-10% had LOC or altered consciousness
    - Caused by blasts, falls, MVA's, wounds

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Post-Concussion Syndrome- Introduction

- After 3 weeks of symptoms, patients will worry about when/if they will recover
- By 6 weeks, PCS can alter lives

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Post-Concussion Syndrome

- **WHO ICD-10 Criteria:** 3 or more of the following lasting > 2 weeks:
  - Headache
  - Dizziness
  - Fatigue
  - Irritability
  - Insomnia
  - Cognitive Deficits (Attention/Memory)

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Post-Concussion Syndrome

- Other symptoms:
  - Photophobia
  - Hyperacusis
  - Feeling “foggy”
  - Blurry vision
  - Depressed/anxious mood

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Risk Factors for PCS

- History of previous concussions
- Female sex
- History of psychiatric illness
- History of cognitive dysfunction
- Age – younger the athlete, longer the recovery
- History of migraine headaches
- ** Severity is not a risk factor!

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Differential Diagnoses

- Depression
- Somatization
- Chronic Fatigue/Pain
- Cervical Injury/Myofascial Pain
- Vestibular Dysfunction
- Visual-spatial deficits
- Combination of above

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Post-Concussion Syndrome

- Imaging is usually negative/equivocal
- Often a “disconnect” between observable signs & symptoms and neurocognitive deficits
- Can have measurable pathophysiology
  - fMRI- activation in the dorsolateral prefrontal cortex; de-activation of medial frontal cortex
  - SPECT scan- persistent abnormalities of brain blood flow
  - Neurochemical imbalances- Serum S100B
  - Electrophysiologic findings- QEEG
- Quantitative postural instability usually associated with physiologic PCS

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Post-Concussion Syndrome- Theories

- Anatomic/Mechanical
  - Acceleration/deceleration → shearing → neuronal depolarization → nerve cell death
  - Diffusion tensor imaging (DTI), QEEG, SPECT demonstrate focal cortical dysfunction, blood-brain-barrier disruption, and reduced global/regional cerebral blood flow
- Physiologic
  - Decreased cerebral circulation
  - Higher resting and post-exertion HR
  - Increased sympathetic activity/ lower parasympathetic activity
  - Central autoregulation is disturbed → cardiorespiratory control of ventilation disrupted → symptoms exacerbated with exertion

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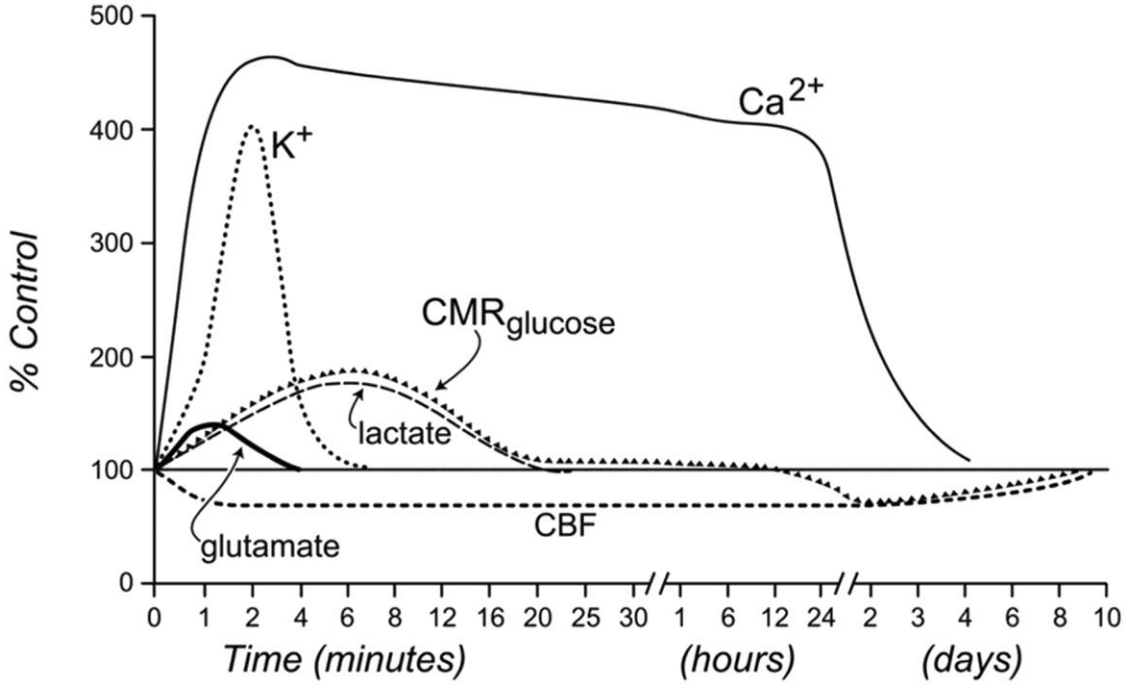
Post-Concussion Syndrome- Theories

- Neurometabolic (Figure adapted from Hovda et al)
  - Metabolic hyperactivity followed by metabolic depression
  - Full metabolic recovery may be prolonged compared to actual symptoms



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Diagnostic Testing

- History
  - Predisposing factors, other accompanying injuries
- Physical Exam
  - MMSE (assess concentration/memory), CN exam (EOM), gait/balance testing, assessment of cervical spine
- Standardized treadmill test using the Balke protocol to differentiate physiologic PCS from non-physiologic PCS
- Neuropsychological testing
  - Full Battery- may last 4-8 hours
  - IMPACT testing- used widely
- Imaging- usually negative

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When to Seek Treatment

- Persistent mild TBI symptoms require individualized evaluation and treatment
- Treatment should be focused on symptomatic and functional improvement

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Treatment

- All mild TBI's are different
- Should not be treated the same
- Individualized treatment necessary

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Treatment/ Rehabilitation

- Initial treatment- Relative physical and cognitive rest
- Education, education, education!!
- A comprehensive mild TBI/Post-Concussion Day Rehab Program is an ideal environment to treat those with PCS
  - Rehabilitation specialists equipped to handle all of the varying degrees of a mild TBI/concussion/PCS
  - Specialists with expertise to address all symptoms with an individualized approach

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The Types of Treatment

The treatment team should include:

- Patient
- Family
- Clinical neuropsychologist
- Physician
- Nursing rehab specialist
- Physical therapist
- Occupational therapist
- Speech therapist
- Case manager/social worker
- Consultants: Neuro-optometry, Psychiatry, Neurology

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Rehabilitation Specialists

- Medical management by a board-certified physiatrist specializing in concussions and brain injury
  - Coordinates treatment team
  - Can provide medical management
  - Can consult specialists as needed
  - Can oversee return-to-play; return-to-work; return-to-school with follow-up appointments as needed

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Medical Management

- Insomnia
  - Educate regarding sleep hygiene
  - Minimize nighttime interruptions
  - Avoid naps if possible
- Medications
  - Trazodone, TCAs, mirtazapine
  - Gabapentin, TCAs for HA
  - Melatonin, valerian root: OTC
  - Avoid diphenhydramine, benzodiazepines, zolpidem if possible

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Medical Management

- Headaches- usually multi-factorial
  - Migraines- TCA, fioricet, propranalol, NSAIDs, “triptans,” antiseizure medications, botulinum toxin using migraine protocol, acupuncture
  - Greater occipital neuralgia- greater occipital nerve blocks with steroid
  - Myofasical neck pain- myofascial release, massage, trigger point injections, acupuncture
  - Comprehensive pain management program may be necessary in refractory cases

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Medical Management

- Cognitive (attention and memory) deficits
  - “Start low and go slow”
  - Provide an adequate therapeutic trial
  - Perform continuous reassessments and define an objective behavioral target
  - Monitor for side effects
  - Consider drug augmentation
  - Change strategy if symptoms get worse
  - Consider half lives of meds

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Medical Management

- Attention/Concentration deficits
  - Methylphenidate, Amantadine
  - (Ar)modafinil if arousal complicates symptoms
- Memory deficits
  - Donepezil, CDP-choline
- Emotional Lability/Depression
  - SSRI's, TCA's, Antiepileptic agents

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Rehabilitation Specialists

- Comprehensive neuropsychological assessment provided by neuropsychologists specializing in brain injury
- Counseling, emotional support and education regarding recovery from brain injury for patients and families
- Cognitive behavioral therapy/neurofeedback
  - Identifies/changes patterns of maladaptive thinking and behavior to help with coping
- Availability to interface with employer/educational staff should work accommodations or an IEP be indicated

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Goals of rehabilitation

- Return to play
- Graduated return to school
- Graduated return to work
- Prevention of long-term sequelae
  - Second Impact Syndrome (SIS)
  - Slower recovery from future neurologic insults
  - Permanent neurocognitive impairment
  - Neurodegenerative disease- Chronic Traumatic Encephalopathy (CTE)
  - Depression

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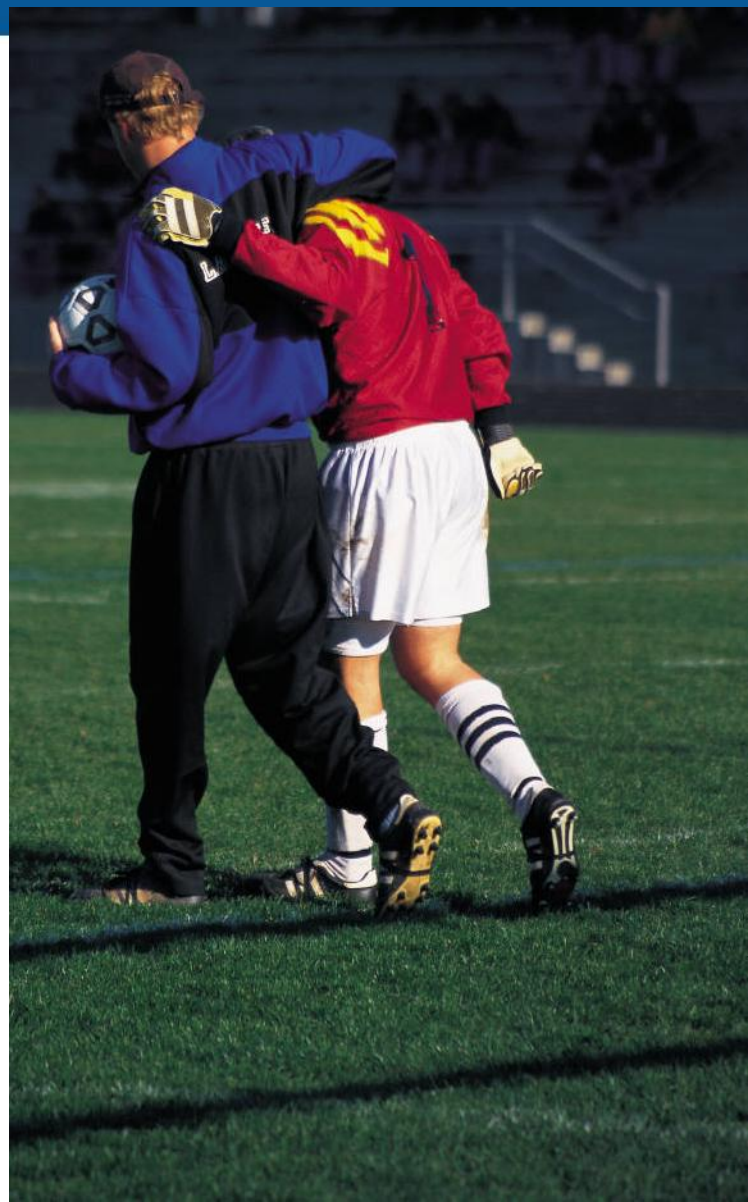
Second Impact Syndrome

- A 2nd TBI/concussion that occurs before metabolic homeostasis (recovery) is restored
- Rare and disputed diagnosis



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Second Impact Syndrome

- Following a mild TBI, the risk of a 2nd concussion is 2-3 times more likely
- Following a 2nd mild TBI, risk is **9 times** more likely a patient will experience a 3rd concussion
- Controversy whether SIS is a complication of recurrent concussion, diffuse cerebral swelling (a recognized complication of TBI in children), or occult subdural injuries.
- Patients under the age of 21 are at increased risk, especially athletes (at increased risk for multiple traumatic impacts)

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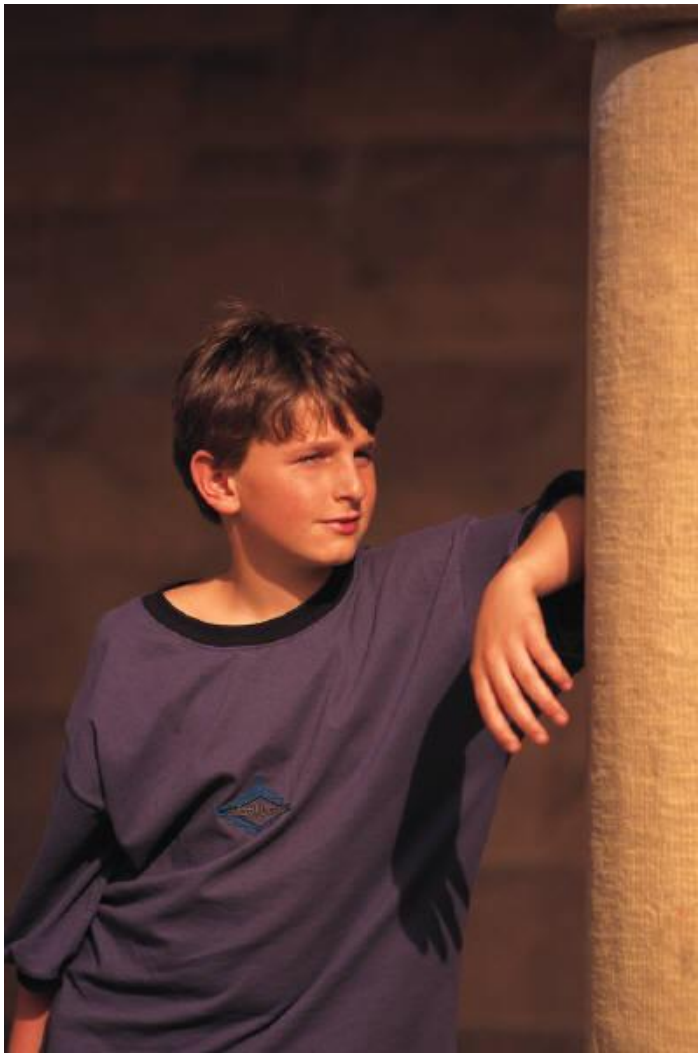
Second Impact Syndrome

- Behavior and personality changes
- Depression and suicide
- Parkinson's Disease
- Speech issues
- Trouble walking
- Dementia
- Even death from brain swelling



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Chronic Traumatic Encephalopathy

- Progressive degenerative neurological process found in some athletes who sustain multiple concussions and sub-concussive blows. This early degenerative process is characterized by cerebral atrophy and increased levels of tau protein, as well as cognitive impairment (dementia) and, in some cases, depression.

McKee /Cantu, 2009; Omalu,/DeKosky 2005.

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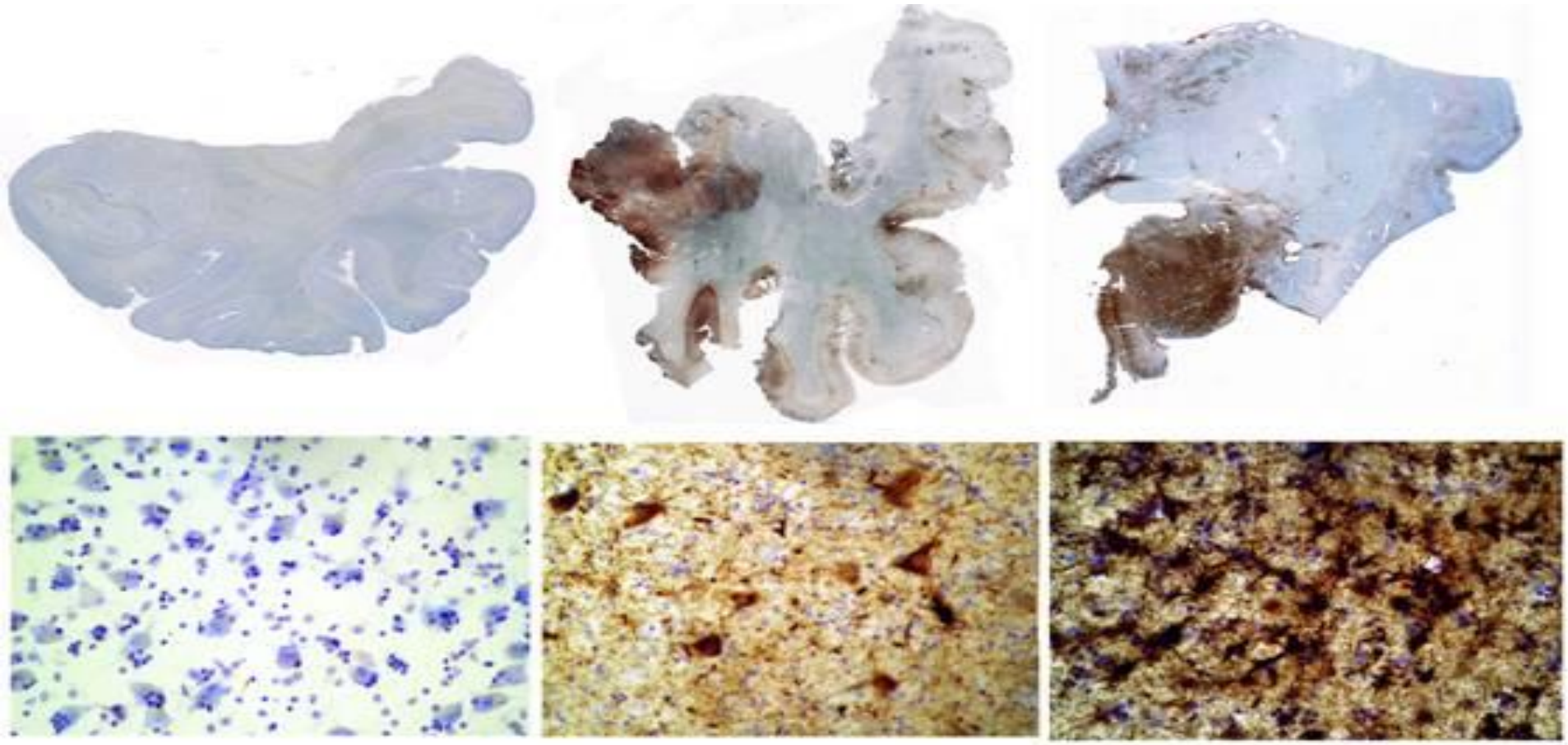
CHRONIC TRAUMATIC ENCEPHALOPATHY

Tau Protein: Amygdala (McKee et al. 2009)



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PCS- Returning to Play

- Graduated return to play protocol
- Progress from one stage to the next only if athlete is asymptomatic

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Returning to Play - Stages

1) No activity: Physical and cognitive rest
2) Light aerobic exercise: Walking, swimming, stationary bike (no resistance training)
3) Sport-specific exercise: Running, skating – No head impact exercises

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Returning to Play - Stages

4) Non-contact training drills, like passing drills (football) – begin resistance training
5) Full contact practice after MD clearance
6) Return to play

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Summary

1) Ongoing mild TBI symptoms are caused by prolonged concussion or another process (cervical injury, migraine HA, depression/anxiety, chronic pain, vestibular dysfunction, visual-spatial deficits, or combination of above
2) Pathophysiology of PCS may reflect anatomic, neurometabolic, and physiologic causes
3) Individualized treatment with early education, a comprehensive mild TBI/Post-concussion Day Rehab Program, and aerobic exercise therapy can be effective

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Questions

Thank you.

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