Concussion
On the Field and in the Office

Patricia Gibbons, MD

Primary Care Internist, Massachusetts General Hospital

Assistant Professor, Harvard Medical School

Head Team Internist, New England Revolution, MLS

Conflict of interest disclosure

- Patricia Gibbons, MD has no conflicts of interest to report.

Objectives

- To understand the status of concussion research and recommendations.
- To understand the basics of the pathophysiology of concussions.
- To diagnose and manage a concussion in the acute setting.
- To diagnose and manage a concussion in the days following a concussion.
- To know when to refer to a concussion specialist.

Concussion = mild traumatic brain injury (MTBI)

- 1.4 million deaths, hospitalizations and ER visits due to TBI in the US per year
- 75-90% are concussions or MTBIs
- 1.6-3.8 million sport and recreation related MTBI in the US per year

Langlois J, et al, J Head Trauma Rehabil, 2006
CDC, National Center for Injury Prevention and Control. Report to Congress, 2003

Why don't internists know more about this? Where is the data?

The bulk of the research is published in journals in the specialties of:

- Neuropsychiatry
- Neurosurgery
- Physical Medicine and Rehabilitation
- Sports Medicine

What populations have been studied?

The vast majority of the high quality studies on humans have been done on high school and collegiate athletes.

Neurology. 2013 Jun 11;80(24):2250-7. doi: 10.1212/WNL.0b013e31828d57dd. Epub 2013 Mar 18.

Summary of evidence-based guideline update: evaluation and management of concussion in sports: report of the Guideline Development Subcommittee of the American Academy of Neurology.

Giza CC[1], Kutcher JS, Ashwal S, Barth J, Getchius TS, Gioia GA, Gronseth GS, Guskiewicz K, Mandel S, Manley G, McKeag DB, Thurman DJ, Zafonte R.

Where are the expert opinion guidelines on evaluation and treatment of concussion

- VA/DOD Management of Concussion/mild Traumatic Brain Injury, Clinical Practice Guideline April 2009
- British Journal of Sports Medicine, 2013 47: 259
- Supplement to the October 2014 issue of Neurosurgery

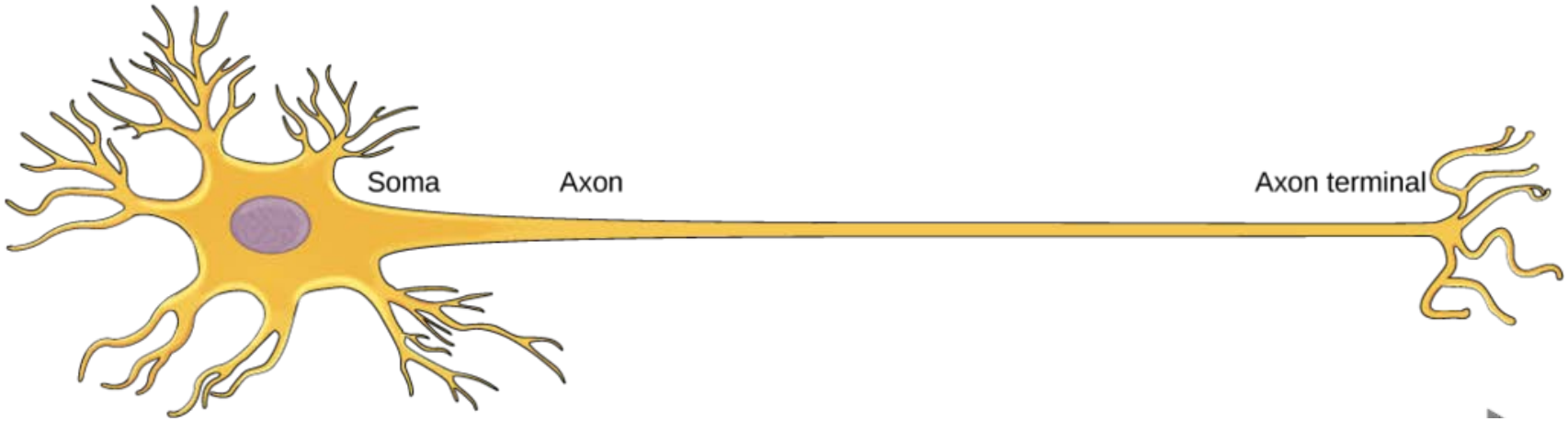
Definition of Concussion

4th International Conference on Concussion in Sport, Zurich, 2012

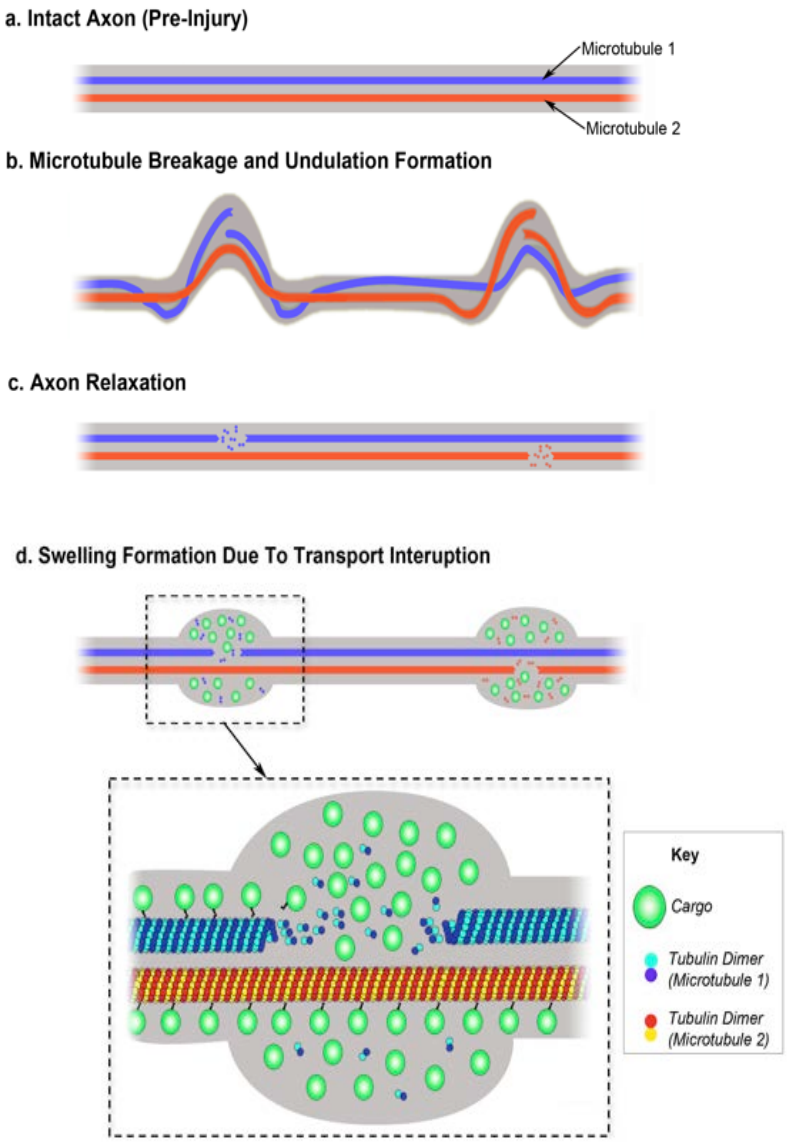
1. Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head.
2. Concussion typically results in the rapid onset of short lived impairment of neurologic function that resolves spontaneously. However, in some cases, symptoms and signs may evolve over a number of minutes to hours.
3. Concussion may result in neuropathologic changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury, and as such, no abnormality is seen on standard structural neuroimaging studies.
4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course. However, it is important to note that in some cases symptoms may be prolonged.

McCrory, et al, Journal of Athletic Training, 2013

Pathophysiology

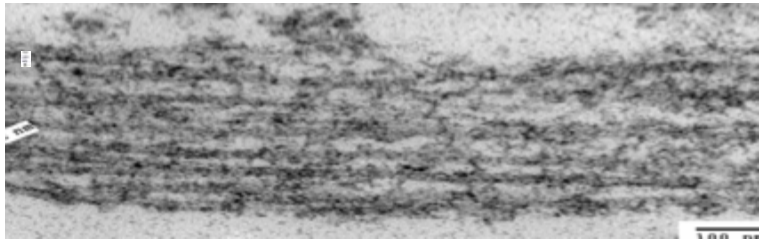


Proposed mechanism of varicosity formation after traumatic axonal injury



Tang-Schomer, Johnson et al., *Exp. Neurol*, 2012
Images courtesy of Dr. Douglas Smith

Transmission electron microscope images of axons



Normal region of axon with microtubules aligned in parallel cables

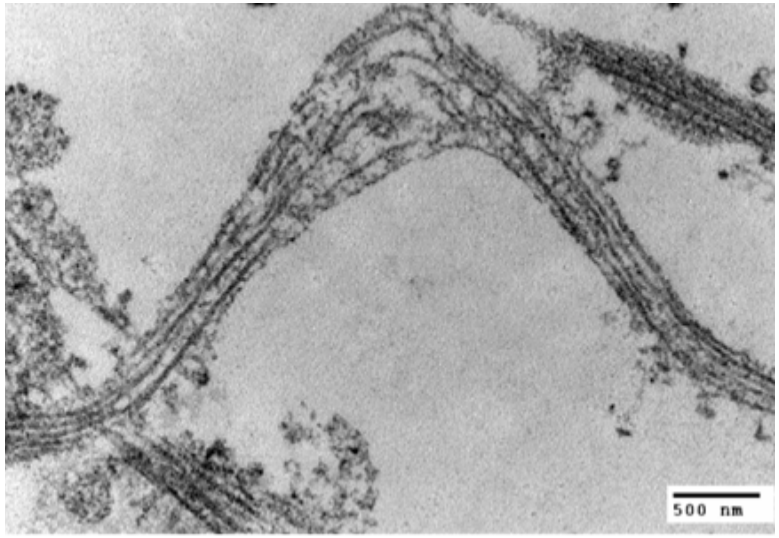
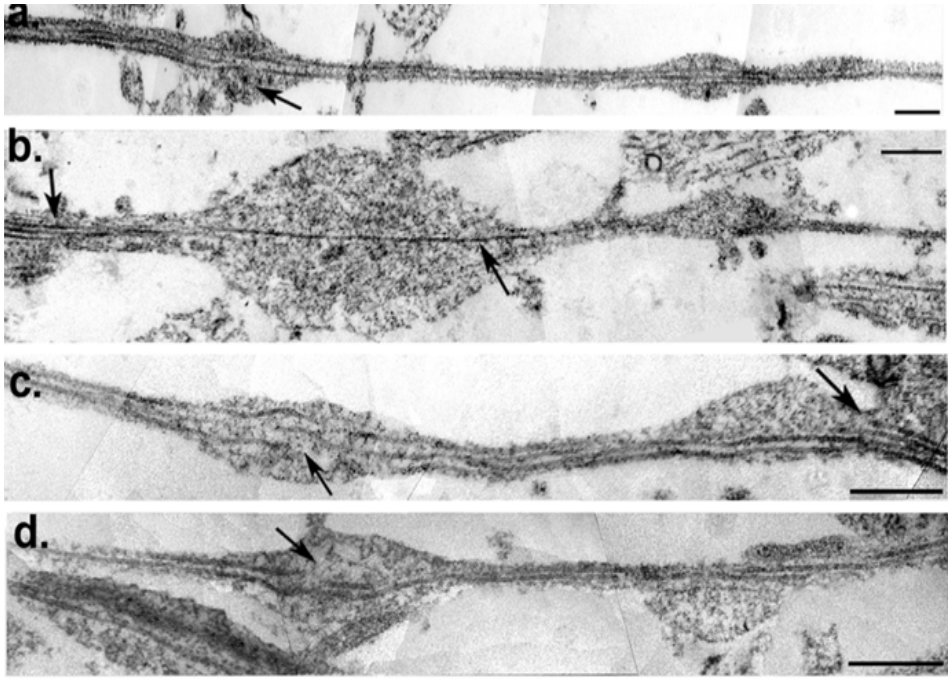


Image of axon within 2 minutes of stretch injury showing widening of the spaces between microtubules near the peak of axon undulations.

Tang-Schomer, Johnson et al., *Exp. Neurol*, 2012
Images courtesy of Dr. Douglas Smith

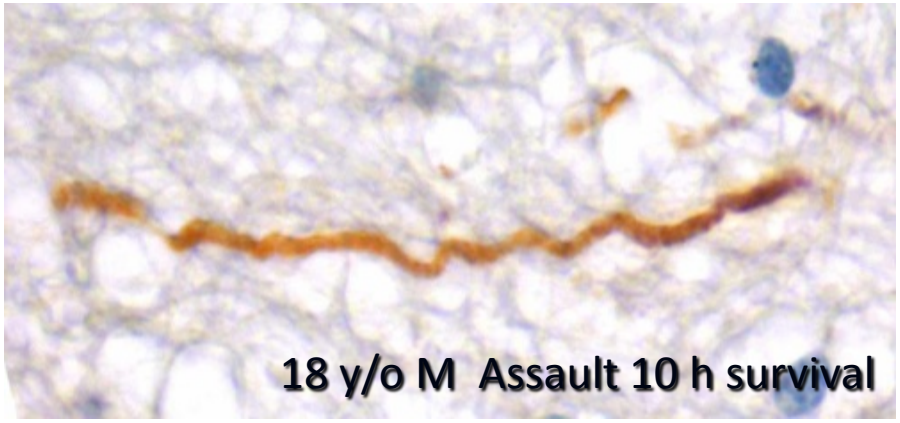
Transmission electron microscope images of axons

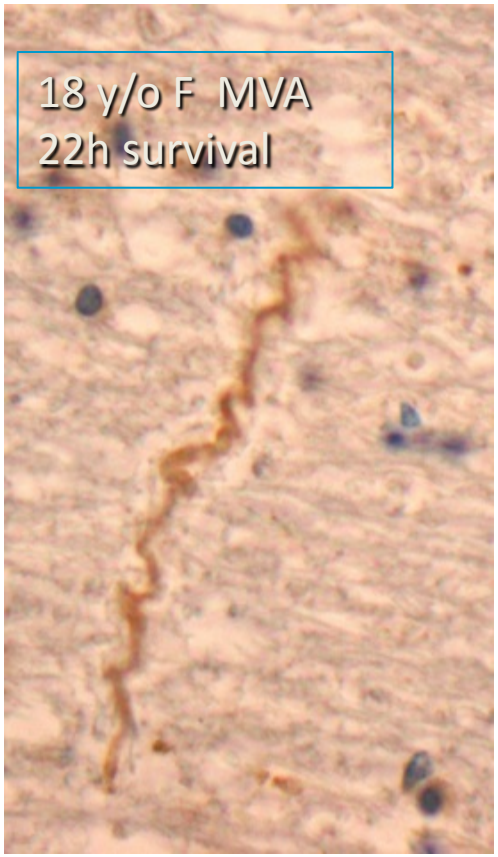


Microtubule breakage and loss in varicose axonal swellings
3 hours after stretch injury

Tang-Schomer, Johnson et al., *Exp. Neurol*, 2012
Images courtesy of Dr. Douglas Smith

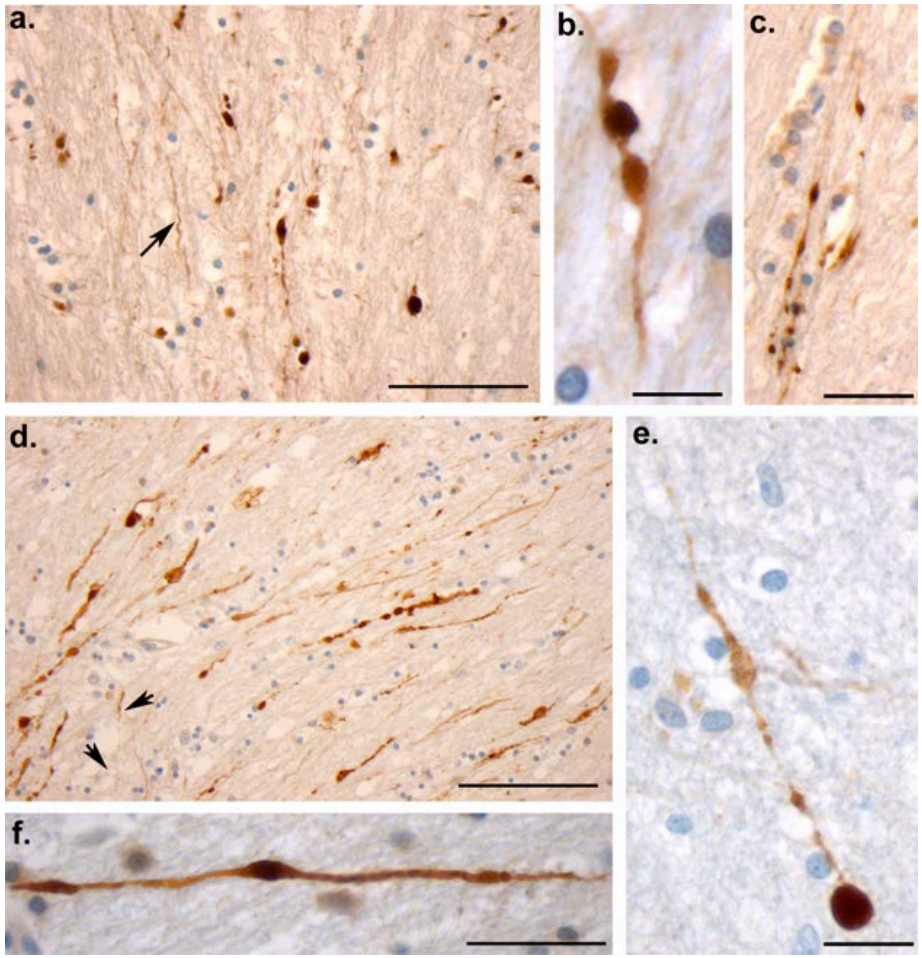
Axonal undulations also found in human and pig TBI





Images courtesy of Dr. Douglas Smith

Axonal varicosities in 4 human cases of acute, severe TBI at post-mortem



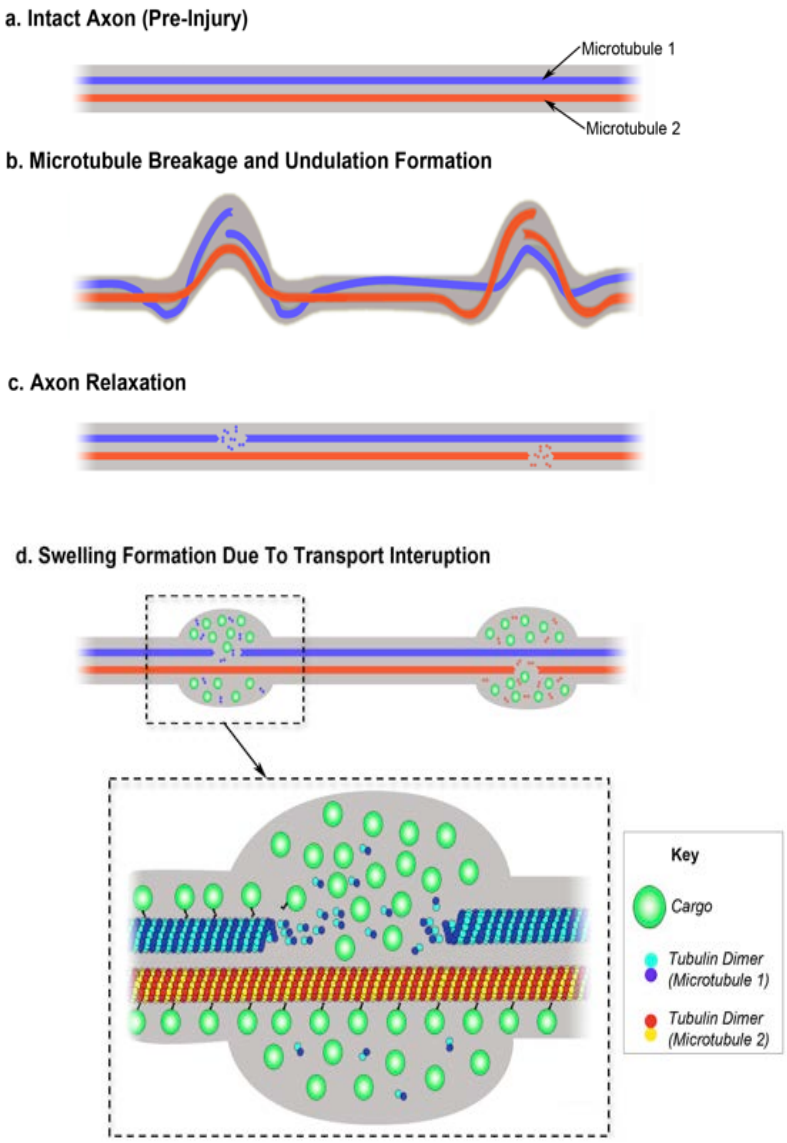
Tang-Schomer, Johnson et al., *Exp. Neurol*, 2012
Images courtesy of Dr. Douglas Smith

Neurometabolic cascade in damaged axons following concussion

- Massive efflux of K+
- Indiscriminate release of glutamate
- Activation of N-methyl-D-aspartate receptors
- Influx of Ca++
- Activation of ATP requiring membrane pumps to restore homeostasis.
- Calcium sequestration in mitochondria leading to decreased ATP production.
- Decrease in cerebral blood flow leading to a supply and demand energy mismatch

Giza C and Hovda D, Journal of Athletic Training, 2001

Proposed mechanism of varicosity formation after traumatic axonal injury



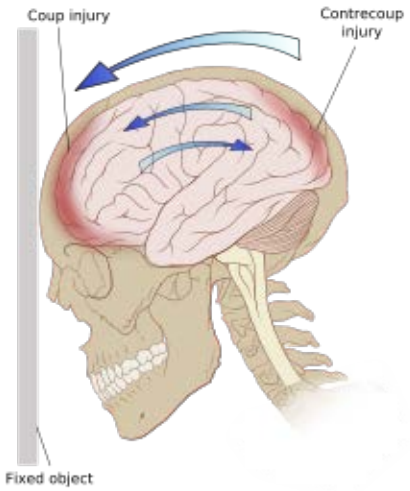
Tang-Schomer, Johnson et al., *Exp. Neurol*, 2012
Images courtesy of Dr. Douglas Smith

Mechanism of Injury

- Direct blow to the head
  - The greater the force the greater the injury
  - Rotational injuries cause more damage
- Blow to the body with force translated to the head
- Acceleration/decceleration-coup/contrecoup
- Blast injury

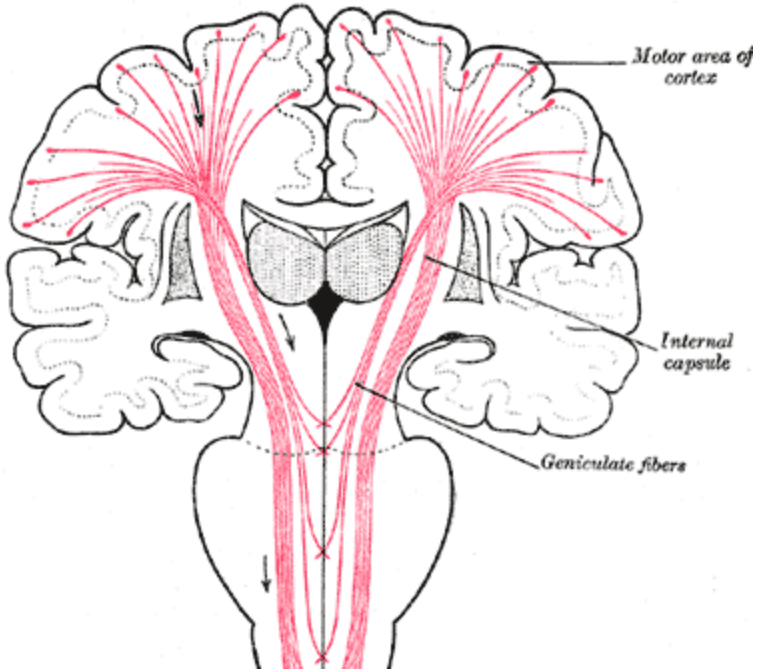
OLD

Contusion



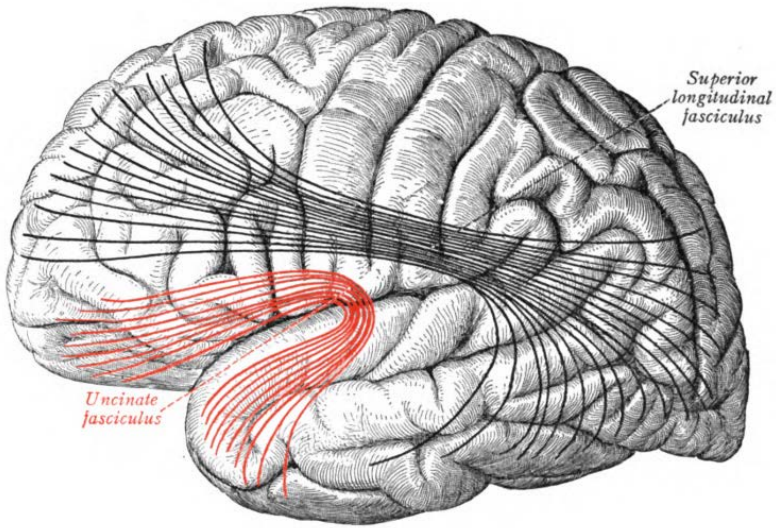
NEW

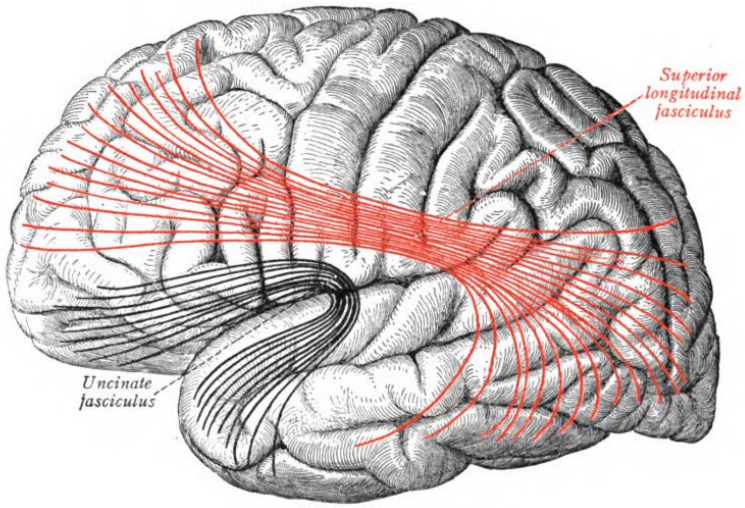
Damage to axons/white matter



Most commonly affected white matter tracts in concussion seen on DTI MRI

Frontal association pathways including: anterior corona radiata, uncinate fasciculus, superior longitudinal fasciculus and anterior corpus callosum





Niogi S, Mukherjee P, J Head Traum Rehabil. 2010

On the Field

Case 1

- While watching the soccer game of your child, there is a scramble for the ball and one of the players for the opposing team falls to the ground. Play continues, but the player doesn't get up. The referee stops play and the coach goes to the player.

- What are you watching for?

Case 1

- As soon as someone is down, look for any movement. Is it volitional? If no movement or non volitional movement, look at the clock to note the time. 30 seconds passes and there is still no movement.

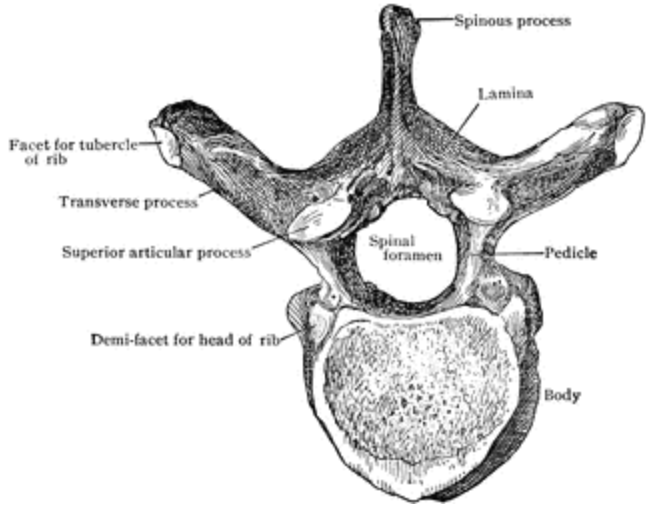
- What do you do?

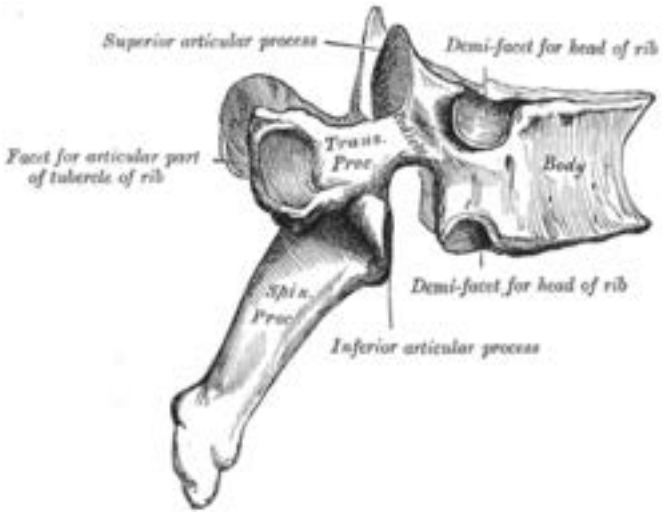
Case 1 with persistent LOC

- If there are no trained medical professionals, such as a trainer or team physician, go to assist with evaluation.
- At the player's side, if there is still no movement direct someone to call 911.
- With loss of consciousness, a spinal injury cannot be evaluated, thus they cannot be moved.
- Next, look for chest rise and check for a pulse. For our purposes today, assume stable vitals as we are talking about concussions.
- Keep anyone from trying to shake or slap them awake. Do not remove helmets or face guards until the neck is cleared unless it is urgently needed for resuscitation.
- If vitals are stable and LOC persists, wait for EMTs to safely transfer, then transport the patient.

Case 1 with resolution of LOC

1. When the player regains consciousness, note the length of time that they were unresponsive.
2. Spinal clearance.
   - Ask if they have any pain in their neck or back. If yes, assess for point tenderness of the spinous processes, transverse processes and paraspinous muscles.
   - If the pain is severe and localizes to a single spinous or transverse process, await EMTs to transfer the player.
   - If they have numbness or weakness of a limb or limbs await the EMTs to transport the player.
   - If they have neck or back pain and you are unable to access the territory without moving them, await the EMTs to evaluate and transfer the patient.
   - If they have no neck pain, back pain, numbness or weakness or if they have pain and it is localized to muscle, ask them to wiggle their fingers and move their feet (they are likely to have shoes on).
   - If they have normal, symmetrical movement, they can move to the side of the field for further evaluation.


Spinous process
Lamina
Facet for tubercle of rib
Transverse process
Superior articular process
Spinal foramen
Pedicle
Demi-facet for head of rib
Body


Superior articular process
Demi-facet for head of rib
Facet for articular part of tubercle of rib
Trans. Proc.
Body
Demi-facet for head of rib
Spin. Proc.
Inferior articular process

Case 1 with resolution of LOC

- The player is helped to their feet and moved to the sidelines.

- What are you looking for?

Intracranial injuries other than concussion

- Subdural hematoma
- Epidural hemorrhage
- Cerebral hemorrhage
- Skull fracture

Red flag signs and symptoms indicating need for urgent neuroimaging

- prolonged loss of consciousness
- repeated vomiting (>1 time)
- loss of consciousness after gaining consciousness
- Deterioration (worsening of lethargy , headache, dizziness or confusion)
- Any focal neurologic signs like increased size of one pupil or unilateral weakness or numbness
- double vision
- severe point tenderness, bony step-off of the skull or depression at site of impact
- raccoon eyes
- Battle sign (retroauricular ecchymosis)
- hemotympanum
- clear rhinorrhea
- otorrhea

Signs of concussion observable by staff

- Appears to be dazed or stunned
- Is confused about assignment
- Forgets plays
- Is unsure of game, score, or opponent
- Moves clumsily
- Answers questions slowly
- Loses consciousness
- Shows behavior or personality change
- Forgets events prior to hit (retrograde amnesia)
- Forgets events after hit (anterograde amnesia)

Lovell M, et al, The American Journal of Sports Medicine, 2004

Symptoms of concussion reportable by athlete

- Headache
- Nausea
- Balance problems or dizziness
- Double or fuzzy vision
- Sensitivity to light or noise
- Feeling sluggish
- Feeling foggy or groggy
- Concentration or memory problems
- Confusion

Lovell M, et al, The American Journal of Sports Medicine, 2004

SCAT3™

Sport Concussion Assessment Tool – 3rd Edition

For use by medical professionals only

Name | Date/Time of Injury: | Date of Assessment: | Examiner:

What is the SCAT3?[1]

The SCAT3 is a standardized tool for evaluating injured athletes for concussion and can be used in athletes aged from 13 years and older. It supersedes the original SCAT and the SCAT2 published in 2005 and 2009, respectively[2]. For younger persons, ages 12 and under, please use the Child SCAT3. The SCAT3 is designed for use by medical professionals. If you are not qualified, please use the Sport Concussion Recognition Tool[1]. Preseason baseline testing with the SCAT3 can be helpful for interpreting post-injury test scores.

Specific instructions for use of the SCAT3 are provided on page 3. If you are not familiar with the SCAT3, please read through these instructions carefully. This tool may be freely copied in its current form for distribution to individuals, teams, groups and organizations. Any revision or any reproduction in a digital form requires approval by the Concussion in Sport Group.

NOTE: The diagnosis of a concussion is a clinical judgment, ideally made by a medical professional. The SCAT3 should not be used solely to make, or exclude, the diagnosis of concussion in the absence of clinical judgement. An athlete may have a concussion even if their SCAT3 is "normal".

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 signs and/or symptoms (some examples listed below) and most often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (e.g., headache), or
- Physical signs (e.g., unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour (e.g., change in personality).

SIDELINE ASSESSMENT

Indications for Emergency Management

NOTE: A hit to the head can sometimes be associated with a more serious brain injury. Any of the following warrants consideration of activating emergency procedures and urgent transportation to the nearest hospital:

- Glasgow Coma score less than 15
- Deteriorating mental status
- Potential spinal injury
- Progressive, worsening symptoms or new neurologic signs

Potential signs of concussion?

If any of the following signs are observed after a direct or indirect blow to the head, the athlete should stop participation, be evaluated by a medical professional and **should not be permitted to return to sport the same day** if a concussion is suspected.

Any loss of consciousness?	Y	N
"If so, how long?"		
Balance or motor incoordination (stumbles, slow/laboured movements, etc.)?	Y	N
Disorientation or confusion (inability to respond appropriately to questions)?	Y	N
Loss of memory:	Y	N
"If so, how long?"		
"Before or after the injury?"		
Blank or vacant look:	Y	N
Visible facial injury in combination with any of the above:	Y	N

1 Glasgow coma scale (GCS)

Best eye response (E)	
No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4
Best verbal response (V)	
No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5
Best motor response (M)	
No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion/Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6
Glasgow Coma score (E + V + M)	of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

2 Maddocks Score[3]

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

What venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week/game?	0	1
Did your team win the last game?	0	1
Maddocks score		of 5

Maddocks score is validated for sideline diagnosis of concussion only and is not used for serial testing.

Notes: Mechanism of Injury ("tell me what happened"?):

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 until cleared to do so by a medical professional. No athlete diagnosed with concussion should be returned to sports participation on the day of Injury.

BACKGROUND

Name: _____ Date: _____

Examiner: _____

Sport/team/school: _____ Date/time of injury: _____

Age: _____ Gender: ☐ M ☐ F

Years of education completed: _____

Dominant hand: ☐ right ☐ left ☐ neither

How many concussions do you think you have had in the past? _____

When was the most recent concussion? _____

How long was your recovery from the most recent concussion? _____

Have you ever been hospitalized or had medical imaging done for a head injury? ☐ Y ☐ N

Have you ever been diagnosed with headaches or migraines? ☐ Y ☐ N

Do you have a learning disability, dyslexia, ADD/ADHD? ☐ Y ☐ N

Have you ever been diagnosed with depression, anxiety or other psychiatric disorder? ☐ Y ☐ N

Has anyone in your family ever been diagnosed with any of these problems? ☐ Y ☐ N

Are you on any medications? If yes, please list: ☐ Y ☐ N

_____

SCAT3 to be done in resting state. Best done 10 or more minutes post excercise.

SYMPTOM EVALUATION

3 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	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 (Maximum possible 132) _____

Do the symptoms get worse with physical activity? ☐ Y ☐ N

Do the symptoms get worse with mental activity? ☐ Y ☐ N

☐ self rated ☐ self rated and clinician monitored

☐ clinician interview ☐ self rated with parent input

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 | N/A

Scoring on the SCAT3 should not be used as a stand-alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion. Since signs and symptoms may evolve over time, it is important to consider repeat evaluation in the acute assessment of concussion.

COGNITIVE & PHYSICAL EVALUATION

4 Cognitive assessment

Standardized Assessment of Concussion (SAC)[4]

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score		of 5

Immediate memory

List	Trial 1	Trial 2	Trial 3	Alternative word list		
elbow	0 1	0 1	0 1	candle	baby	finger
apple	0 1	0 1	0 1	paper	monkey	penny
carpet	0 1	0 1	0 1	sugar	perfume	blanket
saddle	0 1	0 1	0 1	sandwich	sunset	lemon
bubble	0 1	0 1	0 1	wagon	iron	insect
Total						

Immediate memory score total of 15

Concentration: Digits Backward

List	Trial 1	Alternative digit list		
4-9-3	0 1	6-2-9	5-2-6	4-1-5
3-8-1-4	0 1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0 1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0 1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6
Total of 4				

Concentration: Month in Reverse Order (1 pt. for entire sequence correct)

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan	0	1
Concentration score		of 5

5 Neck Examination:

Range of motion Tenderness Upper and lower limb sensation &strength

Findings: _____

6 Balance examination

Do one or both of the following tests.

Footwear (shoes, barefoot, braces, tape, etc.) _____

Modified Balance Error Scoring System (BESS) testing[5]

Which foot was tested (i.e. which is the **non-dominant** foot) ☐ Left ☐ Right

Testing surface (hard floor, field, etc.) _____

Condition

Double leg stance:	Errors
Single leg stance (non-dominant foot):	Errors
Tandem stance (non-dominant foot at back):	Errors

And / Or

Tandem gait[4,7]

Time (best of 4 trials): _____ seconds

7 Coordination examination

Upper limb coordination

Which arm was tested: ☐ Left ☐ Right

Coordination score of 1

8 SAC Delayed Recall[4]

Delayed recall score of 5

X2 ICE Integrated Concussion Exam

Return to play decisions

- Anyone who has exhibited any signs of concussion should be removed from play and should not return to play that day.
- Younger players are at risk for more severe injury if they return to play.
- Players will downplay or deny symptoms to be able to continue to play.
- Resist pressure from coaches, parents or players if you suspect a concussion.

Second impact syndrome

- While the exact nature of the injury is debated, “second impact syndrome is a rare, often fatal, traumatic brain injury that occurs when a repeat injury is sustained before symptoms of a previous head injury have resolved.”

Cantu R, Clinics Sports Med, 1998

All athletes risk worsening their symptoms and prolonging recovery if they continue to play.

Case 1 with resolution of LOC

Where do you go from here?

- No person who has sustained a concussion should be left alone.
- Any red flag signs or deterioration is cause for ER evaluation.
- Recommend cognitive and physical rest for 24-48 hours with graded return to activity when symptoms resolve.
- At a minimum, the concussed player's doctor should be contacted/paged to record the mechanism of injury and signs and symptoms in the post injury period. They should then take over monitoring and recommendations.

Case 2

- A blow to the head or body of a player is observed, but the player doesn't fall or lose consciousness. You see the player holding their head, shaking their head, moving sluggishly, confusedly or stumbling. Play is continuing.

- What do you do?

Case 2

- Again wait 30 seconds to see if anyone is registering the injured player. If play is not stopped and you continue to be concerned, proceed to a sideline official or the coach for your team and point out the injured player so they can stop play. This can feel like an awkward situation, but timely removal from play to avoid a second injury or even further exertion is of the utmost importance.

In the office

Case 3

- A 40 year old, male, small business owner with a history of an anxiety disorder comes to you after being diagnosed with a concussion in the ER. “He hit his head on the flimsy tray of a printer. He "felt something was wrong" in his brain right away. He said his brain felt tingly inside. He had headache. He felt dazed and confused, which worsened over 2 hours. He was unable to return to work that day. He tried to simply watch TV, but could not concentrate. He also noted that 1-2 hours later he began to “speak gibberish” but this resolved spontaneously. He had increasing headache and nausea, but no vomiting.”

History of present illness

- Mechanism of injury
- Signs and symptoms immediately following injury
- Evolution of symptoms over the intervening days, especially how they fluctuate relative to rest/exertion

CDC Concussion signs and symptoms

Physical

- Headache
- Nausea
- Vomiting (<2)
- Balance problems
- Dizziness
- Visual problems
- Fatigue
- Sensitivity to light
- Sensitivity to noise
- Numbness/tingling
- Dazed or stunned

CDC, Concussion Heads Up, Facts for Physicians

CDC Concussion signs and symptoms

Cognitive

- Feeling mentally “foggy”
- Feeling slowed down
- Difficulty concentrating
- Difficulty remembering
- Forgetful of recent information or conversations
- Confused about recent events
- Answers questions slowly
- Repeats questions

CDC, Concussion Heads Up, Facts for Physicians

CDC Concussion signs and symptoms

Emotional

- Irritability
- Sadness
- More emotional
- Nervousness

CDC, Concussion Heads Up, Facts for Physicians

CDC Concussion signs and symptoms

Sleep

- Drowsiness
- Sleeping less than usual
- Sleeping more than usual
- Trouble falling asleep

CDC, Concussion Heads Up, Facts for Physicians

ImPACT
Immediate Post-concussion Assessment Cognitive Testing

- Validated assessment tool for assessment and monitoring
- Good test-retest reliability
- Best if post-concussion test is compared to pre-concussion test in the same individual, but baselines exists.

Case 3

- “The next night he went to the emergency department. They evaluated him, said that he had a concussion, recommended that he go home. They never told him to actually take any time off from work or reduce his exercise program. He did take the following day off as already planned for his friend's birthday. He works 80-100 hours a week. He tried to restart his intensive exercise program right away. He began to notice that he had trouble focusing at work. He had to stop exercising because exercising made his headaches much worse. He stopped exercising and he felt better without the exercise. After a period of time, he tried to exercise again. He walked 2.5 miles per hour for 2 hours, but this made his symptoms worsen. He felt “numb over his whole body the next day.”

- Symptoms due to concussion will follow a predictable pattern of improving with rest and worsening with mental and physical exertion.

Problems due to injury which are not concussion

- Red flag signs or symptoms trigger referral to the ER or head imaging.
- Assess for other problems such as whiplash injury, PTSD or migraines. While there is overlap of symptoms, symptoms due to other causes will not wax and wane related to exertion and rest.

Headache following concussion

- Posttraumatic headache
  - Generalized/pressure sensation which increases as the day progresses
- Posttraumatic migraine
  - Unilateral, moderate-severe, pulsating, associated with nausea, sensitivity to light or nose
- Tension type/musculoskeletal headache
  - Worsened or relieved by pressure, bilateral in the territory of muscles

Predictors of prolonged recovery based on history

Study population; non-referred male veterans s/p concussion

- LOC
- History of prior concussion
- History of psychiatric difficulties such as anxiety and depression, ADD
- Limited social supports
- Lower intelligence/learning disability

Luis C, et al, J. Int. Neuropsychol., 2003

Study population; >16 years of age diagnosed with a concussion in the ER

- Prior head trauma
- Neurologic or psychiatric problems
- Students
- Females
- MVA

Ponsford J, et al, J. Int. Neuropsychol., 2000

Predictors of prolonged recovery based on symptoms

- High overall subjective symptom burden
- Posttraumatic migraine

Meehan W, Mannix R, et al, Neurology, 2014
Lau B, Collins M, et al, Neurosurgery, 2012

Case 3

Factors putting him at higher risk of prolonged recovery

- History of an anxiety disorder

Factors putting him at lower risk of prolonged recovery

- No prior history of concussion
- No LOC
- Good social supports
- High level of intelligence
- Male
- Not a student
- Age

Theoretical factors putting him at higher risk of prolonged recovery

- Rotational injury
- Rest was not initiated in the acute post-concussion phase

Theoretical factors putting him at lower risk of prolonged recovery

- No secondary gain

Physical Exam

- Head and neck exam
- Back/spine exam
- Full neurologic exam plus
  - Oculomotor
    - Convergence - Abnormal if unable to maintain focus on midline object farther than 6 cm from nose.
    - Accommodation – Abnormal if blurred vision in either eye > 15 cm
  - Vestibular
    - Horizontal – maintain gaze on 14 font target at 3 feet while moving head horizontally. Abnormal is onset or increase of symptoms.
    - Vertical - maintain gaze on 14 font target at 3 feet while moving head vertically. Abnormal is onset or increase of symptoms.
  - Balance testing - BESS

BESS – Balance Error Scoring System

Double leg stance for minimum screening purposes

-preferably on a foam surface, shoes off, feet together, arms folded across the chest

-guard the patient

-patient closes eyes for 20 seconds.

-record errors. Abnormal is >1 error

Treatment

- Cognitive and physical rest for 24-48 hours or until symptoms resolve, followed by graded return to activity

McCrory, et al, Journal of Athletic Training, 2013

- Initiation of cognitive and physical rest at any time following concussion if symptoms are still present

Moser, et al, Journal of Pediatrics, 2012

What constitutes cognitive and physical rest?

- Cognitive- No activities such as email, video games, homework or any which exacerbate symptoms.
- Physical- No activities such as exercise, manual labor, housekeeping or any which exacerbate symptoms.

Case 3

- Following the direction to maintain cognitive and physical rest was particularly hard for this patient as he owned his business and was devoted to exercise to maintain a healthy weight.

Management

- Help the patient to strategize to be able to follow your recommendations.
  - Alert work
  - Recruit family or friends to help with child care and ADLs such as shopping.
- Provide letters for work or school. Do not set a return to work or school date until after re-evaluation in the office or on the phone.

Management

- Information on what to expect related to symptoms and recovery decreases anxiety and improves outcomes.

- CDC **ACE Care Plan** is a great resource
  - Work version
  - School version

Ponsford J, t al, J Neurol Neurosurg Psychiatry, 2002

http://www.cdc.gov/concussion/headsup/pdf/ACE_care_plan_returning_to_work-a.pdf

Management

- Reassure your patients that the vast majority of people with concussions recover.

Pain Management

- Acetaminophen alone for the first 48 hours given theoretical risk of intracranial bleeding.
- NSAIDs after 48 hours
- Avoiding sedating medicines, such as opiates
- Consider low dose amitriptyline (10 mg QHS) if acetaminophen is insufficient for control of posttraumatic migraine. Do not dispense more than 10 day prescription.
- Remind the patient to use their symptoms as an alert that they are placing too much demand on their brain and rest or decrease their activity.

Symptom Based Therapies

- Physical medicine and Rehabilitation
- Vestibular therapy
- Vision therapy
- Physical therapy
- Exertion therapy

Reynolds E, Collins MW. Neurosurg. 2014

Graded return to play/activity

Proceed to the next level if asymptomatic at the current level for 24 hours. If post-concussion symptoms return, drop back to the previous asymptomatic level.

1. No activity
2. Light aerobic exercise
3. Sport specific exercise
4. Noncontact training drills
5. Full contact practice
6. Return to play

Adjust this for the individual patient.

McCrory, et al, Journal of Athletic Training, 2013

Case 3

- Two months after his injury he was still symptomatic. His sleep was still disrupted. On average he would wake 2-5 times per night. He would lay awake for 2-3 hours, then sleep for 3-4 hours. Previously, when he hit a pot hole it would feel like an immediate hangover. Now, he felt a mild headache after hitting pot holes. He tried an intensive work out and felt the hangover feeling for the rest of the day, then felt better the next day. No further pain in this left temple.

Persistent post-concussive symptoms

- Most people will recover within 1 week.
- Concussion symptoms in patients seen in the ER on average resolved with in 1-3 months.
- The recovery time of a collegiate athlete was more rapid.

Levin H, et al, J Neurosurg, 1987
McCrea M, JAMA, 2003

When to refer to a concussion specialist

- Refer when symptoms persist.
- Refer when symptoms are severe or the concussion is complex.
- No clear guidelines exist, thus clinical judgment is your best tool.

Case 3

- Two and a half years after his original injury, the patient reported he was back to exercising daily. He would wear a heart rate monitor and keep his pulse below 170 bpm to avoid recurrence of headaches. He was watching calories and had lost the weight he had gained following his concussion.

Promising Radiologic Tools for Diagnosis

- diffusion tensor imaging (DTI) MRI – quantifies white matter integrity by characterizing 3D directionality of water diffusion. In intact white matter with parallel fiber bundles , water diffuses along the direction of the tract. In damaged white matter, water diffuses perpendicularly to the fiber bundles (radial diffusivity).
- Functional (f)MRI – regional neuronal activity draws oxygen rich blood. fMRI studies have demonstrated the MTBI patients “work harder” to complete a simple task.

Niogi SN, Mukherjee P. J Head Trauma Rehabil. 2010
McAllister TW, Sparling MB, et al. Neuroimage. 2001

TBI Biomarkers

- CSF levels of certain biomarkers increase after head trauma
- There is active research to identify biomarkers which increase in the blood after concussion, but this is a difficult area of research.
    - Very low concentrations in blood
    - Levels can go up after contests in which a concussion was not sustained.

Shahim P, Tegner Y, et al. JAMA Neurol. 2014

Chronic Traumatic Encephalopathy

- Diagnosis is made at autopsy
- Worse in athletes who suffer concussion
- Not limited to athletes
- ?Genetic predisposition

References

1. Langlois J, Rutland-Brown W, Wald M, The epidemiology and Impact of traumatic brain injury, A brief overview. Journal of Head Trauma Rehabilitation. 2006;21(5):375-378.
2. Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. Report to Congress on mild traumatic brain injury in the United States: steps to prevent a serious public health problem. Atlanta (GA) Centers for Disease Control and Prevention; 2003.
3. Reynolds E, Collins M, Mucha A, Troutman-Ensecki C, Establishing a Clinical Service for the Management of Sports-Related Concussions. Neurosurgery. 2014; 75:S71-S81.
4. McCrory P, Meeuwisse H, Aubry M, et al, Consensus Statement on Concussion in Sport: The 4th International Conference on Concussion in Sport, Zurich, November 2012. Journal of Athletic Training. 2013;48(4):554-567.
5. Tang-Schomer M, Johnson V, Baas P, Stewart W, Smith D, Partial interruption of axonal transport due to microtubule breakage accounts for the formation of periodic varicosities after traumatic axonal injury. Experimental Neurology. 2012;233:364-372.
6. Giza C, Hovda D, The Neurometabolic Cascade of Concussion. Journal of Athletic Training. 2001;36(3):228-235.
7. Niogi SN, Mukherjee P. Diffusion tensor imaging of mild traumatic brain injury. J Head Trauma Rehabil. 2010;25(4):241-255.
8. Moser R, Glatts C, Schatz P, Efficacy of Immediate and Delayed Cognitive and Physical Rest for Treatment of Sports-Related Concussion. The Journal of Pediatrics. 2012;161(5):922-926.
9. Lovell M, Collins M, Iverson G, Johnston K, Bradley J, Grade 1 or "Ding" Concussions in High School Athletes. The American Journal of Sports Medicine. 2004;32(1):47-54.
10. CDC, Heads Up: Brain injury in your practice http://www.cdc.gov/concussion/HeadsUp/physicians_tool_kit.html
11. Cantu RC, Second-impact syndrome. Clinics in Sports Medicine. 1998; 17:37-44.
12. Luis C, Vanderploeg R, Curtiss, G, Predictors of postconcussion symptom complex in community dwelling male veterans. Journal of the International Neuropsychological Society. 2003;9:1001-1015.
13. Ponsford J, Willmott C, Rothwell A, Cameron P, Kelly A, Nelms R, Curran C, Ng K, Factors influencing outcome following mild traumatic brain injury in adults. Journal of the International Neuropsychological Society. 2000;6:568-579.
14. Meehan WP III, Mannix R. Monuteaux MC, Stein CJ, Bachur RG. Early symptom burden predicts recovery after sport-related concussion. Neurology 2014;83:2204-2210.
15. Lau BC, Collins MW, Lovell MR. Cutoff scores in neurocognitive testing and symptom clusters that predict protracted recovery from concussions in high school athetes. Neurosugery. 2012;70(2):371-379.
16. Levin H, Mattis S, Ruff R, Eisenberg H, Marshall L, Tabaddor K, High W, Frankowski R, Neurobehavioral outcome following minor head injury: a three-center study. Journal of Neurosurgery. 1987;66:234-243.
17. McCrea M, Guskiewicz K, Marshall S, Barr W, Randolph C, Cantu R, Onate J, Yang J, Kelly J, Acute effects and recovery time following concussion in collegiate football players, The NCAA Concussion Study. JAMA. 2003;290(19)2556-2563.
18. McAllister TW, Sparling MB, Flashman LA, Guerin SJ, Mamourian AC, Saykin AJ. Differential working memory load effects after mild traumatic brain injury. Neuroimage. 2001;14(5):1004-1012.
19. Shahim P, Tegner Y, Willson D, Randall J, Skillback T, Pazooki D, Kallberg, Blennow K, Zetterberg H. Blood Biomarkers for Brain Injury in Concussed Professional Ice Hockey Payers. JAMA Neurol. 2014;71(6):684-692.
20. VA/DOD Consensus Conference on the Acute Management of Concussion/Mild traumatic Brain Injury (MTBI) in the Deployed Setting, 2008
21. VA/DOD Management of Concussion/mild Traumatic Brain Injury, Clinical Practice Guideline April 2009.