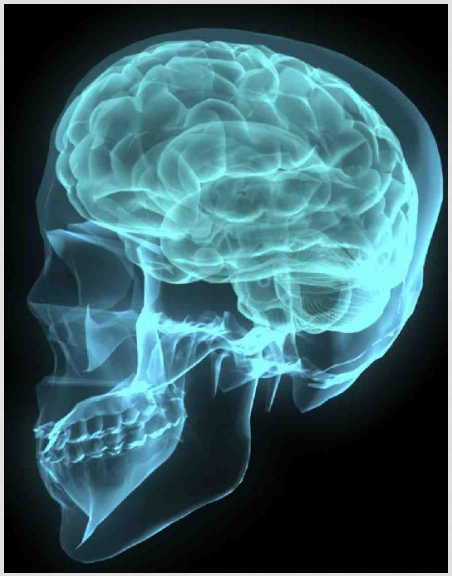


TBI & POST-CONCUSSION SYNDROME *AFTERMATH*

SUMMER IBARRA, PH.D., HSPP
REHABILITATION PSYCHOLOGIST

Summer.ibarra@rhin.com

OBJECTIVES

- To gain an understanding of the incidence and severity of TBI and PCS in the military
- To gain a general understanding of how the brain is injured and expectations for recovery
- To gain an understanding of mild TBI and Post-Concussion Syndrome (PCS)aftermath
  - To include a brief discussion of additional contributing factors
- Learn about treatment options for moderate to severe TBI, mild TBI and PCS

TRAUMATIC BRAIN INJURY (TBI)

- "TBI occurs when an external mechanical force causes brain dysfunction." (Mayo Clinic)

- **"Traumatic brain injury** (**TBI**) is a nondegenerative, noncongenital insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness."

SEVERITY OF TBI

	Mild	Moderate	Severe
Imaging	Normal	Normal / Abnormal	Normal / Abnormal
LOC	0-30 minutes	> 30 minutes < 24 hours	> 24 hours
AOC	A moment up to 24 hours	> 24 hours	Severity based on other criteria
PTA	0-1 day	> 1 and < 7 days	> 7 days
GCS	13-15	9-12	3-8

Classification based on 2009 VA/DoD Clinical Practice Guidelines for Management of Concussion/Mild Traumatic Brain Injury

*LOC = loss of consciousness
*AOC = alteration of consciousness / mental state
*PTA = post-traumatic amnesia
*GCS = Glasgow Coma Scale

MILD TBI (MTBI)

- mTBI and concussion are interchangeable terms
- Diagnostic Criteria for MTBI by the American Congress of Rehabilitation Medicine

A traumatically induced physiological disruption of brain function, as manifested by *at least one* of the following:

- Any loss of consciousness
- Any loss of memory before or after injury
- Any alteration of mental state
- Focal neurological deficit that may or may not be transient
- Severity of Injury does not exceed the following:
  - LOC ≤ 30 minutes
  - After 30 minutes, an initial GCS score of 13-15
  - PTA ≤ 24 hours

COMMON CONSEQUENCES OF TBI

- Moderate to Severe TBI:

Physical	Behavioral - Emotional	Cognitive
• Decreased muscle movement • Disruptions to sensory systems • Problems swallowing • Difficulty with speech • Headaches • Fatigue	• Decreased initiation • Disinhibition • Impulsivity • Irritability • Anxiety • Depression • Disturbed sleep • Decreased awareness	• Slowed processing speed • Difficulty Concentratiing • Difficulty Remembering • Difficulty multi-tasking • Word-finding problems • Inflexibility in thinking • Perseverative

"GENERAL" RECOVERY FROM TBI

- Moderate to Severe TBI:
  - Most rapid recovery occurs in the first 3-6 months
    - Physical issues tend to resolve most quickly
    - Cognitive and Emotional/Behavioral typically longer
  - Recovery slows down some but still continues
    - Beyond 2 years!
  - Setbacks and plateaus are normal
  - May not achieve 100% recovery but can learn compensatory strategies
  - Establish a "new normal"

COMMON CONSEQUENCES OF MTBI

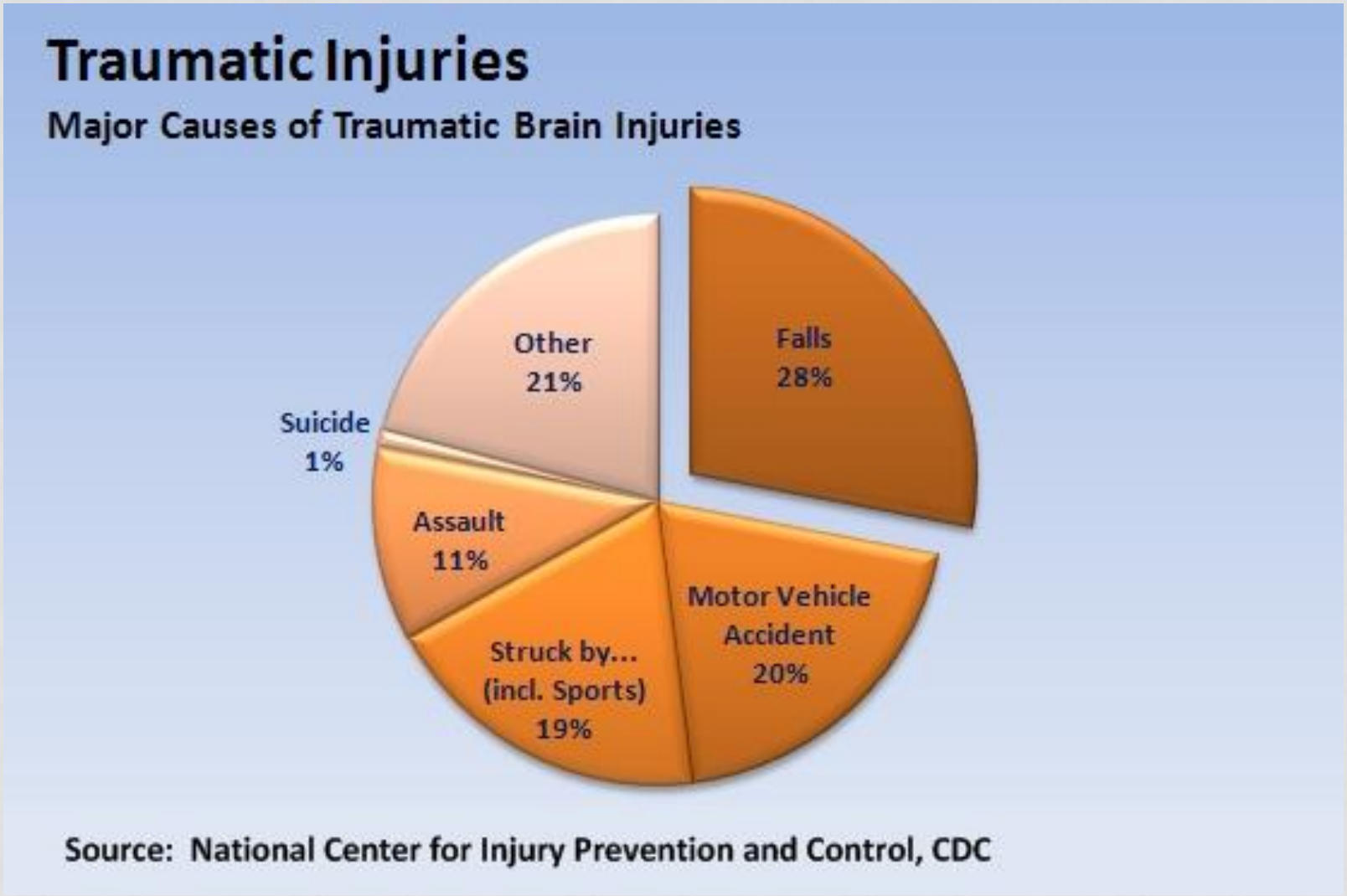
Acute symptoms

Physical	Behavioral - Emotional	Cognitive
• Headache • Nausea • Vomiting • Blurred or Double Vision • Seeing Stars or lights • Dizziness • Sensitivity to light or noise • Tinnitus	• Drowsiness • Fatigue/Lethargy • Irritability • Anxiety • Depression • Sleeping more than Usual • Difficulty Falling Asleep	• Feeling "Slowed Down" • Feeling "in a Fog" or "dazed" • Difficulty Concentratiing • Difficulty Remembering

TBI IN THE CIVILIAN POPULATION

- In the United States each year:
  - Leading cause of death and disability ages 1-44
  - 1.7 million sustain a TBI requiring medical attention
  - 53,000 deaths
  - 5.3 million Americans currently live with disabilities from TBI
  - 75% are classified as mTBI

CAUSES OF TBI (CIVILIAN)



A NEW ERA IN COMBAT

Interceptor Body Armor Vest

Kevlar helmet after an IED attack in Iraq

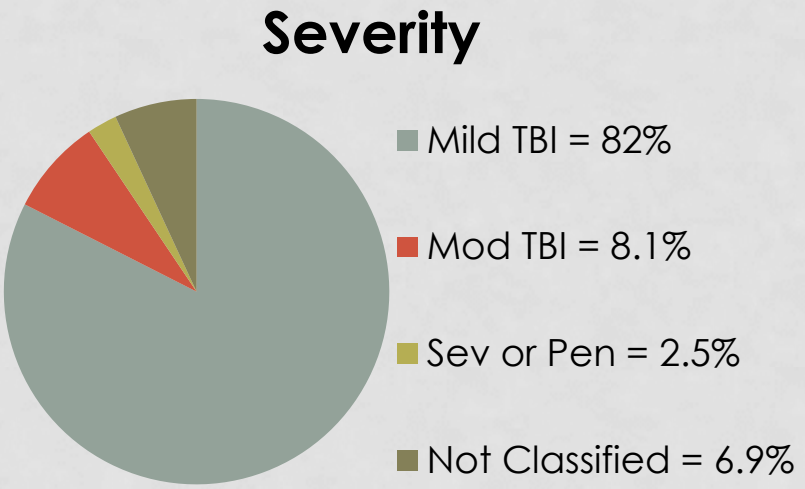
A NEW ERA IN COMBAT

- Advances in in-theater medical care = reduced killed-wounded ratio (less than 1 in 10)
- Improved body armor and vehicle protection has reduced fatalities
- Proportion of head and neck wounds has doubled from the Vietnam War
- Repeated / extended deployment → increased risk of multiple TBIs
- Combat TBI differs from civilian TBI with respect to the extreme physical and psychological conditions of war

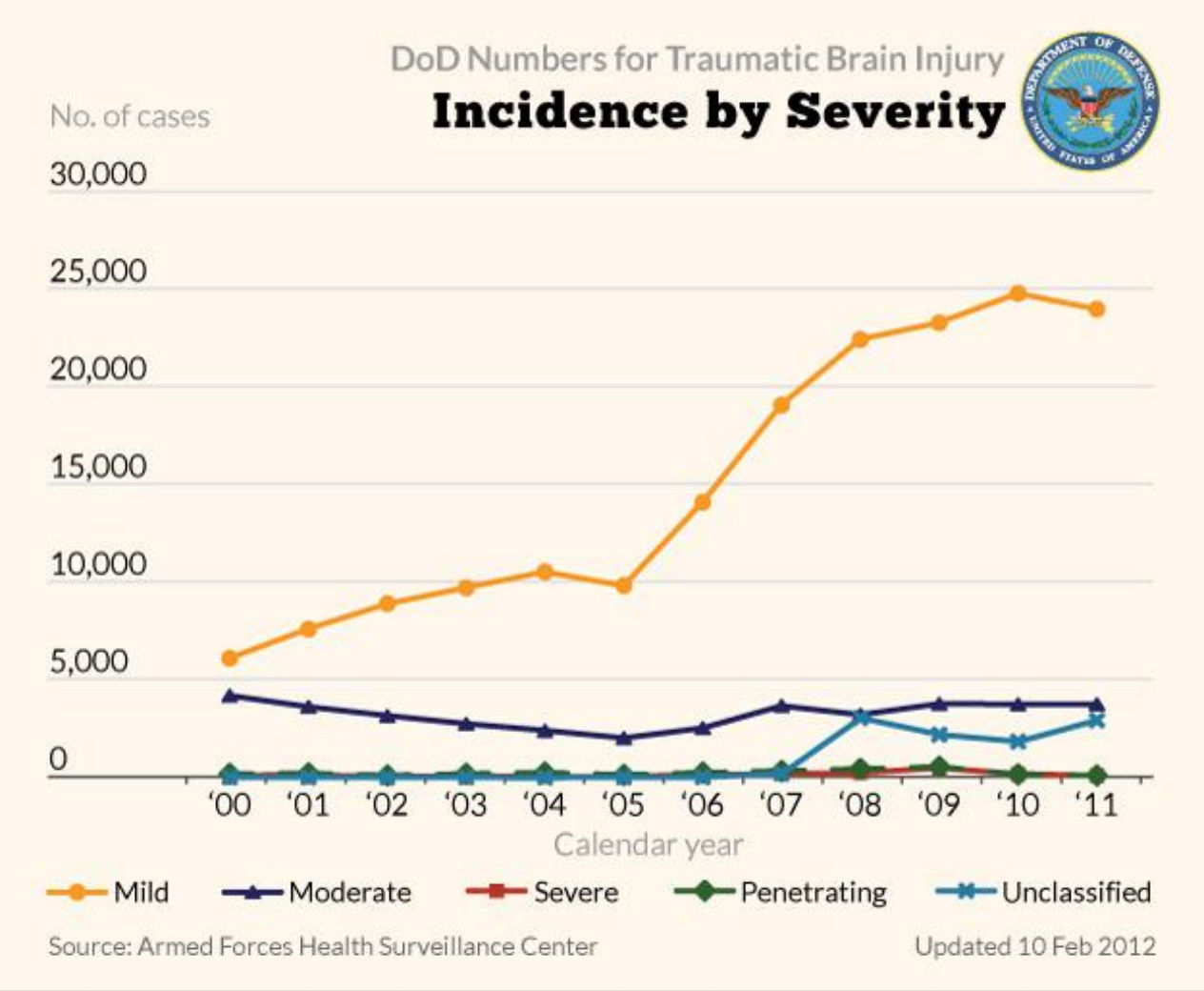
A FEW STATISTICS

- Cost of care for TBI in the military was $21 million in 2003 and $646 million in 2010

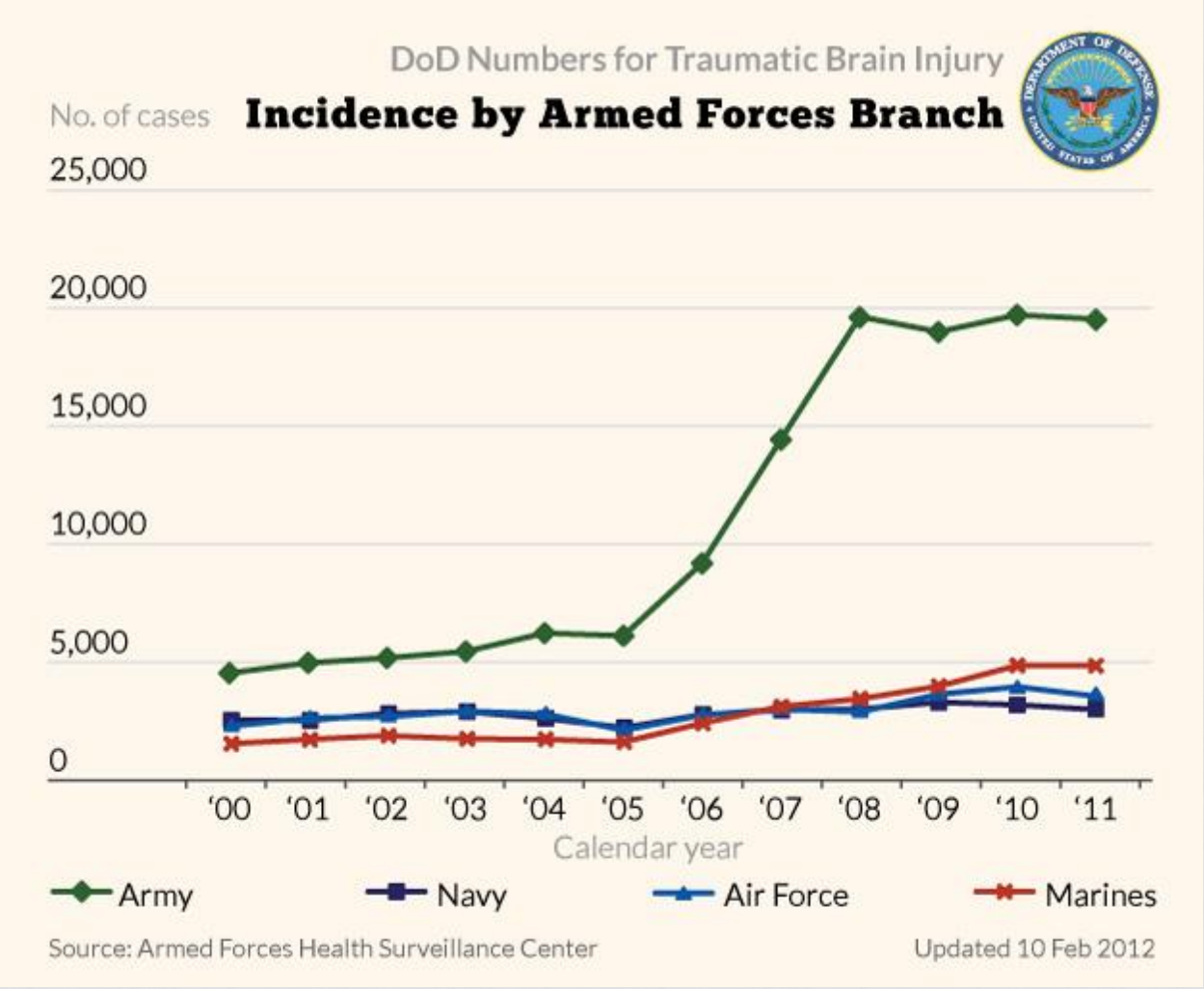
Branch	TBIs 2000 - 2013
Army	168,309
Marines	41,628
Air Force	39,128
Navy	38,846
Total	287,911



TBI SEVERITY IN THE MILITARY



TBI INCIDENCE IN THE MILITARY

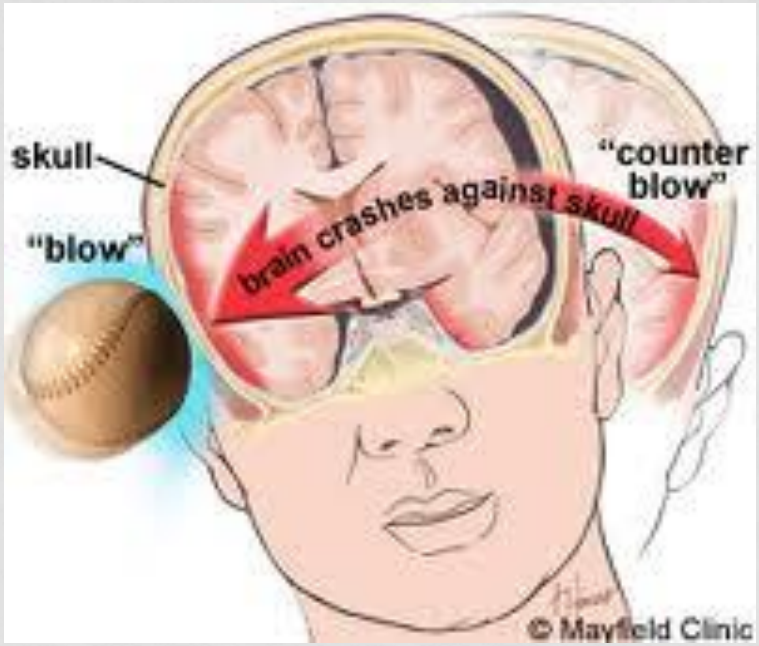


CAUSES OF TBI (MILITARY)

- In the military, the leading causes of TBI both deployed and non-deployed are (in no particular order):
  - Blasts
  - Bullets
  - Fragments
  - Falls
  - Motor vehicle – crashes and rollovers
  - Sports
  - Assaults
- In the deployed setting, blasts are the leading cause of TBI

MECHANISMS OF INJURY

Coup – Contrecoup injury



Diffuse Axonal Injury

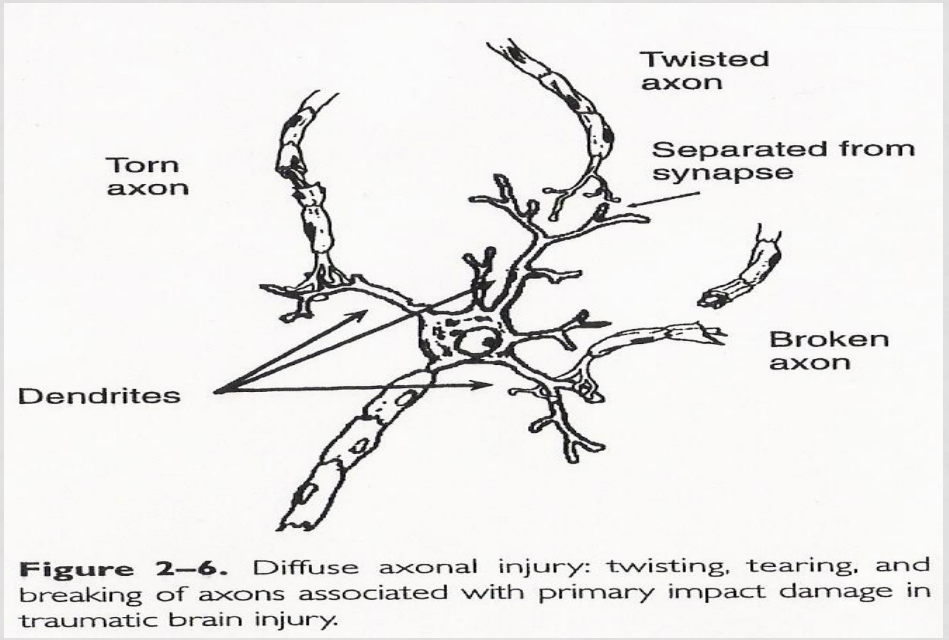


Figure 2–6. Diffuse axonal injury: twisting, tearing, and breaking of axons associated with primary impact damage in traumatic brain injury.

PATHOBIOLOGY IN MTBI AND PCS

"There is little doubt that abnormal neurophysiology is predominant cause of symptoms shortly after injury"

(Iverson, 2005)

STRUCTURAL IMAGING

~ 7-20% of consecutive patients presenting to the ER with MTBI show bleeding, bruising, swelling on Head CT *(Iverson, 2005)*

- "Complicated" MTBI
- Head CT abnormal in 5% of pts with GCS = 15, 30% of those with GCS = 13
- More similar to moderate TBI patients
- "Presence of structural abnormalities argue for causal association between injury and persistent cognitive symptoms"

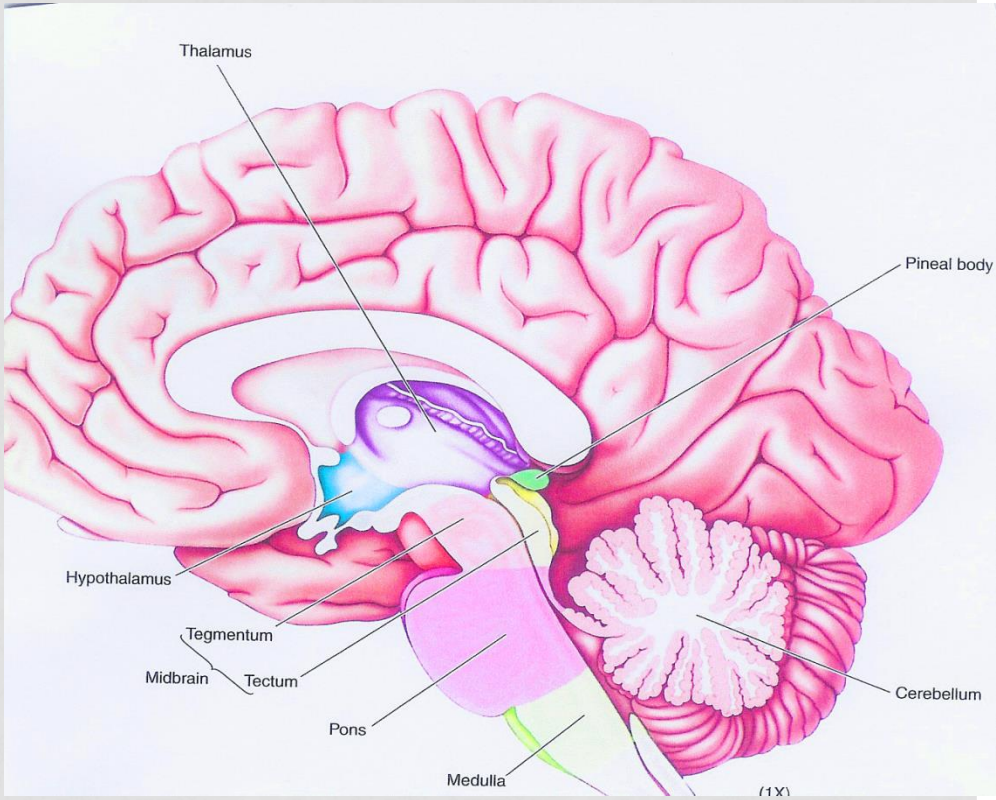
(Mittenberg & Strauman, 2000)

DIFFUSE AXONAL *DISRUPTION*

- Most mTBI have no neuroimaging abnormalities
- Concussive injuries thought to be more metabolic in nature
  - Injured cells exposed to dramatic changes in intracellular/ extracellular environments
  - Energy demand and supply mismatched
  - Cells become vulnerable to even minor changes in blood flow, pressure, etc.
  - This state lasts ≥ 2 weeks in animal models, perhaps longer in humans
  - Problems worst in first 72 hours, rapid improvement over first week

DIFFUSE AXONAL INJURY

- Upper brainstem 95%
- Corpus callosum 92%
- Choroid plexus of third ventricle 90%
- Hippocampus 88%
- Periventricular (3rd ventricle) 83%
- Cingulate gyrus 61%
- Thalamus 56%



BLAST-RELATED INJURY

- **Pathophysiology**
  - Both ***physical*** and ***psychological*** trauma
  - ***Physical***
    - Supersonic blast wave compresses gas-filled spaces (e.g., lungs, GI tract, middle ear) which then rapidly re-expand → shearing and tearing forces damage tissue / perforate organs
    - Blood may be forced from the vasculature into the air spaces and surrounding tissue
    - Tympanic membrane rupture is the most common effect of this type of blast injury
    - Organs surrounded by fluid-filled cavities (e.g., brain and spinal cord) are also susceptible to the primary blast wave
  - Blast injuries to the brain include diffuse axonal injury, skull fracture, coup-contrecoup, subarachnoid and subdural hemorrhage
  - Primary blast waves can cause concussion even without any direct blow to the head
  - Barotrauma caused by acute gas embolism in which an embolism forms in the lungs and travels to the brain, leading to infarction
  - ***Psychological***
    - PTSD, depression, anxiety

BLAST-RELATED INJURY

- **Primary** blast injury
  - Injury from the explosive materials
- **Secondary** blast injury
  - Injury from being hit by matter thrown by the explosion (i.e., projectiles)
  - Most common cause of death by blast injury
  - Head, neck, chest, abdomen, and extremities are particularly vulnerable
  - 10% will have eye injuries; can lead to blindness

BLAST-RELATED INJURY

- **Tertiary** blast injury
  - Injury from being thrown by the explosive blast and hitting against head against another object (e.g., wall or ground)
    - Closed head injuries
    - Factures, dislocations, amputations
- **Quaternary** blast injury
  - Injury from burns, toxic fumes, and others not covered above
  - Also includes exacerbation of chronic medical condition
- **Quinary** blast injury
  - Injury from toxic material absorbed by the body from the blast that affects the immune system and perhaps the autonomic nervous system, leading to an immediate hyperinflammatory state

PCS DIAGNOSIS (ICD-10)

- History of head trauma with LOC preceding symptom onset by a maximum of 4 weeks

- Symptoms in 3 or more of the following categories:
  - Headache, dizziness, malaise, fatigue, noise intolerance
  - Irritability, depression, anxiety, emotional lability
  - Subjective concentration, memory or intellectual difficulties w/o neuropsychological evidence of marked impairment
  - Insomnia
  - Reduce alcohol tolerance
  - Preoccupation with Sx's, fear of brain damage with hypochondriacal concern and adoption of sick role

MTBI AND POST-CONCUSSIVE SYNDROME (PCS)

- Diagnosed concussion
- PCS is a "hot topic" and heavily debated
- Diagnostic criteria can vary
  - Symptoms appearing within one week
  - Symptoms of at least 3 months' duration
- Symptoms typically resolve within 3-6 months
  - Roughly 10-20% have continued symptoms
- Persistent Post-Concussive Syndrome (PPCS)
  - Symptoms lasting longer than 3 or 6 months
- "Permanent" PCS???

PERSISTENT PCS (PPCS)

- "Miserable Minority"
- Prevalence estimates vary:
  - ≤ 5% by 6-12 months *(Iverson, 2005)*
  - *7-15%* have any symptoms one year postinjury *(Hall et al., 2005)*
  - 10-20% of MTBI pts who have persistent symptoms at 6-12 months and beyond *(Millis and Putnam, 1996)*
- Incidence of PPCS: ~ 27/100,000
  - Equal to annual incidence of Parkinson's Disease, Multiple Sclerosis, Guillain-Barre, motor neuron disease, myasthenia gravis combined *(Satz, et al., 1999)*

PCS CONSIDERATIONS

- PCS is not related to TBI severity
- PCS symptoms: non-specific (chronic pain, depression, PTSD & to a varying extent in the normal population)
- Increased stressors associated with increased symptoms
- Premorbid psychological factors
  - Certain persons may be more vulnerable to developing PCS
- Psychological maintenance of symptoms
  - Pathobiological injury begins the process, but emotional factors may maintain PCS

A "MUDDY" PICTURE

- mTBI in the military is often not a clean injury
- Symptom overlap between PCS, PTSD, depression, substance abuse and chronic pain, make accurate diagnosis very difficult
- Researchers suggest that mTBI may make persons more susceptible to PTSD, and PTSD symptoms may serve to exacerbate mTBI symptoms
- "Polytrauma triad" = TBI, PTSD, pain

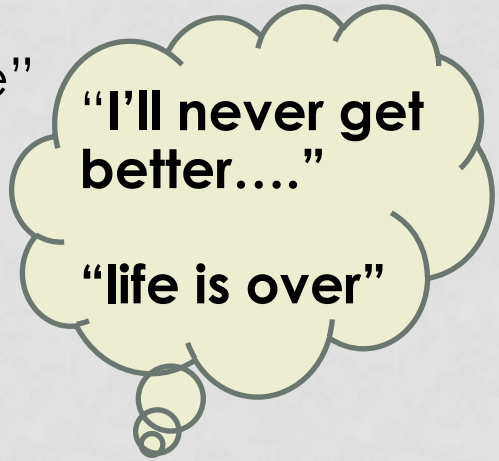
Symptoms	mTBI	PTSD
Experiencing Trauma	X	X
Re-experiencing symptoms		
Intrusive memories	X	X
Nightmares		X
Flashbacks		X
Distress at reminders		X
Avoidance symptoms		
Avoid reminders		X
Social detachments	X	X
Inability/partial recall of trauma	X	X
Diminished interest in activities	X	X
Sense of foreshortened future		X
Arousal symptoms		
Insomnia	X	X
Irritability or anger outbursts	X	X
Concentration problems	X	X
Hypervigilance		X
Exaggerated startle response		X

POST-CONCUSSIVE SYMPTOMS AND PTSD

- Research suggests that those who report experiencing "high stress" tend to report more post-concussive symptoms than those with "low stress"

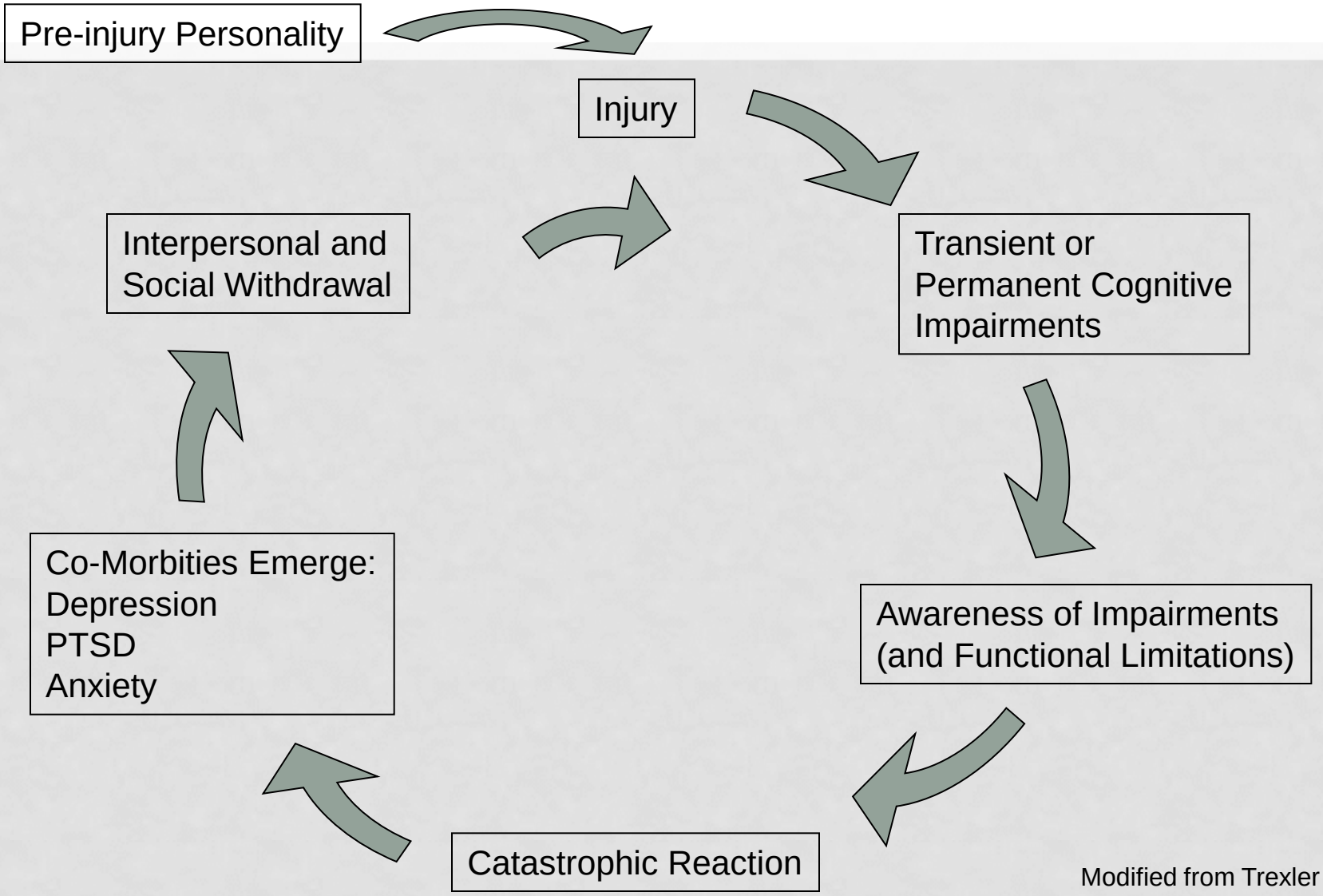
PSYCHOLOGICAL DISTRESS AND PCS

- Anxiety about significance of symptoms maintains selective attention
  - Expectations are reinforced
  - Become convinced "I have brain damage"
  - Cognitive distortions



- Elevated anxiety persists, because patient does not perceive he is improving over time
- Prior coping strategies may no longer be available
- Avoidant coping = strong negative effect on recovery

SPIRAL OF DETERIORATION



Modified from Trexler & Fordyce, 2000

POST-TRAUMATIC HEADACHE (PTH)

- Most frequent symptoms after TBI
  - Ranges from 30-90%
  - 18-22% last more than 1 year
- More likely to occur after mTBI than moderate to severe TBI
- Often resemble migraine headaches
- PTSD and sleep disturbances can complicate treatment of PTH and need to be treated
- Treatment options – medications and behavioral strategies

SLEEP DISTURBANCE

- One of the most common PCS symptoms
  - Insomnia type
- Review of the literature in 2009 (Orff et al.)
  - Sleep disturbance is a result of multiple factors related to the injury
  - More common among mTBI than moderate to severe TBIs
  - Can complicate course of recovery and resolution of PCS symptoms

SLEEP DISTURBANCE

- 114 veterans with blast-related mTBI
- 77% reported sleep disturbance
- Factors associated with report of sleep disturbance:
  - LOC at time of injury
  - Positive screening for PTSD
  - Presence of other emotional distress (anxiety / depression)
  - Pain (headache)
  - Fatigue
- VA recommends and provides Cognitive-Behavioral Therapy for Insomnia

(Farrell-Carnahan et al., 2013)

SOCIAL FACTORS

- Having a relative with TBI changes everyone in family
  - Role loss, caregiving expectations, financial and other pressures
- Can lead to increased depression, anxiety, frustration, stress for family members
- Family stress influences patient behavior

TREATMENT

TREATMENT FOR MODERATE TO SEVERE TBI

- Acute hospitalization – often trauma center
- Inpatient rehabilitation
  - Physiatry, PT, OT, ST, Neuropsychology, nursing
- Specialty nursing facility or L-TAC
- Residential programs
  - E.g., NeuroRestorative
- Outpatient rehabilitation
  - Specialized comprehensive brain injury programs
- Other community services
  - BIAI
  - VR
  - Resource Facilitation

TREATMENT FOR MTBI & PCS

- Military has adopted sports-related strategies to guide safe return to active duty
- Guidelines include:
  - Exposure to blast = 24 hr. rest period (unless required for a mission)
  - If diagnosed with mTBI = off duty until resolution of symptoms; minimum 24 hr. rest period
  - 2 documented mTBIs within 12-month period = off active duty for minimum of 7 days after resolution of symptoms
  - 3 documented mTBIs within 12-month period = comprehensive neurological examination, neuroimaging, if warranted, neuropsychological and functional assessment

TREATMENT FOR MTBI & PCS

- Premorbid psychological health is an important factor in symptom recovery of mTBI
- Symptom Treatment Hierarchy

1 Primary

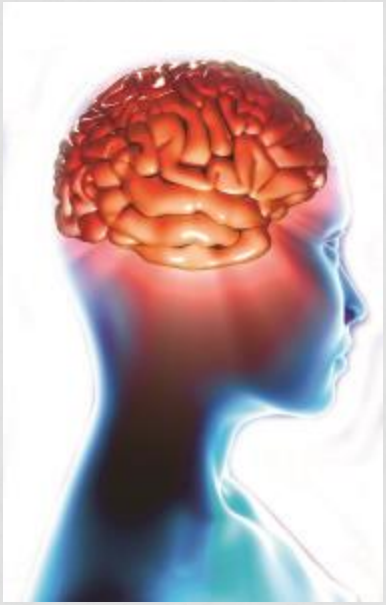
- Depression, anxiety and irritability
- Sleep disorder
- Post-traumatic headache

2 Secondary

- Balance
- Dizziness and vertigo
- Cognitive impairment
- Fatigue
- Tinnitus/noise intolerance

TREATMENT FOR MTBI & PCS

- The patient should be advised that a full recovery of symptoms is seen in the majority of cases
  - Provide education and support for first 3 months

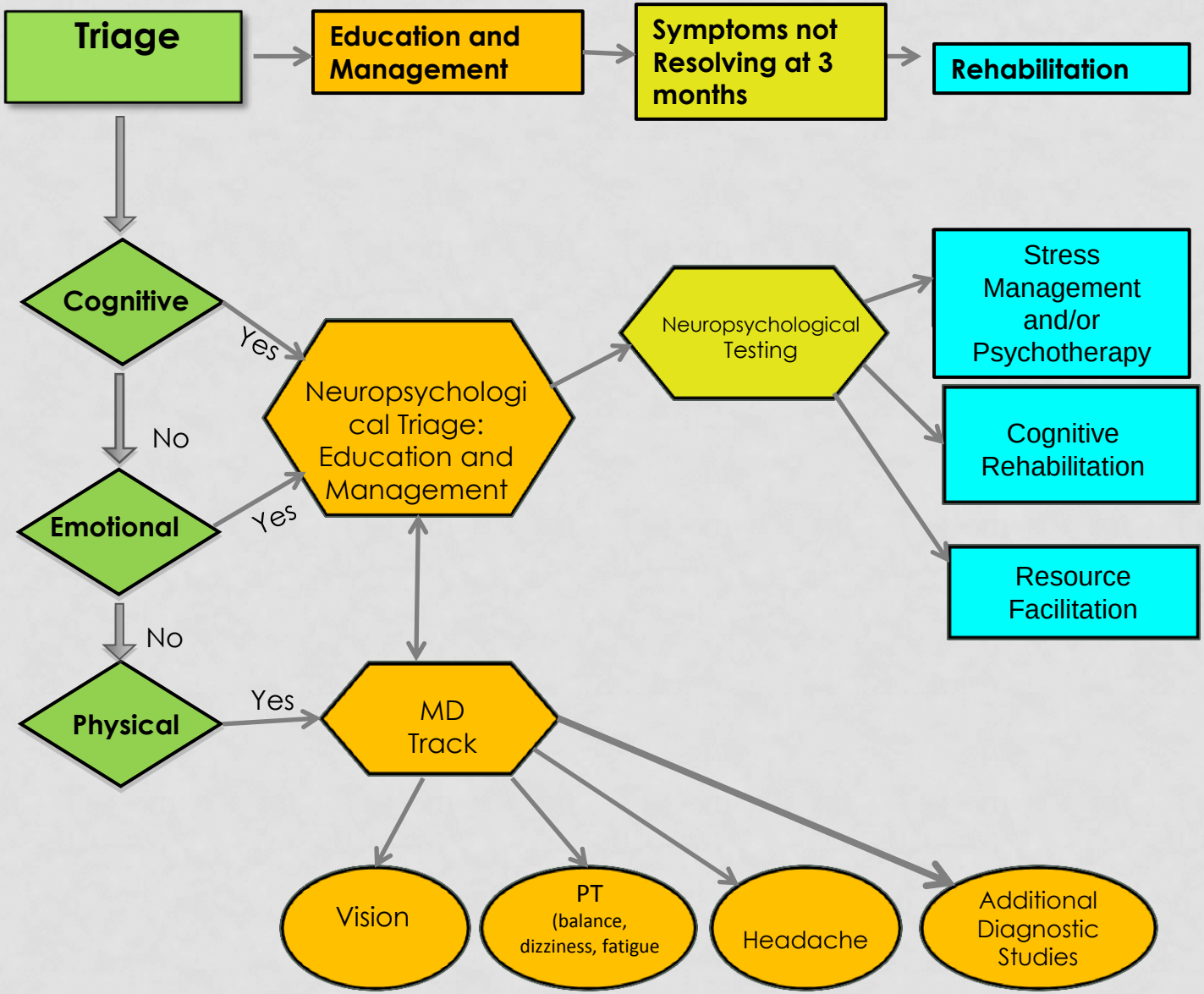


- For patients with
  - co-morbidiites or identified health risks and do not improve by one month, or
  - Persistent symptoms at 3 months post-injury, it is recommended that

The patient should be seen for a comprehensive evaluation at a specialized brain injury program

GUIDELINES: MANAGEMENT

- Education should be provided in printed material combined with verbal review and consist of:
  - Symptoms an expected outcomes
  - Normalizing symptoms
  - Reassurance about expected positive recovery
  - Gradual return to activities and life roles
  - Techniques to manage stress
- Patients with persisting cognitive symptoms should be referred for neuropsychological assessment to derive appropriate treatment recommendations
  - Cognitive rehabilitation
  - Stress Management or psychotherapy
  - Resource Facilitation for return to work
  - Family education and supports


Triage
Education and Management
Symptoms not Resolving at 3 months
Rehabilitation
Cognitive
Yes
No
Emotional
Yes
No
Physical
Yes
Neuropsychological Triage: Education and Management
Neuropsychological Testing
Stress Management and/or Psychotherapy
Cognitive Rehabilitation
Resource Facilitation
MD Track
Vision
PT (balance, dizziness, fatigue
Headache
Additional Diagnostic Studies

GOOD NEWS FOR MOST…

- Outcomes are generally positive
  - International Coma Data Bank: 83% of persons with PTA< 2 weeks had good outcome
  - Cognitive deficits resolve in 1-3 months
  - Other PCS symptoms commonly resolve within 12 months at the latest
    - True for 85-95% of veterans with MTBI
  - Majority of people recover from PCS in 3-6 months

TIPS ON MANAGING TBI & PCS SYMPTOMS

- Irritability and Anger
- Attention and Memory
- Slowed Processing Speed
- Sleep Disturbance
- Fatigue

- ***Mood swings, Anxiety, & Depression

IRRITABILITY AND ANGER

Rage

Anger

Frustration

Irritability

IRRITABILITY AND ANGER

- Prevention Strategies:
  - Learn your early warning signs
  - Know your triggers
  - Be prepared
- Loved ones can help too:
  - Give simple directions
  - Cue, don't criticize
  - Use empathy

IRRITABILITY AND ANGER

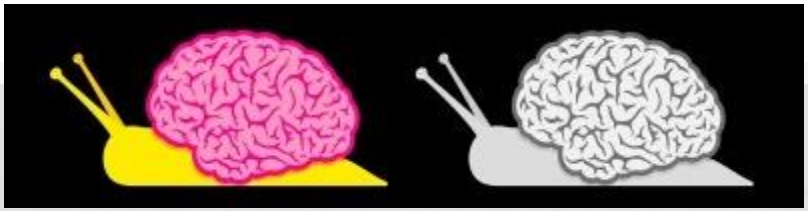
- Management Strategies:
  - Take a time out
  - "Take ten"
  - Use reassuring self-talk
    - "What will this matter in the grand scheme of things?"
  - Release your energy in productive way
    - Exercise; work on a hobby
  - Call a friend
- Loved ones can help:
  - Inquire if something is wrong
    - "No" means "No"
  - Avoid raising your voice
  - Involve them in decision-making

ATTENTION AND MEMORY

Attention
Focus on one task at a time
Break tasks into smaller steps
Work in a quiet area
De-clutter your environment
Use checklists
Prioritize tasks for best part of the day

Memory
Memory notebook; calendar; daily planner
Post visual reminders in key places
Structure a routine
Use alarms in phone
Keep items in the same place
Repeat new information

SLOWED PROCESSING SPEED



- Compensatory strategies:
  - Allow more time to complete a task
  - Let others know you are thinking of a response so they do not continue to ask more questions
  - Politely ask the other person to briefly stop talking so that you can process what they said before they continue

- Loved ones can help by:
  - Presenting information in smaller chunks
  - Giving the person with TBI opportunities to repeat it back to ensure it is understood and to promote memory for the information.

**Anxiety may also need to be addressed

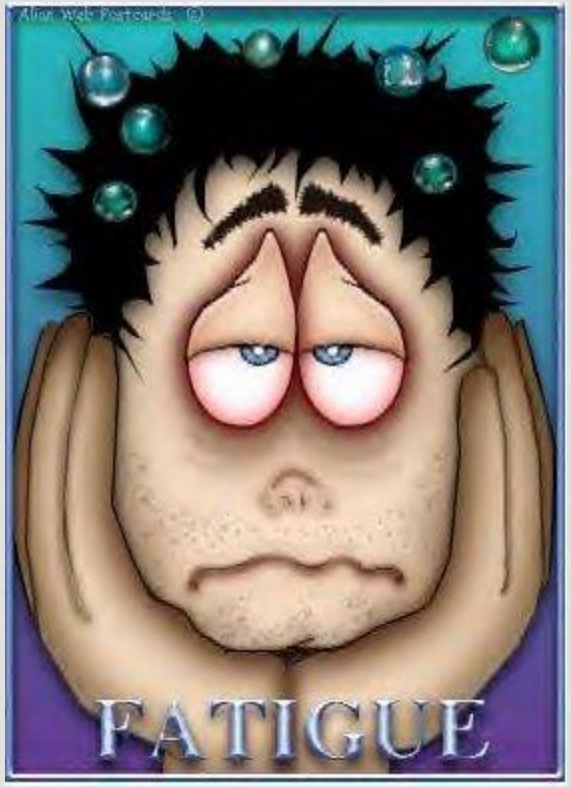
SLEEP DISTURBANCE

- Sleep hygiene tips:
  - Make a sleep routine and stick to it!
  - Consistent bedtime and wake time
  - Use relaxation techniques
  - Cool, comfortable, and dark environment
  - Get up after 30 minutes if can't fall asleep
  - Use earplugs or white noise machine

- Things to avoid:
  - Avoid daytime napping
  - Caffeine, alcohol, nicotine, & sugar 4-5 hours before bedtime
  - Don't eat or drink too much
  - Avoid heavy exercise 2-3 hours before bedtime
  - Do stressful activities in another room

FATIGUE

- Know your warning signs:
  - Increased mistakes
  - Feeling "stuck" or blocked
  - Increased pain
  - Feeling anxious/irritable
  - Increased sensitivity to light and sound
- Management strategies:
  - Maintain a healthy diet & exercise
  - Take pain meds as prescribed
  - Ask for help / delegate tasks
  - Pace yourself; take frequent breaks
  - Prioritize tasks for your best time of day
  - Avoid sensory overload
  - Learn to say "No"

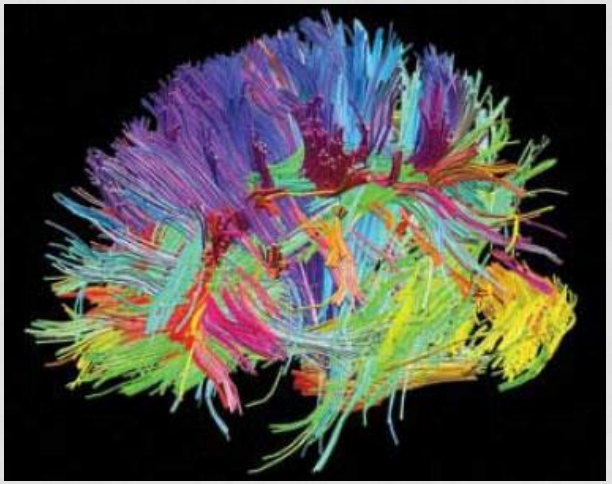


RESOURCES FOR MATERIALS ON TBI

- Lash Publishing
- Brain Injury Association of America
- Brainline.org
- Ontario Neurotrauma Foundation
  - mTBI and concussion guidelines
- DOD and VA TBI websites
  - DVBIC

FUTURE RESEARCH

- Still so much to learn!!
- DVBIC is involved in several on-going projects:
  - Validation of diagnostic tests (neuroimaging techniques)
- Questions to be answered???
  - Determine what prognostic factors are associated with long-term post-concussive symptoms and PTSD as there may be a delay in presentation
  - Identification of biomarkers



Diffusion spectrum image

REFERENCES

- Boyle, E., Cancelliere, C., Hartvigsen, J., Carroll, L. J., Holm, L. W., & Cassidy, J. D. (2014). Systematic review of prognosis after mild traumatic brain injury in the military: Results of the international collaboration on mild traumatic brain injury prognosis. *Archives of Physical Medicine and Rehabilitation, 95(S2),* 230-237.
- BrainLine Military. (2010). Blast injuries and the brain. Retrieved on August 7, 2014 from http://www.brainlinemilitary.org/content/2010/12/blast-injuries-and-the-brain.html
- Cifu, D. X., et al. (2013). Traumatic brain injury, posttraumatic stress disorder, and pain diagnoses in OIF/OEF/OND veterans. *Journal of Rehabilitation Research and Development 50,* 1169-1176.
- Elder, G. A., & Cristian, A. (2009). Blast-related mild traumatic brain injury: Mechanisms of injury and impact on clinical care. *Mount Sinai Journal of Medicine, 76,* 111-118.
- Farrell-Carnahan, L., Franke, L., Graham, C., & McNamee, S. (2013). Subjective sleep disturbance in veterans receiving care in the Veterans Affairs polytrauma system following blast-related mild traumatic brain injury. *Military Medicin, 178,* 951-956.
- Fischer, H. (2014). A guide to U.S. military casualty statistics: Operation New Dawn, Operation Iraqi Freedom, and Operation Enduring Freedom. Congressional Research Service.
- Hoge, C. W., McGurk, D., Thomas, J. L., Cox, A. L., Engel, C. C., & Castro, C. A. (2008). Mild traumatic brain injury in US soldiers returning from Iraq. *New England Journal of Medicine, 358,* 453-463.
- Kennedy, J. E., et al. (2007). Post-traumatic stress disorder and posttraumatic stress disorder-like symptoms and mild traumatic brain injury, *Journal of Rehabilitation Research and Development,* 44, 895-920.
- King, N. S., & Kirwilliam, S. (2013). The nature of permanent post-concussion symptoms after mild traumatic brain injury. *Brain Impairment, 14,* 235-242.
- Legome, E. L. (2013). Postconcussive Syndrome. Retrieved on August 11, 2014 from http://emedicine.medscape.com/article/828904-overview
- Lemonick, D. M. (2011). Bombings and blast injuries: A primer for physicians. *American Journal of Clinical Medicine, 8(3)*, 134-140.
- Orff, H. J., Ayalon, L., & Drummond, S. P. (2009). Traumatic brain injury and sleep disturbance: A review of current research. *Journal of Head Trauma Rehabilitation, 24,* 155-65.
- Ruff, R.M. , et al. (2009). Recommendations for diagnosing a mild traumatic brain injury: a National Academy of Neuropsychology education paper. *Archives of Clinical Neuropsychology, 24,* 3-10.
- Theeler, B., Lucas, S., Riechers, R. G., & Ruff, R. L. (2013). Post-traumatic headaches in civilians and military personnel: A comparative, clinical review. *Headache, 53,* 881-900.
- http://www.mayoclinic.org/diseases-conditions/traumatic-brain-injury/basics/definition/con-20029302
- http://emedicine.medscape.com/article/326510-overview
- http://dvbic.dcoe.mil/about-traumatic-brain-injury/article/tbi-basics
- http://www.merckmanuals.com/professional/injuries_poisoning/mass_casualty_weapons/explosives_and_blast_injuries.html