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Traumatic Brain Injuries in Adults

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Introduction & Brief background

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Learning Objectives

- Define Traumatic Brain Injury (TBI)
- Understand incidence & prevalence rates
- Discuss TBI risk factors and healthcare disparities
- Appreciate TBI classification
- Understand prognosis
- Discuss areas of intervention for chronic phase management

TBI Definition

- At the most basic level, a TBI is an injury that affects how the brain functions
- There are 4 main types:
 - Mild TBI / mTBI or concussion
 - Mild Complicated TBI
 - Moderate TBI
 - Severe TBI

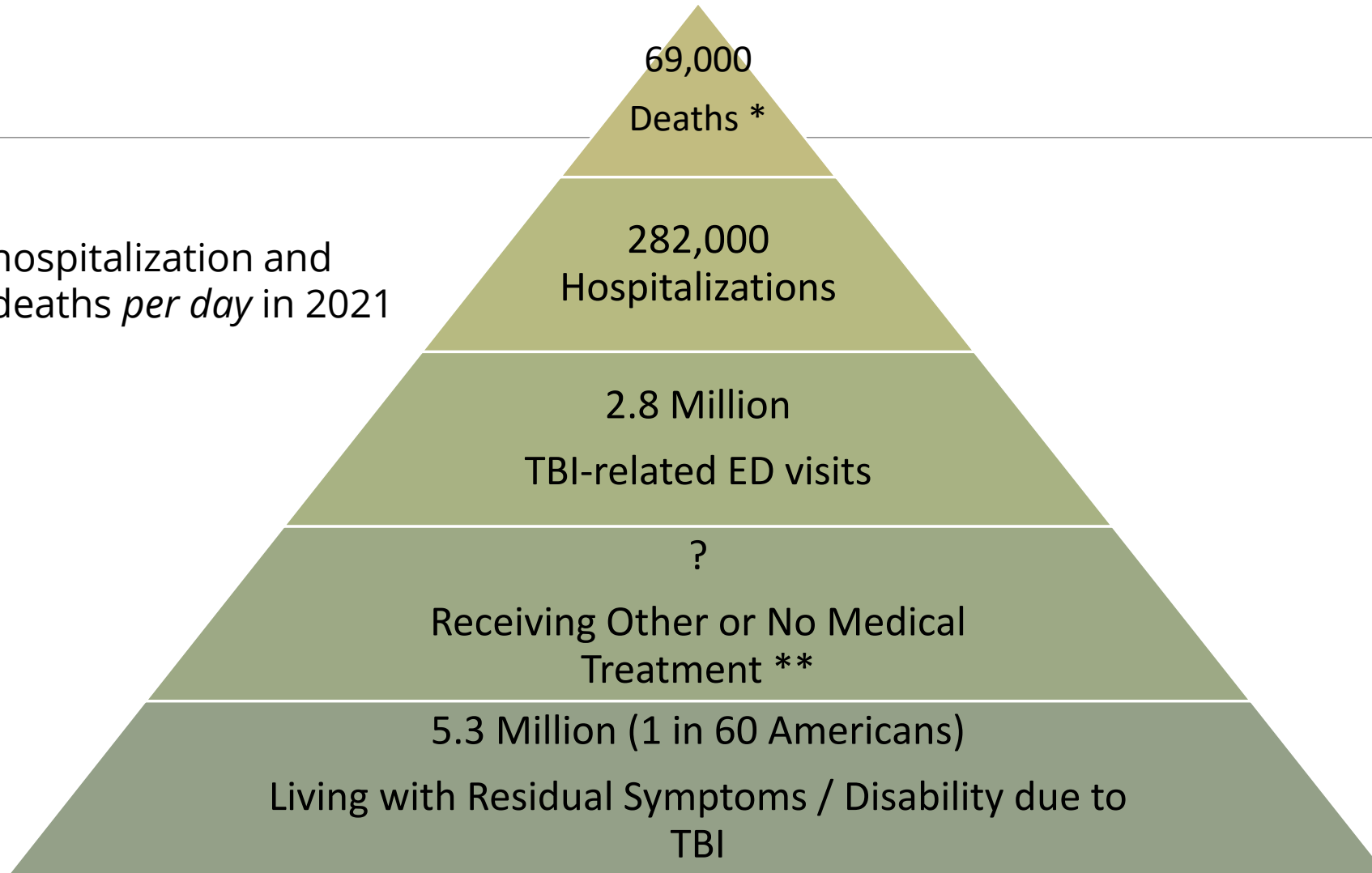
https://www.cdc.gov/traumaticbraininjury/get_the_facts.html

TBI Definition

- “**Moderate to Severe Traumatic Brain Injury** results from damage to brain tissue caused by an external mechanical force, as evidenced by loss of consciousness, posttraumatic amnesia (PTA), positive neuroimaging, or objective neurological findings that can reasonably be attributed to TBI on physical examination or mental status examination.”
- “**Uncomplicated Mild Traumatic Brain Injury**, often referred to as concussion, involves a traumatically induced physiological disruption of brain function that results in a graded set of clinical symptoms that most often resolve spontaneously. Alteration or loss of consciousness and other transient neurologic signs are typically used to define mTBI.”
- Defined separately due to very different recovery courses / outcomes

(Stucky, Kirkwood, and Donders, 2020)

TBI Incidence & Prevalence



~ 611 TBI-related hospitalization and
~ 190 TBI-related deaths *per day* in 2021

TBI Incidence & Prevalence

- 70 – 80% of injuries that occur annually are classified as mild
 - 25% do not seek care following mild TBI
- 20 % of injuries are moderate
- 15-20% of injuries are severe
- People age 75 years and older have the highest numbers and rates of TBI-related hospitalizations and deaths
 - This age group accounts for ~ 32% of TBI-related hospitalizations and 28% of TBI-related deaths
- Males were nearly 2 times more likely to be hospitalized and 3 times more likely to die from a TBI than females

◦ (Stucky, Kirkwood, and Donders, 2020)

◦ https://www.cdc.gov/traumaticbraininjury/get_the_facts.html

◦ <https://www.cdc.gov/traumaticbraininjury/data/index.html>



Primary Mechanisms of TBI

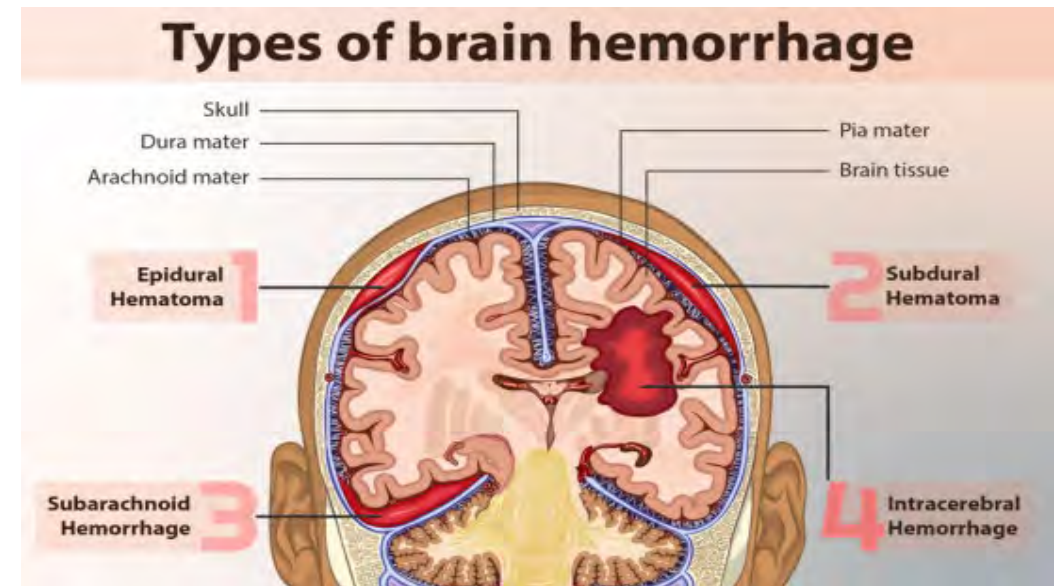
- Falls lead to nearly half of the TBI-related hospitalizations
- Motor vehicle related incidents
- Assaults / being struck by or against an object
- Firearm-related injury
 - More likely to result in Penetrating Brain Injury with different outcomes / focal injury versus diffuse injury associated with traumatic causes

https://www.cdc.gov/traumaticbraininjury/get_the_facts.html

(Stucky, Kirkwood, and Donders, 2020)

TBI Risk Factors

- Age is an independent risk factor, with cause varying by group:
 - 0-7 years: falls and child abuse
 - 15-19 years: motor vehicle related injuries
 - 65 and older: falls
- Relative to younger adults, individuals age 60+ are 4X more likely to develop chronic subdural hematoma
 - Likely related to widening of the cortical sulci with aging and increased bridging vein vulnerability

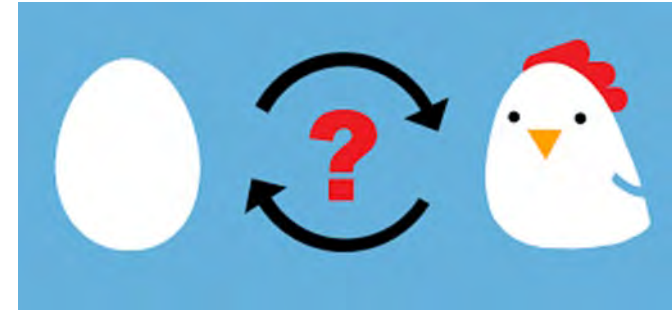


(Stucky, Kirkwood, and Donders, 2020)

https://www.cdc.gov/traumaticbraininjury/get_the_facts.html

TBI Risk Factors

- Other risk factors include:
 - Alcohol / substance use disorder
 - Engagement in high risk behavior
 - Male gender (2:1)
 - History of prior TBI
 - Psychiatric illness
 - Depression, anxiety, behavioral / externalizing disorders such as Conduct Disorder
 - ADHD
 - Lower SES and / or educational achievement
 - Unemployment



(Stucky, Kirkwood, and Donders, 2020)

https://www.cdc.gov/traumaticbraininjury/get_the_facts.html

Health Disparities in TBI

- While anyone can be at risk for sustaining a TBI, certain groups are at highest risk for sustaining a TBI and having poorer outcomes
 - Racial and ethnic minorities
 - American Indian/Alaska Native:
 - Higher rates of motor vehicle crashes, substance use, and suicide, as well as difficulties in accessing appropriate healthcare
 - Black and Hispanic patients:
 - less likely to receive follow-up care and rehabilitation compared to white patients
 - more likely to have poor psychosocial, functional, and employment-related outcomes
 - Military service members and Veterans
 - More than 450,000 U.S. service members were diagnosed with a TBI between 2000 and 2021
 - The majority occur when person is not deployed, such as in MVC
 - People who experience homelessness
 - 2 – 4x more likely to have a history TBI
 - up to 10x more likely to have a history of a moderate or severe TBI



Health Disparities in TBI (cont'd)

- While anyone can be at risk for sustaining a TBI, certain groups are at highest risk for sustaining a TBI and having poorer outcomes
 - People who are in correctional and detention facilities
 - Almost half (46%) of people in correctional or detention facilities such as prisons and jails have a history of TBI
 - Survivors of intimate partner violence (IPV)
 - Survivors of IPV who have a TBI due to an assault are more likely to:
 - be diagnosed with PTSD, insomnia, and depression
 - report worse overall health
 - People living in rural areas
 - More likely to die from a TBI due to:
 - More time needed to travel to emergency medical care
 - Less access to a Level I trauma center (the highest level of medical care)
 - Difficulty getting services, such as specialized TBI care
 - Lower income and those without health insurance





TBI Classification

Assessment of Injury Severity: Acute Factors

- Loss of consciousness (LOC)
- Glasgow Coma Scale (GCS) Score
 - In the field and ED / 30 minutes post injury
 - Score ranges from 3-15 and assesses eye opening (1-4 points), verbal response (1-5 points), and motor response (1-6 points)
- Neuroimaging
 - CT preferred initially to determine fracture or hemorrhage
- Length of coma
- Time to follow commands (GCS motor score = 6)
- Length of confusion post injury / Post traumatic amnesia (PTA)
 - Single best predictor

(Stucky, Kirkwood, and Donders, 2020)

Post Traumatic Amnesia (PTA)

- Also referred to as post traumatic confusion
- Two definitions:
 1. Time from injury to when patient displays continuous memory
 2. Time from emergence from coma (i.e., GCS motor score of 6) to when patient displays continuous memory
- Length of PTA typically set at 2 – 3 consecutive days that the patient is able to demonstrate a measurable level of continuous memory
 - For example: Obtaining a score of 25 + / 30 on the Orientation Log / O-Log for 3 consecutive days

(Stucky, Kirkwood, and Donders, 2020)

Severity Determinants: Cautions and Considerations

- Severity cannot be determined without accurate and objective information obtained during the acute injury period (must review medical record)
- Researchers have proposed various classification systems, but currently, there is no universally accepted TBI classification system
- Not all TBIs are created equal
 - Each patient will have a unique outcome
 - Age, premorbid conditions (i.e., the brain that the TBI happens to), extent (including location) of injury and secondary injury / ies
- A CT scan and MRI of the brain are often necessary after injury. However, these studies will sometimes be normal in patients with clear signs of neurologic compromise due to TBI
 - Lesson: Absence of evidence is not evidence of absence
- No one injury parameter or test is definitive in determining injury severity
 - An extremely wide variation in objective test and clinical findings can be found in all degrees of TBI severity
 - Factors to assess severity could be suppressed by non-neurologic factors
 - Ex: Alcohol / substance use

	mTBI / Concussion	Mild Complicated TBI	Moderate TBI	Severe TBI
GCS	13-15	13-15	9-12	3-8
LOC	0-30 mins	0-30 mins	30 mins – 24 hours	>24 hours / Coma
Neuroimaging	Negative	Positive	Positive or Negative	Positive or Negative
PTA	<24 hours	<24 hours	1 to 14 days*	>14 days*
Prognosis	Anticipate return to baseline. Education to reduce iatrogenic effects. Consider potential impact of comorbidities in older adults.	May recover similar to mTBI or Moderate TBI → refer to Neuropsychology	The more severe the injury, the higher likelihood of ongoing deficits and ongoing need for assistance. Recommend referral for Neuropsychological evaluation to track cognitive status over time and update treatment recommendations to support realistic goals.	

*May vary pending how PTA is tracked and by setting

Concussion / mTBI

- Concussion should be diagnosed based on evidence of an acute biomechanical force causing **IMMEDIATE** neurologic disturbance and **not** on signs and symptoms that appear weeks or months later
- An isolated concussion typically **resolves** within days to weeks
- Focus on gradual increase in activity as tolerated
 - NO MORE “CACOON THERAPY”
- Resolution of concussion symptoms are often prolonged due to **non-injury variables**
- **Expectation** of recovery is critical to optimal patient outcomes
 - Early patient education discussing the expected recovery following a concussion diagnosis is known to reduce the number and duration of post-concussive symptoms

(https://www.cdc.gov/traumaticbraininjury/mtbi_guideline.html; Kennedy & Moore, 2010; Bradford, 2015; Helmick et al., 2015)

Concussion / mTBI Iatrogenic Effects

Iatrogenesis = the **inadvertent and preventable** induction of disease or complications during the process of providing medical care.

Most Common Symptoms of Mild TBI Compared to Symptoms of Everyday Stress

Symptoms	Symptoms of mTBI: % of Patients	Symptoms of Everyday Stress: % of Patients
Poor concentration	71%	14%
Irritability	66%	16%
Tired a lot more	64%	13%
Depression	63%	20%
Memory problems	59%	20%
Headaches	59%	13%
Anxiety	58%	24%
Trouble thinking	57%	6%
Dizziness	52%	7%
Blurry or double vision	45%	8%
Sensitivity to bright light	40%	14%



Physical

- Bothered by light or noise
- Dizziness or balance problems
- Feeling tired, no energy
- Headaches
- Nausea or vomiting (early on)
- Vision problems



Thinking and Remembering

- Attention or concentration problems
- Feeling slowed down
- Feeling foggy or groggy
- Problems with short-term memory
- Problems with long-term memory
- Trouble thinking clearly



Emotional

- Anxiety or nervousness
- Irritability or easily angered
- Feeling more emotional
- Sadness



Sleep

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

Things We Normally Forget

“Symptoms”	% of People
Forget telephone numbers	58%
Forget people’s names	48%
Forget where car was parked	32%
Lose his car keys	31%
Forgets groceries	28%
Forget why they entered a room	27%
Forgets directions	24%
Forgets appointment dates	20%
Forget store location in shopping center	20%
What is his items around the house	17%
Loses wallet or pocketbook	17%
Forgets content of daily conversations	17%

Mild Complicated TBI

Recovery Expectations

- Long term recovery can be variable, from similar to concussion with relative return to baseline, versus similar to moderate TBI with persisting deficits / disability
- As such, recommend neuropsychological evaluation to assess cognitive status / recovery and inform treatment / recommendations
 - Oversight or assistance with higher level daily activities / IADLs (e.g., medication management, financial management, cooking)
 - Can the person return to work? Would they benefit from accommodations?
 - Return to driving?



Moderate and Severe TBI

- The most amount of recovery occurs in the first few months, although recovery is expected for up to one year post injury (and beyond)
- Recovery occurs in stages:
 1. Acute medical care – treatment and medical stabilization. Prevention of secondary injury
 2. Acute inpatient rehabilitation – remediation of deficits, compensatory strategies and adaptation, family education and support with the goal for the individual to return to the community setting
 3. Ongoing rehabilitation therapies (home health and or outpatient) AND
 4. Ideally, intermittent meetings with an interdisciplinary team (PM&R, PT, OT, SLP, Rehab/ Neuropsychology, CM / SW) to support treatment needs and establish realistic goals

Moderate to Severe TBI: Acute Recovery Considerations

- Acute treatment and rehabilitation may focus on:
 - Tracking command following and or PTA
 - Use of environmental modifications (low stimulation) and “brain breaks” to support recovery
 - Support the individual and their family in implementing a consistent and structured daily routine with adequate rest breaks which may in turn support normalizing sleep-wake cycle disturbances
 - Consider need for assessment of medical decision making capacity due to areas of cognitive deficit
 - Medication management of behavioral concerns (e.g., verbal or physical / psychomotor agitation; poor initiation)
- Expect initial cognitive impairment predominantly in attention, memory, processing speed and executive function
- Patients may also demonstrate changes in other aspects of emotional or behavioral function:
 - Irritability
 - Apathy
 - Poor self awareness
 - Acting inappropriately / disinhibited
 - Emotional lability

Moderate to Severe TBI: Acute Recovery Considerations

- SLP may begin to teach cognitive compensatory strategies and construct external memory aids (EMAs) to support the individual in consistent orientation
- Injury summary / “Face sheet” recommended to help the individual understand their injury, increase insight / awareness of current deficits, and identify 2-3 primary goals at each stage of treatment
- Anticipate the most amount of recovery to occur within the first few months post injury
- Recovery will continue for up to one year post injury (and beyond), although objective gains may taper over time
- In general, long-term recovery is variable, with more severe injuries resulting in progressively higher probability of long-term impairments
- However, some individuals with severe TBI eventually experience good overall functional recoveries following rehabilitation
- AND although residual cognitive deficits may persist, some individuals are able to return to independent living, driving, and / or employment with consistent use of cognitive compensatory strategies and support



Post Acute Assessment Tips

Assessment of Injury Post Hospital Discharge

- Subacute stage = > 3 months
 - Brain MRI may be helpful to assess chronic damage
 - Requires **objective** information regarding injury parameters **obtained via medical record review**
 - Cannot determine injury severity based on cognitive test performance (SLUMS, MoCA, Neuropsych Data)
- Interview/Intake questions:
 - Have you ever hit your head so hard that you lost consciousness or needed to get medical care?
 - Mechanism? (MVC? Attack / blunt force?)
 - Would this mechanism reasonably result in a traumatic brain injury? For example: Bumping your head on a cupboard door may not result in a concussion
 - LOC (how long did the person feel dazed or confused, or was unconscious following the injury)
 - Use caution with subjective reports as they are likely to be inaccurate
 - Posttraumatic Amnesia (PTA) - can person recall the events leading up to and following the injury w/o huge gaps
 - Interventions (PCP or hospital admission)
 - Neuroimaging (MRI/CT notes possible trauma residuals)
 - Related Injuries (e.g., broken nose, ribs, or other bodily injuries)
 - Return to ADLs, IADLs? How quickly?

Subacute Assessment Caution

- Retrospective analysis is prone to error
- If injury is moderate to severe, the person is unlikely to be the most reliable source due to their brain injury
- Avoid the Dose Response Bias
 - Mild TBI ≠ Mild deficits
- “Good old days” bias in mTBI
 - Tendency to view oneself as healthier in the past and to underestimate past problems
 - Somatic and or mental health symptom experiences prior to concussion and associated with post concussion symptoms are often minimized
 - Patients with concussion consistently underestimate the normal prevalence of post concussion symptoms in their retrospective reports

TBI Classification & Assessment and Key Points

- For concussion, be mindful of symptom onset
 - Delayed vs. immediate cognitive symptom onset
- Injury classification must be made based on acute factors gathered from the medical record
 - Cannot determine injury severity based on cognitive assessment or subjective report alone
- Concussion vs Moderate or Severe TBI have different recovery trajectories
 - Expect resolution of concussion symptoms in the majority of cases
 - Moderate or Severe TBI are chronic conditions
- In concussion, treatment should be geared toward
 - Reducing iatrogenic effects and education
 - Consideration of co-occurring conditions that may exacerbate unresolved symptoms
- Moderate and Severe TBI, treatment and management should be geared toward:
 - Individually tailored treatment that accounts for the survivors unique cognitive strengths and weaknesses to support CRT and optimize quality of life
 - Mitigating risk factors and navigating adjustment to abilities post injury
 - Account for cognitive, physical, and emotional sequela of the survivor and their family





Treatment & Intervention Considerations

TBI Treatment - CRT

- Inpatient (Acute phase) & Outpatient (Chronic phase)
 - Cognitive rehabilitation therapy (CRT)
 - Can be provided by SLP, OT (functional cognition), and or trained master's level clinicians or Rehab / Neuropsychologists
 - Remediation / Restoration of lost function
 - Compensation / Adaptation to minimize the cognitive impairments
 - Aim is to maximize or optimize skills, while learning new ways of doing things to minimize the problems (e.g., compensation)
 - Individually tailored treatment informed by a comprehensive neuropsychological evaluation to inform cognitive status and integrate appropriate interventions targeted at weaknesses
 - Neuropsychological evaluations (NPE) should be done **after** resolution of Posttraumatic Amnesia



TBI Treatment – CRT (cont'd)

- Inpatient (Acute phase) & Outpatient (Chronic phase)
 - MUST ensure goals are meaningful and functionally relevant
 - Overall Goals of CRT:
 - Reduce symptoms
 - Improve daily function / support the highest level of functioning under the person's new abilities
 - Improve the well-being / overall quality of life of the individual



How Does CRT Work?

- **Neural Plasticity**

- The capacity of neurons to structurally and functionally adapt
- Functional improvement after brain injury is a **relearning process** that involves neural plasticity
- The three basic neural strategies mediating functional improvement after brain injury are: **restoration, recruitment, and retraining**
- The **same** fundamental neural and behavioral signals driving plasticity during learning in the intact brain are engaged during relearning in the damaged brain
- Adjunctive therapies can aid in CRT by enhancing endogenous neural plasticity during treatment
 - Aerobic exercise and BDNF hypothesis
 - Social Skills training and psychotherapy for mood regulation

Caution: CRT in Concussion

- May be considered only when symptoms do not resolve within 30-90 days
 - Want to allow time for recovery / treatment to avoid iatrogenesis
 - Also consider other potential factors to target for treatment (e.g., underlying / suboptimally managed psychiatric concerns and or consideration for substance use patterns)
- May also be considered for patients who have been refractory to treatment
- Trial of CRT should:
 - Be time-limited
 - Identify measurable goals
 - Relate to **reducing activity limitations** and improving participation
- A prolonged course of therapy in the absence of patient improvement is **strongly discouraged**

Caution: Computer Based Interventions

- “Brain games” on a computer
 - Benefits do not typically persist and or transfer to real life functions and skills
 - No real risk expect cost
- Exercise and enriching environments that are cognitively stimulating and allow for socialization show better outcomes



TBI: A Chronic Health Condition

March: Brain Injury Awareness Month

- Counteract notion of brain injury as a “one time event”
- Brain Injury Association of American (BIAA) as an agent to support TBI as a chronic health condition → TBI is NOT currently recognized as such
- Designation would support health insurance benefits as well as allocation of public health resources for study and surveillance
- Critical period is often after individuals are discharged from a hospital or rehab setting
 - What are the supports and ongoing treatment options?
 - Is there a brain injury specialist directing treatment?
- Survivors may experience an “invisible disability” and often discuss their life as before versus after TBI
 - See [Brain Injury: A Lifelong Journey - Brain Injury Association of America \(biausa.org\)](http://biausa.org)

Moderate & Severe TBI: Lifelong Conditions

- Result in physical, cognitive, emotional, and behavioral changes that impact function
- Focus on prevention or reduction of health consequences of TBI through chronic disease management model
- Those requiring inpatient rehabilitation are among the most severely injured and constitute less than 10% of all persons hospitalized with a TBI

Five-year outcomes of persons with TBI*



*Data are US population estimates based on the TBIMS National Database. Data refer to people 16 years of age and older who received inpatient rehabilitation services for a primary diagnosis of TBI.

* Data from the TBI Model Systems (TBIMS) National Database

- Contains data from the largest study of people with moderate or severe TBI who receive inpatient rehabilitation
- Includes information from the time of injury to the end of life

Moderate & Severe TBI: Lifelong Conditions

- Even after surviving a moderate or severe TBI and receiving inpatient rehabilitation services, a person's life expectancy is **9 years shorter**
- TBI increases the risk of dying from several causes. Compared to people without TBI, people with TBI are more likely to die from:



- People with moderate to severe TBI typically face a variety of chronic health problems that add costs and affect the survivor, their family, and their community
- Among those still alive 5 years after injury:
 - 57% are moderately or severely disabled
 - 55% do not have a job (but were employed at the time of their injury)
 - 50% return to a hospital at least once
 - 33% rely on others for help with everyday activities

Moderate & Severe TBI: What Can We Do?

- Ensure accurate diagnosis to inform prognosis and treatment planning
- Create an interdisciplinary team that supports the survivor after hospital discharge:
 - Neuropsychology
 - Rehabilitation Psychology
 - Rehabilitation therapies (PT, OT, SLP)
 - Physical Medicine and Rehab / PM&R management
 - PCP, Psychiatry, Neurology, Neurosurgery
- Once diagnosis is established, integrate proactive management using a chronic disease management model for risk factor modification
- Screen for and treat common, late-developing problems:
 - Depression and suicidal ideation screening should be routine
 - Assess substance use and or misuse
 - Monitor for weight gain secondary to reduced physical mobility and or medication management
 - Ask about quality of life and typical daily routine



Moderate & Severe TBI: What can we do?

- Educate patients and their families on self management and risk factors in an effort to prevent or reduce late-occurring problems
- With the support of neuropsychological evaluations over the course of recovery, account for cognitive strengths and weaknesses in all communications / medical decision making / treatment planning
 - Incorporate the teach back method to support attention and assess understanding
 - Provide written information for the survivor and or their loved ones to refer back to
 - Allow time to process information and provide information in terms appropriate for the survivor



Moderate & Severe TBI: What can we do?

- Educate and encourage lifestyles that **promote brain health**
 - Obtain adequate sleep
 - Engage in physician approved physical activity
 - Keep socially active
 - Keep cognitively active
 - Account for the impact of nutrition on brain health
 - Engage in enjoyed and meaningful activities on a daily basis to support purpose and meaning
- Support the survivor and family, in coordination with the interdisciplinary team, to identify realistic goals in the chronic stage of management
 - Can the survivor live independently? In a supported environment?
 - Can the survivor return to driving?
 - Could vocational rehabilitation be considered? Job coaching? Volunteering?





Questions? Comments?
Thank you!



RESOURCES

- Survivor and Family resources:
 - Cerebrofit: <https://cerebrofit.org/> (Survivors and family can follow on IG)
 - <https://brainwisemediacom/>
 - Navigating Neuropsychology Podcast episodes on Brain Health (great for patients!)
 - <https://www.navneuro.com/all-episodes/categorized/>
- Resources for Survivors, Family Members, and You!
 - Model Systems Knowledge Translation Center for TBI: <https://msktc.org/TBI>
 - CDC TBI and Concussion Resources for Health Care Providers: <https://www.cdc.gov/traumaticbraininjury/providers/index.html>
 - CDC Website: https://www.cdc.gov/traumaticbraininjury/pdf/TBI_Patient_Instructions-a.pdf
 - Brain Injury Association of America: <https://www.biausa.org/>

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