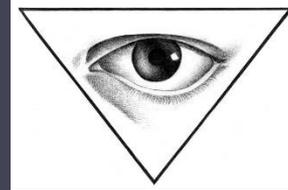


# Diagnosing Mild Traumatic Brain Injury; More than meets the



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# Learning Objectives

- Understand the challenges and necessary elements of a valid mild TBI (mTBI) diagnosis
- Differentiate between the diagnosis of mTBI and post-concussion syndrome or other residual effect of mTBI
- Describe the Chronic Effects of Neurotrauma Consortium (CENC) standardized method of diagnosing lifetime mTBI and learn to apply elements to research and clinical practice

# Poll Question #1

- What is your primary role in VA?
  - a) student, trainee, or fellow
  - b) clinician
  - c) researcher
  - d) Administrator, manager or policy-maker
  - e) Other

## Poll Question #2

- Which best describes your clinical role with regards to mild TBI?
  - a) First responder or emergency department
  - b) Primary care
  - c) Neurology or Rehabilitation
  - d) Neuropsychologic care or assessments
  - e) Other

# TBI Incidence in U.S.

- All severities incidence
  - almost 2 million injuries/year
- Mild TBI (mTBI) incidence
  - >80% of all TBI's are “mild”
  - estimated 1.5 million injuries/year
  - 30% of all high school football players
  - >10% of all OIF/OEF warriors



# Why is mild TBI a concern?

- Most common TBI severity level by a factor of 20x.
- Although “mild”, chronic difficulties may exist
  - Up to 20% may not fully recover within 3 months.
  - Post-concussion syndrome (PCS) = persistence of  $\geq$  TBI-like symptoms  $\geq$  3 months post-event
  - Focal problems may also persist in the absence of full-blown PCS
  - When present, these difficulties are similar to moderate and severe TBI and may be as or more bothersome, and have major impact on life functioning.
- Elevates risk for CTE?
  - Zero rigorous evidence that a single mTBI leads to CTE
  - ? evidence for link to repetitive mTBI is under active study by CENC and others

# Why is diagnosing mTBI challenging?

- TBI is entirely a “Clinical” diagnosis
- Criteria not precisely defined in terms of differential diagnosis (e.g. arrest, shock, syncope, toxicity, fear)
- No confirmatory tests exist
- Diagnosis may be entirely based on self-reported information
- Systematic or idiosyncratic clinical judgment issues
- In mTBI research, inclusion criteria often differ

# DoD/VA Common Definition of TBI

A traumatically induced structural injury &/or physiologic disruption of brain function resulting from external force

**Indicated by new onset or worsening of at least one of the following immediately following the event:**

## **Loss of consciousness (LOC)**

- Any period of LOC or decreased level of consciousness

## **Post-traumatic amnesia (PTA)**

- Any loss of memory for events immediately before or after injury

## **Alteration of consciousness (AOC)**

- Any change in mental state at the time of injury such as confused, disoriented, or slow thinking

## **Neurological deficits that may or may not be temporary**

- Weakness, loss of balance, change in vision, paralysis etc

## **Intracranial lesion**

- A demonstrated structural change to the brain

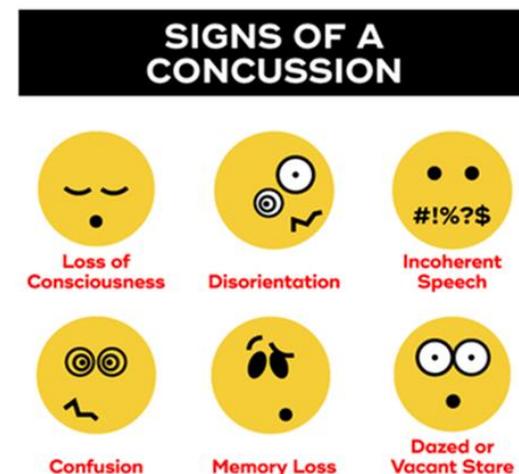
# The severity category of Mild TBI

*Mild TBI or mTBI = Concussion*

- Abnormal Initial Glasgow Coma Score  $\geq 13$ , &/or
- Loss of consciousness (LOC)  $\leq 30$  minutes, &/or
- Post-traumatic Amnesia (PTA)  $\leq 24$  hours, &/or
- Other evidence of immediate AOC consistent with TBI causality, &/or
- Immediate neurologic deficit c/w TBI causality\*
- **Provision: No intracranial abnormalities on head computerized tomography (CT)**

# AOC footnote in DoD/VA CPG on TBI diagnosis

- Alteration of mental status must be immediately related to the trauma to the head.
- Typical AOC exam findings:
  - Looking dazed and uncertain of what is happening
  - Being confused or disorientated
  - Difficulty responding appropriately to mental status questions
  - Being unable to describe events immediately before or after the trauma event
- Typical AOC symptoms:
  - Feeling dazed and uncertain of what is happening
  - Feeling confused
  - Having difficulty thinking clearly

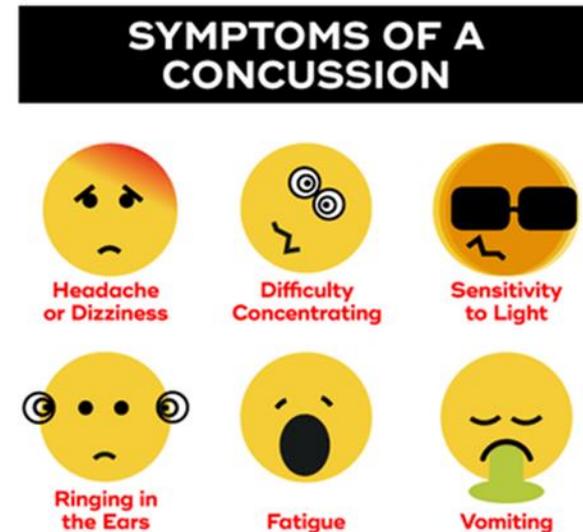


# TBI AOC has overlap with fear and acute stress responses

- Fear response
  - Driven by autonomic nervous system overdrive.
  - The ability to think and reason decreases as time goes on.
- Acute stress reaction can include:
  - Withdrawal
  - Narrowing of attention
  - Disorientation
  - Despair
  - Hopelessness
  - Grief
  - Anger
  - Heightened arousal

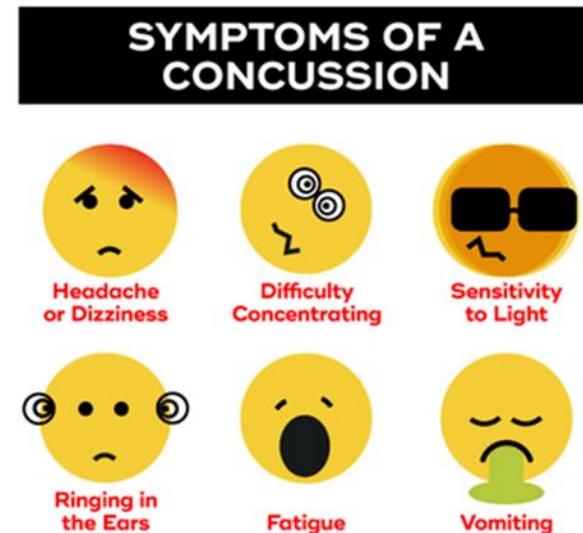
# Early Effects of TBI

- Symptoms
  - Somatic
  - Cognitive
  - Emotional
- Exam Findings
  - Subtle if any
  - Vestibular-Oculomotor
- Role in Diagnosis:
  - Not necessary
  - Can be used as supportive evidence only
  - Immediate AOC is still required



# Late Effects of mild TBI

- Symptoms
  - Somatic
  - Cognitive
  - Emotional
- Exam Findings
  - Rare and subtle if any
  - Vestibular-Oculomotor
- Role in Diagnosis:
  - None
- Postconcussion Syndrome
  - Positive mild TBI diagnosis
  - Persistence of  $\geq 3$  TBI-like symptoms for  $> 3$  months



# Diagnosis of mTBI versus late effects of mTBI (e.g. Post-concussion Syndrome)

- VA TBI screen
  - 4 elements:
    1. Traumatic event
    2. LOC/PTA/AOC immediately after event (e.g. TBI diagnosis)
    3. Early effects of TBI (TBI like symptoms right after event)
    4. Persisting effects of TBI (TBI like symptoms ongoing)
- Positive VA screen requires all 4 elements; thus:
  - Not intended to screen for any past TBI
    - If no active symptoms, historical TBI(s) will screen “negative”
  - Instead, screens for possible late effects of possible TBI
- Limiting to 1<sup>st</sup> 2 elements does screen for any past TBI

# Screening for mTBI: DoD PDHRA (January 2008)

9.a. During this deployment, did you experience any of the following events? **(Mark all that apply)**

- (1) Blast or explosion (IED, RPG, land mine, grenade, etc.)**
- (2) Vehicular accident/crash (any vehicle, including aircraft)**
- (3) Fragment wound or bullet wound above your shoulders**
- (4) Fall**
- (5) Other event (for example, a sports injury to your head). Describe:**

9.b. Did any of the following happen to you, or were you told happened to you, IMMEDIATELY after any of the event(s) you just noted in question 9.a.? **(Mark all that apply)**

- (1) Lost consciousness or got “knocked out”**
- (2) Felt dazed, confused, or “saw stars”**
- (3) Didn’t remember the event**
- (4) Had a concussion**
- (5) Had a head injury**

9.c. Did any of the following problems begin or get worse after the event(s) you noted in question 9.a.? **(Mark all that apply)**

- (1) Memory problems or lapses
- (2) Balance problems or dizziness
- (3) Ringing in the ears
- (4) Sensitivity to bright light
- (5) Irritability
- (6) Headaches
- (7) Sleep problems

9.d. In the past week, have you had any of the symptoms you indicated in 9.c.? **(Mark all that apply)**

- (1) Memory problems or lapses
- (2) Balance problems or dizziness
- (3) Ringing in the ears
- (4) Sensitivity to bright light
- (5) Irritability
- (6) Headaches
- (7) Sleep problems

**Positive screen = concurrence to all four questions**

**Positive screen ≠ concussion diagnosis**

**Need clinician confirmation to diagnose concussion**

## Poll Question #3

- Along with a sufficiently traumatic force to head, which of the following symptoms can alone be diagnostic for a mild TBI (select all that apply):
  - a) Memory gap of impact and immediate aftermath
  - b) Headache immediately after impact
  - c) Traumatic intracranial hemorrhage on head CT
  - d) Dazed and confused for several minutes after impact
  - e) Memory gap for the week before the event

# Immediate vs Delayed Evaluation

## Immediate Eval (during AOC)

- Validated, structured symptom measures and mental status examinations exist to assist the acute diagnosis



## Delayed Eval (after AOC)

- Identifying now resolved immediate AOC relies primarily or solely on self-report



# Alteration of Consciousness (AOC)

- AOC is the **clinical hallmark** of diffuse axonal injury, the primary pathology in TBI
- **PTA & LOC** are discrete clinical phenomena of the AOC spectrum
- Longer PTA (or LOC) = more severe TBI = worse outcome
- Identifying AOC is rarely a diagnostic challenge in Severe TBI
- **In Mild TBI identifying presence of AOC can be difficult**

## Delayed Eval: Sources for Evidence for Immediate AOC

- **Documentation** of History or Exam from First Responders & Urgent Care Providers
- **Witness** report
- **Self-report**, options:
  - Questionnaire format (e.g. VA TBI screen)
  - Unstructured Interview (e.g. typical clinical interview)
  - Structured Interview
  - Semi-structured Interview

# Early Documentation

- Advantages:
  - Relatively “objective”, especially when performed during AOC period
- Disadvantages:
  - Unless LOC or frank confusion is directly observed may not capture information needed to make diagnosis
  - Heavily dependent on skill, expertise, bias and diligence of assessor (witness report could be considered a type of early assessor)

Powell JM, et al. Accuracy of mild TBI diagnosis. Arch Phys Med Rehabil 2008;89:1550-5.

# Self Report: Questionnaire Format

- Advantages
  - Efficient
  - Can be done remotely
  - Standardized
  - Unbiased
- Disadvantages
  - Sensitivity/specificity depends on instrument and prevalence
  - Contradictory or illogical responses can not be vetted

# Self Report: Unstructured Interview

- Advantages
  - Can be individualized
  - Real time vetting of responses and tailoring of f/u questions
- Disadvantages
  - Heavily dependent on interviewer skill/experience
  - Interviewer bias even if skilled
  - Lack of standardization of content
  - Lack of transparency for reproducibility

# Self Report: Structured Interview

- Fully structured Interview
  - Advantages
    - Complete standardization
    - Unbiased
    - Maximal reliability (both inter-rater and test-retest)
  - Disadvantages
    - Efficiency
    - Availability
- Semi-structured Interview
  - Compromise between Un- and Fully Structured

# Evidence for Validity of Methods for diagnosing Mild TBI

- Emergency Department documentation of diagnosis
  - False negative rate of 56% in one study (Powell, 2008)
  - False positives not uncommon (anecdotal)
- Witness Report (if witnessed)
  - No psychometric data available
  - Often have only what the patient was “told” since rarely is the witness available during eval

# Validity of Self-Report

- Questionnaire
  - Scant psychometric data exists despite being primary tool in most published mild TBI identification studies of OIF/OEF population
  - Most are “screening” tools
  - What is gold standard to compare?
- Interview
  - Limited psychometric data
  - Which interview method is best?

# The Brief Traumatic Brain Injury Screen (BTBIS)

- self-report **questionnaire tool** for “probable” TBI
- **compared to semi-structured interview** in a military sample.
- Interview consisted of a series of **primarily open ended questions** with vetting of responses left up to judgment of the interviewer (Masters’ level psychologist or trained staff member)
- **15% of BTBIS pos were false pos** on interview
- False negatives were not sought since only screen positive soldiers were contacted for interview.
- Schwab KA 2007

# OSU TBI-ID (structured interview)

- Designed **for retrospective identification** of TBI
- **Very High inter-rater reliability for TBI with LOC** ( $r=0.9$ ) and # early effects ( $r=0.92$ ) in a Substance Abuse sample (Corrigan 2007); not assessed for mTBI without LOC
- **Mod high test-retest reliability for # early symptoms** ( $r=0.74$ ) and # early fxl effects ( $r=0.72$ ) in a Prisoner sample (Bogner 2009)
- **Reliability of individual items or profiles not reported**
- **Poor predictive validity** (late TBI effects)

## Traumatic Brain Injury Questionnaire (TBIQ)

- **Semi-structured interview** with 12 Y/N response items assessing for a possible TBI incident followed by open-ended interview of the incident(s) identified to determine dx
- **Test-retest reliability had moderate dx agreement** ( $k=0.56$ ) with trained research assistants conducting the interviews in a prison offender sample. (Diamond 2007)
- How open ended question responses were vetted was not reported and inter-rater reliability was not reported

# How CENC multicenter study is addressing these challenges

- Screening for all lifetime potential concussion events (PCEs)
  - Based on OSU TBI-ID
- Validated structured interview for each PCE that generates an algorithm diagnosis
  - VCU retrospective Concussion Diagnostic Interview (VCU rCDI)
  - Walker WC, et al. *J Neurotrauma* 2015;32(7):464-73.
- Open ended interview component to cross check structured interview along with any early/subacute documentation
- If doubt exists, additional unstructured interview may occur, then Site PI either:
  - confirms algorithm, or
  - overrides algorithm, or
  - refers to central diagnosis committee

## How structured interview addresses each component of DoD/VA Common Definition of TBI

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- Any loss of memory for events immediately before or after injury

### **Alteration of consciousness (AOC)**

- Any change in mental state at the time of injury such as confused, disoriented, or slow thinking

### **Neurological deficits that may or may not be temporary**

- Weakness, loss of balance, change in vision, paralysis etc

### **Intracranial lesion**

- A demonstrated structural change to the brain

# Traumatic Force

- Ask patient to describe event
  - If not divulged, ask what they were doing at time of the traumatic impact
  - If not divulged, ask what caused the event
  - If blast, ask about type and distance
  - If combat, motorcycle, or non-motorized transportation (bicycle, ski, skate, etc.) event, ask: Were you wearing a helmet at the time of the impact or sporting event?
- Ask: To your knowledge, was your head struck or did your head hit something?
  - If yes, ask: What struck your head? Or What did your head hit?

## VCU rCDI; open-ended interview component

- Please tell me in as much detail as possible what happened to you and what you felt during and right after this \_\_\_\_\_ (MVA, fall, assault, or etc. type of event)
- Instructions: *Make sure to get a clear narrative about events leading up to the \_\_\_\_\_ (traumatic event), information about the event, and information about what happened after the event including what he/she experienced physically and emotionally.*

# Post-traumatic Amnesia (PTA)

1. First probe recall of event, in particular the traumatic force/insult (e.g. blast, collision)
2. Second, probe for retrograde amnesia (missing memory for immediate beforemath)
3. Third, probe for antegrade amnesia (missing memory for immediate aftermath)

# Structured Interview of PTA

- Do you have personal memory of the impact (collision, fall, assault, or whatever type of traumatic impact was reported) itself?
- Is there a period of time just BEFORE the impact for which you have no personal memory of at all?
- If Yes:
  - What is the last thing that you personally remember occurring just BEFORE the impact?
  - How long was the period of time between [the above thing] and the impact?
- Is there a period of time just AFTER the impact for which you have no personal memory of at all?
- If Yes:
  - What is the first thing that you personally remember occurring just AFTER the impact?
  - How long was the period of time between the impact and [the above thing]?

## Sensitivity Check for False Negative PTA

- Review the prior answers: Does the pattern of responses show continuous memory of immediate fore math, event, and aftermath? (i.e. are responses Yes, No, and No?)
- If No: depending on pattern may have PTA
- If Yes, ask: It sounds like there are no holes or gaps in your memory from that day, is that correct?
  - If Yes, then PTA is ruled out by interview.
  - If No, inform patient: "I need to understand how this fits with the earlier questions," then re-administer questions PTA questions and repeat process. If this leads to identical responses then add unstructured interview to help sort out.

# Loss of Consciousness (LOC)

- Patients may not understand concept, so give definition
- LOC is a state that can't be remembered, so ask how they determined
- Structured interview for LOC:
  - Right after the impact did you become unconscious, that is, you could not see, speak, and move for any period of time?
  - If yes: Were you told this by a witness, or is this based upon your experience?
    - If not witness based: How did you determine this?
  - If yes: How long were you unconscious?
- Caveats:
  - Self determined LOC usually indicates a gap in memory (PTA)
  - Witnessed verified immediate LOC in context of traumatic force to head almost always rules in TBI
  - In CDI, algorithm handles self-determined versus witnessed LOC differently

## Structured Interview for other AOC symptoms

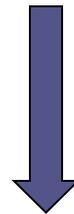
- Did you feel dazed?
- Did you feel confused?
- Did you “see stars”?
- If Yes for any also ask:
  - Did you feel dazed/confused/see stars immediately after the impact or was there a delay?
  - If Immediate, ask how long it lasted
  - If delayed, also ask how long after the impact did it start?

## mTBI diagnosis **Must Have:** Evidence of immediate AOC

- MSE during AOC window c/w AOC (or seizure)
- Patient Interview **after** AOC window
  - Witness corroborated LOC (or seizure)
  - Memory gap pattern c/w TBI physiology
  - AOC symptoms c/w TBI physiology

- Dazed
- Confused
- Saw Stars

Least specific



Most specific

Walker WC et al,  
*J Neurotrauma* 2015

## Poll Question #4

- Immediately after a traumatic event, feeling dazed for a minute or less could be due to:
  - a) TBI
  - b) Acute stress reaction
  - c) Fear response
  - d) All of the above

# CDC criteria for Mild TBI diagnosis

- Furthermore stipulates:

**Post-injury symptoms** (e.g., headache, dizziness, irritability, fatigue, or poor concentration) can be used to support, but **cannot be used to make**, a diagnosis of mild TBI in adults

# Structured Interview for symptoms supportive of TBI diagnosis

- Did your head ache?
- If Yes,
  - Did your head ache begin immediately after the impact or was there a delay?
  - If Delayed, did it start:
    - Within 2 weeks
    - More than 2 weeks after
- Did you have any other feelings or symptoms that you noticed right after or soon after the impact?
- If Yes, complete table below.
  - Other symptom: \_
  - Other symptom: \_

# Poll Question #5

- Headache after a traumatic event may be due to:
  - a) TBI
  - b) PTSD
  - c) Cervical whiplash
  - d) None of the above
  - e) All of the above

# Structured Interview for early medical evaluation

- Were you medically evacuated or treated immediately after the impact at an aid station or other medical center?
- If Yes,
  - Ask for treatment location.
  - Ask if admitted to hospital and for how long
- Importance:
  - is there potentially discoverable immediate or early documentation
  - If records not obtainable, moderate or severe TBI highly unlikely if not admitted to medical facility for a least 2 days

## Poll Question #6

- Along with a sufficiently traumatic force to head, which of the following symptom can be diagnostic for a mild TBI by itself (select all that apply):
  - a) Memory gap of impact and immediate aftermath
  - b) Dizziness & Tinnitus immediately after impact
  - c) Traumatic intracranial hemorrhage on head CT
  - d) Dazed and confused for several minutes after impact
  - e) Memory gap for the week before the event

# Summary VCU retrospective Concussion Diagnostic Interview

1. Cause of event
2. Open-ended query of what happened and what felt
3. Memory of impact
4. Memory gap of immediate beforemath
5. Memory gap of immediate aftermath
6. If 3=Y, 4=N, 5=N, confirm continuous memory
7. Loss of consciousness and how determined
8. Dazed, confused, or saw stars immediately after event
9. Headache or other symptoms immediately after event
10. If/where medically evaluated

## CENC experience with CDI algorithm

- Only 3% of diagnoses overturned
- Most common confounders:
  - Syncope
  - Intoxication
  - Asleep at time of event



