Traumatic Brain Injury and the Neuropsychological Evaluation

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Acknowledgements

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Objectives

• Know the applications of neuropsychological assessment and indications for referral
• Review components of a neuropsychological evaluation and domains of cognitive function
• Review the definition and natural history of mild brain injury/concussion and postconcussion syndrome
• Understand how neuropsychology can be useful in distinguishing between neurocognitive, psychological and other sources of cognitive complaints
The Neuropsychological Evaluation

- Review of medical, educational, and/or vocational records
- Clinical interview with client and collateral sources
- Objective, standardized tests assessing a variety of constructs sensitive to decline in brain injury or neurologic disease
- Test performance is compared to normative standards
  - Norms based on age, gender, education, and race/ethnicity
- Interpretive report with comprehensive treatment recommendations
- Assessment can take several hours
Neuropsychology or Psychiatric evaluation?

• Psychiatric testing
  – Structured (e.g., SCID-5) or clinical interview
  – Acute symptom behavioral inventories (e.g., Beck Depression Inventory-2)
  – Mental status exam (e.g., MMSE or MoCA)
Neuropsychological Tests vs. Cognitive Screens

• MMSE
  – has overabundance of false positives in persons >60 or with <9 years education

• MMSE has a low ceiling
  – those with high IQ will pass despite impairment, resulting in false negatives
  – Will not detect earliest phase of illness

• MMSE will not detect those with atypical presentation
  – Relatively insensitive to frontal-executive and subcortical dysfunction

• MoCA
  – 59% with perfect score were impaired on neuropsychological exam
  – high rate of false positives in persons with persons with limited education or low SES using recommended cut-offs.
The Neuropsychological Evaluation

- Has established clinical and diagnostic utility across multiple clinical disorders
- Sensitive to impaired cognitive function; can determine presence and magnitude of impairment
- Good predictor of later functional status, abilities and capacities
- Following TBI, neuropsychological tests have been shown to be useful in predicting post-injury work status (Machamer et al, 2005)
The Neuropsychological Evaluation: Domains

- Intellectual functioning
- Executive functions (reasoning, sequencing, problem-solving, planning, self-monitoring, inhibition)
- Attention and concentration
- Learning and memory
- Expressive and receptive language
- Visual-spatial cognition and visuomotor praxis
- Motor and sensory function
- Mood and personality
- Motivation and effort
The Neuropsychological Evaluation: Applications

1. Establish or confirm formal diagnoses (e.g., diseases, developmental disorders, trauma related conditions)
2. Identify cognitive strengths and weakness to establish rehabilitation strategies
3. Determine the magnitude and quality of deficits
4. Establish risk for patients considering elective neurosurgical intervention (e.g., epilepsy surgery, deep brain stimulation)
5. Assess cognitive/behavior side effects associated with treatment interventions
The Neuropsychological Evaluation: Applications in Occupational Health

1. Assess return to work readiness following injury or insult that may impair cognitive function (e.g., concussion, occupational exposure).

2. Evaluate individuals identified as having questionable or impaired performance for cognitive malfunction or decline.

3. Differentiation of neurologic dysfunction vs stress-related cognitive complaints
Traumatic Brain Injury
Classification of TBI by Severity

- Mild (Concussion)
- Moderate
- Severe
- Catastrophic

Operationalization - at time of injury
1. Duration of loss of consciousness
2. Initial score on Glasgow Coma Scale (GSC)
3. Length of posttraumatic amnesia (PTA)
Mild
LOC: 0-30 min
PTA: <24 hours
GCS: 13-15

Moderate
LOC: 30 min – 24 hours
PTA: 1-7 days
GCS: 9-12

Severe:
LOC: >24 hours
PTA: >7 days
GCS: 3-8

Catastrophic
dead

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<th>Glasgow Coma Scale</th>
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<tr>
<td><strong>BEHAVIOR</strong></td>
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<td>Eye opening response</td>
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<td>Best motor response</td>
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**Total score:**
Best response: 15
Comatose client: 8 or less
Totally unresponsive: 3
RTW after TBI

- Demographic factors
- Pre-injury characteristics
- TBI severity
- Age
- Physical health
- Behavioral health
- Employer support
- Job modifications/alternate duties
- Other financial support
- Multiple trauma
- Insight

- Neuropsychological domains better predict RTW
  - Intellectual functioning, particularly nonverbal reasoning
  - Memory
  - Speed of mental processing
  - Language
  - Executive skills (sustained attention, working memory, problem solving, organization)

- May be better at predicting RTW failure than success
Increased Diagnosis of Concussion
U.S. 2010-2015

- Age 20-64: 26% increase in concussion diagnosis
- Age 10-19: **71% increase** in concussion diagnosis. 49% more common in males, whose rate spikes in autumn.
- Age < 10: 22% increase
- Rates vary almost 3-fold between the 50 states, implying diagnostic variation between clinicians
- Increase due to increased awareness and lowered diagnostic threshold?

Mild TBI

- 80% of TBIs are mild, aka concussion
- Estimated 1.12 million per year in US (likely underestimate)
- Greater challenge to diagnose
  - Rapid resolution of acute signs and symptoms
  - Absence of objective neuroimaging findings
  - Lack of universally agreed upon criteria for mTBI
Concussion: American Congress of Rehabilitation Medicine 1993

- A traumatically induced physiological disruption of brain function manifested by at least one of the following:
  - Any loss of consciousness (LOC)
  - Any loss of memory for events immediately before or after the accident
  - Any alteration in mental state at the time of the accident (feeling dazed, disoriented or confused)
  - Focal neurologic deficits that may or may not be transient
  - LOC ≤ 30 min, after 30 min Glasgow Coma Scale (GCS) is 13-15, and posttraumatic amnesia (PTA) is ≤ 24 hours

  (J Head Trauma Rehabil 1993, 8, 86-87)
Problems with ACRM definition

- Focal deficits that may be persistent may herald a more severe TBI
- Patient report of feeling dazed, disoriented or confused are nonspecific
  - No significant differences between other injury (no TBI) and mTBI groups in feeling dazed (52% vs. 71%), disoriented (42% vs. 33%) or confused (65% vs. 67%) (Lees-Haley et al., 2001, Archives Clinical Neuropsychology, 689-695)
VA/DOD 2016 Criteria for TBI

- TBI is a traumatically induced structural injury and/or physiological disruption of brain function as a result of external force and is indicated by at least one of the following clinical signs immediately following the event:
  - Any period of LOC or decreased level of consciousness
  - Any loss of memory for events immediately before or after the injury (PTA)
  - Any alteration in mental state at the time of injury (confusion, disorientation, slowed thinking)
  - Neurological deficits (weakness, loss of balance, change in vision) which may or may not be transient
  - Intracranial lesion

https://www.healthquality.va.gov/guidelines/Rehab/mtbi/mTBICPGFullCPG50821816.pdf
## VA/DOD Classification of TBI Severity

(if criteria met in > 1 category of severity, assign the higher level of severity)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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<tbody>
<tr>
<td>Structural Imaging</td>
<td>Normal</td>
<td>Normal or Abnormal</td>
<td>Normal or abnormal</td>
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<tr>
<td>Loss of Consciousness</td>
<td>0-30 min</td>
<td>&gt;30 min and &lt;24 hours</td>
<td>&gt;24 hours</td>
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<tr>
<td>Alteration of consciousness/mental state</td>
<td>Up to 24 hours</td>
<td>&gt;24 hrs; severity based on other criteria</td>
<td>&gt;24 hrs; severity based on other criteria</td>
</tr>
<tr>
<td>Posttraumatic Amnesia (PTA)</td>
<td>0 – 1 day</td>
<td>&gt;1 and &lt;7 days</td>
<td>&gt;7 days</td>
</tr>
<tr>
<td>GCS (best available score in first 24 hrs)</td>
<td>13-15</td>
<td>9-12</td>
<td>&gt;7 days</td>
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</table>
Advantages of VA/DOD criteria

• Requires that definition of TBI be based on acute criteria, not on delayed onset of symptoms

• Presence of intracranial abnormality in someone who otherwise meets criteria for mTBI results in a moderate TBI classification
Complicated mTBI

- mTBI with acute structural abnormality (e.g., hematoma) on conventional neuroimaging
- Recovery course may be prolonged and may resemble those of more moderate TBI
Challenges in Assessing mTBI

• Measuring GCS
  – Recommended to assess 30 minutes after injury

• Determining LOC
  – PTA>LOC, thus self-report of LOC may not be reliable

• Determining PTA
  – What pt *recalls* vs what pt has been told or deduced
  – Assess last memory immediately before and after accident
    • Rule out other sources of amnesia
Concussion is a clinical diagnosis.

- No diagnostic guideline or set of criteria is a substitute for sound clinical judgment.
- 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.
Symptoms of Concussion/mTBI

Early symptoms (first 24 hours)
- Headaches
- Blurred vision
- Nausea/vomiting
- Drowsiness
- Dizziness

Late symptoms
- Fatigue
- Insomnia
- Poor memory/concentration
- Irritability or distress
- Photophobia/phonophobia
Recovery Course in mTBI

• Most methodologically rigorous data from sports concussion; assessment of athletes preseason and then recovery tracked after concussion

• Meta-analytic data indicate:
  - **Mild-to-moderate neuropsychological impairment within 24 hours** across domains, with large effect sizes in global functioning (d = 1.42), memory acquisition (d = 1.03), and delayed memory (d = 1.00).
  - **Cognitive effect is essentially zero beyond 7-10 days**

  (Belanger and Vanderploeg, 2005, JINS, 11, 345-57)
Design, Setting, and Participants  Prospective cohort study of 1631 football players from 15 US colleges. All players underwent preseason baseline testing on concussion assessment measures in 1999, 2000, and 2001. Ninety-four players with concussion (based on American Academy of Neurology criteria) and 56 noninjured controls underwent assessment of symptoms, cognitive functioning, and postural stability immediately, 3 hours, and 1, 2, 3, 5, 7, and 90 days after injury.
Long-Term Mild TBI Cognitive Outcome - All causes

- Studies are clear that vast majority of individuals display full recovery within days or weeks
- Controlled studies show no significant effect compared with appropriate orthopedic controls after 90 days
- For both adults and children, good cognitive and behavioral outcome demonstrated by multiple systematic reviews and meta-analyses.
Prolonged Course in mTBI

• While the vast majority of individuals recover well after mild TBI, a minority of individuals report persistent symptomatology

• Patients reporting persistent problems more likely to come to clinical attention which can result in biased view of outcomes by practitioners
Prolonged Course in mTBI

• “Postconcussion syndrome”
  – Refers to nonspecific symptomatology that persists after mTBI. Not a true syndrome because the symptoms are nonspecific and do not usually occur together.
  – No widely accepted pathology or diagnostic criteria
ICD-10 criteria for Postconcussion syndrome

- history of traumatic brain injury (TBI)
- presence of 3 or more of the following:
  1. headache
  2. dizziness
  3. fatigue
  4. irritability
  5. insomnia
  6. concentration or memory difficulty
  8. intolerance of stress, emotional excitement, or alcohol.
Increased Rate of Postconcussion Syndrome

- The percentage of concussion patients across all ages diagnosed with PCS nearly doubled across age groups 2010-2015
- Gender difference only in adults: 61% female.
Problem with symptom-based approach

• High base rate of symptoms in non-TBI population
  – Not specific to brain injury
  – Likely related to non-injury factors
Postconcussive symptom rates in non-injured controls

Visual problems  40%
Poor balance  14%
Headaches  58%
Dizziness/vertigo  22%
Light sensitive  30%
Word finding  47%
Poor concentration  35%
Forgetful  47%
Temper outbursts  30%
Anxiety  60%
Depression  33%

Paniak et al. 2002, ACN, 17, 319-34
Possible factors influencing symptom reporting acutely, post-acutely, and long after a mild traumatic brain injury

Iverson et al., 2007. In Zasler et al. (Ed.) Brain Injury Medicine
Premorbid mental health problems

- Predictors of outcome in adults with uncomplicated mTBI and general trauma: mTBI predicted PCS during the acute phase after injury, but not at 3 months post-injury. Premorbid psychiatric factors and post-injury anxiety were the strongest predictors of persistent symptoms at 3 months post-injury. (Ponsford et al., 2012, 26, 304-13)

- Preinjury anxiety and depression predicted the development of PCS. mTBI did not predict PCS. (Meares et al., 2011, Neuropsychology, 25, 454–465).
<table>
<thead>
<tr>
<th></th>
<th>Frequency of PCS by Dx</th>
<th>Odds Ratio Risk PCS by Dx</th>
<th>Odds Ratio Headache</th>
<th>Odds Ratio Dizziness</th>
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</thead>
<tbody>
<tr>
<td>mTBI</td>
<td>27%</td>
<td>2.47</td>
<td>2.31</td>
<td>2.14</td>
</tr>
<tr>
<td>PTSD</td>
<td>39%</td>
<td>4.26</td>
<td>2.45</td>
<td>2.41</td>
</tr>
<tr>
<td>Generalized Anxiety Disorder (GAD)</td>
<td>41%</td>
<td>4.76</td>
<td>1.88</td>
<td>2.47</td>
</tr>
<tr>
<td>Depression</td>
<td>55%</td>
<td>8.39</td>
<td>1.96</td>
<td>2.05</td>
</tr>
<tr>
<td>Depression and mTBI</td>
<td>74%</td>
<td>19.76</td>
<td>5.85</td>
<td>7.10</td>
</tr>
<tr>
<td>PTSD and mTBI</td>
<td>75%</td>
<td>20.45</td>
<td>6.16</td>
<td>6.00</td>
</tr>
<tr>
<td>GAD and mTBI</td>
<td>80%</td>
<td>27.26</td>
<td>7.04</td>
<td>8.77</td>
</tr>
<tr>
<td>Somatization</td>
<td>91%</td>
<td>64.74</td>
<td>19.70</td>
<td>37.28</td>
</tr>
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</table>

*(Donnell et al, 2012 *TCN*, 26, 1092-1101)*
Diagnosis by symptoms compromised by inaccurate history

- Poor reliability in self-report of depression history one year after structured interviewing revealed depression. The authors characterized the result as “disheartening” (Coyne et al., 2001, Psychol Assessment).

- Uncorroborated history may be fiction
  - “even when individuals are carefully cued, many instances of TBI were not recalled in adulthood despite the injury having required a period of hospitalization.” (McKinlay et al., JINS, 2016)

- At 1 and 3 months post-injury, parents of concussed children report significantly less preinjury “postconcussive” symptoms than they do in the Emergency Department acutely after injury (Brooks et al., 2014, ACN, 29, 186-93)
Expectations and Outcome

- Survey of 73 British patients who had symptoms 1-3 weeks after concussion. 25% met criteria for PCS at 3 months.
- Initial belief that symptoms would have more severe and prolonged consequences was predictive of PCS (Whittaker et al 2007 JNNP)
Risk factors for prolonged PCS

- Presence of litigation and/or compensation
  - Also delayed RTW, greater symptom severity independent of mTBI severity
- Other associated risks:
  - Premorbid psychological characteristics
  - Psychosocial stressors or injury-related stressors
  - Female gender or older age
  - Low education
Regarding Validity

- Not all people do their best / are truthful on our tests, for a variety of reasons.
  - Litigating claimants with mTBI display inadequate effort in approximately 40% of cases
  - Invalid performance not synonymous with malingering

- Neuropsychology has evidence-based means of assessing effort

- Formal assessment of validity is now considered standard of care by neuropsychological associations
Treatment recommendations mTBI

- Education, normalization, gradual activation, and avoidance of harmful behaviors
- Correct attribution errors or false beliefs about recovery potential
- Address pain, sleep disturbance, ETOH use
- Focus on pragmatic compensatory strategies
Prescribed physical and cognitive rest

• Limited empirical evidence supports the benefit of physical and cognitive rest.

• Complete rest/“cocoon therapy” is not indicated and may be harmful (Collins et al., 2016, Neurosurgery, 79, 912-29)

• Most individuals resume normal activity within 2-6 weeks of injury without significant accommodation
To summarize

- Neuropsychological assessment is sensitive to cognitive dysfunction and has diagnostic utility
- Neuropsychology can discriminate between neurologic dysfunction and cognitive complaints driven by other factors
- Neuropsychological evaluations can be useful in mTBI
- mTBI is defined by LOC<30 minutes, PTA <24 hours, GCS 13-15, lack of neuroimaging findings, and symptoms present immediately
- mTBI is generally a transient injury that revolves in days to weeks, but can take up to 90 days
- Postconcussion syndrome is a nonspecific collection of symptoms that may be unrelated to the concussion, and may be driven by other factors
Thank You!