• Should we have a new taxonomy for severity of brain injury?

• What would that look like?

• What does “mild” brain injury look like?
Note: I’m objective as to whether an individual has in fact sustained a brain injury that’s left longer-lasting residual. Just because an individual complains of residual doesn’t make it related to initial injury; that’s part of what a neuropsychologist does. Still, I don’t believe that we understand what we call mild traumatic brain injury (MTBI) well, and believe that the 10-15% figure quoted as being left with residual is an underestimate...
One of first taxonomies (system of classification) was applied when the Glasgow Coma Scale Score was:

- 13-15 Mild
- 9-12 Moderate
- 3-8 Severe

### Table 1. Glasgow Coma Score

<table>
<thead>
<tr>
<th>Eye Opening (E)</th>
<th>Verbal Response (V)</th>
<th>Motor Response (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4=opens</td>
<td>5=normal conversation</td>
<td>6=normal</td>
</tr>
<tr>
<td>spontaneously</td>
<td>4=disoriented conversation</td>
<td>5=localizes pain</td>
</tr>
<tr>
<td>3=opens to voice</td>
<td>3=words, incoherent</td>
<td>4=withdraws from pain</td>
</tr>
<tr>
<td>2=opens to pain</td>
<td>2=incomprehensible sounds</td>
<td>3=decorticate posturing</td>
</tr>
<tr>
<td>1=none</td>
<td>1=none</td>
<td>2=decerebrate posturing</td>
</tr>
</tbody>
</table>

Adapted from ACS ATLS\(^6\)
• American Congress of Rehabilitation Medicine (ACRM), Centers for Disease Control (CDC), and the World Health Organization (WHO) accept definition for Mild Traumatic Brain Injury (MTBI/mTBI) as those in which:
  
  – Alteration of mental state at the time of the accident (e.g., feeling dazed, disoriented, or confused)
  – Loss of consciousness <30’ following injury
  and
  – Post-traumatic Amnesia <24 hours following injury

• ACRM adds: “Focal neurological deficits that might or might not be transient, but where the severity of the injury does not exceed (2 and 3) or a GCS score falling below 13 after 30 minutes
There are other systems; they vary (why do they vary?):

Department of Defense and Department of Veterans Affairs (2008). "Traumatic Brain Injury Task Force".  

<table>
<thead>
<tr>
<th>Severity of traumatic brain injury[^1]</th>
<th>GCS</th>
<th>PTA</th>
<th>LOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>13–15</td>
<td>&lt;1 day</td>
<td>0–30 minutes</td>
</tr>
<tr>
<td>Moderate</td>
<td>9–12</td>
<td>&gt;1 to &lt;7 days</td>
<td>&gt;30 min to &lt;24 hours</td>
</tr>
<tr>
<td>Severe</td>
<td>3–8</td>
<td>&gt;7 days</td>
<td>&gt;24 hours</td>
</tr>
</tbody>
</table>
Severity of TBI

- Mild, Moderate, and Severe TBI

- Traumatic brain injury severity is commonly described as mild, moderate, or severe. Injury severity is traditionally based on duration of loss of consciousness and/or coma rating scale or score, post-traumatic amnesia (PTA), and brain imaging results. Mild, moderate, and severe TBI may be characterized as follows:
• **Mild TBI**
  – Brief loss of consciousness, usually a few seconds or minutes
  – PTA for less than 1 hour post the TBI
  – Normal brain imaging results

• **Moderate TBI**
  – Loss of consciousness for 1 – 24 hours
  – PTA for 1 – 24 hours post the TBI
  – Abnormal brain imaging results

• **Severe TBI**
  – Loss of consciousness or coma for more than 24 hours
  – PTA for more than 24 hours post the TBI
  – Abnormal brain imaging results
On With Life’s Disorders of Consciousness Program

• **Severe TBI may be further sub-categorized as follows:**

  – **Coma** - a state of unconsciousness from which the individual cannot be awakened

  – **Vegetative State** - a state in which an individual is not in a coma (i.e. awake) but is not aware of the environment

  – **Persistent Vegetative State** - a vegetative state that has lasted for more than a month

  – **Minimally Responsive State** - a state in which a person with a severe TBI is no longer in a coma or vegetative state and inconsistently interacts with/responds to the environment.
• There are other systems...

• It’s easy to say that we need a new taxonomy...

• What should that look like?...

• **Should we have a taxonomy given poor predictive capability?**
Each of these cases involved diagnosis of MTBI:
Epidural hemorrhage (EDH)
Hematoma – blood clot
Diffuse Axonal Injury (DAI)
Subdural hemorrhage (SDH)
Subarachnoid hemorrhage/intraventricular hemorrhage
From Wikipedia; let’s consider:

**Prognosis**

Prognosis worsens with the severity of injury. Most TBIs are mild and do not cause permanent or long-term disability; however, all severity levels of TBI have the potential to cause significant, long-lasting disability. Permanent disability is thought to occur in 10% of mild injuries, 66% of moderate injuries, and 100% of severe injuries. Most mild TBI is completely resolved within three weeks, and almost all people with mild TBI are able to live independently and return to the jobs they had before the injury, although a portion have mild cognitive and social impairments. Over 90% of people with moderate TBI are able to live independently, although a portion require assistance in areas such as physical abilities, employment, and financial managing. Most people with severe closed head injury either die or recover enough to live independently; middle ground is less common. Coma, as it is closely related to severity, is a strong predictor of poor outcome.
Medical complications are associated with a bad prognosis. Examples are hypotension (low blood pressure), hypoxia (low blood oxygen saturation), lower cerebral perfusion pressures and longer times spent with high intracranial pressures. [2][68] Patient characteristics also influence prognosis. Factors thought to worsen it include abuse of substances such as illicit drugs and alcohol and age over sixty or under two years (in children, younger age at time of injury may be associated with a slower recovery of some abilities). [68] Other influences that may affect recovery include pre-injury intellectual ability, coping strategies, personality traits, family environment, social support systems and financial circumstances. [107]
EXAMPLES of common cognitive-communicative, physical, and psychosocial/emotional consequences after mild, moderate, and severe TBI follow (Guidelines for mild traumatic brain injury and persistent symptoms; Ontario Neurotrauma Foundation, 2010; S. Marshall, M.D. et al. – Presented at ACRM as a kind of “gold standard” for management of Persistent Postconcussive Symptoms [PPCS] / Mild Traumatic Brain Injury):

Mild TBI

• Cognitive-Communicative
  – Decreased attention and concentration
  – Decreased speed of processing
  – Memory problems
  – Getting lost or confused
  – Decreased awareness and insight regarding difficulties
• Psychosocial/Emotional
  – Irritability
  – Depression and anxiety
  – Emotional mood swings
• Physical
  – Headache
  – Fatigue
  – Sleep disturbance
  – Visual disturbance
  – Dizziness
  – Nausea
  – Balance problems
Moderate and Severe TBI

**Cognitive-Communicative**
- Decreased attention and concentration
- Distractibility
- Memory problems
- Decreased speed of processing
- Increased confusion
- Perseveration
- Impulsiveness
- Decreased interaction skills
- Decreased executive function abilities (for example, planning, organization, problem solving)
- Decreased awareness of, and insight regarding, difficulties

**Psychosocial/Emotional**
- Dependent behaviors
- Apathy
- Decreased lack of motivation
- Irritability
- Acting out
- Depression
- Denial of difficulties
• Physical
  – Difficulty speaking and being understood
  – Physical paralysis/weakness/spasticity
  – Difficulties with sense of touch, temperature, movement, position
  – Chronic pain
  – Decreased bowel and bladder control
  – Sleep disorders
  – Loss of stamina
  – Appetite changes
  – Partial or total loss of vision
  – Weakness of eye muscles and/or double vision (diplopia)
  – Blurred vision
  – Problems judging distance
  – Involuntary eye movements (nystagmus)
  – Intolerance of light (photophobia)
  – Decreased or loss of hearing
  – Ringing in the ears (tinnitus)
  – Increased sensitivity to sounds
  – Loss or diminished sense of smell (anosmia)
  – Loss or reduced sense of taste
• CDC – “Up to 15% of patients diagnosed with MTBI may experience persistent disabling problems”

• Guidelines – “What cannot be debated is that persistent symptoms following MTBI can result in substantial functional disability interfering with patients’ ability to return to work or school and can result in high levels of stress and low levels of satisfaction with quality of life.” “However, very little guidance is provided for the assessment and management of persistent symptoms that extended beyond the typical acute recovery period.”

• 70-90% of all treated brain injuries are mild

• 100-300/100,000 in population are hospital-treated

• True incidence may be 600/100,000

• 320 million Americans = up to 1.9 million/year MTBI

• “To date, there are few studies that have been conducted longitudinally with acute mTBI samples to help elucidate the evolution of changes in mTBI over time...”
Windham, B. et al. (2015). Small Brain Lesions Equal Big Stroke, Big Mortality Risks. *Annals of Internal Medicine.* (Atherosclerosis Risk in Communities study; followed subjects 14.5 years)

Very small (<3mm) brain lesions, which are often dismissed as benign, more than triple the risk for stroke and stroke-related death in asymptomatic middle-aged and older adults with no history of clinical stroke.

BACKGROUND:
• It is known that the risk of dementia in patients with moderate to severe traumatic brain injury (TBI) is higher. However, the relationship between mild traumatic brain injury (mTBI) and dementia has never been established.

OBJECTIVES:
• We investigated the incidences of dementia among patients with mTBI in Taiwan to evaluate if there is higher risk compared with general population.

METHODS:
• We utilized a sampled National Health Insurance (NHI) claims data containing one million beneficiaries. We followed all adult beneficiaries from January 1, 2005 till December 31, 2009 to see if they had been diagnosed with dementia. We further identify patients with mTBI and compared their risk of dementia with the general population.

RESULTS:
• We identified 28551 patients with mTBI and 692382 without. After controlled for age, gender, urbanization level, socioeconomic status, diabetes, hypertension, coronary artery disease, hyperlipidemia, history of alcohol intoxication, history of ischemic stroke, history of intracranial hemorrhage and Charlson Comorbidity Index Score, the adjusted hazard ratio is 3.26 (95% Confidence interval, 2.69-3.94).

CONCLUSIONS:
• TBI is an independent significant risk factor of developing dementia even in the mild type.
Persistent Problem in Children with Mild Traumatic Brain Injury

Mitchell Rosenthal Memorial Lecture Live Webinar

Wednesday, October 7, 2015
3:00 p.m. eastern/12:00 p.m. (noon) pacific

Keith Yeates, Ph.D., University of Calgary, and H. Gerry Taylor, Ph.D., Case Western Reserve University

In this webinar, our presenters will summarize the natural history, determinants, and functional significance of post-concussive symptoms in children with mild traumatic brain injury (TBI), and describe the kinds of persistent problems that can occur after pediatric mild TBI. They will also discuss the implications for clinical practice in light of persistent problems after mild TBI in children.
BIAUSA has good stuff:


- Includes a video on “Anne’s story” and the following:
  
  - **Definition**
  - What happens in a mild brain injury
  - Diagnosis of Mild Brain Injury
  - What can I do if I have a mild brain injury
  - Mild Brain Injury Issues
  - Mild Brain Injury and Concussion
  - Additional Resources
CASE STUDY – Greg S.

- Neuropsychological update post-injury/residual/return to driving/return to work – Referred by PS Physiatrist, who diagnosed mild brain injury with question of residual deficit 1-year post-injury sustained in MVA.

- Greg was a high-functioning individual, which is relevant. He had a Bachelor’s degree in Business Administration, with a 3.8 GPA, and had an executive accounting position in a government agency. Psychometric estimate of premorbid capability was as falling in the High Average range generally (75th – 84th %ile).

- Non-neuro Speech-Language Pathologist who concluded no significant deficits (based on language data – what does the brain do?)

- No initial positive MRI findings (but see post-eval MRA findings…)

- Neurologist note: “He has no issues with memory,” based on 3/3 words recalled after a 3’ delay; discharged from Speech Therapy. “He has no significant cognitive disability at this time noted on exam.” Physiatrist referred to me.
• 1st %ile findings at times today…; amnestic for 3 of 5 designs after 25'; 7-8 responses on COWAT; Block designs at 16th %ile; 1-A-2-B at 12th %ile; high level of perseveration on an executive function test

• Greg had significant deficits in processing speed, visual-perceptual functioning (right parietal subarachnoid hemorrhage), memory – visual and complex verbal, and phonemic verbal fluency

• Part of the reason for the misidentification in this case had to do with decreased insight/awareness on Greg’s part. He was reporting no change. He was motivated to do his best and made excuses such as, “I was never very good at…” His wife rolled her eyes… She reported word-finding/name-finding much greater than before, memory, processing speed, planning/organizing, and executive difficulties (e.g., cooking from a recipe as he’d been able to do before)
• Post-neuropsychological testing, MRA – Magnetic Resonance Angiogram was ordered, and found AVM, with likely bleed associated with MVA/head trauma. I gave recommendations as to return to driving and return to work.

• Arteries and veins (Fig. 2). MRA can detect aneurysms, blockages of the blood vessels, carotid artery disease, and arteriovenous malformations.
Figure 2. MRA of the brain arteries. MRA can detect aneurysms, blockages of the blood vessels, carotid artery disease, and arteriovenous malformations.
So, in the real world, the label of “Mild” can be used even in what can turn out to be very severely affected individuals.

Why does this happen (these reasons also intersect with each other)?

- You “look good enough, walk good enough, talk good enough…” and people may not observe the difficulties that you still deal with
- People do not understand brain injury
- Professionals do not understand brain injury
- None of us understand brain injury (way up there on my list of questions for God…)
  - (Susan Connors, President of BIAUSA: “Traumatic brain injury is the most misunderstood, misdiagnosed, underfunded public health problem our nation faces”)
• Injuries to axons are not visualized on CT and MRI scans

• People are trying their best

• People don’t know who to ask for help

• If there’s executive dysfunction, awareness/insight may be an issue

• If you’re high-functioning preinjury, Average range performances can be considered relative declines in ability

• Which came first, the chicken or the egg?... Attribution to psychological factors as causative. This needs to be evaluated by professionals who understand these issues, Neuropsychologists, Neuro-based Speech-Language Pathologists, and Physiatrists.
We don’t have a good system for following people longer-term post-TBI so that we can adequately assess and differentiate in these regards. Brain injury is a LIFE-LONG CHRONIC CONDITION (See BIAUSA Position Paper):
<table>
<thead>
<tr>
<th>Title</th>
<th>Conceptualizing Brain Injury As A Chronic Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The Brain Injury Association of America recognizes brain injury as the start of a lifelong disease-causative and disease-accelerative process so that research, education, treatment, and patient management is on a par with other diseases.</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Brent Masel, MD</td>
</tr>
<tr>
<td>Publication</td>
<td>February 2009</td>
</tr>
</tbody>
</table>
“Mild” TBI – a speech-language pathologist’s point of view
Consider the following Case Studies…

Person Served #1: “L.J.”

27 year-old man, rollover MVA

Suspected intoxication at the time of injury

GCS of 7 (severe injury) upon hospital admission, intubated, life-flighted to level II trauma center
Imaging revealed left parietal epidural hematoma with midline shift

Craniotomy for evacuation of hematoma

Left facial paralysis

Documentation of “some behavioral issues” at the acute level of care – antipsychotic medication initiated
2 weeks after accident, discharged home with family and started outpatient speech therapy

Occupational therapy was added to assess visuo-perceptual functioning; physical therapy services were not indicated

Personal goals were to return to independent living and return to job on a county road crew
Speech therapy administered the **RBANS** to assess memory, visuospatial/constructional, attention, and language domains:

<table>
<thead>
<tr>
<th>Domain</th>
<th>Index Score</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Memory</td>
<td>53</td>
<td>0.1</td>
</tr>
<tr>
<td>Visuospatial/constructional</td>
<td>84</td>
<td>14</td>
</tr>
<tr>
<td>Language</td>
<td>87</td>
<td>19</td>
</tr>
<tr>
<td>Attention</td>
<td>53</td>
<td>0.1</td>
</tr>
<tr>
<td>Delayed memory</td>
<td>48</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Total Scale</td>
<td>55</td>
<td>0.1</td>
</tr>
</tbody>
</table>

In addition to formal testing scores, interview revealed possible deficits in executive function, including initiation.
Received speech therapy for a total of 4 weeks targeting memory, attention, executive function, and oral-motor function.

Within the 4 weeks, he returned to staying in his own place during the day, completed the driver’s rehab evaluation course, and had been approved by his treating neurologist to return to work.

Discharge recommendations from speech therapy included returning to work part-time and increasing hours as tolerated, as well as possible accommodations.

He and family reported that he was successfully abstaining from alcohol and expressed understanding of the risks of drinking.
Consider the following Case Studies…

Person Served #2: “P.B.”

58 year old man, MVA in which he was rear-ended
Doesn’t believe he lost consciousness; first thing he remembers is jumping out the vehicle to go after the guy that hit him

Did not receive medical treatment at the hospital – drove his vehicle home
Next day, vehicle insurance company calls, asking for DOB, SSN, accident details – he is unable to recall any of these

Sees the doctor 3 days later with severe headache, tinnitus, and difficulty “keeping things straight” at work
Doctor diagnosed concussion; recommended that he take the next 2-3 days off of work, but documented that if he tried to go back before it is “reasonable”

He returned for follow up 5 days later, stated he still has headache, ringing in ears, and confusion

MRI completed due to report of worsening cognitive issues – “positive for a few non-specific increased white matter signal changes”

Referred to neurologist and neuro-based rehabilitation; told he needed to be off of work for at least 2 weeks
About 3 weeks later, evaluated by PT/OT/ST Speech therapy administered **RBANS:**

<table>
<thead>
<tr>
<th>Domain</th>
<th>Index Score</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Memory</td>
<td>78</td>
<td>7</td>
</tr>
<tr>
<td>Visuospatial / Constructional</td>
<td>92</td>
<td>30</td>
</tr>
<tr>
<td>Language</td>
<td>87</td>
<td>19</td>
</tr>
<tr>
<td>Attention</td>
<td>109</td>
<td>73</td>
</tr>
<tr>
<td>Delayed Memory</td>
<td>71</td>
<td>3</td>
</tr>
<tr>
<td>Total Scale</td>
<td>83</td>
<td>13</td>
</tr>
</tbody>
</table>

In addition to formal testing, executive function symptoms reported: inability to multi-task; concentrate in noisy environments; poor thought organization. Also demonstrated symptoms of impulsivity and impatience with therapy staff.
Seen for speech therapy for ~3 months

Intervention included fatigue management, use of assistive devices for memory and organization, brainstorming and collaborating with doctor/employer on needed compensations

He demonstrated very “rigid” thinking – believed that he could return to former job without accommodations within 30 days

Persistently asked: “How do you fix me?”; “Is there a pill I can take?”; “What are the numbers?”

Observed to be resistant to treatment recommendations including working reduced hours, taking frequent breaks, reducing task demands
Returned to work 6 weeks post-injury; worked 4 hour shifts the first week, 6 hours the second week, 8+ hours the third week

By third week, reported that things were “terrible” – was not taking breaks, was not able to carryover strategies learned in therapy to work environment

About 1.5 months later, he was fired from his job

In addition to difficulties in the work environment, reported difficulties in his family relationships – observed personality changes including increased irritability and depression

Received new orders for PT/OT/ST and returned to neuro-based rehabilitation
The BIG questions

1) Medically, who has the mild injury, L.J. or P.B.?

2) Who REALLY has the mild injury, L.J. or P.B.?
You can’t compare apples and oranges!

The functional impact of brain injury on an individual is RELATIVE and UNIQUE – it cannot be generalized to a group of ANY size!

- age
- gender
- education
- socioeconomic status
- work history
- criminal history
- relationships with others
- prior medical history
- prior psychiatric history
- drug/alcohol abuse
Brain injury does not exist in a vacuum!

Brain injury does not affect ONLY the survivor:

- family
- peers
- employers
- community contacts
Brain injury does not exist in a vacuum!

The brain injury may also contribute to the emergence, or the exacerbation, of other medical and psychiatric conditions:

- substance abuse
- mental illness (e.g., depression, PTSD)
- degenerative diseases (e.g., dementia)
- dysautonomia
- seizures
- sleep difficulties
Neuro-Based Treatment for “Mild” Brain Injury

Physical therapy:
- vestibular assessment/rehabilitation
- high-level dynamic balance
- headache management/musculoskeletal reeducation
- cognitive-motor dual tasking
- endurance training
- community re-integration

Occupational therapy:
- vision assessment/rehabilitation
- return-to-driving (e.g., scanning; response time) and/or community mobility
- instrumental activities of daily living (household management, maintenance)
- return-to-work/school
- fatigue management
- organizational strategies
Neuro-Based Treatment for “Mild” Brain Injury

Speech-Language Pathology:
- Attention
- Memory
- Executive Function (problem solving; judgment; planning/organization; initiation; inhibition)
- Language (word-finding; high-level comprehension)
- Return-to-work/school
- Fatigue management
- Financial management
- Medication management
Neuro-Based Treatment for “Mild” Brain Injury

Case Management:
- referrals for additional services – substance abuse, psychiatric, medical specialists, respite for caregivers, driving evaluation, day programs
- collaboration with family members to promote well being and adaptive coping with changes due to brain injury
- collaboration with employers to facilitate return to work
- communication with doctor(s), medical case manager(s), legal representation, and insurance payers
- connection with local support groups and neuro-resource facilitators
Neuro-Based Treatment for “Mild” Brain Injury

Neuropsychology
- comprehensive assessment of cognitive function
- return to work/school recommendations
- initial/continued therapy recommendations
- expert witness testimony
Principles of Neuro-Based Treatment

Each injury is different; the functional impacts are relative and unique.

Plans of care are driven by the person served.

Interventions include not only the survivor, but the support system — mutually reinforcing interactions.

Interventions should combine restoration of function and compensation for lost function.

Interventions should include facilitating self-advocacy and autonomy.

Interventions should focus on facilitating positive change in the survivor and his/her environment, not trying to fix the brain injury.
Questions? Comments?

Dr. David S. Demarest, PhD
ddemareast@onwithlife.org

Courtney Huber, MS, CCC-SLP
chuber@onwithlife.org

www.onwithlife.org