Traumatic Brain Injury
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Introduction
Traumatic brain injury (TBI) is a significant cause of death and contributor to disability in the United States. While some cases are mild and result in full recovery, other individuals with more significant injury experience residual neurologic effects that impact the individual, their family, care givers, as well as society. This newsletter provides a brief overview of TBI statistics, causes, and classification and discusses mild TBI/post-concussion syndrome presentation, treatment, return to work, and case management considerations.

Causation and Statistics
TBI is an injury to the brain that causes a disruption of its normal functioning. Falls are the major cause of TBI and account for almost half of all TBI emergency room visits, especially in children and adults over age 65. Other causes of TBI include being struck by an object, motor vehicle accidents (including whiplash type injuries), violence, self-harm, and blast injuries (especially for military personnel).

In 2013, the Centers for Disease Control and Prevention (CDC) estimated that there were 2.5 million emergency room visits for TBI and more than 282,000 hospitalizations and 56,000 deaths with a diagnosis of TBI. It is estimated that approximately ten percent of TBI results from work injuries.

Patients who experience mild TBI generally experience time-limited symptoms and have favorable outcomes. However, patients with moderate to severe TBI may report more prolonged and significant symptoms and functional limitations. Long-term disability due to TBI in the U.S. occurs in an estimated 80-90,000 people annually, contributing to an estimated 3.2 to 5.3 million persons living in the U.S. with some degree of lifelong disability due to TBI. Thus it is understandable that the economic burden due to TBI can be substantial. In fact, the financial impact of TBI in the U.S. has been estimated as $14.6 billion for medical treatment and $69.2 billion for lost productivity.

Symptoms and Clinical Findings
TBI symptoms and physical findings can vary due to the different causes, associated injuries, patient factors, complications, etc. TBI presentation is dependent upon a number of factors, including:

- Type of injury (e.g. direct impact, whiplash type injury, penetrating object)
- Structural injury to the brain (e.g. microscopic injury to brain cells, bruising or “contusion” of the brain, brain swelling or “edema,” bleeding into brain tissue or surrounding structures, or penetrating injury)
- Severity score (e.g. Glasgow Coma Scale or other assessment scales)
- Additional injuries (e.g. neck, internal organs, blood loss, musculoskeletal, or low oxygen or “hypoxia”)
- Age
- Medical comorbidities
- Other factors.

1 https://www.cdc.gov/traumaticbraininjury/get_the_facts.html
TBI is the result of both primary and delayed injury effects. Primary brain injury occurs at the time of injury directly due to the trauma. Secondary brain injury develops over hours to days as a result of changes to chemicals that transmit brain electrical signals (neurotransmitters), from inflammatory changes as a result of changes in blood flow to brain tissue, from electrolyte imbalance, or from death of brain cells.

There are a number of tools to assess TBI severity scores utilizing clinical presentation or findings on brain imaging tests (CT scan and MRI). The most widely accepted TBI severity score is the “Glasgow Coma Scale” (“GCS”), commonly administered approximately 30 minutes after injury and assessed serially. GCS consists of scores assessing eye opening, verbal response, and motor responses (see Table 1).

Table 1 Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Score</th>
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<tbody>
<tr>
<td><strong>Eye Opening Response</strong></td>
<td></td>
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<tr>
<td>Spontaneous – open with blinking at baseline</td>
<td>4</td>
</tr>
<tr>
<td>To verbal stimuli, command, speech</td>
<td>3</td>
</tr>
<tr>
<td>To pain only (not applied to face)</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
<tr>
<td><strong>Verbal Response</strong></td>
<td></td>
</tr>
<tr>
<td>Oriented</td>
<td>5</td>
</tr>
<tr>
<td>Confused conversation, but able to answer questions</td>
<td>4</td>
</tr>
<tr>
<td>Inappropriate words</td>
<td>3</td>
</tr>
<tr>
<td>Incomprehensible speech</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
<tr>
<td><strong>Motor Response</strong></td>
<td></td>
</tr>
<tr>
<td>Obey commands for movement</td>
<td>6</td>
</tr>
<tr>
<td>Purposeful movement to painful stimulus</td>
<td>5</td>
</tr>
<tr>
<td>Withdraws in response to pain</td>
<td>4</td>
</tr>
<tr>
<td>Flexion in response to pain (decorticate posturing)</td>
<td>3</td>
</tr>
<tr>
<td>Extension response in response to pain (decerebrate posturing)</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
<tr>
<td><strong>Head Injury Classification</strong></td>
<td></td>
</tr>
<tr>
<td>Severe Head Injury</td>
<td>GCS score of 8 or less</td>
</tr>
<tr>
<td>Moderate Head Injury</td>
<td>GCS score of 9 to 12</td>
</tr>
<tr>
<td>Mild Head Injury</td>
<td>GCS score of 13 to 15</td>
</tr>
</tbody>
</table>

The interpretation of responses used to assign GCS point scores may be affected by additional factors outside of the brain injury, including whether the patient has been given medications that cause sedation or to temporarily paralyze them during treatment; when patients are intubated to place them on a ventilator; if the patient is intoxicated from drugs or alcohol; and other factors including prior injuries or medical conditions. However, GCS is generally easy to administer, reproducible, widely accepted, and correlates with overall prognosis. Scores are added to obtain a total score that is used to assign a head injury classification ranging from mild to severe.

Patients with moderate to severe TBI may have isolated brain injury, but many patients experience other injuries as well. Residual neurologic symptoms and functional deficits may persist, affecting alertness,
orientation, memory, attention, emotions, speech, vision, coordination, strength, ability to walk, breath, etc. Many patients develop subsequent seizures. The nature and severity of symptoms is also affected by the presence and severity of findings on CT scan including bleeding, contusion, brain swelling, and the need for neurosurgery to address brain injuries.

“Concussion” is a term used to describe a mild traumatic event (mild TBI) involving the head with or without loss of consciousness, resulting in the onset of acute neurologic symptoms that generally resolve spontaneously. Acute symptoms may include brief loss of consciousness and amnesia for the event (retrograde amnesia) or events after the injury (anterograde amnesia). Other acute symptoms may include headache, dizziness, nausea, vomiting, disorientation, irritability, and mild incoordination and memory deficits. Over the next few days, patients may develop mood changes, experience problems with thinking and concentration (cognitive impairment), develop sensitivity to light or noise, or have difficulty with sleep. Some patients experience “post-concussion syndrome” with persistence of these symptoms and may experience some psychological complaints including personality change, anxiety, or depression. Seizures are more common in patients with severe TBI and brain injuries such as bleeding, though they may occur in a small minority of patients with mild TBI.

Treatment
Evaluation and treatment of TBI depends upon the nature and severity of the injury, the presence of additional injuries, comorbid medical conditions, and other factors.

Patients with severe TBI may have an isolated head injury, though they often experience additional injuries to the spine, extremities, chest, abdomen, or other organs. These patients require careful pre-hospital management, including maintenance of blood pressure and breathing and oxygenation when needed (often requiring airway intubation for GCS of 8 or less), as well as stabilization of the cervical spine (in case of fractures) and care for additional injuries. In-hospital evaluation includes:

- Stabilization of breathing, oxygenation, and blood pressure
- Assessment and stabilization of additional injuries
- Cervical spine CT scan to rule out fracture
- Brain imaging with CT scan to look for bleeding and structural injuries
- Neurosurgical consultation; and
- Consultation with other physicians to treat any medical, general surgery, facial, or orthopedic injuries.

Patients with severe TBI may require urgent neurosurgery to treat penetrating injuries, bleeding causing pressure on the brain (epidural, subdural, or intracranial hemorrhage), and at times, a portion of the skull may be removed (decompressive craniectomy) to treat brain swelling and elevated pressure in the brain that cannot be corrected with non-surgical treatments. Severe TBI commonly requires management in intensive care units to provide supportive care to maintain vital signs, to treat medical and other injuries, and to monitor brain pressure with an intracranial pressure monitor. Severe TBI with elevated intracranial pressure is often managed by administering barbiturate and sedative medications as well as medications to cause temporary paralysis in an effort to reduce brain metabolism and agitation; facilitate control of breathing on a ventilator; and control intracranial pressure, blood pressure, and heart rate while permitting the brain to heal. Some patients undergo treatment to lower their body temperature (induced hypothermia) to lower brain metabolism and reduce secondary injury.

Medications are commonly administered to treat seizures. Certain medications have been evaluated with a goal to protect the brain from secondary injury (neuroprotective treatments), though there is a lack of consensus regarding efficacy. Some patients with severe TBI may end up in a “vegetative” state that requires longer term ventilator support and nutrition in addition to other medical care. Other patients with severe TBI require a variety of treatments depending upon their symptoms and neurologic deficits, including interdisciplinary brain rehabilitation treatment; cognitive retraining; physical, occupational or speech therapy; and involvement of neurologists, psychiatrists, physical medicine and rehabilitation physicians, and other clinicians to treat symptoms and assist recovery. The Centers for Disease Control and Prevention (CDC) has information regarding severe TBI on its website “Traumatic Brain Injury & Concussion,” found at https://www.cdc.gov/traumaticbraininjury/severe.html.
The CDC has estimated that adopting the Brain Trauma Foundation (BTF) in-hospital guidelines for the treatment of adults with severe TBI could decrease deaths by 50%, reduce medical and rehabilitation costs by $288 million annually, and save up to $3.8 billion annually in estimated annual societal costs.

Patients with mild TBI or concussion merit assessment by a health care provider to evaluate neurologic and mental status including whether there was any loss of consciousness and the duration, amnesia (e.g. recall for details of the injury, prior to and after injury), alertness, concentration (e.g. ability to spell a word, reverse the letters, recall after five minutes), memory (e.g. ability to recite and recall three words after five minutes), and other neurologic symptoms and findings.

Brain imaging is not routinely required for patients with mild TBI. When imaging is required in emergency settings, CT scan is preferred due to availability, speed of imaging, and its ability to identify most findings like intracranial bleeding that would prompt surgical decisions. The Canadian CT head rule was developed to improve decision making, and recommends acute brain CT scan in the following settings (see Figure 1):

Figure 1 Canadian CT head rule

<table>
<thead>
<tr>
<th>High Risk (for Neurological Intervention)</th>
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<tbody>
<tr>
<td>1. GCS score &lt; 15 at 2 hrs after injury</td>
</tr>
<tr>
<td>2. Suspected open or depressed skull fracture</td>
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<tr>
<td>3. Any sign of basal skull fracture*</td>
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<tr>
<td>4. Vomiting ≥ 2 episodes</td>
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<tr>
<td>5. Age ≥ 65 years</td>
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<table>
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<tr>
<th>Medium Risk (for Brain Injury on CT)</th>
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<tr>
<td>6. Amnesia before impact ≥ 30 min</td>
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<tr>
<td>7. Dangerous mechanism ** (pedestrian, occupant ejected, fall from elevation)</td>
</tr>
</tbody>
</table>


Patients with concussion should be hospitalized for initial observation when there has been:
- A longer duration of loss of consciousness
- More significant symptoms
- GCS less than fifteen
- Seizures
- Abnormal brain CT scan (e.g. intracranial bleeding)
- Neurologic deficits on exam
- If there is no person capable of monitoring the patient at home for the next day
- Or, for patients with medical conditions like bleeding disorders or on anticoagulants that increase the risks of complications.

Patients who do not have one of these identified risks may be safely observed at home, with recommendations to return if they develop problems including severe or worsening drowsiness and difficulty arousing the individual, confusion, headache, restlessness, vision changes, vomiting, weakness, incoordination, or seizures.

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6 https://www.researchgate.net/publication/5638387_Using_a_Cost-Benefit_Analysis_to_Estimate_Outcomes_of_a_Clinical_Treatment_Guideline_Testing_the_Brain_Trauma_Foundation_Guidelines_for_the_Treatment_of_Severe_Traumatic_Brain_Injury_and
7 http://ohri.ca/emerg/cdr/chead.html
Patients with initial abnormal brain CT scan should have a repeat scan within 24 hours to look for any progression. Repeat CT scan is also indicated for patients with worsening of clinical status, but is not necessary for patients with an initial normal study who are improving. Brain MRI may be performed in patients who have persistent post-concussion symptoms to look for potentially relevant findings such as small areas of bleeding, contusion, or injury. However, brain MRI may at times demonstrate “findings” that are due to age or medical conditions like hypertension or diabetes rather than due to injury.

A thorough medical and neurologic evaluation including tests for orientation and memory are generally considered sufficient to assess many patients with mild TBI. There are a number of standardized examinations (often used for athletes) to detect, grade, and follow mild deficits. These include:

- Standardized Assessment of Concussion
- Post-concussion Symptom Scale and Graded Symptom Checklist
- Sport Concussion Assessment Tool
- Westmead Post-traumatic Amnesia Scale
- Immediate Postconcussion Assessment and Cognitive Testing (ImPACT)

Neuropsychological testing is a detailed, multi-hour evaluation performed by a trained psychologist. Most patients with mild TBI do not require this in-depth evaluation. Rather, it is reserved for settings where there are persistent cognitive or psychologic symptoms and additional evaluation is requested to rule out other causes including psychological disease, dementia type disorders, to help target treatment, or make decisions regarding return to certain jobs that require higher level cognitive functioning or safety sensitive work, etc.

Individuals who present with uncomplicated, mild TBI often benefit from education (reassurance regarding symptoms, symptoms to prompt reevaluation, adequate rest, time-limited modification of activities with progressive reactivation), brief observation, and physical and cognitive rest for 24 hours or more. As symptoms resolve, individuals should be permitted to gradually increase activities, including work. The CDC has a patient information handout regarding expectations after concussion ([https://www.cdc.gov/traumaticbraininjury/pdf/tbi_patient_instructions-a.pdf](https://www.cdc.gov/traumaticbraininjury/pdf/tbi_patient_instructions-a.pdf)) and tips to help with recovery ([https://www.cdc.gov/traumaticbraininjury/recovery.html](https://www.cdc.gov/traumaticbraininjury/recovery.html)).

Temporary work modifications should be tailored to the individual and their symptoms. Options to consider include shorter hours, rest breaks, reduction of computer use, altered lighting, decreased lifting tasks, and/or avoidance of any activities that may place the worker at risk based upon their symptoms and exam findings (e.g. driving, working at heights, use of hazardous equipment).

Patients who experience post-concussion symptoms can be treated with reassurance that most patients improve within three months in addition to symptomatic care. Headaches (tension-type and migraine) are common and patients should avoid excessive use of analgesics including aspirin, non-steroidal anti-inflammatories, headache medications like Fioricet or Fiorinal, and opioids as these drugs may worsen headaches or result in dependence. Medications, such as Amitriptyline or Propranolol, are options to treat headaches and may help with associated symptoms including irritability, insomnia, anxiety, or depression. Triptan medications, like such as Imitrex, may be used for episodic migraine headaches. Patients with true vertigo experience symptoms perceived as the room spinning. In the absence of injury to the inner ear or brain, vertigo symptoms may be treated with vestibular therapy or medications, such as Meclizine. Psychologic symptoms, including anxiety or depression, may respond to brief counseling, including cognitive behavioral therapy, antidepressant, or anxiolytic medications. Seizures may develop in a small number of patients with mild TBI. Seizures in the first week after trauma are not considered epilepsy. However, seizures may occur as late as one to two weeks after injury. Anticonvulsant medications are used to treat seizures, though routine use after TBI does not prevent the development of seizures.

**Outcomes**
The outcomes for patients with severe TBI are dependent upon the nature and severity of injury (e.g. initial GCS score, presence and severity of findings on brain CT scan or MRI such as bleeding or damage to brain tissues), age, medical complications, and other factors. Approximately twenty percent of patients hospitalized for TBI may die from their injuries, with a death rate up to thirty percent or more for patients with GCS of 8 or
lower. Approximately five to fifteen percent of patients with severe TBI may remain in a vegetative state. Most patients with severe TBI have residual neurologic deficits, with estimates that perhaps twenty-five percent are fully functional and independent long-term. Recovery can be prolonged for patients with severe TBI.

The prognosis for patients with mild TBI is more favorable. Some patients with very mild TBI experience rapid recovery of symptoms. For other patients with mild TBI/postconcussion syndrome, many experience resolution of symptoms by one month, and most have recovered by three months. A small number of patients with mild TBI (e.g. ten to fifteen percent) may report symptoms that persist for a year or more. Factors associated with worse prognosis for mild TBI/postconcussion syndrome include the following:

- GCS 13
- Intracranial bleeding or depressed skull fracture
- Repeated concussions
- Advanced age and pre-existing conditions including neurologic disease and headaches, psychological conditions (e.g. depression, anxiety, post-traumatic stress disorder, poor coping), low expectations for recovery
- Litigation, including litigation due to motor vehicle accident and workers’ compensation
- Inconsistent findings on neuropsychological testing

The majority of patients with mild TBI return to work within one to three months after injury. In contrast, patients with moderate TBI may remain out of work for up to six months or more post injury.

Best practice guidelines from ODG Return-To-Work Pathway suggest the following targets for patients with concussion:

- Mild concussion: 3-7 days
- Severe concussion, non-cognitive/modified work: 14 days to indefinite
- Severe concussion, cognitive work: 84 days to indefinite

Conclusions

TBI is a heterogeneous condition and thus case management considerations need to be tailored to the severity of injury, post-injury symptoms and functional limitations, need for surgical intervention and complications, age and medical comorbidities, as well as other factors. Education of patients and family members regarding recovery and assistance of family members to enhance treatment compliance and attendance at appointments is recommended. Treatment must be targeted to address the individual’s specific symptoms and functional deficits. Neuropsychological evaluation may be of benefit for patients with inconsistencies to rule out other causes of residual symptoms or to assist with return to activities and work. Case managers, employers, and patients need to assess barriers to return to work and collaborate on effective strategies to overcome these barriers and optimize outcomes.

For more information email us at mms@aig.com.

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8 https://www.ncbi.nlm.nih.gov/pubmed/21282727
14 http://www.odg-twc.com/