Standardized Clinical Management of Traumatic Brain Injury by the U.S. Military

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INTRODUCTION

Traumatic brain injury (TBI) is a common disorder associated with military service. For Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (Afghanistan) (OEF), TBI has been referred to as the “signature injury of the war” (Warden, 2006).

The exact incidence and prevalence of this disease among OIF and OEF troops is uncertain. There are estimates that as many as 19.5 – 40 percent of those deployed are affected. For civilians, the TBI rates are also uncertain with estimates suggesting that as many as 8 million head injuries occur each year in the United States alone. The reasons for the uncertainty are that many patients receive care by non-medical professionals, do not seek medical attention at all or are improperly diagnosed. This is particularly true for mild TBI (mTBI), where signs and symptoms may be subtle. For moderate to severe TBI, where diagnosis is more certain, among U.S. civilians there are an estimated 1.7 million new cases per year.

Recently, the U.S. military, in response to this rising TBI problem, has instituted a system-wide standardized approach to diagnosis and clinical management of TBI. Critical elements of this approach are criteria for TBI screening; return to duty; neuroimaging; and, especially important, clinical practice guidelines for prehospital, in-hospital, and chronic treatment. As this is a collaborative effort between the Department of Defense (DoD) and the Veterans Administration (VA), it is national in scope. This may be the first such large system-wide effort to apply clinical practice guidelines (CPG) for TBI patients. Importantly, this has been endorsed and mandated at the highest level of command, which ensures it adoption and execution by medical care providers.

SEVERITY OF TRAUMATIC BRAIN INJURY

There are three major TBI categories: mild, moderate, and severe. These are differentiated by the patient’s presenting Glasgow Coma Score (GCS). A traumatic injury to the brain leading to a GCS of 13-15 is defined as mild. If the GCS is 9-12, it is moderate TBI and if 8 or less, then it is severe.

mTBI is further clarified by the Mild Traumatic Brain Injury Section of the American Congress of Rehabilitation Medicine (1993) as the loss of consciousness (LOC), loss of memory preceding or following injury (amnesia), alteration in mental status at time of injury, and/or focal neurological deficit. The American Academy of Neurology’s (AAN) Quality Standards Subcommittee (1997) reports that mTBI and concussion is often associated with brief (< 5 min) loss of consciousness or situational awareness where the person suffers a performance decrement within their required environmental context.

In clinical practice, mTBI and concussion are used interchangeably. However, they are distinct. Concussion is altered function following injury. mTBI is a pathological state of brain resulting from injury.

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Concussion has 3 grades of severity (American Academy of Neurology, 1997). The grades are differentiated by duration of altered mental status and any loss of consciousness. Although not part of the original AAN criteria, amnesia is an independent diagnostic indicator of TBI severity, with the loss of memory preceding (retrograde) or following (post-traumatic or anterograde) injury. Grade 1 concussion is defined as injury leading to altered mental status lasting less than 15 minutes without loss of consciousness. Grade 2 concussion is altered mental status lasting more than 15 minutes without loss of consciousness. Grade 3 concussion is any loss of consciousness.

Moderate TBI is usually associated with prolonged loss of consciousness and/or neurological deficit (Geocadin, 2004). These patients require advanced medical care including neurosurgical and neurointensive care. Later, as they recover, they may develop post-concussive syndrome. (Jarell et al., 2003)

Severe TBI is when injury causes the patient to be significantly neurological compromised such as obtundation or coma. Typically, this is associated with significant neurological injury, often with structural brain or skull lesions revealed by neuroimaging, e.g., head CT scan revealing skull fracture, intracranial hemorrhage and early diffuse cerebral edema. Severe TBI patients require advanced medical care even in the pre-hospital setting. After initial resuscitation and stabilization in the field, severe TBI patients should be quickly evacuated directly to the nearest combat support hospital (CSH) with neurosurgical capability. These patients need airway protection, mechanical ventilation, neurosurgical evaluation, neurocritical care, intracranial pressure (ICP) monitoring, and highly skilled nursing in a trauma or neurointensive care unit. For these patients, recovery will be prolonged and often incomplete with many not surviving to 1 year (Ashwal et al., 1994; Brain Trauma Foundation, 2007; Bullock et al., 2006).

mTBI

Diagnosis and therapy begins at the site of injury, whether the battlefield or the playing field. It is now required that all troops at risk of TBI be evaluated as soon as possible after exposure. During combat operations, at risk is defined as being within a certain distance of an explosive blast. That distance is different depending on circumstances, such as being mounted or dismounted when exposed. Evaluation is done using the military’s standardized MACE or military acute concussion evaluation. This is a paper based tool developed by the Defense and Veterans Brain Injury Center (DVBIC). It begins with obtaining relevant patient information including history, especially exposure details, e.g., blast versus impact, etc. Embedded within the MACE is the SAC or standardized assessment of concussion. The SAC is a neuropsychological clinical test of orientation, concentration, memory, processing, etc. It is based on a similar test used by the National Football League. At present, there are 6 versions of the SAC so as to minimize the effect of learning the test.

Without a history of altered mental status, if the SAC is normal and the patient does not have any symptoms, he/she does not have TBI and is returned to duty. However, some patients may have symptoms, such as dizziness, for which other non-TBI etiologies are considered such as dehydration. This and other mild symptoms are treated conservatively with simple therapies such as rehydration or sleep hygiene. The patient may need to be referred to an advanced medical care provider such as the battalion surgeon, who is typically a physician.

With a history of change in mental status after injury and abnormal SAC (score < 25) then the patient has suffered mTBI with impairment and is referred to an advanced medical care provider. A more detailed history and neurological exam is performed. If there are any neurological deficits, the patient is evacuated to the nearest CT for neuroimaging. If CT is normal, patients are returned to their unit to be managed. These patients are automatically taken off of combat operation duty (“take a knee”) for a prescribed period of time, on the order of a few days. During this time, patients are treated symptomatically based on the VA/DoD “Clinical Practice Guidelines for Management of Concussion/mTBI” (2009). These guidelines have both pharmacological and nonpharmacological (such as sleep, physical therapy, etc.) treatment recommendations. Patients are given crossword puzzles, Sudoku and similar cognitive games. Finally, there are daily education sessions to teach each patient about his/her disease, including possible symptoms (headache, dizziness, insomnia, etc.) and expectations of recovery, in other words that most mTBI patients fully recover. An important aspect of this care is that each patient is purposely kept with his/her unit. By doing so, the service member has an important support group and is able to maintain a sense of normality and purpose (Bell et al., 2009).

If the SAC remains abnormal or symptoms persist beyond 7 days, patients are referred to an in-theater restoration center, which are clinically staffed with a neurologist and/or occupational therapist. These are located near a CSH so that more advanced medical care can be rendered. The neurologist is able to perform more detailed neurological and medical assessments, treat with a wider selection of medications and test with more sophisticated methods. The occupational therapist can provide a more focused nonpharmacologic treatment plan. Typically, patients stay up to 14 days here. If they still have not recovered, then they are evacuated out of theater (Linquist et al., 2010).

This approach has been very successful. Most service members are able to stay with their unit throughout treatment. The majority of those that have been referred to the restoration centers have been able to return to their units. The recovery rate exceeds 90 percent (Bell et al., 2009).

If a service member incurs 3 concussions over the course of their deployment, he/she is removed from further combat operations. The service members call this the “three strikes and you are out” rule (Hancock, 2008).

### Moderate to Severe TBI

It is especially important for medical care for moderate to severe TBI to begin at the site of injury. In 2000, the Brain Trauma Foundation published the first edition of “Guidelines for the Prehospital Management of Severe TBI,” which is now in its second edition. Recognizing the need for similar CPG for the battlefield, the Brain Trauma Foundation and the U.S. military developed the “Guidelines for the Field Management of Combat-Related Head Trauma.” These CPG are specific treatment recommendations and goals to be used by medics, corpsmen, and other prehospital medical care providers for use on the battlefield. The emphasis is on maintaining optimal physiology to support the injured brain and prevent exacerbation of injury while under the constraints of military operations (Badjatia et al., 2008; Knuth et al., 2005).

Key guidelines are preventing hypoxia, maintaining perfusion (systolic blood pressure > 90 mmHg), and avoiding potentially deleterious interventions (prophylactic hyperventilation). This is accomplished by placing an artificial airway if the patient’s GCS ≤ 8, supporting breathing and oxygenation if oxygen saturation < 90 percent, and maintaining systolic blood pressure > 90mmHg. Unless a patient is actively herniating, hyperventilation and mannitol are to be avoided. They are not effective for prophylaxis. Mannitol should also not be used when mainten-
ance of intravascular volume can be assured. Other guidelines are analgesic and sedation use, which are important to optimize patient safety, particularly during evacuation. Of note, no particular resuscitation fluid is endorsed as none have sufficient evidence to show clear superiority. However, hypertonic fluids are preferred as they may have benefit in maintaining serum osmolality, which could be beneficial for intracranial pressure (ICP) management (Knuth et al., 2005).

The GPG also include triage and evacuation. As early as reasonably possible, a GCS for each patient should be determined as well as evaluation of pupillary function. Patients with GCS < 13 should be evacuated as early as possible to a CSH with a neurosurgeon.

Military in-hospital care of moderate to severe TBI treatment has benefited from advances previously developed for civilian TBI. The same civilian developed CPG are used in OEF and OIF CSHs. These in-hospital CPG are directed at optimizing the general physiology; avoiding exacerbation of injury; careful clinical monitoring; and preventing conditions that could worsen outcome, such as deep vein thrombosis (DVT). The key guidelines are placing an artificial airway if the GCS ≤ 8, placing an ICP monitor for GCS ≤ 8, criteria to obtain neuroimaging, maintaining ICP < 25mmHg, systolic blood pressure > 90mmHg, pO2 > 60mmHg or O2 saturation > 90%, normothermia, and hematocrit ≥ 28. Cerebral perfusion pressure (CPP) is kept between 50 to 70 mmHg if fluids or vasoactive agents are needed to achieve this range. If assistive therapy is not required to keep CPP above 50, then it is permitted to be at any level above that. To optimize cerebral venous drainage, the patient’s head is to be keep midline and the head of the bed at 30°. Antiepileptic medications are given for only the first 7 days to minimize the occurrence of early post-traumatic seizures. To prevent DVT, anticoagulation begins as soon as hemorrhages are stable. The approach is using sequential compression devices (SCD) and anticoagulation with low molecular weight heparin (LWMH) or low dose unfractionated heparin (LDUH), with or without mechanical compression devices such as graduated compression stockings and SCD. If intracerebral hemorrhage is present, then it is recommended that only SCD are used until the risk of further bleeding decreases, at which time anticoagulation may be started. Also important is early institution of nutritional support and gastrointestinal prophylaxis to prevent stress ulcers (Brain Trauma Foundation, 2007; Geerts et al., 2008).

In the event of cerebral herniation, mannitol and hyperventilation can be considered. Again, mannitol can be used so long as the patient’s intravascular volume can be maintained. Hyperventilation should be to pCO2 34 – 36mmHg. Neither should be used as prophylaxis against herniation. As many combat wounded suffer from hemorrhagic shock and/or dehydration, hypertonic saline solutions are often considered, including 3% saline infusion or 23% saline bolus. Hemicraniectomy is also a therapeutic option frequently used, especially with long evacuation times from theater back to the U.S. during which managing ICP can be challenging (Ling et al., 2009).

Nutrition is now recognized to be an important component of proper TBI care. The patient should be fed as soon as practical. In moderate to severe TBI, patients usually need nasogastric or orogastric tubes. This is preferred over using parenteral nutrition as enteric feeding more easily allows meeting metabolic needs. Another benefit is that by minimizing free water, enteral feeds can help maintain the intravascular osmolar gradient used in treating intracranial hypertension. Since most TBI patients have some cerebral edema, hyperosmotic feeds are typically used. As, the injured brain is hypermetabolic, TBI patients typically require 140 percent of their basal metabolic caloric needs (Brain Trauma Foundation, 2007).

A concern is the risk of cerebral vasospasm. Armonda et al. (2006) reported that close to 50 percent of a series of patients with blast related severe TBI developed cerebral vasospasm that
led to symptomatic neurological deterioration. This is diagnosed with neurological examination, transcranial Doppler, and cerebral angiogram. It is often responsible for delayed or late neurological deterioration. Treatment with intra-arterial nicardipine at the site of spasm is effective in reversing this and restoring neurological function (Armonda et al., 2006).

Close neurological monitoring is essential for optimal outcome. While in the acute period, all TBI patients need to be examined neurologically on a regular basis—at least every hour for the first 24 hours and then less often as clinically indicated. Patients with intracranial lesions require continuous ICP and CPP measurements. Typically, the most critical period is during the 48 to 96 hours following injury when cerebral edema is greatest. Thereafter, edema gradually resolves and the patient should improve clinically.

CONCLUSION

Sadly TBI is a common consequence of armed conflict. Clinical estimates of prevalence are high. In light of this, the military has enacted a comprehensive system wide program to identify, treat and rehabilitate TBI wounded service members. It uses evidence based CPG. Even though there is not yet a specific “brain rescue” or neuroprotective drug, evidenced-based CPG for treatment and return to duty provide a rational approach to proper management of the TBI patient. It must be emphasized that this is merely a beginning. To be truly effective, the CPG must be regularly updated. More research and quality assurance follow-up are essential. The system in place is imperfect so there is ample opportunity for improvement. The ultimate goal is that every TBI service member will receive the highest level of medical care—no matter where they are.

DISCLAIMER

The opinions expressed herein belong solely to the author. They do not nor should they be interpreted as representative of or endorsed by the Uniformed Services University of the Health Sciences, Defense Advanced Research Projects Agency, United States Army, or Department of Defense.
REFERENCES


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