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Blast Related Traumatic Brain Injury

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Traumatic brain injury due to blast related trauma is discussed. The focus of this paper is to highlight the complex interaction blast related brain injury has on many body systems. This paper reviews and summarizes data involving the etiology, complications and treatment of brain injury due to blast related trauma. Implications including the functional limitations and vocational outlook considerations are discussed and the differences between blast related traumatic brain injury and non-blast related traumatic brain injury is highlighted.

Traumatic Brain Injury (TBI) is currently occurring in the military population at dramatic rates. Estimates in the ongoing war on terror Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) put the number of blast related TBIs as high as 320,000 (MacDonald et al., 2011). With the use of unconventional weaponry such as improvised explosive devices (IED), blast related poly-traumas, which are injuries to both the brain and other body systems at the same time, are causing complicated injuries that affect the person through many mechanisms at once including physical, cognitive, psychological, or psychosocial impairment. This has required interdisciplinary action to investigate and disseminate the available research in order to understand and address the medical and the psychosocial needs of our military members. It is the goal of this paper to update rehabilitation professionals serving this population with accurate and current information about TBIs to help serve this specific population.

Etiology of Traumatic Brain Injury

According to the National Institute of Neurological Disorders and Stroke/National Institutes of Health (2011) and the Mayo Clinic Staff (2011), TBI is an injury to the brain from an insult to the head which causes the brain to collide with the inside of the skull resulting in damage such as tearing, bruising, bleeding or swelling of the brain tissue or when a penetrating object enters the skull with force damaging the tissue directly. This damage, referred to as closed TBI or open TBI respectively, results in disruption to the function of the brain. The severity of the injury may be categorized as mild, moderate or severe and may or may not result in loss of consciousness and is determined using the Glasgow Coma Scale (GCS), the length of loss of consciousness (LOC), and the length of posttraumatic amnesia (PTA) according to the American Congress of Rehabilitation Medicine (ACRM) (1993 as cited in Jones, Young, & Leppma, 2010). While moderate and severe injuries may require immediate life saving procedures, mild injuries may be more subtle and are harder to diagnose. Mild TBI (MTBI), or concussion, makes up about 75% of TBIs each year (CDC, 2011). MTBI is defined by: a LOC lasting less than 30 minutes, GCS score of 13 or higher, PTA lasting less than 24 hours, any alteration of mental state at the time of the trauma, and any transient or persistent focal neurological signs according to ACRM (1993 as cited in Jones et al., 2010).

Symptoms of Traumatic Brain Injury

Sources (Mayo Clinic Staff, 2011; NINDS/NIH, 2011; CDC, 2011) agree there are many symptoms and complications associated with TBI. These include headache, confusion, dizziness, blurred vision, ringing in the ears (tinnitus), fatigue, change in sleep patterns, behavioral or mood changes, memory problems, trouble with concentration and attention, vomiting, convulsions, dilation of pupils, slurred speech, numbness or loss of coordination, and agitation. There may also be many complications from the TBI including altered consciousness, seizures, infections, nerve damage, sensory issues, as well as problems with cognition, communication, behavior and emotion. Nerve damage may include paralysis and loss of vision or sense of smell. Cognitive problems may include memory, learning, reasoning, problem solving, judgment, attention and concentration, multitasking, organization and initiation (beginning or completing tasks). Communication problems may include aphasia (difficulty understanding or producing language), inability to organize thoughts, dysarthria (reduced or inability to form words due to loss of muscle control of the mouth and/or face), and trouble with nonverbal cues and meaningful changes in pitch and tone. Behavioral

changes may include issues with self-control, risky behavior, verbal or physical outbursts, and lack of awareness of ability or inaccurate self-image. Emotional changes may include depression, anxiety, mood swings, irritability, and lack of empathy or motivation. Sensory problems may include tinnitus (ringing in the ears), impaired eye-hand coordination, blind spots or double vision, balance problems, persistent tingling, itching or pain.

It is estimated that 1.7 million people sustain TBIs annually, males are 1.5 times as likely as females to sustain a TBI, and military duties increase the risk (Defense & Veterans Brain Injury Center, 2011; CDC, 2011). The most common causes in the civilian population are falls at a rate of 35% and motor vehicle accidents at 17% (CDC, 2011). In the military population, however, the leading causes of TBI are blast related impacts from explosions, rocket-propelled grenades, and improvised explosive devices (IEDs) (Defense & Veterans Brain Injury Center, 2011).

Mechanisms of Blast Related Brain Trauma

Blast related brain injuries have a different mechanism of action than other brain injuries. In non-blast related brain injuries, physical damage to the brain results from blunt or penetrating trauma or from acceleration-deceleration movement in a whiplash effect that creates a coup when the brain hits the front of the skull and a countre-coup when the brain rebounds back and strikes the back of the skull. This action tears nerve fibers and bruises the brain tissue and can also damage the olfactory, oculomotor, optic, and acoustic nerves in the brain (Kennedy et al., 2007). According to Kocsis and Tessler (2009) during a blast related injury, there are rapid changes in air pressure resulting in the over-pressurization and then under-pressurization on the brain as the blast wave passes over the brain. The result is a form of barotrauma, where air filled tissues and organs are subjected to differing pressures, resulting in damaging stretching and shearing forces. Although the exact mechanism is still unclear, studies show focal damage similar to other closed head injuries and some animal models suggest there are also diffuse axonal injury, white matter damage, and changes in myelin (Kocsis & Tessler, 2009). During a blast trauma, there is also the secondary blast effects resulting from flying fragments and shrapnel penetrating the brain. There are tertiary effects when the individual is thrown with force into other objects which result in injuries similar to the acceleration-deceleration injuries in the civilian population. And there are quaternary blast injury from burns, exposure to toxic fumes, and smoke (Kocsis & Tessler, 2009).

Complications of Blast Related Trauma

A problem facing military personnel is that blast related TBI is not always identified accurately. Blast related TBI occurs simultaneously with other life threatening injuries that may require immediate attention. Blast exposure is common in combat zones and there may not be any immediate outward signs of injury. Service members may be reluctant to be medically evacuated and separated from their unit and the symptoms may not be identified until much later when the service member finishes his or her deployment (Defense & Veterans Brain Injury Center, 2011). Even then, determining that a patient has a TBI may be difficult because the TBI may be co-morbid with other developing conditions such as posttraumatic stress disorder (PTSD) and/or depression which may have similar and overlapping symptoms (Defense & Veterans Brain Injury Center, 2011). Also, some patients with a history of PTSD and coping through avoidance may self-medicate with alcohol and other drugs further masking symptoms (Jones et al., 2010).

PTSD is a psychiatric disorder that develops when a person has experienced a traumatic and life threatening event. It is characterized by a re-experiencing of the event through recurrent intrusive recollections of the event, nightmares of the event, flashbacks, delusions, and hallucinations of the event, and intense distress and physiological reactivity to cues that symbolize the event (American Psychiatric Association [APA], 2000). With PTSD the person avoids stimuli associated with the trauma. Symptoms include problems with sleep, irritability, difficulty concentrating, hypervigilance, an exaggerated startle response, diminished interest in significant activities, feelings of detachment, restricted affect, and a sense of a foreshortened future (APA, 2000). Jones et al. (2010) sites that PTSD is often co-morbid with TBI, and the same trauma that caused the TBI may have also caused the PTSD. Furthermore, they describe several concerns when trying to disseminate the overlapping manifestations of these disorders. The first is that the behavioral and emotional symptoms may not be apparent until much later after the military member has returned home to their community health care provider. Secondly, some symptoms are overlapping such as amnesia; and it is difficult to determine whether it is an organic symptom due to brain injury or a psychological symptom due to the experience of the trauma. In fact, the amnesia itself may cause the person to not remember enough details of the event to expose the head injury at all. Lastly, because of the stigma associated with psychiatric conditions, the person may purposely attribute their symptoms of PTSD to the more acceptable TBI.

The overlapping symptoms of PTSD and TBI include: experienced trauma, intrusive memories, social de-

tachments, an inability to recall the trauma, diminished interest in activities, insomnia, irritability, and concentration problems (Jones et al., 2010). Co-occurring TBI and PTSD have also been known to interact with each other further complicating diagnosis and treatment. Burke, Degeneffe, and Olney (2009), report that both TBI and PTSD may affect the ability to regulate anxiety as TBI can deplete the cognitive assets needed to develop the cognitive strategies necessary to cope with PTSD resulting in an increased PTSD response.

Seizure disorder is another complication of TBI. Posttraumatic epilepsy (PTE) is the diagnosis given when there is two or more unprovoked seizures, which are seizures occurring at least seven days after the injury (Chen, Ruff, Eavey, & Wasterlain, 2009). According to Chen et al. (2009), statistics show that PTE occurs in mild TBI at a rate of 0.7%, in moderate TBI at a rate of 1.2%, and in severe TBI at a rate of 10%. The risk for developing PTE depends on the severity of TBI. Chen et al. (2009) further found Vietnam veterans with penetrating brain injuries have a 53% risk of developing PTE, veterans with closed-head trauma with visually confirmed cerebral injury through cerebral imaging have a risk between 10% to 25%, veterans with non-penetrating moderately severe head injury have a risk of 5%. The PTE risk among veterans with mild TBI is unknown, however, it is estimated that because of the high energy exposure in blast related injuries, the risk may be between 1% to 5% (Chen et al., 2009). Seizures may not be present during the initial rehabilitation and may begin as long as 5 to 20 years later; and may cause life threatening conditions such as disruption of blood pressure and heart rate control, disruption of respiratory and body temperature control, and aspiration during the seizure which may develop into pneumonia (Chen et al., 2009). The seizures may also develop as partial seizures which may present as subtle changes in mood and behavior and in the military population may be mistaken for PTSD (Chen et al., 2009).

Other complications include infections, auditory and vestibular dysfunction, visual impairments, insomnia, and postconcussive syndrome (PCS). According to Dau, Oda, and Holodniy (2009), there are many infections seen in veterans with TBI that may be associated with blast injuries, burns, shrapnel fragments, pulmonary infections from lung injuries, tracheotomies, intubation, antimicrobial resistant organisms, hospital acquired infections, infections from implanted prosthetic devices like skull caps, and infections acquired abroad. These infections complicate treatment of TBIs and increase morbidity. Auditory and vestibular dysfunctions occur in blast related TBIs because air-filled and air-fluid filled organs within the body are the most susceptible to injury from the blast waves (Howe, 2009). Auditory impairment includes peripheral hearing loss, central auditory processing deficits, vestibular impairment, and tinnitus (Fausti, Wilmington, Gallun, Myers, & Henry, 2009). Symptoms include dizziness, hearing loss, tinnitus, and even comprehension of speech; some of the symptoms mimic PTSD and cognitive deficits. Visual impairments result from damage to the eye itself caused by the blast, axonal shearing from the blast force (which may lead to axonal swelling and disconnection), damage from flying objects and thermal burns from the blast, or from occipital lobe damage (Cockerham et al., 2009). TBIs can cause focal cerebral lesions, including hematomas and hemorrhage that may compromise visual neuronal pathways (Cockerham et al., 2009). Insomnia and other sleep disruptions are common after a brain injury and may be related to the TBI, or be secondary to depression, anxiety, or pain. Insomnia may also be due to the pharmacologic treatment of the TBI or its complications, may delay and disrupt recovery, and decrease quality of life of the patient (Zeitzer, Friedman, & O'Hara, 2009). PCS is diagnosed when a person, who has had a head trauma with loss of consciousness, has ongoing symptoms of headache, dizziness, malaise, fatigue, noise tolerance difficulties, irritability, depression, anxiety, emotional lability, subjective concentration difficulties, memory difficulties, intellectual difficulties, insomnia, reduced alcohol tolerance, with a preoccupation of symptoms and fear of brain damage (World Health Organization, 1992 as cited in McCrea et al., 2008). Any or all of these complications can interfere with diagnosis and treatment of TBI.

Treatment and Symptom Management

The usual treatment for TBIs are directed at reducing damage by maintaining blood pressure and oxygen supply, and minimizing secondary damage from swelling and bleeding by using medications such as diuretics, anti-seizure drugs, and coma-inducing drugs (Mayo Clinic Staff, 2011). Surgery may be necessary to remove hematomas (clotted blood), repair skull fractures, or open the skull to relieve pressure (Mayo Clinic Staff, 2011). Computerized Tomography (CT-also known as computed tomography) and Magnetic Resonance Imaging (MRI) are used to produce images of the damaged brain tissues for assessment (Mayo Clinic Staff, 2011). Assessments must be done in many areas including physical, cognitive and behavioral to address the chronic sequelae of TBI. Rehabilitation is an ongoing process to recover abilities and skills that may have been lost depending on which areas of the brain were affected. Rehabilitation may include working with many specialists including physiatrists, occupational therapists, physical therapists, speech and language pathologists, neuropsychologists, case managers, rehabilitation nurses and counselors, recreational therapists, and vocational counselors (Mayo Clinic Staff, 2011). Education for patients and families is crucial and should

emphasize recovery and gradual resumption of as many of their responsibilities as possible, teaching compensatory strategies, and making environmental modifications as needed (Department of Veterans Affairs, Department of Defense, 2009).

Because co-morbid conditions complicate the treatment of TBIs, pharmacotherapy and psychotherapy may be used differently to treat TBI, PTSD, and depression. The question then is, what is the treatment when the person has more than one of these conditions and how are all the symptoms delineated and managed? Halbauer et al. (2009) suggests using a biopsychosocial model as a multidimensional approach applied to symptom clusters to create a differential diagnostic nosology for treating TBIs. They break the symptoms down into clusters that include: (1) cognitive dysfunctions including memory, attention, language, visuospatial cognition, sensory-motor integration, affect recognition, and executive function; (2) neurobehavioral disorders including mood, affect, anxiety, posttraumatic stress, psychosis, sleep, and libidinal disorders; (3) somatosensory disruptions including changes in smell, vision, hearing, equilibrium, taste, and somatosensory perception; (4) somatic symptoms including headache and chronic pain; and (5) substance dependence (Halbauer et al., 2009). Each cluster is comprehensively evaluated and an individualized treatment plan is developed. They suggest this approach will help clinicians facilitate rehabilitation and minimize the risk of missing problems in patients with TBI. Treatment for neurobehavioral sequelae includes pharmacological intervention. According to Chew and Zafonte (2009), neuro-stimulants can be used to improve attention, dopaminergic agents augment arousal, SSRIs treat depression, and beta blockers can be used to control agitated behavior.

Because there are so many facets related to the management of the symptoms and complications of TBI, in 2009 the Department of Veterans Affairs dedicated a whole issue of the Journal of Rehabilitation Research and Development to TBI. This issue, volume 46(6) includes a clinical practice guideline with algorithms for the defining, assessment, treatment, and symptom management of TBI. This journal edition also includes recommendations for functional assessment, patient and family education, and functional and vocational activities. Leskin, Lew, Queen, Reeves, and Bleiberg (2007) suggested using a life care planning approach they adapted from Roger O. Weed, to "facilitate continuity of care, comprehensively identify current and future needs, and coordinate life-long care across institutions and geographic locations" (p. xxiv). With this method a standardized approach is used to identify all the patients projected needs across a lifespan and plan for the care and cost accordingly.

Functional Limitations and Vocational Impact

Degeneffe et al. (2008) have noted that most people with TBI define normalcy in their lives by comparing their post-injury abilities to what they could do before their injury and have trouble accepting their post-injury limitations. Furthermore, people with TBI who are most successfully adjusted are those who are able to maintain supportive social relationships and engage in productive activities. In addition, work has been found to be a key indicator of successful transition because it provides social status, identity, and income.

Functional limitations of the patient need to be assessed in order to determine if a return to work is plausible. The limits the individual may have depend on which area of their brain has been affected by injury and most importantly, the severity of the injury (Schwartz, 2009). The areas to assess are as follows: physical, including balance, fatigue, pain, hemiparesis, uneven gait, ataxia, apraxia, decreased motor speed, seizure disorders, and sensory deficits; cognitive, including impairments in attention, memory, concentration, visual and auditory processing, verbal reasoning, critical thinking, language, and awareness; and psychosocial, which includes changes in personality, emotional lability, flat affect, depression substance abuse, frustration intolerance, impulsivity, inhibition, and lack of initiative (Schwartz, 2009). Other factors affecting outcome are length of coma, duration of post traumatic amnesia, age at the time of injury (the older the person the worse the outcome), and pre-injury educational level (more education equaling a better outcome), and lastly, pre-injury work history (Schwartz, 2009). Other perceived barriers when attempting a return to work are accessibility, transportation, lighting, noise, crowding, memory impairment, irritability, slowness, concentration and a perceived lack of support (Degeneffee et al., 2008).

Some people with TBI recover completely, some require compensatory strategies to aide them, while others will not be able to return to productive lives (Schwartz, 2009). Supported employment is one option for persons with brain injury which may include: community placement, job matching, employer education, and job support.

For those whose goal is returning to work, Schwartz (2009) outlines three components to a supported employment program: (1) assessment of residual skills, (2) identifying through situational assessment areas where compensatory strategies may be used, and (3) applying those strategies through on-the-job training. Another strategy Schwartz (2009) outlines is an intervention model that includes: assessment of learning style, a work sample evaluation, domain specific training, learning functional skills, supported employment, environmental engineering of the work site, and prosthetic devices. Anosognosia or an inability to recognize

one's own impairment has been identified as a barrier to these approaches. The patient's awareness of their limitations is thereby critical to the effective determination of these areas of deficit that need to be targeted for assistance (Schwartz, 2009).

According to Degeneffe et al. (2008), the first step in vocational rehabilitation is to refer clients for a neuropsychological evaluation to determine post-injury limitations like attention, concentration, alertness, processing speed, memory, learning, executive functioning, and language abilities. Next they suggest cognitive rehabilitation which includes retraining or relearning cognitive skills, substitution or using alternative strategies to compensate for impaired systems, and compensation which includes using devices such as planners and tape recorders to replace lost abilities. Next they suggest an individualized placement process that may include intensive and ongoing vocational rehabilitation services. Lastly, they recommend using community reintegration programs including the Clubhouse model.

A Clubhouse offers psychosocial support through task-oriented and social activities that facilitate adjustment to community life. Although originally developed for people with mental illness, the Clubhouse model has been adapted for people with brain injuries. In this model, the members are in charge of the Clubhouse and work alongside staff in running daily operations and may include tasks such as typing notes from clubhouse meetings and washing dishes (Degeneffe et al., 2008). Berens (2008) found that 89% of people with brain injuries receiving vocational services through an Acquired Brain Injury (ABI) Clubhouse had positive vocational outcomes.

The Department of Veterans Affairs and Department of Defense (2009) recommends in their Clinical Practice Guideline: vocational interventions (such as modifying the length of the work day, gradual work reentry, additional time for task completion, change of job, and environmental modifications, such as a quiet work space or additional supervision), vocational evaluation, and possible referral to a structured program for community integration. McNamee, Walker, Cifu, and Wehman (2009) suggest that many limitations can be overcome by job redesign and linking with businesses that are willing to partner with the patient to create a type of customized employment or individualized supportive employment.

Veterans who sustained a TBI while on active duty may be eligible for the Vet Success Program through the Department of Veterans Affairs. This program provides comprehensive vocational rehabilitation including: vocational evaluation and counseling services, employment services such as job training and resume development, on-the-job training and apprenticeships , college or vocational training, support services such as case management and medical referral, and Independent living services for veterans who have a service connected disability (Department of Veterans Affairs, Department of Defense, 2009). Further information is available at http://www.vba.va.gov/bln/vre.

Research and Future Outlook

There are many new avenues being researched today, such as neuroimaging and pharmacology. Using high-tech neuroimaging to detect subtle abnormalities in patients with TBI, new methods may be able to detect metabolic, micro-structural, and functional network changes (Van Boven et al., 2009). Van Boven et al. (2009) suggests "the development of multivariable models combining structural, neurochemical, physiological, and psychophysical or neurobehavioral findings can be anticipated to be an active area of future research (p. 737)." These researchers believe information about relearning, predilection, distinguishing neural signatures and more will contribute to the development of new approaches to managing TBI. Likewise, Chew and Zafonte (2009) believe that research in pharmacological intervention holds the key to enhancing memory, function, attention, and behavioral states including depression and agitated behaviors. Halbauer et al. (2009) suggests creating a differential diagnostic nosology will help rehabilitation experts provide comprehensive treatments for TBI patients with somatic and neuropsychiatric diagnoses.

Although the research is exponentially expanding, it is clear that what is needed is a way for rehabilitation experts to cross boundaries and share information and for coordination of all the available services to improve. Sayer et al. (2009) suggests that patients with comorbidities present challenges to the VA's current models of care coordination which depend on consultation with specialists instead of integrative care. They suggest research focus on a systematic approach in education and care coordination with a desired outcome of best practices guidance. See Appendix A for internet resources for persons with TBI and their families.

Conclusion

With the high rate of blast related brain injury occurring in the military today along with poly-traumas and complications that are co-occurring, TBI is one of the most complicated injuries to treat. The resulting brain injury can be mild with little to no recognizable symptoms to severe and catastrophic injury that leaves the person with the injury in an altered state of consciousness. To determine the effect of a brain injury many areas including physical, cognitive, communication, behavioral, emotional, and sensory changes need to be assessed. There are many different disciplines of rehabilitative care that may be involved

with the injured person and coordination of care and services needs to be systematic, integrative, and comprehensive to address the many areas of life that may be affected. See Appendix B for a brief list for vocational rehabilitation counselors to consider when assisting persons with a blast related TBI and Appendix C for other resources for vocational rehabilitation counselors working with persons with TBI.

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Appendix A

Internet Resources for Persons with TBI and their Families

- Defense and Veterans Brain Injury Center – Provides clinical research, educational programs, and clinical care for active duty military, their beneficiaries, and veterans with TBI (http://www.dvbic.org/)
- Vocational Rehabilitation & Employment Services – Provides comprehensive vocational services to veterans with a service-connected disability (http://www.vba.va.gov/bln/vre)
- National Institute of Neurological Disorders and Stroke – Provides education and research about brain injury (http://www.ninds.nih.gov/disorders/tbi/tbi.htm)
- Brain Injury Association of America – Provides advocacy, awareness, research and education about brain injury and includes local support groups (http://www.biausa.org/living-with-brain-injury. htm)
- American Veterans with Brain Injuries – Provides a web-based peer support network and information resources for veterans with brain injury (http://www.avbi.org)
- Side By Side Brain Injury Clubhouse – Provides rehabilitation and community reintegration for persons living with brain injury (http://www.sidebysideclubhouse.org)

Appendix B

Questions for Vocational Rehabilitation Counselors working with Persons with TBI

1. How severe was the injury (mild, moderate, severe)?
2. Are there complications/co-morbid conditions involved?
3. What barriers do these conditions create for employment?
4. What are the functional limitations involved (physical, cognitive, emotional)? If no neuropsychological, then strongly recommend obtaining one.
5. Are there other perceived barriers to employment (transportation, accessibility, functional limitations, visible scars, etc.)?
6. What are the residual transitional skills? Will the military assignment translate into civilian occupations? Recommendation is to do a vocational evaluation.
7. What strategies/assistive technology can be applied?

8. Would the individual benefit from a community reintegration program?
9. Does the individual need supported employment services?

Appendix C

Resources for Vocational Rehabilitation Counselors Working with Individuals with TBI

(1.) A list of neuropsychologist questions by Weed and Field (2001, p. K37)

(2.) A Functional assessment checklist (Department of Veterans Affairs, Department of Defense, 2009, p. 31)