

## **Traumatic Brain Injury Assessment and Therapy Current and Future Perspective**

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Traumatic brain injury (TBI) is among the most common neurological conditions afflicting Americans. There are 1.4 million new cases of TBI each year in the United States. The Centers for Disease Control and Prevention estimates that at least 5.3 million Americans currently have a long-term or lifelong impairment and the need for help to perform activities of daily living as a result of a TBI. TBI is also unfortunately a very common injury of the Iraq War. It has been estimated that over 300,000 troops deployed to Iraq or Afghanistan may have suffered some form of a TBI to date.

### **TBI Outcomes**

TBI related impairment in function depends on the mechanisms of injury as well as the location and the extent of brain damage. TBI can result in a simple concussion with no impairment in functioning. Alternatively, TBI can result in a mild, moderate, or severe impairment or a devastating irrecoverable vegetative state. Fortunately, the vast majority of TBI cases are mild with limited permanent impairment in functioning. However, at least 20% of individuals sustain moderate to severe TBI which can result in long lasting and significant impairment in functioning, disability and inability to maintain a job. These individuals are most commonly young men (aged 15 to 24) with a lifetime of disability, employment limitations, requiring significant support from family and caretakers at a significant cost to society. The CDC estimated that lifetime costs can range from \$600,000 to \$1,870,000 to care for a survivor of severe TBI. The costs associated with caring for Iraq and Afghanistan soldiers who have sustained a TBI are estimated to reach \$35 billion over the course of the soldiers' lifetime. Approximately 80,000 individuals develop long-term disability from TBI each year in the US.

Management of severe TBI patients with chronic impairments requires a comprehensive team of specialists, clinical assessments, imaging and laboratory testing to facilitate recovery and improve prognosis. There are no FDA approved medications or surgical options to help patients with chronic impairments from TBI. It is important for the scientific and clinical community to explore new technologies and developments to offer hope and help the civilian and military patients suffering from the consequences of TBI.

### **Assessment of TBI Functional Impairments**

TBI can damage brain regions associated with various functions resulting in impairments in consciousness, movement, balance, sensation and cognition. Frontal lobe injury has a particularly significant impact on an individual's functioning, ability to be employed and disability. Frontal lobe TBI can result in impairment in attention, judgment, memory, cognition, communication, decisional capacity, carrying out tasks in a logical sequence, as well as behavioral limitation such as impulse control, anxiety, mood fluctuations and apathy. Clearly, limitations in frontal lobe function from severe TBI will affect ones ability to be employed. Thus, evaluation of frontal lobe impairment and functional capacity is crucial for patients with chronic TBI.

## **Clinical Assessments of Frontal Lobe Function**

There are a number of clinical tests that can assess various functions of the frontal lobes. These include various standardized, validated measures and scales designed to broadly measure frontal lobe function. These assessments should be conducted in a systematic and organized fashion to comprehensively and optimally evaluate patients with TBI related impairment. These assessments should be performed by a multidisciplinary group of professionals including physical medicine and rehabilitation specialists, neuropsychologists, psychiatrists, physical therapists, occupational therapist, speech therapists, and other associated health care professionals.

One example of a systematic and organized approach for evaluating frontal lobe cognitive and behavioral function in chronic TBI patients is the International Classification of Functioning, Disability and Health (ICF) (WHO, 2001). The ICF provides a comprehensive organization of validated tests to identify outcomes in severe TBI, and conceptualizes disability into: organ systems (brain function), the individual (functional independence), society (community participation) and subject well being. These assessments are obtained via objective testing of the patients, as well as patient and family interviews.

Brain function assessments can be performed via standardized neurological examination, neuropsychological battery of tests, brain imaging, and laboratory testing. Functional independence can be measured using standardized instruments of the amount of assistance and supervision the subject requires as determined by rehabilitation professionals and primary caregivers. Community participation, uses proxy (family/caretaker) input to assess engagement in economic, social, recreational and cultural activities. The ICF defines community participation as fulfillment of developmentally and culturally appropriate social roles such as worker, student, spouse, parent, or citizen. Finally, Subjective well-being can be measured by self-report and includes indices of mood (depression, anxiety, apathy), fatigue, pain and the extent of life satisfaction.

There is no single clinical test or approach that provides the ultimate answer for TBI impairment and the ability to perform work in the economy. Rather, there are a multitude of approaches and tests designed for capturing impairment from TBI. The ICF is just one example of a systematic and organized means of evaluation these patients and providing a framework to operationalize these outcome dimensions. It is important to note that disruption of the function of the frontal lobe is a crucial predictor of the ability to maintain a job. In this context, clinical assessment of frontal lobe function is important to determine if one is able to work in the economy.

## **Imaging**

In the past decade, magnetic resonance imaging (MRI) has become increasingly important for evaluating brain disorders. High resolution scanners such as 3 T and higher field magnets as well as specific MR sequences such as diffusion tensor imaging (DTI) are dramatically improving our understanding of the structural damage to the brain of TBI patients. In addition, functional MRI (fMRI) and Positron Emission Tomography (PET) scanning techniques are providing a unique window into the function of the human brain. PET and fMRI allow us to evaluate the brain regions involved in communication, behavior/emotions, cognition, attention and decision making. In the next few years, these imaging tools and technologies will be increasingly utilized to study TBI patients. The combinations of the structural and functional brain imaging with the clinical assessment of TBI impairment, will improve our capabilities and the precision of evaluating frontal lobe dysfunction in TBI patients.

## **Therapeutic Options for TBI**

Therapeutic options for the chronic TBI patient typically involve a multidisciplinary team approach consisting of physical therapy, speech therapy, occupational therapy, behavioral therapy, and cognitive rehabilitation specifically tailored for each person to increase the individual's independence and functioning. Cognitive and behavioral rehabilitation therapies target the frontal lobe dysfunction in TBI. The goal is to improve self-awareness, motivation memory, attention and concentration, self-monitoring and self-regulation, functional or social communication and emotional well-being. Cognitive improvement in TBI patients will also facilitates other rehabilitation therapies such as physical therapy and vocational rehabilitation. These integrated rehabilitation services are often limited for persons with chronic TBI due to personal financial constraints and insurance reimbursement that is minimal or non-existent. In addition, there is no FDA approved or proven medications or surgical therapies for reducing the impairment and facilitating recovery in TBI patients.

## **Deep Brain Stimulation (DBS)**

In the past decade a promising new therapeutic approach using a brain pacemaker, also known as deep brain stimulation (DBS) has emerged with over 55,000 brain implants worldwide. DBS is an FDA approved and Medicare reimbursed therapy for patients with Parkinson's disease, tremor and dystonia. DBS has allowed for a significant improvement in functioning, independence and quality of life improvement with return to work and resumption of daily activities for severe and medication intractable patients.

In the past several years, new clinical trials have investigated the potential of brain pacemakers to treat various neurological and psychiatric disorders including severe, disabling and medication intractable epilepsy, depression, and obsessive compulsive disorder (OCD). These studies are showing that DBS can significantly improve the mood and functioning in severely depressed patients, lessening the anxiety and obsessions in OCD, and improving the overall functioning, independence, quality of life and employment in these severely disabled patients.

Recent studies are investigating the use of DBS in patients with severe TBI and in a minimally conscious state (MCS). An initial report in a patient in MCS has demonstrated promise with DBS resulting in improvements in arousal, attention, responsiveness and feeding. DBS is most likely activating the reduced functioning of frontal lobe from the TBI. Given the limited therapeutic options for patients with significant TBI related impairments, the use of DBS may provide hope and benefit for patients with moderate to severe TBI by improving the functioning of the damaged frontal lobes of the brain.