Traumatic Brain Injury

Focus on Military / Soldiers

The signature injury of the military action in Iraq is a condition called Traumatic Brain Injury. This condition is caused by blasts and shock-waves that damage soldiers' brains. In an attempt to educate people about this critical issue, a website (www.soldierstbi.org) has been created that supplies necessary Traumatic Brain Injury information to the general public, including patients and their families. The information includes an overview and explanations of causes, symptoms, diagnosis, treatment, funding and additional resources.

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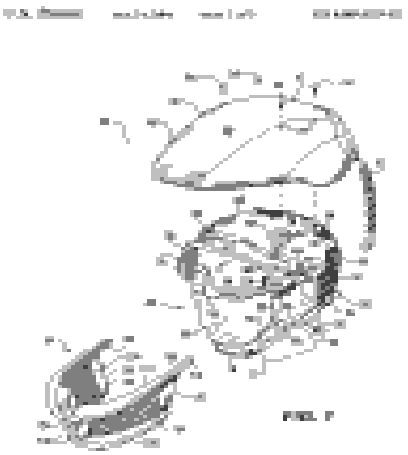
With recent advancements in military and medical technology, soldiers are surviving trauma that they never could before. Improvements in body armor are protecting their internal organs; new, heavier equipment, with better side protection has been developed, along with new boots, goggles, and weapons. The interceptor body armor is the current army standard. It consists of an outer tactical vest made of Kevlar and small-arms protective inserts. These inserts made of an alumina ceramic, backed by a spectra shield. The shield, which is made of ultra high molecular weight polyethylene (UHMWPE,) has a yield strength of 2.4 GPa. The ceramic blunts the kinetic energy by shattering, and the spectra shield stops the fragments. This armor will stop three nine millimeter bullets traveling at 838 meters per second. Extensive improvements concerning structures and vehicles have been made. Armored and uparmored vehicles now have better steel shielding surrounding the windows and doors, in addition to reinforced hinges, extensive overlapping of ballistic protection and shielding, roll-over vehicle protection and run-flat tires. These safety precautions help deflect blasts and protect drivers and passengers in the case of attack, collision or nearby detonation of Improvised Explosive Devices (IEDs.) A multitude of structures are erected to enhance the physical security of the soldiers, including barracks and headquarters, cover from viewscreens, blastwalls, road barriers, gates, observation posts, mortar roofs, rocket screens and vehicle checkpoints. As a result of the improved equipment, the majority of injuries affect soldiers' extremities – their limbs and heads (and brains.) In an effort to protect soldiers' brains, they are now issued new headgear – Advanced Combat Helmets – which have replaced the old Kevlar helmets. A diagram of an ACH can be seen in Figure 1. These new helmets are about three-and-a-half pounds lighter, cushioned, easier to sight weapons while wearing, and have a different suspension system. The new suspension system improvements are in direct response to the number of shock-wave induced injuries, in an

attempt to protect soldiers' heads (and brains) from injury. However, these new “Brain Buckets” are not protection enough; blasts and shock-waves are damaging solders’ brains, causing bruising from impacts with the inside of the skull (concussions) and deterioration from changes in cellular metabolism. Doctors are calling this condition Traumatic Brain Injury (TBI.)

Figure 1: Diagram of an Advanced Combat Helmet



Excluding military statistics, TBI affects approximately 1.5 million Americans every year, striking about 80,000 of them with long term disabilities. Currently 5 million Americans are disabled. There are greater than 50000 deaths per year as a result of traumatic brain injury. Common causes can be seen in Table 1. Males are more frequently affected, specifically young males (due to high prevalence of transportation accidents and crashes) though a high number of people older than 65 are affected, due to an increase in falls. Re-injury is

common. After the first instance, it is three times more likely for someone to suffer a second injury, after which they are eight times more likely to suffer a third. The prevalence of soldiers returning from combat with Traumatic Brain Injury is a startling number. About 65% of the injured soldiers returning from combat in Iraq and Afghanistan, who are treated by Walter Reed Army Medical Center, are suffering from some degree of TBI. Due to the complications involved in diagnoses, a concrete number cannot be accurately determines. The best approximation, taken from reported cases of TBI, estimates the number to be around 160,000 afflicted soldiers, with many more undiagnosed, misdiagnosed and still deployed.

Table 1: Percentages of Common Causes of TBI

Percentage	Causes
44%	Transportation Accidents
26%	Falls
13%	Other/Unknown
9%	Non-firearm Assaults
8%	Firearms

The explosions injuring soldiers are caused by IEDs - improvised explosive devices – which are varied, but include car bombs, makeshift roadside bombs and mobile phone and radio bombs. The blasts and shock-waves cause different injuries; there are primary, secondary, and tertiary injuries from an explosion. Primary blast injuries are due to the shock-wave itself, while secondary blast injuries are a result of missiles being propelled by the blast force, and tertiary blast injuries are due to impact with another object. The primary and

tertiary injuries manifest in different ways; shock-waves can cause a change in the metabolism of cells, cell death, and twisting of the brain on the brainstem while impacts cause bruising of the brain and concussions from the brain impacting the inside the skull. Shock-waves are generally responsible for changes in cell metabolism, leading to increased cell death. Inflammation responses from the brain as a result of these damages promote the release of tumor necrosis factor alpha and interleukin beta - reagents in the brain that induce cell death. Necrotic cell deaths occur when the cell swells, causing lysis (cell membrane breakage.) The disrupted cell membrane leads to cell death and randomized DNA fragmentation. Apoptosis is another form of cell death, resulting from cell shrinkage and the formation of apoptotic bodies – where the cell breaks apart into several vesicles. There is a condensation of chromatin, nuclear fragmentation and internuclear DNA fragmentation. The symptoms that result from these types of damages can vary widely, and can manifest differently in each patient, making a diagnosis of TBI very difficult, as signs are frequently overlooked or initially dismissed.

TBI shares many symptoms with Post Traumatic Stress Disorder (PTSD,) leading to confusion in diagnosis and other problems. As an example, many people don't seek help when they are experiencing symptoms of either condition, due to the stigma associated with PTSD - that it reflects poorly on the mental strength of a person. The most basic definitions of PTSD and TBI reflect the differences between the two. PTSD is “an anxiety disorder that develops in reaction to traumatic events.” A person with PTSD must have been in at least one situation where they felt that life was threatened or that he/she was going to be injured which resulted in feelings of helplessness and/or terror. PTSD has three main kinds of symptoms; re-experiencing, avoidance, and arousal. Re-experiencing manifests itself as nightmares and

an unconscious and unpleasant reaction to different types of stimuli. Avoidance symptoms include an 'avoidance' of objects that remind the patient of the event and thoughts that are related (however minor) to what the person experienced. Arousal is a physical reaction that shows itself as reduced concentration, sleeping problems, hyper vigilance, and problems with anger control. TBI is "a physical injury to the brain, often caused by exposure to one or more explosions, or other blows to the head. Injuries can be penetrating or closed, and the latter can be mild, moderate or severe." The different severities of TBI are depicted in Table 2. The severity of TBI is defined by acute injury characteristics, not by the severity of any symptoms at a point in time, which can be intermixed with sign and symptoms of injuries to peripheral vestibular system and varied psychological states. There are a number of symptoms associated with TBI, which can be seen in Table 3. There are external - that is, outwardly recognizable - symptoms, and internal – requiring scans, etc – symptoms. There are three cardinal neuropathologic dimensions considered in diagnosis: distribution, severity and types of pathology.

Table 2: Diagnosis Criteria of levels of severity of TBI.

	Mild	**Moderate**	**Severe**
Loss of Consciousness	< 1 hr	1 < x < 24 hrs	> 24 hrs
Amnesia	< 24 hrs	1 < x < 7 days	> 1 week

Table 3: Symptoms of TBI

External Symptoms		Internal Symptoms
periods of unconsciousness	amnesia	concussive & bruising damages*
difficulty initiating activities	poor judgment	lesions: focal, multifocal & diffuse
impaired cognitive abilities	seizures	changes in cellular activity
impaired physical functioning	muscle spasticity	internal swelling
impaired behavioral functioning	fatigue	
impaired emotional functioning	headaches	
trouble concentrating	balance problems	
slowed ability to process information	depression	
organizational problems	mood swings	
memory loss	anxiety	
agitation	impulsivity	

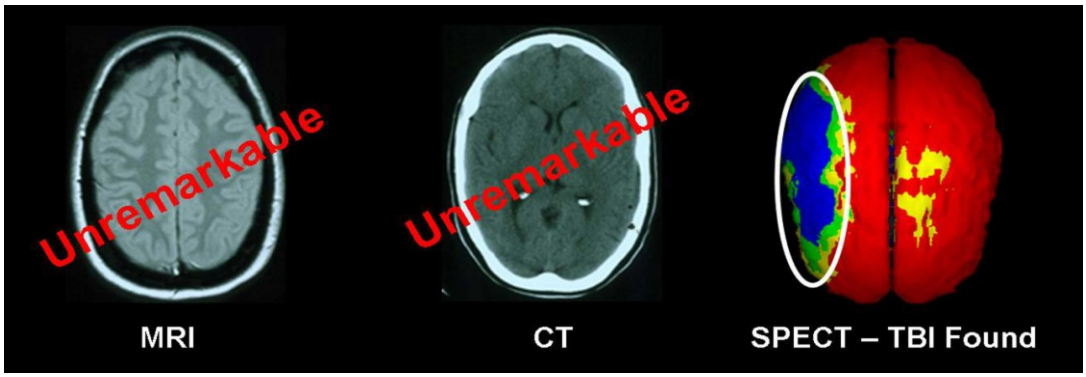
*the brain damage can be diffuse damage – bruising of many parts of brain, leading to brain swelling, brain death, coma, brain stem injury, and seizures.

With such a list of symptoms, TBI is difficult to detect, difficult to diagnose and is often confused with other afflictions. While there are many neurological tests that assess cognitive performance, there are very few that deal with the effects of TBI on dynamic motor performance. In previous studies, moderate to severe TBI patients who complained of an unstable gait were assessed to study their movements with regard to healthy people. These subjects showed increased caution, a slower walking pace, a shorter stride, and an increase in the motion of their center of mass. The motion of the center of mass was also faster than the control subjects'. This study tested mild TBI in patients who had had a concussion within the last 48 hours. In the first part of the study, the subject walked without doing anything else. The concussed subjects had a slower pace and a smaller upper body sway than the healthy subjects. The second part of the study assessed the subjects' walking ability while

concentrating on another task. The concussed subjects had a shorter stride, slower pace, and greater body sway than the controls. The study concluded that a person with mild TBI showed no real problems with walking, except when concentration was needed for something else. The authors concluded that this could be a problem for athletes and other persons who might need to think while performing any sort of dynamic motor activities.

Diagnosis of traumatic brain injury is attempted through a variety of tests, including the Glasgow coma scale / degree of consciousness, the Rancho Los Amigos Level of Cognitive Functioning Scale, the Disability Rating Scale, the Functional Independence Measure and the Functional Assessment Measure. A number of brain scans are also employed, including CT scans, CAT scans, MRIs and SPECT scans. Mild TBI doesn't usually show any abnormalities on brain imaging, leading to further diagnostic complications. Recent studies have shown there to be a quantitative diagnostic possibility for TBI with diffusion-weighted MRI scans and MR-based brain and cerebrospinal fluid measurements. However, the best results are seen with SPECT scans – Single Photon Emission Computed Tomography, which use gamma ray emitting radioscopes and a gamma camera to create 3-D, computer-generated renderings of the brain. The results depend on an injection of radioactive tracer that is absorbed by the brain within a minute, allowing an accurate reading of cerebral blood flow. These scans are 95% accurate in ruling out TBI, but give more false positive results than the alternative scans. Unfortunately, SPECT scans have much worse resolution when compared to other scans, for example MRIs. An image can be seen in Figure 2, showing the unremarkable CT and MRI results, as well as the relatively poor level of detail of the SPECT scan. Cost may also be a factor, as CT and SPECT scans cost approximately $1000/scan, and MRIs cost approximately $1800/scan.

Figure 2: Comparison of MRI, CT and SPECT scans



While the numerous and varied symptoms of TBI, the similarities between TBI and other conditions, and the accuracy of scans (or lack thereof) all make diagnosis difficult, there is one more aspect of Traumatic Brain Injury that hurts diagnosticians and patients the most. TBI causes severe self-awareness deficits; people suffering from TBI can be unaware of their affliction, even while exhibiting multiple symptoms, to the extent that they vehemently deny their symptoms, even when they are pointed out by outside observers. In one case, a man had lost all of social skills and was unaware of it; he unknowingly sexually harassed a female, making her uncomfortable with his staring. He was not only unaware of it at the time, but also indignantly un-accepting of the news when it was later pointed out to him by witnesses. These patients with self-awareness deficits report higher functioning than their relatives while medical personal report lower patient functioning than relatives. Patients with mild and severe TBI report the same percentage of "their memory and concentration issues not bothering them at all" (33%) despite the fact that patients with severe TBI have more extensive damage.

One of the problems with treatment and research for traumatic brain injury is funding. In 2007, the Congressional Budget allotted $366 Million for TBI treatment and research. The Department of Defense appropriations towards medical research problems were $150 Million in 2007. While these sound like large numbers, the average lifetime cost of care for someone suffering severe TBI is $600,000 to $1,875,000. With the number of soldiers returning with TBI, and resources running low, a funding problem is looming, the effects of which are already being felt.

A great number of our soldiers are returning home with this ‘signature injury’ of the war. Blasts and shockwaves are damaging their brains; their brains are getting bruised and twisted inside the skull, and cells are being damaged and killed. There are numerous symptoms that are not singular to TBI, and can manifest differently across all patients, making diagnosis very difficult. Different brain scans are typically used for diagnosis, but there are drawbacks to each. Once a diagnosis is made, the next step is treatment. Due to the nature and complexity of brain injuries, most treatments are a response to symptoms, not necessarily injury. Experimental treatments are being explored in animal studies.

With so many complications regarding symptoms and diagnosis, its no wonder that such a large number of patients go undiagnosed and without medical treatment. In an attempt to help rectify this problem, a website (www.soldierstbi.org) has been created that supplies necessary Traumatic Brain Injury information to the general public, including patients and their families. It contains information including causes, symptoms, diagnosis, treatment, funding and additional resources. In addition, there is a changing 'Featured Article'

concerning TBI, to keep readers up to date with progress made with treatment, medical breakthroughs, news from overseas and similar topics. Eventually a message board will be included, for the public to post their experiences, advice, questions, etc.

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