An Innovative Approach to BLAST INJURY RECOVERY

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CARING FOR MILD traumatic brain injury (mTBI) continues to be challenging for both the military and the Veterans Administration (VA). The Army can make a difference in the care provided to Soldiers by incorporating aspects of sports medicine's approach to treating closed head injuries. Several sports medicine "best practices" can assist in caring for Soldiers who have been exposed to explosive blasts and are suffering from mTBI.

Traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD) are often confused and incorrectly interchanged when referring to consequences associated with blast injuries. These afflictions are not the same, and a Soldier can be diagnosed with both. TBI is a physical wound to the brain. PTSD is a physiologically induced wound to the mind (i.e., information processing and mental functioning). The focus here is on TBI, primarily in its mild form, mBTI.

Sports teams have taken aggressive steps to mitigate brain injury on playing fields. The number of collegiate and high school football players incurring closed head injuries resulting in mortality has dropped over the last half century due to increased awareness and research. In 1968, for example, 36 fatalities related to head injury were reported. By 1990, however, the average number was five per year.[1] Comparatively, the Army's challenge has escalated since the start of the War on Terrorism. An estimated 150,000 Soldiers have been diagnosed with some level of traumatic brain injury, primarily from exposure to explosive blasts.[2]

The Army and the VA are taking action to find best care practices by making mTBI awareness a top priority. All leaders are directed to participate in the on-line educational TBI awareness and treatment program.[3] The VA's lead organization for this program is the Defense and Veterans Brain Injury Center (DVBIC) in Washington D.C. The DVBIC facilitates innovative partnership ventures with private and public sectors by bringing together the experts from both sides to identify the best technology and achieve the best care possible.

This article explores blast effects on the brain and identifies some best practices the military can adopt from established sports related programs. The essential core of sports-related programs for dealing with head/brain concussion is three-fold:

- Sports teams conduct extensive pre-season cognitive testing to establish a neuropsychological baseline on every player. These reports become invaluable in both the detection of and the recovery from concussive

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PHOTO: A 22-year-old Army specialist exposes a scar on his scalp as he scratches his head while working with speech pathologist Sara Granberry at Vanderbilt Medical Center, 2 August 2007, Nashville, TN. The scar is a result of a rocket attack. The Soldier now suffers from traumatic brain injury, the "silent epidemic" of the Iraq war. (AP Photo, Mark Humphrey)

injury. Sports teams use several inexpensive and easily obtained software packages to gather data and conduct accurate cognitive testing. These cognitive testing database software packages are web-based and can be networked using mobile hand-held devices.[4]

- Sports trainers and physicians use an integrated approach to recognize trauma and evaluate the rate of recovery of a player with mTBI. Paramount in this effort is the combined use of scanning technology and cognitive testing in the detection and recovery phases of an injury. An example of emerging technology that has outperformed the accuracy of traditional brain imaging is the Magneto Encephalography (MEG). The MEG system is twice as accurate as traditional systems in identifying post concussive abnormalities.[5] Integrating this new imaging technology with cognitive testing management systems produces a holistic approach to diagnosing and treating closed head injuries.[6]
- Sports teams have thorough testing regimens that evaluate patient recovery and validate readiness for athletes to return to play. Trainers and coaches alike recognize the increased risk of serious injury or even death when a player suffers a second concussion when not fully recovered from the first.[7] Care providers typically use scanning technology to determine the readiness of an athlete to safely return to play.

Athletes, unlike Soldiers, do not routinely risk their lives responding to the call for duty to the Nation. Soldiers, however, relate easily to competitive team sports and exhibit the same spirit to win. Frequently, winning entails personal risk. Infusing sports best practices with current Army mTBI identification and treatment procedures can greatly enhance overall Soldier recovery and readiness. By adopting these best practices, the Army will gain a system that provides increased objectivity and greater accuracy in assessing brain injury. Soldiers, like athletes, sometimes need to be told when to rest.

Understanding Blast Mechanics

A blast produces an energy wave that causes an immediate change in atmospheric pressure. There are three blast phases: primary, secondary, and tertiary. The primary phase creates a wave of energy pressure that leads to the secondary and tertiary blast phases. Even though improvised explosive devices (IEDs) seek to cause penetrating damage, this initial energy wave surrounds the body, causing an extreme but temporary change in atmospheric pressure on the organs and the cardiovascular system.[8] We know that this surrounding pressure can cause a Soldier to feel dazed or even to lose consciousness, but the full consequences of exposure to this energy wave are not well understood with regard to the human body, especially the brain.[9]

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The secondary blast effect is made up of physical elements that are picked up by the primary blast energy wave and propelled through the air, often impacting and injuring the human body with assorted shrapnel.[10] Finally a tertiary blast effect results in the body being thrown into or against an object. A tertiary effect, for example, occurs if a Soldier's head snaps back from the blast pressure and hits the inside of the vehicle door with sufficient force to cause injury.[11]

Understanding these three phases of blast effects is crucial. We take extensive measures to protect Soldiers from the secondary and tertiary elements of the blast by providing state of the art equipment such as helmets, eye protection, groin protection, additional hardening of vehicles, and even seatbelts. However, we need to do much more to identify the best way to protect troops from the impact of primary blast effects pressure on the brain.

Effects of Blast on the Brain

Brain bleeding is a common effect from a blast event. Bleeding can occur immediately, or it may take several days for blood vessel seepage to appear. Some scanning techniques effectively identify bleeding and swelling. What is more difficult to identify, however, is the damage caused by a sheering and stressing of the microscopic nerve axons in the brain. This damage is referred to as Diffuse Axonal Injury (DAI). Because the brain is

made up of billions of microscopic nerve cells, DAI can go undetected. Severe whiplash or jolting of the head can contribute to injuring these axonal fibers.

The most feasible way to determine DAI is cognitive testing.[12] Unfortunately, axonal fibers cannot be visualized on Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) scans. Consequently, sports teams combine both cognitive testing and scanning technologies to provide an optimum diagnosis. For these reasons, the sports industry invests substantial time and resources in using cognitive testing methods to build a player's baseline.

Brain damage can occur even when the head does not sustain a direct blow. When the body below the neck receives massive injury from a blast, hypoxia can occur. Hypoxia is oxygen deprivation with the potential to result in brain damage.[13] James P. Kelly, a leading sports brain injury advisor to sports teams like the Chicago Bears, recently described this condition.[14] When the body is under incredible surrounding pressure like that produced from a blast or massive physical trauma, the results are similar to that of "holding a tube of toothpaste and squeezing." As the blood rushes to the head there is no place for it to go. The normal pressure of blood flow from the heart and the rush caused by the pressure of the blast compete for limited space, causing shock and imbalance in the cardiovascular system.

This pressure can produce a state of hypoxia and potential DAI or bursting of blood vessels.[15] When rabbits and rats were exposed to blasts in the thoracic region, even while the head area was protected by steel plates, a pattern of neuronal abnormalities similar to DAI occurred.[16]

Risk From Exposure to Repeated IED Blasts

U.S. ground forces are experiencing high levels of blast exposure. These effects are being studied in both a combat and home-station environment. Army programs that clear blast injury victims for return to duty must be objective, standardized, and above all accurate. To protect troops, maneuver commanders today develop unit policies derived from lessons learned from previous commanders or from their own personal experiences after repetitive combat tours.

A recent U.S. Air Force study conducted in the combat zone at Forward Operating Base Anaconda, just outside Baghdad, Iraq, determined that upwards of 60 percent of the Soldiers exposed to IED or other blasts suffered tympanic membrane, or eardrum damage. Importantly, the presence of tympanic membrane damage is a good marker to identify potential brain injury.[17]

Captain Dennis Terry, United States Military Academy boxing coach, recently noted that when training for upcoming bouts, he counsels his cadets to neither deliver nor take any more head punches than necessary. The coach further explains that military leaders are beginning to understand that troops do not just shake off concussions. People with a first time head injury or concussion are at a 50 percent greater risk of death should they be injured a second time before the symptoms of the initial injury are gone. This effect is called second impact syndrome.[18]

Today's Soldiers are averaging three to four year-long combat tours over a six-year period. Their dedication to the mission and each other increases their risk of being exposed to multiple IED blasts. A historical example of Soldiers repeatedly exposed to blasts occurred in April of 2004 when Muqtada al-Sadr's al-Madi Army Militia held a terrorist siege on the holy city of Najaf. The lead element for the Stryker battalion opposing the terrorists was the scout platoon led by 1LT John Hicks.

Five RPGs simultaneously hit the third vehicle in the platoon. The explosions threw everyone to the floor and knocked out all electrical power and communications. The Scouts returned fire with their .50-caliber machineguns and Mark-19 grenade launchers. Moments later, Hicks received a report from the disabled vehicle via the crew's squad radios. They reported that no one was injured and the damage could be repaired in a few minutes. The Scouts moved forward several hundred yards past the ambush site. As they dismounted, the enemy struck again.[19]

Although blasts were reported by the unit, they were not reported against particular crew members or individuals in the fast-moving combat environment. Soldiers rarely report an injury unless it is visible and requires immediate medical attention. Today's leaders continue to struggle with accurately accounting for mTBI in a combat environment.

U.S. Army, SPC Clinton Tarzia

Soldier in 1LT Hicks' scout platoon scanning for possible IEDs along the convoy route to Najif, Iraq, April 2004.

Affecting the Life of a Soldier

Based on my experiences as both a commander on the ground in combat and a chief of staff at a major installation concerned with Soldier well-being, I have witnessed the daily struggle of Soldiers and their families dealing with mTBI. A Soldier exposed to a severe blast may experience an immediate loss of consciousness or become dazed and confused following the event. Much like a sports player suffering from a concussion, the Soldier can have symptoms including migraine headaches, dizziness, irritability, difficulty sleeping, loss of balance, and short term memory problems.[20] Table 1 identifies common symptoms associated with blast related brain injury. Unlike most sports related concussions, however, blast related concussion symptoms can persist for months and in some cases actually increase in severity over time. Any one of these symptoms can immediately affect a Soldier's ability to shoot his weapon, move under fire, and to communicate with others on the battlefield. Exposure to a second blast can have additive effects on the brain, thus greatly increasing the risk of death or permanent loss of cognitive function. Upon returning to home-station and rejoining family, Soldiers with mTBI can experience challenges readjusting to everyday life. Family members may have difficulty understanding the changes because there are no apparent physical wounds. Frustrated and not understood, a Soldier may become overwhelmed with previously simple tasks such as driving a car or just managing to be in the right place at the right time.

Sleep deprivation and memory problems plague both family and military life and can lead to a downward spiral in quality of life. Unable to reintegrate into family life and maintain the rigors of unit training, Soldiers may feel they are becoming increasingly isolated. Many do not want to call attention to their symptoms for fear of being labeled as a problem or viewed as weak by peers and/or leaders. When struggling with issues such as these a Soldier can become aggressive, seek to self medicate, abuse alcohol, and fall into a pattern of misconduct.

Common Symptoms of Brain Injury

- Difficulty organizing daily tasks
- Blurred vision or eyes tire easily
- Headaches or ringing in the ears
- Feeling sad, anxious, or restless
- Easily irritated or angered
- Feeling tired all the time
- Feeling light-headed or dizzy
- Trouble with memory, attention, or concentration
- More sensitive to sounds, lights, or distractions
- Impaired decision making or problem solving
- Difficulty inhibiting behavior, impulsive
- Slowed thinking, moving, speaking, or reading
- Easily confused, feeling easily overwhelmed
- Change in sexual interest or behavior

Table 1. Veterans Affairs Quick Fact TBI Card information.

Comparing the Cognitive Testing Approaches

The Department of Veterans Affairs has recommended that care providers use the Glasgow Coma Scale as the accepted cognitive testing methodology for post-deployment determination of brain injury severity. This method is subjective as it relies on a patient's own account of symptoms and his or her recollection of the incident, thus, the evaluation depends on the patient's memory of the event.[21] When dealing with mTBI, the simple reality is that he or she may not remember the event at all or may have forgotten many of its details, particularly when time has passed since the date of injury.

The primary cognitive testing system used immediately following a suspected brain injury is called the Military Acute Concussion Evaluation (MACE). This is a very simple checklist used to conduct initial screening when diagnosing a Soldier exposed to a blast.[22] This method is limited to only one version of cognitive questions and is completed by hand. MACE assessment is rudimentary in comparison to athletic testing systems as it does not assess reaction time with any accuracy or provide data for use against a comparison baseline.

Zoroya has claimed that injured troops in Iraq and elsewhere have cheated on the very problem-solving tests used to spot traumatic brain injuries to avoid being pulled out of combat units. Lieutenant Colonel Michael Jaffee of the DVBIC stated, "With highly motivated individuals . . . there is a motivation to stay with the unit and stay on the job or in the game."[23]

Sports cognitive testing methods such as evaluating against a cognitive data point greatly improve accuracy and allow for objectivity, thus increasing the probability of detection and recovery. These systems rule out the possibility of cheating or deception. The systems being used by sports teams to capture data and assist in managing brain injury recovery include: Automated Neuropsychological Assessment Metrics (ANAM), Immediate Post Concussion Assessment and Cognitive Testing (ImPACT), and CogState Sport. Adopting any one of these concussion management programs would greatly increase Soldier readiness and care.[24]

One of the most successful cognitive testing protocols for sports teams is the ANAM Sports Medicine Battery (ASMB).[25] With baseline cognitive average of mental agility documented, any substantial deviation in test scores can mean a breakdown in information processing capability. If an injury is caused by blast exposure, one can quickly identify slowed response time as well as changes in information processing. Upon identification of injury, Dr. James Kelly declared that first and foremost we must "rest" the injured brain.[26] As a player recovers, he or she uses the ASMB to help decide when to return to play.

Recovering players should be tested both at rest and while physically taxed to rule out second impact syndrome and any remaining symptoms prior to return to play. Documenting the time spent unconscious at the point of injury is also a critical factor in the required length of time an athlete must demonstrate symptom free behavior prior to returning to play.[27] For example, a player who has lost consciousness for a few seconds must be symptom free for a week. For injured Soldiers, a detailed neurological cognitive evaluation, both at rest and while exerted, is essential in the evaluation of recovery. As part of a reintegration testing and training program, Soldiers should be able to demonstrate both the cognitive and dexterity skills necessary to survive in combat prior to returning. An example of reintegration testing in a combat environment situation might be demonstrating proficiency in the basic combat skills like shooting a weapon, moving under fire, and communicating, all executed at half-step, walk, and then run speeds. Ideally, progressive recovery would be measured by multiple testing and cognitive comparisons against previously acquired baseline data.

The ImPACT concussion management program is another universally practiced cognitive testing program used to capture data on players. At present, about half of baseball's 30 professional teams

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belong to ImPACT concussion management programs. These teams can identify mTBI in players who show drops in cognitive testing following a head injury. Veteran trainer Stan Conte of the Los Angeles Dodgers is keenly attuned to the risks of putting a player back on the field after an injury. Conte says, "The worst thing anybody can do—a doctor or a trainer—is put somebody else in harm's way without even knowing it."[28]

CogState Sport is widely used by athletes to perform cognitive associated tests over the Internet. Regardless of the player's location, he or she can access the system, view the appropriate cognitive reaction history, and/or request to take a test.[29] The system reports a cognitive testing score via email and allows for the compilation and storage of preseason averages.[30] CogState Sport and similar cognitive testing systems have tremendous potential for supporting an Army continuously on the move. By introducing a cognitive testing protocol similar to ASMB, CogState Sport, or ImPACT, the military can better and more effectively diagnose mTBI. Additionally, data could identify trends and assist the Army in countering the enemy and the effects of IEDs on Soldiers. CogState Sport software is relatively inexpensive, only costing $40.00 per administration, and the necessary computer hardware is already in our current fielded micro-processors.[31]

Using Magnetoencephalography (MEG) to Determine Abnormality

Several scanning and imaging technologies are available to further evaluate head trauma. Injuries resulting from massive brain hemorrhaging are comparatively easy to identify. That is not the case with respect to mTBI, however. Soldiers suffering from mTBI frequently do not display obvious markers for brain injury. Consequently, scanning technology is an important element in detection. In a recent study comparing scanning technologies, the MEG achieved 86 percent accuracy in positively identifying abnormalities in patients with closed head injuries. Other scanning technologies were less effective. The MRI and Single Photon Emission Computed Tomography identify abnormalities at the levels of 18 percent and 40 percent respectively.[32] The data strongly suggest the MEG scanning system is the preferred diagnostic tool for detecting abnormalities in personnel mTBI symptoms.

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Tests sponsored by the University of Pittsburgh School of Medicine demonstrate the value of both functional MRI and neuropsychological cognitive testing for determining when athletes can safely return to play without risk of suffering Second Impact Syndrome.[33] Our Soldiers need the same combination of medical and technological support before being returned to mission.

Finding a Solution

Sports teams have identified effective means for identifying and managing player concussions. The military should follow suit and make the following adjustments:

- **Pilot an "off-the-shelf" cognitive testing program like ASMB, CogSport, or ImPACT to build a pre-combat Soldier baseline database in support of all Soldiers in the Reserve and active component**. Introduce this testing at basic training and in support of all deploying units. Establish policies that ensure units test and consolidate individual data prior to deployment. Link these concussive management programs to Army Knowledge Online web-based systems, allowing Soldier access via the Internet throughout the world. Educate leaders, trainers, and Soldiers on the importance of this data contribution. Invite sports medicine experts to share knowledge with our leaders about concussive injury. Increase our understanding of primary, secondary, and tertiary phases of blasts and their respective impacts on the body and the brain.

- **Teach leaders and care providers to recognize that blast-related injuries like diffused axonal injury can go undetected without the proper evaluation**. Develop a comprehensive cognitive testing and scanning capability that can deploy to the installation or combat zone as needed. Develop policy to ensure standard scanning technology is available at each duty station. Leaders

must know what scanning technology is available and ensure these technologies are available to support Soldiers. Installation commanders should track scanning technology and operators at installations in the same manner they track sensitive items in a combat unit and establish policies that measure rate of use and Soldier accessibility.

● **Develop policies that standardize recovery protocols for all Soldiers**. Use both cognitive testing and scanning technology to assist in the management and verification of Soldier readiness before returning to the combat environment. Integrate these procedures into current deployment and combat operations models. Coordinate efforts between deployed units and home-station operations to ensure medically evacuated Soldiers are tracked by rear detachment commanders and are integrated into a recovery program.

Infusing sports best practices with current Army mTBI identification and treatment procedures will enhance our overall Soldier recovery and readiness and ultimately return these heroes back safely to their families. ***MR***

courtesy of Mountain Post, Fort Carson, CO

Purple Heart awarded to Soldier with traumatic brain injury from an IED blast while serving with 2d BCT, 2ID in Iraq, April 2007.

NOTES

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