J Head Trauma Rehabil
Vol. 21, No. 5, pp. 398–402

Military TBI During the Iraq and Afghanistan Wars

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Traumatic brain injury (TBI) is an important source of morbidity in the Iraq and Afghanistan wars. Although penetrating brain injuries are more readily identified, closed brain injuries occur more commonly. Explosion or blast injury is the most common cause of war injuries. The contribution of the primary blast wave (primary blast injury) in brain injury is an area of active research. Lessons learned from the sports concussion and civilian mild TBI literature are useful. Individuals with TBI and posttraumatic stress disorder require treatment of both conditions. Families and communities need to be cognizant of the needs of these returning veterans. **Key words:** *blast injury, brain injury, concussion, Iraq war, mild TBI, military, TBI*

UNDERSTANDING the types of injuries being sustained by our American military personnel is necessary to care adequately for these individuals as they return from Iraq and Afghanistan for treatment and, ultimately, back to our communities. This report will discuss the epidemiology of traumatic brain injury (TBI) in the military, the relevance of TBI to the military, issues regarding blast injury, co-occurrence of posttraumatic stress disorder (PTSD) and TBI, and data from the Walter Reed Army Medical Center (WRAMC) Defense and Veterans Brain Injury Center (DVBIC).

MILITARY EPIDEMIOLOGY

Even in peacetime, military personnel have a higher rate of TBI than civilians.[1] For example, military females have an incidence rate of TBI roughly on par with civilian males.[1] Military populations also differ from civilian cohorts in that all patients are employed at time of injury and tend to have low rates of substance abuse, as military populations are subject to random urine screens. During war, the incidence of TBI increases, and the etiology of these injuries reflects the wounding patterns of that war. The incidence of penetrating brain injury increases, though closed brain injury remains more common than progressive hemorrhagic injury.[2] Furthermore, in Afghanistan and Iraq, there is very little access to alcohol; thus, use of alcohol at the time of injury is virtually nonexistent in the current wars.

Injuries to the brain have often been categorized as "head and neck" injuries. Thus, it may be difficult to know the precise number of TBIs that occur, and comparisons to prior wars are influenced by possible changes in data-gathering methodologies. Head wounds may include superficial scalp lacerations, though it would be unlikely for that to cause an evacuation out of the war zone. Still, in previous conflicts such as Operation Desert Storm about 20% of those treated for wounds had head injuries.[3,4] Several factors suggest that the number of TBIs in the current wars is higher than previous wars.

In the current conflict, mortality has declined, and it is believed that this is because of the advances in body armor worn by the military personnel.[5] With the high-quality

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The views expressed in this presentation are those of the author and do not reflect the official policy of the Department of the Army, the Department of Defense, or the US Government.

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body armor, individuals who may have died in previous wars may survive with possible injuries to extremities and head and neck. Also, both medical and lay communities have more sophisticated knowledge regarding the effects of closed brain injury, including mild TBI. Issues of the management of sports concussion[6] and the effects of repeated mild TBI[7-9] are more commonly discussed in the literature. Finally, more TBI may be occurring in the current war because of the frequency of explosive, or blast attacks. Military sources report that approximately two thirds of army war zone evacuations are due to blast.[10] A recent report cited that 88% of injuries seen at a second echelon treatment site were due to blast. Although many injured individuals seen at the second echelon were treated and returned to duty, others were evacuated out of the war zone.[11]

BLAST INJURY

Although explosion injuries are not new, the high amount of explosive material and the predominance of this form of injury in the current war are significant. The term "shell shock" was used in World War I to describe those individuals who were rendered incapable of fighting for some period following blasts. Although the etiology of shell shock was debated between a physical reaction and a psychological reaction, that exposure to multiple explosions could render an individual incapable of continued fighting was noted frequently in the literature. Similarly, that an individual could be killed without evidence of bodily injury was noted and attributed to the "wind" of the injury.[12]

Injury to air filled organs (eg, ear, lungs, gastrointestinal tract) is well described in the literature. Although death due to blast is well documented,[13] discussion of closed brain injury in survivors is lacking. Reasons for this are not totally clear, but could include the potential to overlook mild to moderate closed brain injury during mass casualty events that produce life-threatening wounds requiring all available medical assets.

Injuries occur as a direct result of blast wave-induced changes in atmospheric pressure (*primary* blast injury), from objects put in motion by the blast that then hit people (*secondary* blast injury), and by individuals themselves being put in motion by the blast and then hitting something, such as the ground or inside of a military vehicle (*tertiary* blast injury).[13,14] In an explosion, the air blast will move radially in an open field, but will deflect off surfaces in an enclosed space. Individuals close by each other may sustain very different injury severity depending on the exposure to these deflecting waves.[13] Because of the nature of blasts in a war environment, most casualties have experienced some mechanical injury (secondary or tertiary blast) as well as any contribution from the primary blast wave. Although these secondary and tertiary (mechanical) injuries to the brain may be expected to involve similar pathophysiology to that of civilian mechanical injuries (eg, falls, motor vehicle accident), the concomitant exposure to primary blast is much less well understood. In addition, we know virtually nothing about any possible sequelae of exposure to multiple blasts when an individual does not sustain injuries that require medical evacuation from the war zone.

Understanding the potential relationship of primary blast wave to brain injury in survivors, as well as any contribution of primary blast on secondary, tertiary, and quaternary blasts, is of paramount importance. Although human studies of survivors have largely focused on the lung and gastrointestinal tract injuries, a limited amount of human and animal studies suggest that primary blast injuries to the brain do occur and require better understanding. Describing survivors in the Balkan wars, Cernak et al[15] noted increased numbers of neurological injuries in those injured by blast, with patients exhibiting abnormalities of neurological examination, electroencephalographic, and neuroendocrine profiles. One report from military physicians relates Marines experiencing primary blast injury resulting in "headache, tinnitus, low-grade concussion, and abdominal pain."[16] A report

characterizing veterans (largely from the Viet Nam war) with PTSD with and without a history of blast injury suggests that those exposed to blast sustain more current attentional difficulties as well as a different qEEG pattern.[17] Laboratory studies utilizing blast tubes demonstrate formation of cytoplasmic vacuoles and myelin alterations in the hippocampus of blast-exposed rodents. Ultrastructural changes were observed even in rodents with blast to the thorax while the head was protected.[18]

Blast is overwhelmingly the most common wounding etiology in the current conflicts.[10,16] More than 1700 individuals have sustained TBI since the beginning of the war.[19] Of all the individuals medically evacuated to the WRAMC who sustained injuries from hostile forces, 28% had a TBI.[20] A descriptive analysis of 433 individuals with TBI who were seen at the WRAMC helps to characterize this growing population. Concomitant amputation occurred in 19% of these TBI patients, with lower extremity amputation being more common than upper extremity.[2] Mild TBI accounted for less than half of the sample, whereas moderate and severe (including penetrating) accounted for 56%. Penetrating brain injury was seen in 12% of the total group; closed TBI accounted for 88% of the group, confirming that closed brain injury is more common in this war.[2]

Military patients are being studied closely to discern whether early injuries or later functioning are affected by exposure to blast. Preliminary characterization of blast and nonblast closed brain-injured patients seen at the WRAMC note that those injured in blast were significantly more likely to have had a skull fracture, seizure, and lower extremity amputation than those not injured in a blast. The patients injured in a blast were also more likely than their counterparts to have had symptoms of an acute stress reaction or PTSD. There was no difference in the number of postconcussive symptoms endorsed by both groups.

In another protocol, paratroopers at Ft. Bragg who had previously been deployed were asked about their experience of injuries in general, and TBI in particular, while deployed. These injuries, in general, would have been treated locally and would not have required a medical evacuation. Essentially, all reported TBIs during deployments, in this nonhospitalized sample, were mild TBI.

PTSD

A number of recent studies have investigated the development of PTSD following TBI (for review, see Klein et al[21]). The studies suggest that those with mild TBI have a greater risk of developing PTSD than those with severe brain injuries and longer periods of unconsciousness. Reports on the natural history of mild TBI suggest that most patients will make a good recovery.[22] However, the civilian data relating to recovery after mild TBI may not be fully applicable to those who sustain mild brain injury in a war zone. As cited above, data from patients seen at the WRAMC suggest that symptoms of PTSD or acute stress disorder were reported more often in those injured by blast than in those who received their TBI from other mechanisms.

Although symptoms of PTSD and postconcussion syndrome do overlap (eg, attentional problems, depression), some symptoms are characteristic only of PTSD (eg, flashbacks and other reexperiencing phenomena); other symptoms are characteristic of postconcussion syndrome, but not PTSD (eg, headache, nausea/vomiting, dizziness). Clinicians will need to consider each diagnosis and the possible co-occurrence of the two diagnoses in war veterans presenting with co-occurring symptoms, for example, anxiety, depression, difficulty concentrating, or attentional problems.

CONCLUSION

Clearly, TBI is an important issue for the wars in Iraq and Afghanistan. Although penetrating brain injuries have always been associated with war,[23] frequent occurrence of closed brain injury in this war is increasingly acknowledged. One source stated that the number of serious brain injuries is

approximately 5 times the number of amputees.[24] Possible reasons for an increase in closed TBI include the effectiveness of body armor in saving those who would have been killed previously, increased identification of closed TBI due to increased understanding of the potential sequelae of mild and moderate closed brain injury, and the prominence of blast as an injury mechanism.

Important issues include the prompt identification, assessment, and treatment of TBI. Whereas early identification of penetrating and severe brain injury is readily accomplished, identification of mild to moderate closed brain injury in a war zone is more difficult. Current training programs for medics help identify those with mild TBI and less severe other injuries who may not require medical evacuation from the war zone. These individuals may be assessed, rested, and monitored by their medics while they are recovering from their concussion.

For those who are medically evacuated, WRAMC DVBIC continues to screen 100% of those who have been injured by blast, motor vehicle accident, falls, or gunshot wound to the head or neck. In this way, those who have sustained a TBI along with their other wounds may be identified and treated. It has been shown that educational interventions have the best evidence base as treatment of mild TBI,[25] underscoring the need to provide educational counseling to these patients. Also important is identifying the concomitant TBI for other treating physicians who can then be cognizant of the possible challenges of the patient in fully understanding information and directions about care of other injuries.

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