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Review

Bomb blast, mild traumatic brain injury and psychiatric morbidity: A review

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ABSTRACT

Traumatic brain injury (TBI) arising from blast exposure during war is common, and frequently complicated by psychiatric morbidity. There is controversy as to whether mild TBI from blast is different from other causes of mild TBI. Anxiety and affective disorders such as Post-traumatic Stress Disorder (PTSD) and depression are common accompaniments of blast injury with a significant overlap in the diagnostic features of PTSD with post-concussive syndrome (PCS). This review focuses on this overlap and the effects of mild TBI due to bomb blast. Mild TBI may have been over diagnosed by late retrospective review of returned servicemen and women using imprecise criteria. There is therefore a requirement for clear and careful documentation by health professionals of a TBI due to bomb blast shortly after the event so that the diagnosis of TBI can be made with confidence. There is a need for the early recognition of symptoms of PCS, PTSD and depression and early multi-disciplinary interventions focussed on expected return to duties. There also needs to be a continued emphasis on the de-stigmatisation of psychological conditions in military personnel returning from deployment.

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Introduction

The rate of survival of soldiers in war has increased from 2:1, injured to dead in WWII, to 7.4:1 in Operation Iraqi Freedom (OIF)[28] and with it more complex rehabilitation needs to improve the level of function of those who survive their wounds.[58] The use of improved body armour, tourniquets, advances in resuscitation and trauma systems, early damage control surgery, and critical care air transport teams account for the increased rates of survival for those injured at proximity to point sources of explosions that previously might have caused death.[54,58]

Traumatic brain injury (TBI) caused by bomb blast has been described as the 'signature wound of the war on terror'[6] and its

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identification and management a source of interest and controversy.[12,71] Survivors of blast injury frequently suffer a TBI of variable severity ranging from a mild concussion to severe 'blast brain' with cerebral swelling, with or without penetrating injury and burns. Is the brain susceptible to injury from explosions in the absence of penetrating injury? What might be the mechanisms of such injury, and are the current acute markers of brain injury adequate for the assessment and what is the longer term outcome? Few studies have provided long-term observations on the effect of blast injury to the brain.[5,15,29,42,63,72]

Scope of the problem

An extensive non-governmental study by the Rand Corporation noted that 2726 cases of TBI were diagnosed in returned personnel between 2001 and 2007, with an estimated societal cost of $590–910 million dollars.[70] The 1-year estimate of societal cost associated with treated cases of mild TBI is up to USD $32,000 per case, while estimates for moderate to severe TBI range from USD $268,000 to more than USD $408,000.[70] The authors estimate that about 320,000 service members may have experienced a TBI, ranging from mild concussion to severe penetrating TBI, during deployment up to October 2007, with only 43% reporting being evaluated by a physician.[70]

The treatment of military personnel from the USA with PTSD and depression post-combat exposure estimated by the Rand Corporation to cost as much as USD $6.2 billion in the 2 years following deployment which includes both direct medical care and costs for lost productivity and suicide.[70]

A number of epidemiological studies of personnel returned home from the current conflicts have linked impairment post-deployment, with or without blast exposure, primarily to depression or anxiety related disorders such as PTSD.[27,35,61,74] The experience of field hospitals is that blast-related brain injury occurs, often in conjunction with other physical injuries and that wounds to the face, head and neck are common.[30,32,53,80]

Studies of personnel who have returned home have defined traumatic brain injury (TBI) as any disturbance of consciousness; including being dazed or seeing stars, or not remembering the injury.[35,61,74] Population estimates of total TBI in these studies[35,61,74] are between 10 and 15% of deployed samples, noting that 4% of non-deployed soldiers also experience a TBI during the same time period.[74] Xydakis et al.[79] have suggested that delay, in surveying soldiers may have lead to under-reporting of the extent or occurrence of head injury. In the heat of battle lack of documentation of a head injury or exposure to bomb blast will exacerbate this problem. In practice the US Department of Veterans Affairs uses historical data as a screen for blast exposure and then proceeds with physical, radiological and neuropsychological screening.[56]

Over half the veterans reported by Schneiderman et al.[61] had more than one mechanism of injury, suggesting multiple concussions. Schneiderman et al.[61] stratified the severity of mild TBI in their sample of veterans from Iraq and Afghanistan and found an association of persistent symptoms with more severe TBI, multiple injury mechanisms and the presence of PTSD, and noted that the findings of association between TBI and PTSD could relate to the stress of wounding and deployment or brain injury manifesting as PTSD.[61]

In support of this observation Chen et al.[18] showed that there is neuroimaging evidence of neural dysfunction, in concussed depressed compared to non-depressed athletes with and without concussion. Concussed athletes as a group showed reduced insula gray matter, and those athletes who were also depressed showed reduced gray matter in the medial frontal and temporal areas. Chen et al.[18] suggest that the changes causing depression were related to the concussion itself.

A survey of UK armed forces personnel found post-concussional syndrome (PCS) symptoms such as memory and concentration problems, tinnitus, visual disturbance, irritability and affective disturbance were related to blast exposure, but the same symptoms were related to other in theatre exposures.[27] In this study participants were asked if they had been under attack at any time from explosive munitions. The authors suggest PCS symptoms may be a non-specific marker of psychological distress and there is overlap between the symptoms of PCS, and stress for example irritability and concentration problems.[27]

There is some data concerning more severely injured soldiers who were admitted to hospital.[76] Of 433 patients received between January 2003 and April 2005 at the Defence and Veterans Brain Injury Centre (DVBRC) at Walter Reed Army Medical Centre (WRAMC) 68% received their injury from blast, 88.8% had a closed TBI and 43% had a post-traumatic amnesia (PTA) of less than 24 h.[76] Post-concussive symptoms were almost universal.[76] A further 183 brain injured patients were admitted to four polytrauma rehabilitation centres (PRC) between September 2001 and January 2006, of whom approximately 20% had closed head injury due to blast, a slightly smaller proportion than those with closed brain injury from other causes, most commonly vehicle trauma.[58] Vasterling et al.[74] described a pattern of increased reaction time, poor concentration and short-term memory problems in soldiers returned from Iraq, independent of the effects of TBI. They suggested that this may represent both an adaptive mechanism and the effects of a prolonged stressful environment.[74]

Mechanisms of injury

The types of injury arising from blast are described as primary through to quaternary, being the effect of a blast pressure wave, penetrating trauma from fragments, the direct concussive and contre-coup effects of collapsing structures and of being thrown by the blast wind and striking the head against fixed structures, and injuries due to burns, asphyxia and exposure to toxins respectively.[25,43,48,55] The blast pressure wave or primary blast injury is unique to explosions.[25,48,55] Individuals are likley to be affected by some or all of these mechanisms sustaining multiple injuries.[30,32,43,63,77]

Direct effects of the pressure wave

An explosion causes a high pressure wave to sweep across the immediate surrounds at about the speed of sound.[25,26] The intensity of the blast wave declining as a function of distance to the third power from its source.[77] Enhanced explosive devices, with secondary ignition of disseminated explosive, spread the point source from which the explosion radiates causing more damage from the primary blast effect.[25] Possible mechanisms of brain injury from the primary blast are the primary pressure wave transiting the skull and body[43,25], air embolism[14,19] and acceleration/deceleration of the head.[3,43] Where the wave meets tissues of different density there will be further turbulence.

Animal research has demonstrated transcranial transmission of pressure waves[17] resulting in skull fractures and structural and ultra-structural damage to the brain.[16,39–41] Transmission of an intravascular pressure wave up the neck may also contribute.[16,40,43] Protective devices provide limited protection.[16,30]

Air embolism

In the lung, the air gas interface creates the phenomenon of spalling where air enters the pulmonary circulation by blasting though the alveoli creating the phenomenon of blast lung.[77] Air embolism is unlikely to be a factor in mild TBI following blast