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Influence of Combat Blast-Related Mild Traumatic Brain Injury Acute Symptoms on Mental Health and Service Discharge Outcomes

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Abstract

Assessment of acute mild traumatic brain injury (mTBI) symptoms after a combat blast could aid diagnosis and guide follow-up care. Our objective was to document acute mTBI symptoms following a combat blast and to examine associations between acute symptoms and mental health and service discharge outcomes. A retrospective cohort study was conducted with 1656 service personnel who experienced a combat blast-related mTBI in Iraq. Acute mTBI symptoms were ascertained from point-of-injury medical records. The associations between acute symptoms and posttraumatic stress disorder (PTSD), postconcussion syndrome (PCS), and type of service discharge were examined. Disability discharge occurred in 11% of patients, while 36% had a non-disability discharge and 52% had no recorded discharge. A PTSD and PCS diagnosis was made in 19% and 15% of the sample, respectively. The most common acute mTBI symptoms were headache (62.8%), loss of consciousness (LOC) (34.5%), and tinnitus (33.2%). LOC was predictive of PTSD (odds ratio [OR] 1.54; 95% confidence interval [CI] 1.18, 2.00) and PCS (OR 2.08; 95% CI 1.56, 2.77), while altered mental status (OR 1.53; 95% CI 1.07, 2.17) and previous blast history (OR 1.83; 95% CI 1.15, 2.90) also were predictive of PCS. While no acute mTBI symptoms were associated with discharge outcomes, injury severity was associated with disability discharge. LOC after blast-related mTBI was associated with PTSD and PCS, and injury severity was predictive of disability discharge. The assessment of cognitive status immediately after a blast could assist in diagnosing mTBI and indicate a need for follow-up care.

Key words: combat blast injury, functional outcomes, mental health, traumatic brain injury

Introduction

Traumatic brain injury (TBI) has been described as a predominant injury of the wars in Iraq and Afghanistan, with the majority of injuries caused by blasts or explosions.[1] Of the 30,000 U.S. service members who have been wounded in action since March 19, 2003, approximately 9000 have been diagnosed with TBI.[2] It has been estimated that 10% 20% of all service members deployed as a part of Operation Enduring Freedom and Operation Iraqi Freedom may have experienced a brain injury.[3,4]

Mild TBI (mTBI), also known as concussion, is often unrecognized due to the severity of the other injuries occurring in a combat setting, particularly life threatening injuries and obvious external injuries.[5] While the primary indicators for an mTBI diagnosis are loss of consciousness (LOC), post traumatic amnesia, and Glasgow Coma Scale score, acute clinical symptoms can include headache, nausea, vomiting, dizziness, sensitivity to light, and difficulty remembering or concentrating.[6] Due to the austere environment in which these combat blast related mTBI occur, it is often difficult to collect point of injury information regarding acute mTBI symptoms. To date, the nearest assessment to the point of injury has been at the end of deployment, which can occur many months after the mTBI.[3,7 9] Most neurocognitive sequelae of mTBI are resolved within 48 hours,[10] so post deployment symptoms may be influenced by other factors, such as posttraumatic stress disorder (PTSD).[3,7]

Long term impairments associated with mTBI include memory and sleep problems, headache, difficulty concentrating, and other emotional and behavioral problems. Combat mTBI also has been associated with development of specific mental health outcomes in

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postdeployment screening including PTSD and postconcussion syndrome (PCS).[8,11,12] Civilian studies have highlighted the vocational outcomes of these impairments, with up to 40% of individuals diagnosed with mTBI having not returned to work by six months post injury.[13–15] Career performance outcomes have been examined in brain injured military personnel as well, but the focus has been on the spectrum of TBI severity.[16]

Acute mTBI symptoms following a combat blast reported at the time of initial medical evaluation have not been previously examined. While there have been studies published on both mental health and career performance outcomes in non combat and combat TBI,[8,11,12,16,17] none focus specifically on combat blast related TBI. The objectives of this retrospective cohort study were to describe acute signs and symptoms of service personnel diagnosed with an mTBI within 48 hours following a combat blast, and to examine the relationship between acute symptoms and mental health (PTSD, PCS) and service discharge outcomes.

Methods

The study sample was identified from the Expeditionary Medical Encounter Database (EMED), formally the Navy Marine Corps Combat Trauma Registry, which is maintained by the Naval Health Research Center (NHRC) in San Diego, California. The EMED contains information abstracted from U.S. service members' medical records completed by military providers at forward deployed treatment facilities in the combat zone, nearest to the point of injury. It is linked with inpatient and outpatient medical record information and tactical, personnel, operational, and deployment related data obtained from other U.S. Department of Defense databases.[18] This study was approved by the NHRC Institutional Review Board (Protocol NHRC.2009.0023).

Between March 2004 and December 2007, there were 1713 male service personnel who experienced a combat blast episode and were assigned a clinical diagnostic code consistent with a mTBI (*International Classification of Diseases, 9th Revision* [ICD 9] codes 850.0, 850.11, 850.12, 850.5, 850.9). The study sample was restricted to men due to a low proportion of injured women. A blast episode was defined as a documented mechanism of injury of an improvised explosive device (IED), grenade, rocket propelled grenade (RPG), rocket, land mine, or mortar. Each subject had an encounter at a Level 1 or Level 2 medical treatment facility (MTF) within 48 hours of the injury and an encounter form entered in the EMED that included a provider recorded mTBI diagnosis. Level 1 and Level 2 MTFs are forward area units including immediate first aid facilities (Level 1) and units providing surgical resuscitation by forward mobile surgical teams (Level 2). Of the 1713 injured service personnel, 1666 (97.3%) had complete records (their record included a clinician narrative or subjective, objective, assessment, plan [SOAP] note from which the acute symptoms were assessed) in the EMED for analysis and 1656 (96.7%) were able to be linked to the Career History Archival Medical and Personnel System (CHAMPS), which constituted the final sample size for this report.

ICD 9 codes were assigned to each injury described on the encounter form by trained clinical staff. In addition to the assignment of diagnostic codes, injury severity was documented with two different standardized measures of injury severity: the Abbreviated Injury Scale (AIS) and the Injury Severity Score (ISS).[19] The AIS is an anatomically based injury severity scale that scores each injury on a scale from 1 (relatively minor) to 6 (unsurvivable) within six body regions (head, face, chest, abdomen, extremities, and external). The ISS, an overall measure of injury severity with a range of 1 to 75, is derived from the AIS scores and is composed of the three most severely injured body regions.[20] An extracranial ISS was calculated to quantify the severity of extracranial injuries by excluding the head AIS from the ISS.[21]

All outcome variables were ascertained via CHAMPS, a database maintained at NHRC that contains career and medical information for Navy and Marine Corps active duty personnel beginning in January 1, 1965, and personnel from all services since 1988. CHAMPS contains detailed service information and medical information such as hospitalizations and outpatient visits, including diagnoses made at any of these visits. The detailed service and medical events are arranged in chronological order, from the time of enlistment until the time of service end. The discharge event status was updated in CHAMPS on September 30, 2009, for this data set, which resulted in a range of follow up time between 1 year 9 months, and 5 years 7 months.

Individual demographics (age, military rank, branch of service) and injury circumstances (type of blast, personal protective equipment usage) were ascertained for each subject from the EMED. Age was reported in years and calculated by the date of injury minus the date of birth. The date of the first recorded medical encounter at a Level 1 or Level 2 facility was used if the date of injury was not available. Military rank was categorized as junior enlisted (E1–E3), midlevel enlisted (E4–E5), senior enlisted (E6–E9), and officers/warrant officers. Military branch of service was categorized as Air Force, Army, Navy, or Marine Corps. The type of blast was categorized as IED, grenade, RPG, land mine, rocket, or mortar.

The narrative clinician notes (SOAP note) on the field medical record form were reviewed for 12 acute mTBI symptoms documented within 48 hours of the blast. These recorded symptoms were based on the service personnels' reports and documentation of the acute symptoms in the clinician notes. A description of the criteria for the symptoms is provided in Table 1. A ''yes'' was recorded if the symptom was reported in the SOAP note, and a ''no'' was recorded if the symptom was either denied or not documented. In addition to the acute symptoms, data were extracted on previous blast exposure and a previous combat mTBI diagnosis documented in the EMED or in the SOAP note. Reliability of the data extraction was assessed, with 10% of the final sample chosen randomly with a test retest reliability of more than 90% for any single recorded symptom.

Table 1. Definitions of Symptoms Recorded From Clinician's Documentation on EMED Field Medical Record Forms

Symptom	*Criteria for symptom*
Loss of consciousness	Loss of consciousness including unsure
Altered mental status	Disruption in orientation; confused, dazed, lethargic
Amnesia/memory	Loss of memory surrounding event, deficit detected at exam
Headache	Headache, any pain level
Nausea	Nausea, queasy feeling
Vomiting	Vomiting, emesis, dry heaves
Dizzy	Dizziness, vertigo, room spinning
Lightheaded	Lightheaded, woozy
Balance deficit	Unstable gait, sway on Romberg, ataxia, loss of stability
Auditory	Change in hearing; ear numbness, pressure; NOT tinnitus/pain
Tinnitus	Ringing/buzzing in one or both ears
Visual deficit	Visual loss, blurry not due to foreign body; light sensitivity
Previous blast	Documented in SOAP note or EMED
Previous combat concussion	Combat related, documented in SOAP note or EMED

EMED, Expeditionary Medical Encounter Database; SOAP note, subjective, objective, assessment, plan.

Discharge status was ascertained from CHAMPS, and only events after the injury were examined in this study. Type of discharge (disability, non disability, no discharge) was determined by the examination of the discharge event codes. Disability discharge was defined as a discharge event code with the term ''disability'' in the verbal description of the event code, and non disability discharge included all other discharge event codes. Personnel without a discharge code were categorized as no discharge. Diagnoses of PTSD and PCS were determined by ICD 9 codes and required documentation on two separate records of the diagnosis in either inpatient or outpatient visits more than 30 days after the date of injury. Total follow up time was calculated as the date of discharge (if discharged occurred) or the date of the most recent status update (if no discharge was documented) minus the date of injury.

Data analysis

Demographics, injury characteristics, acute symptoms, extracranial ISS, and follow up time were compared between the discharge outcomes (disability, non disability, no discharge) and the mental health outcomes (PTSD, PCS). Categorical variables were compared using chi square, and the means of continuous variables were compared using *t* tests for mental health outcomes and analysis of variance for discharge outcomes. To examine the relationship between acute mTBI symptoms, injury severity, and outcomes, logistic regression was used for the mental health outcomes and multinomial logistic regression for the discharge outcomes, with no discharge as the reference category. Independent variables included extracranial ISS, five acute mTBI symptoms (LOC, altered mental status, amnesia, headache, tinnitus), previous blast exposure, and history of previous concussion. Age at time of injury (five year intervals) was reported as an independent variable as well as considered as a covariate, along with branch of service (Marine Corps vs. other), race (Caucasian vs. other), type of blast (IED vs. other), and follow up time. Pay grade was not used as a covariate due to missing data, although results did not change substantially when placed in the multivariate models. All data analysis was completed using SAS software version 9.2 (SAS Institute Inc., Cary, NC), and level of significance was set at $p \leq 0.05$.

Results

Of the 1656 service personnel diagnosed with an mTBI from a combat blast, 11% ($n = 190$) were discharged with a disability discharge event code, 36% ($n = 600$) had no report of disability in the discharge record, and 52% ($n = 866$) had no recorded discharge. For the mental health outcomes, 19% ($n = 319$) were diagnosed

Table 2. Demographic and Injury Characteristics by Discharge and Mental Health Outcomes Among Service Personnel Diagnosed With Mild Traumatic Brain Injury

	Discharge outcome (N = *1656*)			*Mental health outcomes* (N = *1656*)			
	Disability (n = *190*) *Mean (SD)*	*Non disability* (n = *600*) *Mean (SD)*	*No discharge* (n = *866*) *Mean (SD)*	*PTSD* (n = *319*) *Mean (SD)*	*No PTSD* (n = *1337*) *Mean (SD)*	*PCS* (n = *254*) *Mean (SD)*	*No PCS* (n = *1402*) *Mean (SD)*
Age (years)	22.2 (3.0)[c]	23.0 (3.8)	25.6 (5.8)	23.6 (4.6)	24.4 (5.1)	24.1 (4.9)	24.3 (5.1)
Extracranial ISS	21.1 (24.8)[c]	11.0 (15.5)	11.9 (18.0)	14.8 (20.3)[a]	12.1 (17.7)	13.2 (18.8)	12.5 (18.2)
Follow up time (years)	1.8 (0.7)[c]	1.6 (0.9)	3.3 (0.7)	2.6 (1.0)	2.5 (1.2)	2.5 (0.9)	2.5 (1.2)
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Race/ethnicity							
Caucasian	152 (80.0)	490 (81.7)	677 (78.2)	255 (79.9)	1064 (79.6)	196 (77.2)	1123 (80.1)
African American	13 (6.8)	34 (5.7)	44 (5.1)	19 (6.0)	72 (5.4)	11 (4.3)	80 (5.7)
Hispanic	8 (4.2)	34 (5.7)	78 (9.0)	23 (7.2)	97 (7.3)	21 (8.3)	99 (7.1)
Other	17 (8.9)	42 (7.0)	67 (7.7)	22 (6.9)	104 (7.8)	26 (10.2)	100 (7.1)
Pay grade*							
Junior enlisted	117 (61.6)[a]	328 (57.4)	332 (38.3)	162 (55.3)[a]	615 (48.8)	113 (48.9)[a]	664 (50.2)
Midlevel enlisted	58 (30.5)	225 (37.5)	331 (38.2)	97 (33.1)	517 (41.0)	83 (35.9)	531 (40.1)
Senior enlisted	5 (2.6)	10 (1.6)	105 (12.1)	30 (10.2)	90 (7.1)	30 (13.0)	90 (6.8)
Officer/warrant	0	8 (1.3)	35 (4.0)	4 (1.4)	39 (3.1)	5 (2.2)	38 (2.9)
Branch of service							
Marine Corps	151 (79.5)[a]	522 (87.0)	656 (75.5)	254 (79.6)[a]	1075 (80.4)	201 (79.1)	1128 (80.5)
Navy	9 (4.7)	30 (5.0)	59 (6.8)	29 (9.1)	69 (5.2)	16 (6.3)	82 (5.8)
Army	30 (15.8)	46 (7.7)	151 (17.4)	35 (11.0)	192 (14.4)	37 (14.6)	190 (13.5)
Air Force	0	2 (< 1)	0	1 (< 1)	1 (< 1)	0	2 (< 1)
Type of blast							
IED	173 (91.0)	525 (87.5)	779 (89.9)	281 (88.1)	1196 (89.4)	233 (91.7)[a]	1244 (88.7)
Land mine	4 (2.1)	32 (5.3)	27 (3.1)	9 (2.8)	54 (4.0)	2 (< 1)	61 (4.3)
Mortar	5 (2.6)	18 (3.0)	19 (2.2)	11 (3.4)	31 (2.3)	11 (4.3)	31 (2.2)
RPG	5 (2.6)	14 (2.3)	27 (3.1)	15 (4.7)	31 (2.3)	7 (2.8)	39 (2.8)
Rocket	2 (1.0)	6 (1.0)	5 (< 1)	3 (< 1)	10 (< 1)	1 (< 1)	12 (< 1)
Grenade	1 (< 1)	5 (< 1)	8 (< 1)	0	14 (1.0)	0	14 (1.0)

[a] $p \leq 0.05$.
[b] $p \leq 0.01$.
[c] $p \leq 0.001$.
*Subject numbers for pay grade do not add to total sample due to missing data.
PTSD, posttraumatic stress disorder; PCS, postconcussion syndrome; SD, standard deviation; ISS, Injury Severity Score; IED, improvised explosive device; RPG, rocket propelled grenade.

with PTSD and 15% ($n=254$) were diagnosed with PCS. The service personnel with a disability discharge were slightly younger (22.3 years vs. 23.0 years non disability discharge, and 25.6 years for no discharge; $p<0.001$), while age did not differ within each mental health outcome (Table 2). Marines were the predominant service represented in the sample. The extracranial ISS score was higher in the disability discharge group compared with the non disability and no discharge groups. Service personnel with a dis ability discharge had a higher extracranial ISS (21.1 vs. 11.0 and 11.9, respectively; $p<0.001$). Extracranial ISS was higher in per sonnel diagnosed with PTSD (14.8 vs. 12.1 respectively; $p<0.05$).

Of the 12 acute mTBI symptoms recorded from the narrative clinician notes in the field medical record forms, the most common acute symptom reported in the full sample was headache (62.8%), followed by LOC (34.5%) and tinnitus (33.2%). Four additional symptoms were reported in at least 10% of the full sample: altered mental status (14.3%), auditory symptoms (13.6%), nausea (11.8%), and dizziness (11.2%). Thirty two percent of the sample reported three or more acute symptoms (data not shown). While length of LOC is unknown in this study, all service personnel were conscious at the time these symptoms were queried. When the symptoms reported across the disability outcome groups were compared, there was a difference in the proportion between the groups in three of the 12 reported symptoms (Table 3). The pro portion reporting LOC was higher in the disability discharge group, but the report of headaches and tinnitus was lower in the same group. The results were similar for the mental health outcomes except the proportion reporting amnesia was higher in the PTSD diagnosis group and altered mental status was reported more fre quently in the PCS diagnosis group.

Table 4 shows the odds of discharge (disability and non disability with no discharge as reference) and mental health out comes (PTSD and PCS) by extracranial ISS, five of the 12 acute mTBI symptoms (LOC, altered mental status, amnesia, headache, tinnitus), previous blast exposure, and history of previous concus sion. Those five acute symptoms, as well as a history of previous blast and previous concussion, were chosen as independent vari ables since they were significantly different in at least one of the outcome variables in the initial univariate analysis (Table 3). Injury severity assessed by extracranial ISS was predictive of disability discharge in both the univariate and multivariate models. LOC was predictive of disability discharge, PTSD, and PCS in the univariate analysis, and it remained associated with PTSD (odds ratio [OR] 1.54; 95% confidence interval [CI] 1.18, 2.00) and PCS (OR 2.08; 95% CI 1.56, 2.77), after controlling for the covariates. In addition, altered mental status (OR 1.53; 95% CI 1.07, 2.17) and a history of a previous blast (OR 1.83; 95% CI 1.15, 2.90) were predictive of PCS in the multivariate models. While a history of a previous concussion, headache, and tinnitus were associated with the out comes in the univariate analysis, they were not significant in the multivariate model.

Discussion

To our knowledge, this paper is the first to describe acute symptoms (within 48 hours) of a concussion after a combat blast. The most common symptom reported was headache, which is consistent with McCrea and colleagues' findings from a sample of college athletes after a reported concussion.[22] The frequency of the symptoms in the current sample was universally lower than those reported by McCrea, including headache (63% vs. approximately 80%), nausea (12% vs. approximately 40%), and dizziness (11% vs. approximately 70%). By contrast, LOC was reported more frequently in the current sample (34%) compared with studies of high school and college athletes (7% 18%).[22] There are numerous differences between both the subjects and study environment that could explain these discrepancies, including the chaotic nature of a combat blast and the potential for additional severe injuries in a

Table 3. Initial Symptoms by Discharge and Mental Health Outcomes Among Service Personnel Diagnosed With Mild Traumatic Brain Injury

	*Discharge outcome (*N = *1656)*			*Mental health outcomes (*N = *1656)*			
Symptom	*Disability (*n = *190)* n *(%)*	*Non disability (*n = *600)* n *(%)*	*No Discharge (*n = *866)* n *(%)*	*PTSD (*n = *319)* n *(%)*	*No PTSD (*n = *1337)* n *(%)*	*PCS (*n = *254)* n *(%)*	*No PCS (*n = *1402)* n *(%)*
Loss of consciousness	90 (47.4)[c]	202 (33.7)	279 (32.2)	142 (44.5)[c]	429 (32.1)	125 (49.1)[c]	446 (31.8)
Altered mental status	28 (14.7)	79 (13.2)	130 (15.0)	48 (15.0)	189 (14.1)	51 (20.1)[b]	186 (13.3)
Amnesia/memory	16 (8.4)	34 (5.7)	54 (6.2)	28 (8.8)[a]	76 (5.7)	22 (8.7)	82 (5.8)
Headache	92 (48.4)[c]	406 (67.7)	542 (62.6)	183 (57.4)[a]	857 (64.1)	156 (61.4)	884 (63.0)
Nausea	17 (8.9)	68 (11.3)	110 (12.7)	38 (11.9)	157 (11.7)	37 (14.6)	158 (11.3)
Dizzy	19 (10.0)	74 (12.3)	92 (10.6)	38 (11.9)	147 (11.0)	35 (13.8)	150 (10.7)
Balance deficit	10 (5.3)	16 (2.7)	36 (4.2)	14 (4.4)	48 (3.6)	13 (5.1)	49 (3.5)
Vomiting	5 (2.6)	21 (3.5)	28 (3.2)	12 (3.8)	42 (3.1)	12 (4.7)	42 (3.0)
Lightheaded	6 (3.2)	17 (2.8)	16 (1.8)	5 (1.6)	34 (2.5)	3 (1.2)	36 (2.6)
Tinnitus	43 (22.6)[b]	202 (33.7)	305 (35.2)	89 (27.9)[a]	461 (34.5)	70 (27.6)[a]	480 (34.2)
Auditory	26 (13.7)	94 (15.7)	106 (12.2)	43 (13.5)	183 (13.7)	37 (14.6)	189 (13.5)
Visual deficit	13 (6.8)	34 (5.7)	41 (4.7)	22 (6.9)	66 (4.9)	19 (7.5)	69 (4.9)
Previous blast	32 (16.8)	76 (12.7)	111 (12.8)	44 (13.8)	175 (13.1)	51 (20.1)[c]	168 (12.0)
Previous combat concussion	21 (11.0)	38 (6.3)	59 (6.8)	28 (8.8)	90 (6.7)	29 (11.4)[b]	89 (6.3)

[a] $p \le 0.05$.
[b] $p \le 0.01$.
[c] $p \le 0.001$.
PTSD, posttraumatic stress disorder; PCS, postconcussion syndrome.

Table 4. Unadjusted and Adjusted Odds Ratios of Discharge and Mental Health Outcomes Among Service Personnel Diagnosed With Mild Traumatic Brain Injury

	Discharge outcome (N = *1656*)*				*Mental health outcomes* (N = *1656*)			
	Disability discharge (n = *190*)		*Non-disability discharge* (n = *600*)		*PTSD* (n = *319*)		*PCS* (n = *254*)	
Independent variable	*Unadjusted OR (95% CI)*	*Multivariate*† *OR (95% CI)*	*Unadjusted OR (95% CI)*	*Multivariate*† *OR (95% CI)*	*Unadjusted OR (95% CI)*	*Multivariate*† *OR (95% CI)*	*Unadjusted OR (95% CI)*	*Multivariate*† *OR (95% CI)*
Age (5-yr interval)	0.37[c] (0.28, 0.49)	0.36[c] (0.26, 0.50)	0.55[c] (0.48, 0.63)	0.53[c] (0.44, 0.64)	0.85[a] (0.74, 0.97)	0.83[b] (0.73, 0.96)	0.97 (0.85, 1.12)	1.01 (0.88, 1.16)
Extracranial ISS	1.02[c] (1.01, 1.03)	1.01[b] (1.00, 1.02)	1.00 (0.99, 1.00)	1.00 (0.99, 1.01)	1.01[a] (1.00, 1.01)	1.00 (1.00, 1.01)	1.00 (0.99,1.01)	1.00 (0.99, 1.00)
LOC	1.89[c] (1.38, 2.60)	1.20 (0.80, 1.81)	1.07 (0.86. 1.33)	0.86 (0.61, 1.22)	1.70[c] (1.32, 2.18)	1.54[b] (1.18, 2.00)	2.08[c] (1.58, 2.72)	2.08[c] (1.56, 2.77)
Altered mental status	0.98 (0.63, 1.52)	0.85 (0.50, 1.47)	0.86 (0.63, 1.16)	0.82 (0.53, 1.28)	1.08 (0.76, 1.52)	0.99 (0.70, 1.40)	1.64[b] (1.16, 2.32)	1.53[a] (1.07, 2.17)
Amnesia	1.38 (0.77, 2.47)	1.10 (0.50, 2.44)	0.90 (0.58, 1.41)	0.90 (0.44, 1.84)	1.60[a] (1.02, 2.51)	1.42 (0.89, 2.25)	1.53 (0.93, 2.49)	1.29 (0.78, 2.15)
Headache	0.56[c] (0.41, 0.77)	0.88 (0.58, 1.35)	1.25[a] (1.00, 1.56)	1.41 (0.99, 2.00)	0.75[a] (0.59, 0.97)	0.90 (0.69, 1.19)	0.93 (0.71, 1.23)	1.11 (0.81, 1.50)
Tinnitus	0.54[c] (0.37, 0.78)	0.76 (0.48, 1.18)	0.93 (0.75, 1.16)	1.09 (0.78, 1.53)	0.73[a] (0.56, 0.96)	0.77 (0.58, 1.02)	0.73[a] (0.54, 0.98)	0.73 (0.54, 1.00)
Previous blast	1.38 (0.90, 2.12)	1.55 (0.73, 3.29)	0.99 (0.72, 1.34)	1.33 (0.70, 2.52)	1.06 (0.74, 1.52)	0.89 (0.55, 1.46)	1.84[c] (1.30, 2.61)	1.83[a] (1.15, 2.90)
Previous concussion	1.70[a] (1.01, 2.87)	0.96 (0.38, 2.44)	0.92 (0.61, 1.41)	0.57 (0.25, 1.29)	1.33 (0.86, 2.08)	1.49 (0.81, 2.73)	1.90[b] (1.22, 2.96)	1.15 (0.64, 2.07)

[a] $p \leq 0\ 05$
[b] $p \leq 0\ 01$
[c] $p \leq 0\ 001$
*Reference category is ''no discharge ''
†Adjusted for branch of service (Marine vs other), race (white vs other), type of blast (IED vs other), follow-up time
PTSD, posttraumatic stress disorder; PCS, postconcussion syndrome; OR, odds ratio; CI, confidence interval; ISS, Injury Severity Score; LOC, loss of consciousness

blast compared with an injury on an athletic field. Also, McCrea's study was an active surveillance of symptoms immediately after a concussion rather than information extraction from clinical notes that were written up to 48 hours post injury.

LOC was the only acute mTBI symptom associated with both PTSD and PCS in the multivariate models with altered mental status also associated with PCS. Studies have questioned the value of LOC as a predictor of neuropsychological functioning after mTBI in both athlete and non athlete samples, instead favoring altered mental status and amnesia as predictors of concussion outcome.[22 25] It is possible that due to differences in mechanism, LOC is a stronger predictor of outcome in blast related TBI compared with blunt trauma. Further, sports concussions may not be a good model for blast related TBI. Alternatively, in the absence of LOC, blast related TBI may be difficult to diagnose because of the austere environment in which it occurs, or possibly the lack of adequate diagnostic capabilities. The current findings highlight the importance of LOC in the prediction of PTSD and PCS in mTBI and concur with previous studies on the role of altered mental status on outcome. Contrary to previous literature,[26] amnesia was not related to either mental health outcomes in this sample.

While cognitive functioning symptoms such as LOC and altered mental status were valuable in predicting the mental health outcomes, no other point of injury symptoms were associated with the mental health or discharge outcomes. From these findings, acute mTBI symptoms may not be indicative of TBI severity. In addition, these acute symptoms resolve and may not contribute to either mental health or functional outcomes. Further, only injury severity was associated with the discharge outcome, as extracranial ISS was predictive of disability discharge. This is not unexpected, since greater injury severity may result in more long term disabilities.

A history of a previous blast was predictive of PCS in the multivariate model. Although a history of previous concussions was not predictive of any outcomes, undiagnosed concussions may have occurred during these blast events. The cumulative effect of brain injuries has been well documented in repeat concussions occurring in sports related injuries, which include decreases in cognitive performance in jockeys,[27] and contributes to mild cognitive impairment and depression in retired football players.[28,29] Accurate documentation of previous concussions including concussions occurring prior to entering military service, during previous deployments, and during the current deployment is necessary to understand the full impact that repeat TBIs have on service personnel.

There are limitations to the current study. Injured service personnel must be evaluated medically within 48 hours of the injury to have been included in the study. Considering a higher proportion of the current sample reported LOC, compared with active surveillance of high school and college athletes, service personnel who experienced LOC after a blast may be more likely to seek care than those without LOC. Since the delay between the injury and the documentation of acute mTBI symptoms could be as long as 48 hours, symptoms could have subsided and not been reported. While data extraction was found to be reliable, it depended on clinical notes written in forward MTFs without standardized documentation. A symptom was considered not present if it was not documented in the clinical notes, which could lead to a lower overall proportion of some symptoms. Reliable quantification of acute symptoms, such as length of LOC or amnesia, was not possible.

The primary strength of this study is that the mTBI diagnosis was made by clinical providers on scene, near the point and time of injury, rather than from post deployment TBI diagnoses or from self reported measures such as post deployment surveys, eliminating the possibility of recall bias. Follow up PTSD and PCS diagnoses were made by medical providers rather than by self report and required two separate documented diagnoses of the conditions to be considered positive for the conditions in this study.

Conclusion

Our study is the first to associate acute mTBI symptoms following a blast related mTBI with long term outcomes. We found that LOC and, to a lesser extent, altered mental status, were significant predictors of PTSD and PCS in service personnel who were diagnosed with mTBI after a combat blast episode. In contrast, acute mTBI symptoms were not predictive of service discharge outcomes and extracranial injury severity was the only significant predictor of disability discharge. If service personnel experience LOC or altered mental status after a blast episode, follow up for adverse outcomes, such as PTSD and PCS, should be considered.

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Author Disclosure Statement

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14. ABSTRACT

Assessment of acute mild traumatic brain injury (mTBI) symptoms after a combat blast could aid diagnosis and guide follow-up care. This study's purposes were to document acute mTBI symptoms following a combat blast and to examine associations between acute symptoms and mental health and service discharge outcomes.

A retrospective cohort study was conducted of 1656 service personnel who experienced a combat blast-related mTBI in Iraq. Acute mTBI symptoms were ascertained from point-of-injury medical records. The associations between acute symptoms and posttraumatic stress disorder (PTSD), postconcussion syndrome (PCS), and type of service discharge were examined.

Disability discharge occurred in 11%, while 36% had a non-disability discharge and 52% had no recorded discharge. A PTSD and PCS diagnosis was made in 19% and 15% of the sample, respectively. The most common acute mTBI symptoms were headache (62.8%), loss of consciousness (LOC) (34.5%), and tinnitus (33.2%). LOC was predictive of PTSD (odds ratio [OR] 1.54; 95% confidence interval [CI] 1.18, 2.00) and PCS (OR 2.08; 95% CI 1.56, 2.77), while altered mental status (OR 1.53; 95% CI 1.07, 2.17) and previous blast history (OR 1.83; 95% CI 1.15, 2.90) were also predictive of PCS. While no acute mTBI symptoms were associated with discharge outcomes, injury severity was associated with disability discharge.

LOC after blast-related mTBI was associated with PTSD and PCS, and injury severity was predictive of disability discharge. The assessment of cognitive status immediately after a blast could assist in diagnosing mTBI and indicate a need for follow-up care.

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