

Posttraumatic Stress Disorder in Combat Casualties With Burns Sustaining Primary Blast and Concussive Injuries

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Background: There is a heightened focus on postexplosion functional outcomes in combat casualties. Previously, we reported a high prevalence of posttraumatic stress disorder (PTSD) (32%) and mild traumatic brain injury (mTBI) (41%) in patients with explosion-related burns. We hypothesized that the prevalence of PTSD in patients with burn was associated with primary blast injuries (PBIs) and mTBI.

Methods: We reviewed the records of 333 patients admitted consecutively to the United States Army Institute of Surgical Research burn center for explosion-related injuries between March 2003 and March 2006. By using the Posttraumatic Checklist, Military Version (PCL-M), patients were evalu-

ated for PTSD symptoms (PCL-M score ≥ 44). Loss of consciousness defined mTBI. Patient data were analyzed in groups based on PTSD (yes or no), mechanism of injury (improvised explosive device [IED] vs. other explosive), PBI (yes or no), and mTBI (yes or no).

Results: Of 333 patients, 119 had PTSD assessments. Overall, PTSD was 22% (26 of 119). The prevalence of PTSD differed between mechanism of injury groups ($p = 0.03$). In the IED group ($n = 105$), 25% had PTSD symptoms and 18% had mTBI; patients injured by other explosive devices ($n = 14$) had no PTSD symptoms and one had mTBI ($p = 0.04$; $p = 0.69$, respectively). Also in the IED group, in patients with PBI, PTSD was 45%

(9 of 20) compared with 20% (17 of 85) without PBI (odds ratio=3.27; 95% confidence interval, 1.17–9.16). More patients with PBI and mTBI (4 of 6; 67%) had PTSD symptoms compared with other patients (22 of 99; 22%) (odds ratio, 7.00; 95% confidence interval, 1.20–40.78). No other associations were found between PBI and mTBI.

Conclusion: IED-wounded burn patients with PBI and mTBI have a greater prevalence of PTSD. Patients who did not have IED-related injuries did not have PTSD and only one had mTBI.

Key Words: Posttraumatic stress disorder, Primary blast injury, Mild traumatic brain injury, Burn injury, Explosion.

J Trauma. 2009;66:S178–S185.

In the present conflict, a number of service members are surviving traumatic injury even though the severity of injury has increased since the start of the war.^{1–4} Because more soldiers are surviving, the potential long-term psychologic effects related to injury severity are of particular interest. Examining how injury is experienced and the type of injury may lead to a better understanding of the development of psychologic sequelae and provide a means to improve outcomes.

In the Iraq and Afghanistan (Operation Iraqi Freedom/Operation Enduring Freedom [OIF/OEF]) conflicts, explosive munitions are the prevalent mechanism of injury (MOI) and the predominant cause of military casualties. Improvised explosive devices (IEDs) alone account for 60% to 78% of war injuries.^{5,6} This rampant use of the inexpensive, readily

assembled IEDs has been coined the signature weapon of OIF/OEF.⁷ Hence, with the increasing use of the IED, exposure to explosive injuries has become more frequent.

The explosion-related injuries soldiers sustain range from primary (blast wave), secondary (projectiles proximal to blast wave), tertiary (shock wave and dynamic overpressure), and quaternary (miscellaneous, i.e., fire, toxic inhalation, or asphyxiation).⁸ Primary blast injuries (PBIs) result from the blast wave pressure oscillations inflicting tissue damage by compression and shear stress on vulnerable air-filled organs. PBI, which occur in close proximity to the blast center, can result in eardrum damage (rupture of the tympanic membrane [TM]), lung damage (pulmonary or alveolar septa rupture), or visceral damage without causing death. Research focusing on explosion injuries demonstrates a notable incidence (16–35%) of TM rupture^{9,10} that is the result of blast wave exposure.¹¹ Thus, combat casualties with burns and PBI are often in close proximity to the blast center. In an open air environment, standoff distance for fireball-induced burns is less than that necessary for PBI in the eardrums.⁵

In addition to the presence of PBI, sustaining any period of loss of consciousness (mild traumatic brain injury [mTBI]) from an explosion has also been associated with the occurrence of psychologic deficit.^{12,13} The Defense and Veterans Brain Injury Center reports 22% of soldiers returning from OIF/OEF as having evidence of mTBI.¹⁴ One theory suggests using PBI—more specifically, TM rupture—as an additional

Submitted for publication November 20, 2008.

Accepted for publication January 16, 2009.

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DOI: 10.1097/TA.0b013e31819ce2d6

Report Documentation Page

Form Approved
OMB No. 0704-0188

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1. REPORT DATE 01 APR 2009		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Posttraumatic stress disorder in combat casualties with burns sustaining primary blast and concussive injuries				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Mora A. G., Ritenour A. E., Wade C. E., Holcomb J. B., Blackbourne L. H., Gaylord K. M.,				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX 78234				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 8	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

biomarker of mTBI.⁹ Other research affirms a link between an mTBI and a greater likelihood of psychologic deficit, specifically, posttraumatic stress disorder (PTSD).¹³ This increased risk of altered mental status, concussive symptoms, and PTSD associated with exposure to the detonation of explosive munitions is a great concern to medical providers. Identifying biomarkers of exposure to explosive munitions will help to improve care and neuropsychological health outcomes in combat casualties.

The intent of our retrospective analysis was to examine the association between PBI, mTBI, and PTSD in combat casualties with burns. We hypothesized that patients with PBI will have a greater prevalence of PTSD symptoms compared with those without PBI. Patients sustaining mTBI as a result of an explosion will also have an increase in PTSD symptoms. Furthermore, the combination of PBI and mTBI will be associated with a greater prevalence of PTSD symptoms.

METHODS

Study design was a retrospective review of clinical records of combat casualties injured in explosions during OIF/OEF and treated at the United States Army Institute of Surgical Research (USAISR) Burn Center between March 2003 and March 2006. All combat casualties with burns are evacuated to the USAISR, the sole DOD burn center. The Joint Theater Trauma Registry, maintained by the USAISR, was the database queried for the study. The Joint Theater Trauma Registry is a database of medical records with demographic, diagnostic, and treatment data of combat-wounded combat casualties who were treated in Afghanistan/Iraq, Germany, and continental US military medical facilities. After approval from the Brooke Army Medical Center Institutional Review Board, institutionally maintained databases and electronic records were searched for combat casualties injured in explosions. By using excel (Microsoft, Redmond, WA), we created a study database that included demographics, date of injury, date of admission, date of discharge, length of hospital stay, number intensive care unit days, percent total body surface area, Injury Severity Score, MOI, PBI, and records of consciousness status.

PBI was defined by sustained TM rupture, blast lung injury, and intestinal blast injury.⁸ The codes from the International Statistical Classification of Diseases and Related Health Problems (ICD) used to identify the presence of primary blast were as follows: 872.61 for open wound of ear drum, 860 for traumatic pneumothorax closed, 861.21 for pulmonary contusion closed, and 203.43 for closed injuries to the stomach, small intestine, or colon. After the query, the clinical records of combat casualties with evidence of explosion injuries were reviewed to assure diagnosis of PBI rather than nonblast trauma. Consciousness status to determine mTBI was queried using both codes from ICD and Abbreviated Injury Scale scores for indications of trauma to the head, concussive injuries, and indications of consciousness at time of injury. A loss of consciousness

served as the definition for mTBI.¹² To ensure an accurate determination of diagnosis, individual clinical records were examined by an independent panel of reviewers.

A database maintained by the USAISR of all PTSD Checklist, Military Version (PCL-M) scores was queried to establish the presence of PTSD symptoms in the combat casualties injured during the study period. From the start of the war in 2003 to January 2007, the PCL-M was administered to combat casualties based on PTSD symptomatology and clinical staff referral. The PCL-M is a 17-item self-report tool used by the USAISR staff, psychiatric mental health clinical nurse specialist, to screen for PTSD. Scores range from 17 to 85 and PTSD is indicated by a score of 44 and above. An alert score of 44 or greater increases diagnostic efficiency to 0.90.¹⁵ The PCL-M has three clusters or subsets: reexperiencing, numbing, and hyperarousal. PCL-M was designed to parallel the diagnostic criteria detailed in "*Diagnostic and Statistical Manual of Mental Disorders*", 4th edition (DSM-IV). Per the DSM-IV, a diagnosis of PTSD occurs when symptoms persist for more than 30 days after the traumatic event. Combat casualties with a PTSD assessment 30 days postinjury were included in our analysis to parallel the diagnostic criteria in the DSM-IV. We ensured inclusion of all PTSD assessments completed by those in our study database. For those with multiple assessments, the highest total score was included in the analysis. The sample was then divided into three subgroups: MOI (IED vs. other explosive munitions), PBI (yes or no), and loss of consciousness at time of explosion (yes or no).

Statistical analysis was performed with SAS version 9.1 (SAS Institute Inc., Cary, NC). For categorical data, χ^2 test, when necessary Fischer's exact, and odds ratios were used. For parametric data, analysis of variance was performed. With non-parametric data (large standard deviations), a median was used in place of mean to compute *p* values. A *p* value of less than 0.05 was considered to be a significant finding.

RESULTS

Three hundred thirty-three patients admitted to the USAISR Burn Center from OIF/OEF sustained burn and blast injuries from explosions between March 2003 and March 2006 (Fig. 1). Two hundred fourteen were excluded as they did not have a PCL-M assessment. One hundred nineteen had PCL-M assessments at least 30 days after injury and were included in the study. In the 119 patients, there was a 21.8% (26 of 119) incidence of PBI (23 TM, 1 TM and blast lung, and 2 blast lung only) with an overall 22% prevalence of PTSD symptoms. Patients with PBI and no PBI had a PTSD prevalence rate of 35% (9 of 26) and 18% (17 of 93), respectively (*p* = 0.075). Further analysis yielded a disproportionate frequency of a predominant MOI (analysis of variance, *p* = 0.004). Other group characteristics were not different (Table 1). In our sample, 25% (26 of 105) of IED-wounded combat casualties manifested PTSD symp-

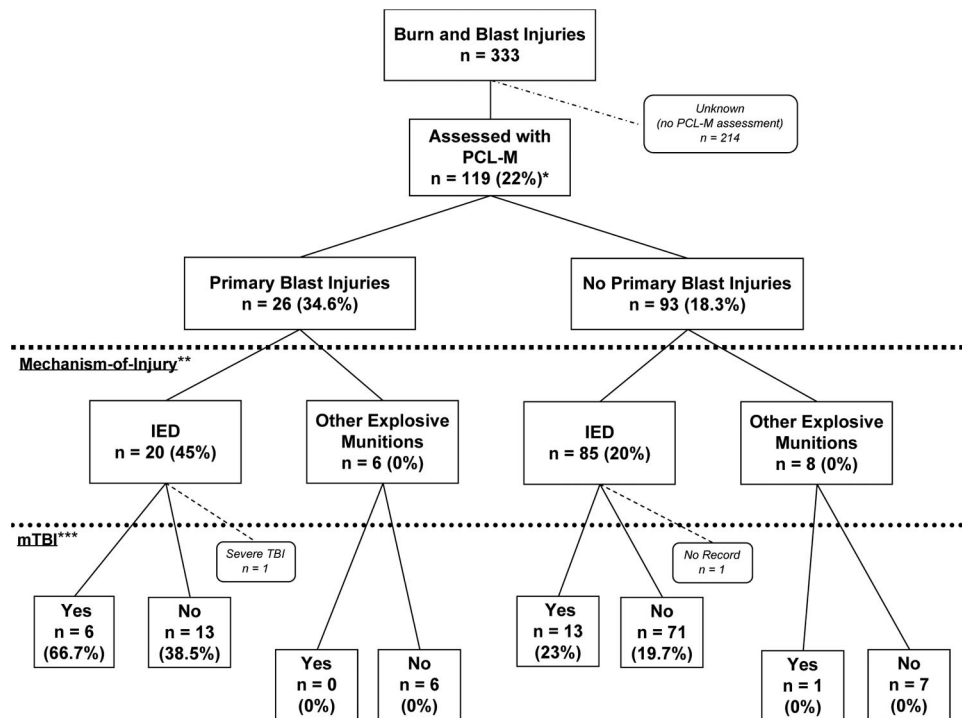


Fig. 1. Study population categorized based on blast-related injuries and mechanism of injury with the respective percentage in group with PTSD. *(%) Prevalence rate of PTSD in group. **Separation of combat casualties based on explosive munitions. IED versus other explosive munitions was the most natural separation as counts of explosives other than IED individually were too small for further statistical analysis. ***Based on a review of medical charts, we noted mTBI records as yes or no.

toms versus 0% (0 of 14) in those with injuries because of other explosives ($p = 0.0379$). Therefore, subsequent analysis of subgroups was performed adjusting for mechanisms of injury.

Focusing on the 105 who sustained IED-related injuries, the prevalence of PTSD symptoms was 45% (9 of 20) in the PBI and 20% (17 of 85) in the no PBI group ($p = 0.04$) (Table 2), suggesting a significant association between PBI and PTSD (odds ratio, 3.27; 95% confidence interval, 1.17–9.16). A review of PTSD symptoms (yes or no) based on IED explosions yielded no further demographic differences.

The mental status of patients immediately after impact of explosion was determined for 117, irrespective of MOI. Twenty patients (17%) had indications of mTBI documented in their medical records. Adjusting for PTSD symptoms (yes or no), no relationship was found in the presence of mTBI, 37% versus 16%, respectively ($p = 0.243$). Eighteen percent of the IED-related casualties had mTBI, but no difference was noted between patients having sustained PBI (32%) and no PBI (16%) in the presence of mTBI ($p = 0.113$) (Table 3). Similarly, adjusting for mTBI (yes or no), no differences were found in outcomes related to PTSD, 37% versus 23%, respectively ($p = 0.243$) (Table 4). However, soldiers injured by IED with concomitant PBI and mTBI more often presented with PTSD symptoms (odds ratio, 7.00; 95% confidence interval, 1.20–40.78).

DISCUSSION

In this retrospective study of combat casualties with burns, we identified an association between PBIs and PTSD. IED-wounded combat casualties with burns had a higher prevalence of PTSD symptoms and those with PBI and mTBI had an even greater prevalence of PTSD symptoms. Combat casualties injured by IED explosions did not have PTSD symptoms and only one combat casualty had mTBI. Demographic analysis identified no significant differences between groups and subgroups.

Burn Injuries

Fireball-induced burns and PBI are physiologic clues of proximity to blast center and exposure to the blast effects. In our study sample, we found total trauma severity was related to burn injury as total body surface area was associated with Injury Severity Score ($R^2 = 0.6581$). Because of the nature of our study, our results may not be generalized to other patient populations.

Mechanism of Injury

Our findings confirm that the type of device accountable for explosion-related injuries, i.e., MOI, plays a role in the outcome of patients. The increasing use of explosives in theater and other regions of political conflict are noted in the literature.^{16–18} As a result, the impact explosions have on the

Table 1 Characteristics of Study Population (119) With Burn and Blast Injuries, Noted by Sustained Primary Blast Injuries

	PBI		No PBI		<i>p</i>
	n	% or Mean ± SD	n	% or Mean ± SD	
Gender (% male)	26	85%	93	96%	NS
Age (yr)	26	26.3 ± 6.1	93	25.9 ± 6.0	NS
TBSA	26	14.1 ± 14.3	93	15.0 ± 15.8	NS
ISS	26	12.7 ± 13.0	93	12.3 ± 10.9	NS
GCS*	24	13.6 ± 3.3	91	13.0 ± 4.0	NS
LOS	26	20.0 ± 17.6	93	27.2 ± 48.2	NS
ICU days	26	5.3 ± 8.9	93	7.4 ± 20.7	NS
MOI (% IED)	26	77%	93	91%	0.0044 [†]
Multiple assessments (%) [‡]	26	38%	93	52%	NS
Number of days postinjury [§]	26	193.7 ± 171.9	93	189.7 ± 175.2	NS
mTBI (%)	25	24%	92	15%	NS
PTSD (%)	26	35%	93	18%	0.0747

* Glasgow Scores from initial emergency room admission were used. A total of four did not have GCS noted in their medical chart (two, PBI and two, no PBI).

[†] Based on ANOVA. χ^2 analysis of MOI based on IED (yes or no) confirmed significance ($p = 0.043$).

[‡] (%) With more than one PTSD assessment.

[§] Number of days from the date of injury to the date the PTSD assessment was completed.

^{||} In our review of medical records, one patient from the PBI group had severe TBI and subsequently excluded. Additionally, there was one patient from the no PBI group that mTBI (yes or no) could not be determined from medical chart review.

GCS, Glasgow Scores; ISS, Injury Severity Score; LOS, length of hospital stay; ICU, intensive care unit.

Table 2 Comparison Between IED (105) and Non-IED-Wounded (14) Combat Casualties Sustaining Primary Blast Injuries vs. No Primary Blast Injuries

	IED					Other Explosive					<i>p</i> *
	PBI		No PBI		<i>p</i>	PBI		No PBI		<i>p</i>	
	n	% or Mean ± SD	n	% or Mean ± SD		n	% or Mean ± SD	n	% or Mean ± SD		
Gender (% male)	20	80%	85	95%	0.0412	6	100%	8	100%	NS	0.0125
Age (yr)	20	26.4 ± 6.1	85	26.1 ± 6.1	NS	6	26.3 ± 6.6	8	24.0 ± 4.2	NS	NS
TBSA	20	10.2 ± 8.9	85	14.7 ± 15.9	NS	6	27.3 ± 21.1	8	18.0 ± 15.4	NS	NS
ISS	20	10.3 ± 12.6	85	12.5 ± 11.1	NS	6	21.0 ± 11.6	8	9.8 ± 8.8	NS	NS
GCS	18	13.2 ± 3.7	83	13.0 ± 4.0	NS	6	14.8 ± 0.4	8	13.5 ± 4.2	NS	NS
LOS	20	16.4 ± 16.6	85	27.9 ± 50.1	NS	6	32.0 ± 16.4	8	19.6 ± 17.4	NS	NS
ICU days	20	2.9 ± 6.0	85	7.7 ± 21.5	NS	6	13.5 ± 12.5	8	4.0 ± 4.7	NS	NS
Multiple assessments (%)	20	45%	85	53%	NS	6	17%	8	37.5%	NS	NS
Number of days postinjury	20	189.5 ± 178.6	85	188.4 ± 173.8	NS	6	207.8 ± 162.2	8	203.5 ± 201.2	NS	NS
mTBI [†]	19	32%	84	16%	NS	6	0%	6	0.2%	—	—
PTSD [‡]	20	45%	85	20%	0.0402	6	0%	8	0%	—	—

* Comparison of all four groups performed by analysis of variance.

[†] Statistical analysis of PBI vs. no PBI in other explosives and comparison of all four groups could not be completed because of the 0% incidence of mTBI.

[‡] Comparison of PTSD prevalence in IED-related PBI vs. no PBI yielded in an odds ratio of 3.27 (95% confidence interval, 1.17–9.16). Statistical analysis of PBI vs. no PBI in other explosives and comparison of all four groups could not be completed because of the 0% prevalence of PTSD.

GCS, Glasgow Scores; LOS, length of hospital stay.

physiologic^{19,20} and psychologic outcome of its victims has become more evident.^{21,22} IED-involved injured combat casualties had a greater prevalence of PTSD largely because of the fact that PTSD was not present when injuries were a result of other explosives. Each explosive device has a unique radius of propagation and the distance the blast wave travels

is relevant to the frequency seen in explosion survivors with blast-related injuries. Because the intensity of the blast wave dissipates quickly, the wave does not travel significantly further than the fireball radius or even the radius of the blast center itself, resulting in few survivors sustaining PBI. Even specific to IEDs, standoff distances vary between the carrier

Table 3 Comparison Between IED-Wounded Combat Casualties Sustaining Primary Blast Injuries (Yes or No) and mTBI (Yes or No)

	PBI					No PBI					p
	mTBI		No mTBI		p	mTBI		No mTBI		p	
	n	% or Mean ± SD	n	% or Mean ± SD		n	% or Mean ± SD	n	% or mean ± SD		
Gender (% male)	6	83%	13	84%	NS	13	86%	78	97%	NS	0.0261
Age (yr)	6	28.0 ± 4.7	13	25.9 ± 6.6	NS	13	29.1 ± 9.0	78	25.4 ± 5.2	NS	NS
TBSA	6	8.1 ± 6.9	13	15.4 ± 15.7	NS	13	17.0 ± 10.6	78	14.6 ± 16.7	NS	NS
ISS	6	7.8 ± 9.3	13	12.3 ± 11.2	NS	13	15.0 ± 11.6	78	11.7 ± 10.8	NS	NS
GCS	6	13.0 ± 4.9	13	12.8 ± 3.7	NS	13	13.1 ± 3.9	78	13.2 ± 3.8	NS	NS
LOS	6	11.7 ± 7.6	13	20.7 ± 17.8	NS	13	27.2 ± 29.6	78	27.3 ± 51.2	NS	NS
ICU days	6	1.0 ± 2.5	13	6.0 ± 9.6	NS	13	4.4 ± 5.6	78	8.0 ± 22.4	NS	NS
Multiple assessments (%)	6	33%	13	37%	NS	13	43%	78	54%	NS	NS
Number of days postinjury	6	117.2 ± 80.4	13	213.2 ± 191.0	NS	13	232.8 ± 205.0	78	181.9 ± 170.8	NS	NS
PTSD*	6	67%	13	26%	NS	13	21%	78	20%	NS	0.0655

* Analysis of PTSD prevalence in the PBI and mTBI vs. all other groups yielded an odds ratio of 7.00 (95% confidence interval, 1.20–40.78). GCS, Glascoma Scores; LOS, length of hospital stay; ICU, intensive care unit.

Table 4 Analysis of PTSD Prevalence in Comparison Groups Based on Clinical Presentation (Yes or No)

	Yes PTSD% (N/Group N)	No PTSD% (N/Group N)	Total N	p*
PBI	35% (9/26)	18% (17/93)	119	0.0747
IED	25% (26/105)	0% (0/14)	119	0.0379
IED-wounded				
PBI	45% (9/20)	20% (17/85)	105	0.0402†
mTBI	37% (7/19)	23% (19/84)	103	0.2434
PBI and mTBI	67% (4/6)	23% (22/97)	103	0.0343‡

* χ^2 -based statistical analysis.

† Odds ratio, 3.27 (95% confidence interval, 1.17–9.16).

‡ Odds ratio, 7.00 (95% confidence interval, 1.20–40.78).

used (e.g., briefcase, sedan, and semitrailer). Still, IEDs have a substantially greater radius of propagation, so the blast wave travels to a greater distance. Because of these mechanistic effects, Veteran Affairs Polytrauma Rehabilitation Centers embarked on reviewing findings—often overlooked—of typical physical and psychologic sequelae associated with a particular MOI and go further in proposing a MOI approach when evaluating and treating patients.²³

Primary Blast Injury

Within our study population, 22% sustained PBI. Eighty-nine percent of PBIs involved TM and in the IED-adjusted PBI group, 95% of these injuries were TM. Reportedly, 10% to 35% of explosion-related combat casualties sustain TM ruptures.^{8–10,24} PBI is one of an array of explosion-related injuries; however, few casualties have PBI as the dominating injury.⁸ Thus, it is thought that regardless of the body armor worn in combat, exposure to blast can be detected by examining PBI.

The ear is most vulnerable to blast overpressure and damage becomes evident at 5 psi.^{10,25} Blast overpressure-

induced TM is then a marker of exposure and indicative of the proximity to the explosion's origin. In light of this, some studies suggest the use of PBI, TM in particular, as a marker of mTBI implicated with explosions. Xydakis et al.⁹ used the definition of mTBI as loss of consciousness and found an increase risk in the presences of TM. Well, over half (61%) of the patients with TM observed by Xydakis et al. had a loss consciousness, suggesting the presence of mTBI.

Mild Traumatic Brain Injury

Our findings suggest that combat casualties are at risk for developing PTSD if they sustain a neurologic insult such as mTBI along with PBI, despite an independent influence from mTBI alone. Although we observed a 19% incidence of mTBI in our study, other studies found rates of 36%⁹ and 5%¹³ in explosion-injured US soldiers. One of the largest studies found that 19% of the soldiers returning from OIF/OEF reported head trauma irrespective of other comorbidities. Our findings are similar to findings discussed in a study report from the RAND Corporation; however, in a more severely injured population.²⁶

Clinicians and patients alike should remain cognizant of the effects of mTBI. The occurrence of multiple head trauma outcome had an exponential increase in morbidity. When subsequent head trauma is endured before full recovery from previous head trauma, the diagnostic label is known as second-impact syndrome and has a mortality rate of 50%.²⁷ Even mild head injuries put soldiers at risk of decreased functional outcomes. A recent study suggests that PTSD symptoms may be influenced by subtle head trauma such as explosion-incurred concussions. Of soldiers with evidence of mTBI, 44% met the criteria for PTSD diagnosis, implying an associated risk of mTBI and development of PTSD symptoms.¹³ In contrast to the study associating mTBI with PTSD, our sample had a higher

percentage of mTBI. Despite this comparison finding, in our study mTBI alone did not predict PTSD outcome.

Independently compared mTBI is not a predictor of PTSD and correspondingly PTSD is not principally influenced by mTBI. However, both are likely to coexist in the presence of PBI. More than one third of patients with evidence of mTBI developed PTSD, whereas another study reported almost half (44%).¹³ Four percent of our study population sustained concomitant mTBI and PTSD after IED adjustment. This is comparable with the overall 7% findings in soldiers deployed to OIF/OEF.²⁶

The differences and similarities in symptomatology between PTSD and mTBI have been evaluated.^{28–32} Despite the overlap between the two diagnoses, experiencing a period of loss of consciousness is a definitive difference. Although neither mTBI nor PTSD may be visible at the initial treatments of explosion-related injuries, generally mTBI subsides, whereas PTSD worsens. Further research is necessary to understand the relationship between the PTSD and mTBI.

Posttraumatic Stress Disorder

In previous wars, awareness of potential psychological implications became apparent many years postwar, after service members retired, and when veterans sought medical care within veterans affairs facilities.^{33–35} The prevalence of mental health disorders begs the attention of healthcare providers. Current studies of psychological problems in noninjured combat veterans for OIF/OEF report a range of PTSD from 9% to 44%.^{13,36–38} One study reports that one fifth of US soldiers returning from OIF/OEF deployments meet criteria for PTSD diagnosis.²⁶ The incidence of PTSD has been reported as 27% to 46% in burn-wounded combat casualties^{30,39} and 8% to 45% in civilians with burns.^{40–42}

In the study design, we included patients with delayed manifestation of PTSD symptoms. A total of three patients did not initially screen positive for PTSD, but in subsequent screenings did meet the alert level of the PTSD assessment. All three sustained IED-related injuries, one sustained PBI and mTBI, whereas the other two sustained neither. The decision to expand the review period allotted sufficient time to stabilize postdeployment symptoms and establish PTSD symptoms.^{36,43,44}

Limitations of this study include retrospective review of clinical records, which may have not been complete or accurate and personal bias related to using a self-report instrument.

CONCLUSION

We found that PTSD is a function of injury type and MOI. The IED-wounded with burns and PBI had an increased prevalence of PTSD; though, in the presence of mTBI, there was an even greater prevalence of PTSD. Knowledge of explosive type, PBI, and mTBI will lead to optimal and early interventions that could attenuate the prevalence of chronic PTSD.

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DISCUSSION

Dr Alan L. Peterson: Mora et al. have provided an interesting report on the prevalence of the symptoms of posttraumatic stress disorder (PTSD) in a population of military combat casualties with burns seen at the United States Army Institute of the Surgical Research Burn Center. This study investigated the individual and combined contribution of traumatic burns with primary blast injuries (PBI) from improvised explosive devices (IEDs) or other explosive munitions, with or without a mild traumatic brain injury (mTBI).

Burns, amputations, PTSD, and mTBI have been described as the four signature injuries seen in US military personnel serving in support of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). The most common cause of these four signature injuries is some type of explosion that results from a roadside bomb, mortar, rocket, rocket propelled grenade, or some form of an IED. Indeed, the use of some type of explosive device might be described as the signature weapon of OIF/OEF. In addition to being the primary cause of injury and death in OIF/OEF veterans, explosive weapons are hypothesized to be the primary cause of PTSD.

In the present study, Mora et al. provide some evidence to support this hypothesis. Combat casualty burn patients who were also injured by a PBI were not significantly more likely to report symptoms of PTSD as compared with patients with no PBI (35% [9 of 26] vs. 18% [17 of 93], respectively). This lack of statistical difference is rather surprising considering the apparent large difference between groups on visual inspection of the data and warrants further investigation. However, the method of injury in patients with burn did have an impact on PTSD. Patients who had been burned during an IED explosion were significantly more likely to report symptoms of PTSD (25% [26 of 105]) as compared with those who had experienced turns from other explosive munitions (0% [0 of 14]). Those with a combination of burn + IED + PBI were also significantly more likely to report symptoms of PTSD (45% [9 of 20]) as compared with those without a PBI (20% [17 of 85]). Similarly, those with a combination of burn + IED + mTBI were also significantly more likely to report symptoms of PTSD (67% [4 of 6]) as compared with those without an mTBI (22% [22 of 99]). These results provide some support to the hypothesis that explosive weapons are the primary cause of PTSD in OIF/OEF veterans.

The linking of psychological health and mTBI data to the Joint Theater Trauma Registry database provides for a rich data set for the exploration of the potential behavioral health impact of combat casualty trauma. Unfortunately, the PTSD screenings in the present study were not available for the majority (64%) of the patients with burn and when the screen-

ings were first initiated they were only given to patients suspected as possibly having PTSD. This may have introduced a selection bias resulting in a higher rate of PTSD symptoms in those patients actually evaluated than might have been present in the entire population of burn patients. In addition, some of the cell sizes in the data set analyzed are relatively small, resulting in large differences in cell sizes in the between group comparisons. Some of these findings might best be described as trends, and this data will need to be reanalyzed as the data set grows.

PTSD is one of the few mental disorders where the cause is known, it is caused by exposure to a traumatic stressor. In Iraq and Afghanistan, explosions are the most common traumatic stressor, and the combination of explosions, burns, PBI, and mTBI appear to place military personnel at significantly higher risk for the development of PTSD. These findings are consistent with some of the findings from civilian studies that have investigated the single and combined effect of multiple aspects of a single traumatic event. For example, one civilian study¹ investigated crime victim groups and evaluated the individual and combined contribution of rape, life threat, and

physical injury in addition to the crime on the development of crime-related PTSD. The results showed a significant additive impact of these different aspects of trauma exposure. Only 9.2% of crime victims developed PTSD in the absence of rape, injury, and life threat. In contrast, those 79% of crime victims who were raped, physically injured, and feared for their lives during the assault developed PTSD. The results of this civilian study and the present study by Mora et al. highlight the importance of the type of trauma as well as the potential combined impact of different components of a traumatic event and the risk for development of PTSD. The present study makes an important contribution to the scientific literature on PTSD and will undoubtedly prompt additional research studies to further investigate the risk of PTSD in combat casualties.

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