Acute Assessment of Traumatic Brain Injury and Post-Traumatic Stress After Exposure to a Deployment-Related Explosive Blast

Lt Col Monty T. Baker, BSC USAF†; John C. Moring, PhD*; Willie J. Hale, PhD*‡; Jim Mintz, PhD*; COL Stacey Young-McCaughan, AN USA (Ret.)*; Richard A. Bryant, PhD§; Donna K. Broshek, PhD‖; Jeffrey T. Barth, PhD‖; Robert Villarreal, MS*; Cynthia L. Lancaster, PhD¶; Steffany L. Malach, PhD***; Jose M. Lara-Ruiz, MA*‡; Col William Isler†; Lt Col Alan L. Peterson, BSC USAF (Ret.)*‡††; for the STRONG STAR Consortium*

ABSTRACT Introduction: Traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD) are two of the signature injuries in military service members who have been exposed to explosive blasts during deployments to Iraq and Afghanistan. Acute stress disorder (ASD), which occurs within 2–30 d after trauma exposure, is a more immediate psychological reaction predictive of the later development of PTSD. Most previous studies have evaluated service members after their return from deployment, which is often months or years after the initial blast exposure. The current study is the first large study to collect psychological and neuropsychological data from active duty service members within a few days after blast exposure. Materials and Methods: Recruitment for blast-injured TBI patients occurred at the Air Force Theater Hospital, 332nd Air Expeditionary Wing, Joint Base Balad, Iraq. Patients were referred from across the combat theater and evaluated as part of routine clinical assessment of psychiatric and neuropsychological symptoms after exposure to an explosive blast. Four measures of neuropsychological functioning were used: the Military Acute Concussion Evaluation (MACE); the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS); the Headminder Cognitive Stability Index (CSI); and the Automated Neuropsychological Assessment Metrics, Version 4.0 (ANAM4). Three measures of combat exposure and psychological functioning were used: the Combat Experiences Scale (CES); the PTSD Checklist-Military Version (PCL-M); and the Acute Stress Disorder Scale (ASDS). Assessments were completed by a deployed clinical psychologist, clinical social worker, or mental health technician. Results: A total of 894 patients were evaluated. Data from 93 patients were removed from the data set for analysis because they experienced a head injury due to an event that was not an explosive blast ($n = 84$) or they were only assessed for psychiatric symptoms ($n = 9$). This resulted in a total of 801 blast-exposed patients for data analysis. Because data were collected in-theater for the initial purpose of clinical evaluation, sample size varied widely between measures, from 565 patients who completed the MACE to 154 who completed the CES. Bivariate correlations revealed that the majority of psychological measures were significantly correlated with each other ($ps \leq 0.01$), neuropsychological measures were correlated with each other ($ps \leq 0.05$), and psychological and neuropsychological measures were also correlated with each other ($ps \leq 0.05$). Conclusions: This paper provides one of the first descriptions of psychological and neuropsychological functioning (and their inter-correlation) within days after blast exposure in a large sample of military personnel. Furthermore, this report describes the methodology used to gather data for the acute assessment of TBI, PTSD, and ASD after exposure to an explosive blast in the combat theater. Future analyses will examine the common and unique symptoms of TBI and PTSD, which will be instrumental in developing new assessment approaches and intervention strategies.

*Department of Psychiatry, University of Texas Health Science Center at San Antonio, 7550 Interstate Highway 10 West, Suite 1325, San Antonio, TX 78229.

†Wilford Hall Ambulatory Surgical Center, 2200 Bergquist Drive, San Antonio, TX 78236.

‡Department of Psychology, University of Texas at San Antonio, One UTSA Circle, San Antonio, TX 78249.

§School of Psychology, University of New South Wales, 11 Botany Street, Sydney, New South Wales 2052, Australia.

‖Department of Psychiatry, University of Virginia School of Medicine, 1215 Lee St, Charlottesville, VA 22908.

¶Department of Psychology, University of Nevada, Reno, 1664 N Virginia Street, Reno, NV 89557.

**Brooke Army Medical Center, 3551 Roger Brooke Dr, San Antonio, TX 78219.

††South Texas Veterans Health Care System, 7400 Merton Minter Boulevard, San Antonio, TX 78229.

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INTRODUCTION

Deployed military service members are at increased risk of sustaining a deployment-related head injury from exposure to an explosive blast or other events. The prevalence of blast-related injuries has been estimated to be about 15% in military personnel deployed in support of Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF).[1] Blast-related injuries accounted for about 80% of all injuries during OEF/OIF deployments.[2–6] Blast exposure can result in a spectrum of physical and neurocognitive injuries related to primary (pressure of the blast), secondary (projectile objects), tertiary (being thrown into other objects), and

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quaternary (electromagnetic radiation, poisonous gas from exposure, etc.) events.[2,7,8]

Traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD) have been referred to as "signature injuries" of OEF/OIF and are common sequelae of blast exposures. TBIs are categorized as mild, moderate, or severe. More than 80% of all deployment-related TBIs are categorized as mild TBIs (mTBI) and are commonly referred to as concussions.[9,10] The symptoms of mTBI include exposure to a blast or other head injury event resulting in (1) a loss of consciousness less than 30 min, (2) incomplete or partial memory of the event that caused the injury, and/or (3) feeling disoriented, dazed, or confused.[11] In most cases, symptoms related to an mTBI abate within 2 wk after the head injury. Persistent symptoms that continue to be present 6 mo after the initial mTBI are referred to as post-concussion syndrome (PCS).[12,13]

Other psychological symptoms may complicate a clear diagnosis of TBI. For instance, acute stress disorder (ASD) requires at least one symptom from each of the following domains: re-experiencing (e.g., recollections, images, nightmares), avoidance of reminders of the traumatic event, and hyperarousal. In addition, three or more of the following dissociative symptoms must be present: numbing or detachment from emotions, reduction in awareness of surroundings, derealization, depersonalization, and dissociative amnesia.[14] The dissociative symptoms associated with ASD are similar to symptoms of TBI, including feeling dazed or confused, loss of memory of the event, and disorientation. Therefore, for a patient with a TBI and ASD, it is difficult to determine whether the dissociative symptoms are related to the injury or are in response to extreme psychological trauma. Some research suggests that the currently available screening measures for TBI and PTSD cannot distinguish the two disorders and cannot reliably predict symptom trajectory for patients who might have either or both disorders.[15–17] Therefore, continued examination and improvement of assessments for these conditions is critical so that clinicians will have the appropriate tools to identify the underlying cause or causes of symptom presentation for treatment planning and implementation.

Most studies on TBI severity and symptom presentation were conducted after deployed service members returned home.[18–20] Therefore, empirically based interventions for deployed clinicians are lacking, and knowledge of the acute emotional, behavioral, and neurocognitive symptoms is limited. Kennedy and colleagues examined service members who were evaluated for blast-related TBI immediately after a medical evacuation and found that those who returned to duty after recovering from concussion were younger and less likely to endorse symptoms of post-traumatic stress.[8] Those who recovered more quickly reported less severe headaches at the time of the injury as well as an absence of combat stress.

The results from Kennedy and colleagues provide insight as to which variables are predictive of the TBI recovery process, and most importantly, service members were evaluated at a time more proximal to the blast injury.[8] However, more information is needed concerning the neurocognitive profile and psychiatric symptoms that result from blast injuries. Moreover, it remains important to evaluate individuals as temporally close as possible to the time of the blast injury.

The primary purpose of this manuscript is to provide a detailed description of the methodology used and data collected for what we believe is the largest study to date of the acute assessment of TBI and post-traumatic stress symptoms after exposure to a deployment-related explosive blast. The sample includes 801 U.S. military service members assessed in Iraq typically within a few days after a blast exposure. Lack of consistent documentation in the deployed medical record and memory difficulties in the patients prevented the calculation of the mean duration of time between the blast explosion and clinical assessment. Descriptive tables are provided for (1) patient demographic variables, (2) number of neuropsychological and psychological measures completed by individual patients, (3) number of completed pairs of measures, (4) descriptive statistics for neurological and psychological measures, and (5) correlations among psychological and neuropsychological measures. The data were collected as part of acute clinical evaluations of patients, and the specific assessment measures used to assess each patient were based on the clinical judgment of the provider depending upon the clinical presentation of the patient. Despite the large sample size of this potentially rich data set, there are a number of methodological and data limitations that must be clarified. Therefore, we believe it is prudent to first publish a methodology manuscript to describe the methods used and data collected for the study. Future data analyses will include subsets of the overall data set, which will add additional complexities to the analysis and interpretation of the data.

METHOD

The neuropsychological and psychological assessment of patients occurred between September 2006 and September 2007 at the Air Force Theater Hospital, 332nd Air Expeditionary Wing, Joint Base Balad, Iraq. At the time of the study, the Air Force Theater Hospital was one of the largest and busiest combat support hospitals in Iraq. It was co-located with the Contingency Aeromedical Staging Facility where the majority of U.S. military patients in Iraq who required aeromedical evacuation were staged prior to transport out of the combat theater.[21,22] At the time of the initiation of the assessments, no in-theater policy existed for the routine assessment of patients after a head injury. The first author of the study (MB) established an acute assessment battery for neuropsychological and psychological symptoms in patients referred for evaluation after sustaining a head injury with a suspected mild TBI. He trained all of the mental health staff who administered the measures. The staff who administered the measures included other psychologists, social workers, and mental health technicians, all with specialty training in mental health and assessment. The battery was based on guidance provided by military PTSD and TBI subject matter experts.

Soon after the establishment of this acute TBI assessment battery, the Air Force Theater Hospital at Balad became the primary referral site for TBI patients throughout Iraq. All patients were evaluated as part of routine clinical assessment of symptoms of TBI and psychological health symptoms to determine suitability for return to duty in the combat theater. Military Institutional Review Board (IRB) approval was obtained at Wilford Hall Medical Center in 2008 to establish a repository of de-identified patient data which were used for the data analysis for this study.

Patients

A total of 894 patients completed an acute assessment of neuropsychological and/or psychological functioning as part of routine clinical care after exposure to a deployment-related traumatic event. Data from 93 patients were removed from the data set for analysis because they experienced a head injury due to an event that was not an explosive blast ($n = 84$) or they were only assessed for psychiatric symptoms ($n = 9$). This resulted in a total of 801 blast-exposed patients for data analysis.

Measures

The specific battery of neuropsychological and psychological assessments used to assess individual patients was based on the clinical judgment of the assessor, the clinical presentation of the patient, and the amount of time available to assess the patient. Therefore, every patient assessed did not routinely complete the entire battery. All of the assessments were administered by a deployed military clinical psychologist, clinical social worker, or mental health technician. A summary description of each measure including information on the measure's components, scores and psychometrics is presented in Supplemental Table 1.

Neuropsychological Measures

Four neuropsychological measures were administered to assess cognitive functioning:

Military Acute Concussion Evaluation. The Military Acute Concussion Evaluation (MACE) is a standardized, clinician-administered assessment developed by the Defense and Veterans Brain Injury Center and was derived from the Standardized Assessment of Concussion (SAC).[23] Current Department of Defense guidelines indicate that anyone who was dazed, confused, "saw stars," or lost consciousness, even momentarily, as a result of a blast, fall, motor vehicle crash, or other event involving abrupt head movement, a direct blow to the head, or other head injury, is an appropriate person for evaluation using the MACE. Lower scores on the MACE indicate greater cognitive deficits.[24–26] MACE scores may be used in the serial assessment of concussions and in determining cognitive improvement or decline. Additionally, the MACE can be useful in evaluating serial concussion symptoms within 6 h of a blast injury.[8]

Repeatable Battery for the Assessment of Neuropsychological Status. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) is a clinician-administered measure of neurocognitive functioning demonstrated to be clinically valid and reliable in the brief screening of individuals with TBI,[27–30] and it produces a total score. Low Total Scale scores indicate greater cognitive impairment across all domains: attention, construction skills, language and memory.

Cognitive Stability Index. The Headminder Cognitive Stability Index (CSI) is an assessment tool using 10 subtests to monitor memory, attention, response speed, and processing speed.[31,32] The test battery is clinically valid and reliable for neurocognitive screening.[31] Lower scores indicate greater impairment. The CSI was found to be clinically valid and reliable for neurocognitive screening.[31]

Automated Neuropsychological Assessment Metrics, Version 4.0. The Automated Neuropsychological Assessment Metrics, Version 4.0 (ANAM4) is a battery of neuropsychological tests developed in 1984 to provide a standardized and valid method of testing used for a number of different military applications.[33–38] The ANAM tests three general factors: processing speed/efficiency, retention/memory, and working memory. Previous military-relevant research found the ANAM to be a sufficient measure of anatomical and functional changes among healthy humans under stress.[36] Collected data produces an ANAM Performance Report (APR), in which an individual's performance is compared with normative data.[38,39] The APR includes three summary variables commonly used in data analysis: mean response time for correct responses, percent correct, and a cognitive efficiency throughput score for each subtest. The throughput score is a combination of accuracy and reaction time. Vincent and colleagues[39] published normative data based on a large healthy military sample of 107,500 active duty service members, which include the three summary variables and percentiles scores for each scale and subtest. Lower scores indicate greater impairment.[40–46]

Psychological Measures. Three psychological measures were administered to assess psychological functioning and combat exposure:

PTSD Checklist-Military Version. The PTSD Checklist-Military Version (PCL-M) for the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV*) is a 17-item self-report measure that evaluates how much patients have been bothered by PTSD symptoms in the past month as a result of stressful life events.[47–52] By definition, PTSD cannot be diagnosed until at least 30 d after exposure to a traumatic event. However, in deployed settings the PCL is routinely administered as an acute assessment measure within the first few days or weeks after a trauma exposure. Therefore, it was administered as part of the acute assessment battery of psychological symptoms.

Acute Stress Disorder Scale. The ASDS is a 19-item self-report inventory that assesses ASD symptoms during the first 30 d after trauma exposure.[53] The ASDS indexes ASD and PTSD based on the *DSM-IV* criteria.

Combat Experiences Scale. The Combat Experiences Scale (CES) is a list of 22 stressful experiences that may have occurred during the deployment.[54] This scale measures trauma exposure for individuals treated in the deployed setting. Individuals indicate if they have experienced any of the events and how much of an emotional impact the events had on them during a deployment. The scale includes items such as "Being shot at," and "Seeing dead or seriously injured Americans." It should be noted that the CES was designed and validated in another era of combat and may not be as valid on the population sampled in the current study.

RESULTS

The patient demographic variables are described in Table I. Complete demographic data were missing or not available for some patients. Of the demographic data available, 98% were males, 75% were between the ages of 18 and 29, and 62% were married. Outside of the missing data, the largest race/ethnicity reported was White/Caucasian (74%), followed by Hispanic (12%) and Black/African American (5%). Based on reported data, about 80% of patients were active duty, 14% were National Guard, and 5% were Reserves. In terms of military grade and completed data, 92% were enlisted personnel between the grades of E-1 to E-6. More than half of the patients (59%) who provided data indicated that they had sustained a previous head injury prior to the blast-event head injury they were being evaluated for as part of their current assessment.

The total number (and percentage) of patients who completed each individual neuropsychological and psychological measure is included in Table II. The number of completed neuropsychological measures ranged from a high of 565 on the MACE to a low of 158 on the ANAM4. The number of completed psychological measures ranged from 489 on the PCL-M to 154 on the CES.

Table III shows the number of completed pairs of measures for each neuropsychological and psychological measure. The largest number of completed pairs of neuropsychological measures was for the MACE, which included 186 completed pairs for the MACE and RBANS, 146 for the MACE and ANAM4, and 125 for the MACE and CSI. For the psychological measures, the largest number of completed pairs was for the PCL-M, which included 328 completed pairs for the PCL-M and ASDS and 127 for the PCL-M and CES. The largest number of completed pairs of combined neuropsychological and psychological measures was 429 for the MACE and PCL-M.

TABLE I. Patient Demographic Variables (N = 801)

Demographic Variable	N	Percent
Gender		
Male	689	86.0
Female	16	2.0
Missing	96	12.0
Age range		
18–24	373	46.6
25–29	160	20.1
30–34	69	8.6
35–39	65	8.1
40–44	24	3.0
45+	19	2.4
Missing	91	11.4
Race/Ethnicity		
White/Caucasian	168	21.0
Black/African American	12	1.5
Hispanic/Latino	27	3.4
American Indian/Alaskan Native	4	0.5
Asian	5	0.6
Native Hawaiian/Pacific Islander	2	0.2
Other	9	1.1
Unknown	481	60.1
Missing	93	11.6
Marital status		
Married/Partnered/Engaged	284	35.4
Single/Never married	153	19.1
Divorced/Separated	19	2.4
Unknown	345	43.1
Branch of service		
Army	575	71.8
Marines	96	12.0
Air Force	20	2.5
Navy	2	0.2
Missing	108	13.5
Component		
Active duty	549	68.6
National guard	98	12.2
Reserves	37	4.6
Unknown	117	14.6
Military grade		
E-1 to E-3 (Junior enlisted)	149	18.6
E-4 to E-6 (NCOs)	491	61.4
E-7 to E-9 (Senior NCOs)	21	2.6
O-1 to O-3 (Junior officers)	21	2.6
O-4 to O-6 (Field grade officers)	9	1.1
Missing	110	13.7
Prior history of head injury		
Yes	409	51.1
No	279	34.8
Unknown	6	0.7
Missing	107	13.4

NCO, noncommissioned officer.

Table IV provides descriptive statistics for the neuropsychological measures. The overall mean score for the group of service members who completed the MACE (N = 565)

TABLE II. Number of Neuropsychological and Psychological Measures Completed by Individual Patients (N = 801)

Measure	N	Percent
Neuropsychological measures		
MACE	565	70.54
RBANS	313	39.08
CSI	202	25.22
ANAM4	158	19.72
Psychological measures		
PCL-M	489	61.05
ASDS	328	40.95
CES	154	19.23

TABLE III. Number of Completed Pairs of Measures (N = 801)

	MACE	RBANS	CSI	ANAM4	PCL-M	ASDS	CES
MACE							
RBANS	186						
CSI	125	53					
ANAM4	146	92	69				
PCL-M	429	212	114	151			
ASDS	274	183	95	149	328		
CES	101	52	50	97	127	107	

was 26.42 (SD = 3.01). Cognitive impairment varied among individuals as the obtained scores ranged from 8 to 30. Further analyses of the domain scores can identify specific cognitive problems.

On the RBANS (N = 313), the overall mean score was 84.72 (SD = 16.43), with a range of 40– 160. Further analyses of index scores can be conducted to identify specific cognitive problems.

The CSI was not developed to produce an overall cognitive performance score. However, average scores of the four factors based on service members who completed the CSI (N = 202) ranged from 87.64 (SD = 27.93) to 94.44 (SD = 15.63), with a range of 50–150. Further analyses of subtest scores could help identify specific cognitive problems.

Similarly, the ANAM4 was not developed to produce an overall cognitive performance score. The six obtained subtest throughput scores for the group of service members who completed the ANAM4 (N = 158) ranged from 16.83 (SD = 6.73) to 165.00 (SD = 65.70). Ranges for each throughput differ. Further interpretation of subtest scores could help identify specific cognitive problems.

Table V provides descriptive statistics for the psychological measures. The overall mean score for the group of service members who completed the PCL-M (N = 489) was 37.42 (SD = 15.84), with a range of 17–85. Using the suggested cutoff score of 34 for nondiagnostic screening purposes,[55] approximately 30% (n = 145) of service members were identified that may meet full criteria for a PTSD diagnosis. The Cronbach's alpha (an estimate of internal consistency) for the PCL-M was 0.94. The Cronbach's alpha for each subscale was as follows: re-experiencing, α = 0.90; avoidance, α = 0.88; and arousal, α = 0.87.

On the ASDS (N = 328), the overall mean score was 47.34 (SD = 18.88), with an obtained range of 19–195. Using the suggested cutoff scores of 56 for nondiagnostic screening purposes,[53] approximately 39% (n = 127) of service members may be at risk for developing PTSD. The Cronbach's alpha for the ASDS subscales was as follows: dissociation, α = 0.82; re-experiencing, α = 0.85; avoidance, α = 0.86; arousal, α = 0.89; total scale, α = 0.95. Additional assessment would be required for diagnostic specificity.

On the CES (N = 154), the overall mean score was 17.44 (SD = 11.80), with a range of 0–66. The mean score indicates that most patients who were assessed had significant exposure to traumatic events while deployed. The Cronbach's alpha for the CES was 0.94.

Supplemental Tables 2–5 include the correlation values among the total and subscale scores for the neuropsychological and psychological measures. Bivariate correlations were performed to assess the strength of the relationship among the neuropsychological and psychological measures, separately. Supplemental Table 2 includes correlations between the MACE total and domain scores and the psychological measures. The MACE significantly correlated with the PCL-M and ASDS at the 0.01 and 0.05 levels, but not with the CES. Supplemental Table 3 includes correlations between the RBANS total and domain scores and the psychological measures. The RBANS significantly correlated with the PCL-M and ASDS at the 0.01 and 0.05 levels. Additionally, only the RBANS immediate memory domain score significantly correlated with the CES at the 0.05 level. Supplemental Table 4 includes correlations between the CSI's four factors and the psychological measures. The CSI factor scores significantly correlated with the PCL-M and ASDS at the 0.01 and 0.05 levels. The CSI Response Speed was the only subscale of the CSI that correlated with the CES, at the 0.01 level. Supplemental Table 5 includes correlations between the ANAM4 total and subtest scores and the psychological measures. The ANAM4 significantly correlated with the PCL-M and ASDS at the 0.01 and 0.05 levels. Additionally, only the ANAM4 simple reaction time, and Simple reaction time (R) subtest scores significantly correlated with the CES at the 0.01 and 0.05 levels, respectively.

Supplemental Table 6 includes the total scores and subscale scores of the neuropsychological batteries, which were correlated with each other at the 0.01 and 0.05 levels. The strongest correlations among the neuropsychological measures were between the CSI factors and the ANAM4 subtests (ranging from 0.51 to 0.58; $p < 0.05$) and between the RBANS attention domain score and the CSI attention factor ($r = 0.72$; $p < 0.05$).

Supplemental Table 7 includes the psychological measures; all significantly correlated with each other at the 0.01 level. Among the psychological measures, the two measures of post-traumatic stress symptoms (PCL-M and ASDS) were strongly correlated ($r = 0.88$; $p < 0.001$). In addition, both of the measures of post-traumatic stress symptoms were moderately correlated with reports of exposure to combat

TABLE IV. Descriptive Statistics for Neuropsychological Measures[a]

Neuropsychological Measures	Number of Patients	Possible Range of Scores	Mean Score	Standard Deviation
MACE total score	**565**	**0–30**	**26.42**	**3.01**
Immediate memory	487	0–15	14.46	1.31
Orientation	485	0–5	4.34	0.083
Concentration	483	0–5	3.86	1.09
Delayed recall	483	0–5	3.77	1.18
RBANS total score	**333**	**40–160**	**84.72**	**16.43**
Immediate memory	333	40–160	86.19	16.24
Visuospatial construction	333	40–160	100.08	15.30
Language	333	40–160	85.60	14.13
Attention	333	40–160	84.89	19.66
Delayed memory	333	40–160	82.66	20.44
CSI total score	**N/A**[b]	**N/A**[b]	**–**	**–**
Response speed	221	50–150	92.05	25.62
Memory	235	50–150	87.64	27.93
Attention	225	50–150	90.28	14.89
Processing speed	235	50–150	94.44	15.63
ANAM4 total score	**N/A**[b]	**N/A**[b]	**–**	**–**
Code substitution delayed[c]	155	0.4–154.6	30.12	15.06
Code substitution learning[c]	157	0.4–97.6	39.13	12.40
Matching to sample[c]	155	0.6–96.6	24.16	11.65
Mathematical processing[c]	155	0.6–144.8	16.83	6.73
Processing speed[c]	157	2.4–150.6	73.28	27.58
Simple reaction time (*R*)[c]	155	9.8–356.4	163.43	69.70
Simple reaction time[c]	158	4.2–366.2	165.00	65.70

[a]Sample sizes for number of patients with complete data to calculate total scores differs from those completing subscales due to random missing data.
[b]The CSI and ANAM4 were not developed to produce a total score. Range of scores for the ANAM4 is based on military normative data reported by Vincent and colleagues.[39]
[c]Score is derived from percent correct and speed of the task (throughput scores).
Bold face text represents values from the total scale score.

TABLE V. Descriptive Statistics for Psychological Measures[a]

Psychological Measures and Subscales	Number of Patients	Number of Items	Possible Range of Scores	Mean Score	Standard Deviation	Alpha
PCL-M	489	17	17–85	37.42	15.84	0.95
Re-experiencing	490	5	5–25	11.04	5.21	0.91
Avoidance	470	7	7–35	13.38	6.30	0.88
Hyperarousal	486	5	5–25	13.02	5.58	0.87
ASDS	328	19	19–95	47.34	18.88	0.95
Dissociation	332	5	5–25	12.95	5.24	0.83
Re-experiencing	332	4	4–20	9.83	4.73	0.85
Avoidance	330	4	4–20	8.82	4.60	0.86
Hyperarousal	331	6	6–30	15.77	6.89	0.90
CES	154	22	0–66	17.44	11.80	0.92

[a]Sample sizes for number of patients with complete data to calculate total scores differs from those completing subscales due to random missing data.
Bold face text represents values from the total scale score.

experiences on the CES (PCL-M: $r = 0.55$; $p < 0.01$; ASDS: $r = 0.57$; $p < 0.01$).

DISCUSSION

For U.S. military service members deployed in support of OEF/OIF, explosive blasts were the primary cause of about 80% of all combat-related injuries, and this is the highest proportion reported in any large-scale military conflict.[4,56–57] As noted previously by leading military trauma surgeons[58], explosive blasts cause more complex and multiple forms of damage than any other wounding agent. Blasts often result in polytrauma with multiple psychological and physical injuries. The present study is the first large study to collect psychological and neuropsychological data from deployed active duty service members assessed soon after blast exposure. The purpose of this study was to describe the methods used to assess for TBI, ASD, and PTSD among deployed service members assessed acutely in theater after exposure to an explosive blast. The current manuscript provides an overview of (1) the methods for the data collection, (2) the neuropsychological and psychological measures used, (3) the patient demographic characteristics, (4) the number of individual and combined measures collected, (5) the descriptive statistics for the measures, and (6) the correlations between measures. There are a number of other analyses planned for these data that are beyond the scope of this initial methods paper.

Our findings indicated that patients had significant exposure to traumatic events while deployed. A significant association was found between self-reports of combat experiences and the psychological symptoms. Based on the range of ASDS scores, over a third of service members that completed the ASDS (39%) were identified as at-risk for developing PTSD. Similarly, based on PCL-M scores, less than a third of the sample that completed this measure (30%) met criteria for probable combat-related PTSD following criteria set by Bliese and colleagues.[55] Using the PCL-M cutoff score of 34 was appropriate for this study, as it is also the cutoff point used by the Department of Defense to screen military populations. The current findings also suggest that there is a relationship between ASD symptoms following exposure to a blast injury and cognitive performance on neuropsychological tests. Specifically, it was found that while patients generally performed below average to average on neuropsychological tests measuring different cognitive domains (e.g., attention, memory, executive functioning), there were significant correlations between performance on the MACE, RBANS, CSI, ANAM, and the psychological measures.

The study does include a number of limitations. There were insufficient data collected to differentiate the types of blast explosions (e.g., overpressure, duration, function of device, simple versus complex, secondary and tertiary head injuries, etc). The prospective data collection occurred in a busy in-theater hospital, which resulted in differences in measures administered and missing data. Clinician judgment was used to determine the specific assessment battery used for each patient, which resulted in inconsistencies in the number of measures administered to each patient. It would have been preferable to have a deployed clinical neuropsychologist to provide expert clinical judgment in the selection and administration of the measures. However, there was not a neuropsychologist available at the deployed location. Patient fatigue or distress as a result of answering questions about combat experiences could explain missing data points. The study would have been strengthened by the use of a control group who had not been exposed to a blast explosion and who were assessed in theater using the same measures. However, the collection of such data was not feasible due to military medical operational requirements. Despite differences in the individual assessment battery used, missing data, and the lack of a control group, the circumstances in which the psychological measures and neuropsychological batteries were obtained make this a unique sample and valuable study.

Using this data set, future data analyses will be conducted to try to clarify the relationship among symptoms of post-traumatic stress, acute stress, TBI, and PCS. The ability to identify unique and common symptoms will help clinicians better differentiate between neurological impairment and psychological symptoms, develop the most parsimonious diagnosis for individuals with blast injuries, and help guide the use of evidence-based treatment strategies to alleviate distress and impairment.[59] Further interpretation of the three subscales on the PCL-M and ASDS for individual patients could identify severity level among the re-experiencing, avoidance/emotional numbing, and hyperarousal symptom clusters. Other studies will examine the extent to which prior history of head trauma interacts with blast injuries to increase deleterious effects and whether loss of consciousness significantly predicts level of impairment following blast exposure.

The data gathered in Balad, Iraq will provide useful information concerning the immediate psychological and neurological effects of blast injury among active duty military service members. Considering the large numbers of patients with symptoms of PTSD, TBI, and PCS within this population, it is imperative that researchers and clinicians more fully understand the shared and unique symptoms of these disorders. The increased investigation of blast-related injuries is anticipated to result in more effective assessment, triage, and treatment strategies.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Military Medicine* online.

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