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The Boston Assessment of Traumatic Brain Injury–Lifetime (BAT-L) Semistructured Interview: Evidence of Research Utility and Validity

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Abstract

Objective—Report the prevalence of lifetime and military-related traumatic brain injuries (TBIs) in Operation Enduring Freedom and Operation Iraqi Freedom (OEF/OIF) veterans and validate the Boston Assessment of TBI–Lifetime (BAT-L).

Setting—The BAT-L is the first validated, postcombat, semistructured clinical interview to characterize head injuries and diagnose TBIs throughout the life span.

Participants—Community-dwelling convenience sample of 131 OEF/OIF veterans.

Design—TBI criteria (alteration of mental status, posttraumatic amnesia, and loss of consciousness) were evaluated for all possible TBIs, including a novel evaluation of blast exposure.

Main Measures—BAT-L, Ohio State University TBI Identification Method (OSU-TBI-ID).

Results—About 67% of veterans incurred a TBI in their lifetime. Almost 35% of veterans experienced at least 1 military-related TBI; all were mild in severity, 40% of them were due to blast, 50% were due to some other (ie, blunt) mechanism, and 10% were due to both types of injuries. Predeployment TBIs were frequent (45% of veterans). There was strong correspondence between the BAT-L and the OSU-TBI-ID (Cohen $\kappa = 0.89$; Kendall τ-b 0.95). Interrater reliability of the BAT-L was strong (κs >0.80).

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Conclusions—The BAT-L is a valid instrument with which to assess TBI across a service member's lifetime and captures the varied and complex nature of brain injuries across OEF/OIF veterans' life span.

Keywords

assessment; blast; OEF/OIF; traumatic brain injury (TBI); veterans

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MILD TRAUMATIC BRAIN INJURY (mTBI) is the so-called signature injury of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF), yet its identification and diagnosis are controversial and fraught with challenges. Diagnosis of military-related mTBI in OEF/OIF veterans is complex and unique from the diagnosis of civilian-acquired brain injuries in a number of ways. This is due to the novel mechanism of injury (exposure to blast(s) such as an improvised explosive device), the frequent co-occurrence of head injury and psychological trauma during the chaos of combat that make the determination of altered mental status (AMS) difficult, and the difficulty obtaining in-theater documentation of symptoms at the time of injury for determining the presence or absence of mTBI. Although in-theater documentation of injuries is improving in more recent years, for the majority of OEF/OIF veterans, injuries were not reliably documented at the time of injury (especially pre-2010; see *U.S. Medicine* 2011, Army Medical Communications for Combat Casualty Care [MC4] electronic medical record use began in 2010). Thus, records are not generally available. The detection of TBI, and mTBI in particular, in returning veterans is thus primarily reliant on self-report of a historical event, which often occurs in the context of a military trauma. Such estimates suggest that between 9% and 23% of OEF/OIF veterans experienced at least 1 mTBI during service.[1–5]

Semistructured interviews are the acknowledged standard for diagnosing remote mTBI but have largely been developed for the civilian population and may have less utility in the characterization of TBI among this new veteran cohort. Available assessment tools designed for military TBI assessment generally do not assess civilian injuries, which are common in this cohort,[1] and often are more focused on determining absence or presence of military TBI rather than specifically establishing the severity of mTBIs that are much more common in this cohort. Furthermore, they often do not estimate the duration of key symptoms: AMS, posttraumatic amnesia (PTA), and loss of consciousness (LOC). For these reasons, we developed the Boston Assessment of Traumatic Brain Injury–Lifetime (BAT-L) as part of our VA Rehabilitation Research and Development–supported Translational Research Center for TBI and Stress Disorders (TRACTS) Center of Excellence at the VA Boston Healthcare System. The Neuropsychology clinical service and Polytrauma clinic at the VA Boston Healthcare System realized the need for a comprehensive, semistructured interview to assess military TBI. This clinical interview was used as the starting point for the BAT-L when the TRACTS Center of Excellence began data collection in 2009. The tool was adapted to assess TBI across the life span as well as military TBI. Guidelines for establishing a timeline for AMS, PTA, and LOC, the forensic approach to the interview, and diagnostic categories were all refined over time as the distinctive experiences of OEF/OIF veterans were realized. The BAT-L, unlike existing TBI interviews, includes detailed assessment of blast exposure and blast-related TBI, evaluates TBIs acquired throughout a veteran's lifetime, and includes specific probes targeting the unique experiences of this cohort of veterans in an effort to help the examiner assess the physiological disruption of consciousness in the context of co-occurring traumatic events.

BLAST-RELATED TBIs

Exposure to munitions is considered to be the most common cause of mTBI among OEF/OIF veterans[6] underscoring the importance of including assessment of blast exposure and blast-related TBI in brain injury interviews tailored to this new veteran cohort. Exposure to blast varies widely among veterans from Iraq and Afghanistan, ranging from no exposure to multiple daily occurrences during 1 or more deployments that could result in hundreds of exposures over several years.

The occurrence of unique neuroradiologic changes after a blast-related mTBI is still unclear.[7,8] Animal models have demonstrated neuropathologic changes secondary to blast-related mTBI, including white matter hemorragages, chromatolytic changes in neurons, diffuse brain injury, and subdural hemorrhage.[9] These changes are common to mechanical mTBI, thus a unique blast TBI model has yet to be definitively established. The hypothesis that blast-related TBI causes axonal injury has received the most attention.[7] While blast-related mTBI has not been observed to result in a distinct profile of neuropsychological deficits relative to blunt-impact injuries,[10,11] characterization of TBI among OEF/OIF veterans requires careful attention to brain injuries sustained in the relatively novel context of blast exposure.

MULTIPLE TBIs

Many OEF/OIF veterans report a history of brain injuries before joining the military as well as after returning home. In addition, history of previous TBI is higher among military service members reporting a deployment-related TBI.[1] Given the high prevalence of multiple TBIs among OEF/OIF veterans, a relevant TBI assessment must consider head injuries incurred throughout a veteran's lifetime. Recurrent concussion, particularly when occurring within close temporal proximity, may result in greater neurologic impact and complicate recovery.[10,12] Inattention to this common predeployment injury could result in inaccurate attribution of behavioral symptoms of the more recent deployment-related mTBIs.

PHYSIOLOGICAL VERSUS PSYCHOLOGICAL SYMPTOMS

A TBI acquired during OEF/OIF deployment is especially challenging to diagnosis because physical and emotional trauma frequently co-occur, such as during a combat situation with threat of physical harm to oneself or others. Consequently, psychological sequelae, including disorientation and confusion that can occur during these life-threatening situations, can be misperceived by the veteran as symptoms of brain injury (eg, AMS). Further complicating the assessment of deployment-related TBI, combat itself is often disorienting and confusing due to the chaos of battle and the sensory changes that may result from blast exposure (eg, hearing loss, tinnitus, decreased vision due to debris/dust/sand). The BAT-L was designed to help the examiner disentangle the psychological reaction from the physical reaction to the injury. To address this complex issue, the semistructured interview uses a forensic approach to TBI assessment. The patient is asked to describe, in detail, the events leading up to, during, and after the injury.[13] Questions are asked in multiple formats; different sources are identified and queried (from the veteran's best recall) to crosscheck facts when possible; consistency of timeline is considered and queried when appropriate. The focus is on the physical injury, accompanying symptoms, as well as the context in which the injury occurred. This approach grounds the veteran in a military and medical framework. In doing so, the examiner can guide the patient to provide specific details about the injury while minimizing emotional triggers more common to posttraumatic stress disorder assessment. Through retelling of the events, with follow-up questions to identify evidence of impaired mental functioning, memory gaps, unresponsiveness, witness reports, psychological reaction, and medical treatment, the interviewer assesses the primary markers of a TBI: AMS, PTA, and LOC.

Effort is made to establish a shared terminology as described by Vanderploeg et al.[14] between examiner and the veteran through the use of examples and follow-up questions to ensure veterans understand the symptoms being queried. Effort is also made to distinguish altered consciousness from emotional responses by drawing comparisons between previous emotional events in which the patient did not sustain a blow to the head. In addition, the BAT-L directly asks about witness observations as another source to confirm the occurrence of a physiological disturbance of consciousness. Although the BAT-L structures and guides the interviewer to make this distinction, we note that it still remains an issue of clinical judgment and that interviewer clinical expertise and training in mTBI is essential to successfully use this tool.

MILITARY TBI ASSESSMENT TOOLS

We are aware of 3 published military TBI assessment tools available at the time of publication: the VA TBI Identification Clinical Interview,[14] the Warrior-Administered Retrospective Casualty Assessment Tool (WARCAT),[15] and the Structured Interview for TBI Diagnosis.[16]

Vanderploeg et al[14] recently published their VA TBI Identification Clinical Interview. This semistructured clinical interview was developed through consultation with TBI subject matter experts and is designed to provide a standardized method for determining presence or absence of TBI during military deployment during the follow-up VA Second Level TBI Evaluation. The VA TBI Identification Clinical Interview has many strengths, including avoidance of terminology unfamiliar to veterans (LOC, Altered Mental Status), attempting to minimize over- or underreporting, and detailed querying of postinjury symptoms to attempt to determine whether they are linked to the injury or to alternative causes.

The WARCAT, developed by Terrio and colleagues,[15] is a clinical interview developed to assess military TBI injury history and associated somatic (ie, headache, dizziness, balance) and neuropsychiatric symptoms (ie, irritability, memory) at the time of injury as well as postdeployment.

Donnelly and colleagues[16] developed the Structured Interview for TBI Diagnosis specifically to serve as a comparison clinical interview to establish reliability, sensitivity, and specificity of the VA TBI Clinical Reminder. It is a brief clinician-administered screen that collects information similar to the WARCAT and is also focused on military deployment.

Each of these instruments are well-designed clinical tools but were not detailed enough in their assessment of TBI for our research setting. Specifically, these military TBI tools are focused on military injuries and as a result do not address the high prevalence of predeployment brain injuries in this population[1] or possible postdeployment injuries. In addition, they are generally designed more for detection of TBI rather than the specific grading of severity of mTBIs that are most common in this cohort. Furthermore, they often do not include careful estimation of duration of AMS, PTA, and LOC.

OHIO STATE UNIVERSITY TBI IDENTIFICATION METHOD

Currently, the Ohio State University TBI Identification Method (OSU-TBI-ID) is the only published semistructured interview to have demonstrated that a retrospective TBI interview can produce psychometrically sound data.[17,18] One can both qualify and quantify the number of injuries by assessing items including, but not limited to, the number of TBIs, severity, and age at first injury.[18] The 3 most significant injuries are further examined to ascertain age of onset and duration of symptoms experienced. Preliminary interrater reliabilities and predictive validity have been established by the developers of this instrument.[17,18] The OSU-TBI-ID has limitations for the assessment of military acquired TBIs because it does not specifically probe for blast exposure and related injuries, and it was not designed to parse out physiological from psychological responses to trauma (common to combat TBI). Consequently, there is a clinical and research need for a TBI assessment tool designed to capture the unique experiences of brain injuries sustained by OEF/OIF veterans. Comparison of the BAT-L with the only other validated TBI assessment instrument will provide critical information regarding the validity of this novel tool.

METHODS

Participants

One hundred thirty-one consecutive participants (112 men/19 women) who were deployed veterans of OEF/OIF and enrolled in the VA Rehabilitation Research and Development–supported TBI Center of Excellence at VA Boston Healthcare System, TRACTS, participated in this study (see Table 1 for participant demographics). Participants enrolled in the TRACTS Center of Excellence are recruited from throughout the Boston Metropolitan area via a full-time recruitment specialist for TRACTS who attends Yellow Ribbon Events, Task Force Meetings, and other events involving Army and Air National Guard, Marine and Marine Reserves, and Army and Army Reserve Units. Our sample is diverse in that it includes active-duty and veteran service members from each branch of military service. This group of veterans is a convenience sample, and self-selection for participation in medical research should be considered.

The following exclusionary criteria are applied to the TRACTS study sample overall: history of seizures; prior serious medical illness, such as cerebrovascular accident and myocardial infarction; current active suicidal and/or homicidal ideation, intent, or plan requiring crisis intervention; current Diagnostic and Statistical Manual of Mental Disorders (*Fourth Edition*) diagnosis of bipolar disorder, schizophrenia, or other psychotic disorder (except psychosis NOS [not otherwise specified] due to trauma-related hallucinations); or cognitive disorder due to general medical condition other than TBI.

Deployment characteristics

Total months deployed was the sum of all OEF/OIF deployments. Time since last deployment was also calculated from month of return home to study appointment date (see Table 1).

Procedure

Boston Assessment of Traumatic Brain Injury–Lifetime—The BAT-L questionnaire is a preliminary screen administered as a self-report questionnaire to first direct the veteran to the many and varied types of life events that may result in a blow to the head or exposure to high-velocity force, which are then explored in detail in semistructured clinical interview format. The various types of injuries are presented in a list format, and veterans indicate whether the injury has occurred in their lifetime, and if so, whether there was LOC associated with the injury, and whether they felt “dazed or confused” at the time of the injury.

Boston Assessment of Traumatic Brain Injury–Lifetime—The BAT-L is unique in its assessment of blast exposures/injuries. The BAT-L queries 2 different aspects of blast: (1) number of exposures to blasts within 100 m and (2) number of TBIs due to blast. With regard to blast exposures, their frequency at incremental distances (<10, 10-25, 25-100 m) are queried in detail and recorded. To demonstrate the BAT-L approach and types of probes used to establish blast exposure and blast-related TBIs, see the Supplemental Digital Content (available at: http://links.lww.com/JHTR/A70) for an excerpt of the instrument.

TBI is assessed during 3 time epochs: (1) before military service (premilitary), (2) during active military training and duties (military: blast-related and other mechanism(s) during combat, training, or other activities during active duty), and (3) after returning stateside (postmilitary). The 3 most severe injuries in each epoch are evaluated. We are careful to query for falls, accidents (motor vehicle and other), training injuries, assault, and sports-related military injuries, as these are the most common mechanisms of injuries reported in addition to blast events. In addition, TBI history for each of these life epochs is queried multiple times and with probes (eg, any falls during childhood such as a fall from a bike or a tree? Did you play any sports in which you experienced a blow to the head?).

The 3 primary criteria for assessing TBI (AMS, PTA, and LOC) are evaluated through detailed recall of the events before, during, and after the injury to establish a timeline for the injury, assess for PTA/AMS not reported, and assist the veteran in estimation of the indices if necessary. Examples are given (see Supplemental Digital Content, available at: http://

links.lww.com/JHTR/A70). Open-ended questioning is used to prevent response bias. A forensic approach to carefully querying and eliciting detailed self-report information, while avoiding leading questions, is used. Other factors that might be interpreted as alterations of consciousness (eg, chaos and confusion due to explosions, gunfire, sensory deprivation, psychological response) are queried (see Supplemental Digital Content for examples of cues, available at: http://links.lww.com/JHTR/A70). Substance use at the time of the injury is another confounder that clouds self-report of injury details and is queried and recorded. Given that any form of altered mental state may limit recall of a historical TBI, veterans are asked whether they recall the events themselves or whether they are relying on the reports of witnesses and this is recorded. Details specific to military settings are queried such as protective gear, type of vehicle involved, reports of medics if known, diagnosis by medical professional if known, and changes to duty postinjury.

The severity of TBIs is then rated according to Department of Defense (DoD) criteria (see Table 2); mTBIs, or concussion, are further subdivided into grade I, II, or III injuries according to a hybrid classification system (see Table 2). The 3 worst TBIs for each category of injury are captured and reviewed at a weekly TBI diagnostic consensus meeting consisting of at least 3 doctoral-level psychologists. Although relatively uncommon in occurrence, if more than 3 TBIs during each time period occur, details are queried and recorded. To create a summary index of lifetime TBI burden, a BAT-L Total score is calculated. Each injury is assigned a score from 0 to 5: 0, no TBI; 1, mTBI grade I; 2, mTBI grade II; 3, mTBI grade III; 4, moderate TBI; and 5, severe TBI. Then the scores for the 3 worst TBIs across all 4 categories of injury (blast-related, military other, premilitary, and postmilitary) are summed, yielding a lifetime total TBI score (BAT-L Total score: range = 0-60). Summary data include the number of TBIs in each category (blast-related, military other, premilitary, and postmilitary), TBI severity for each injury (mild grade I, II, and III; moderate; and severe), BAT-L Total score, and continuous variables such as duration of LOC, PTA, and AMS for each injury.

Finally, the occurrence and duration of neurobehavioral symptoms after each injury are recorded (eg, headaches, dizziness, fatigue, trouble thinking, nausea, poor coordination, balance problems, slowed reaction times, sensory changes, paresthesias, mood changes, sleep trouble). Attention is paid to the onset and duration of these symptoms. Specifically, symptoms that were present acutely are differentiated from symptoms that were present before the injury as well as symptoms that persist after the injury.

In this study, all BAT-L interviews were conducted by doctoral-level psychologists with extensive neuropsychology training in the sample reported. Interview time was not limited in any way and varied greatly, depending on the number of injuries. To evaluate the interrater reliability of the BAT-L, 1 psychologist listened to the audiotapes of the BAT-L interview for 40 participants (2 other raters; 20 participants per rater). This psychologist rated the worst TBIs for each time epoch, and correspondence between the raters was compared.

Calculation of Summary Scores: OSU-TBI-ID and BAT-L—Corrigan and colleagues[17,18] developed and validated the OSU-TBI-ID. The OSU-TBI-ID is an interviewer-administered questionnaire that captures the lifetime history of TBI and generates summary indices that reflect the likelihood that consequences have resulted from lifetime exposure to TBI. These summary indices range from 1 to 5 (see Table 4).

To evaluate the validity of the BAT-L, TBI diagnosis was compared between the BAT-L and the OSU-TBI-ID. All questions covered in the OSU-TBI-ID are subsumed within the BAT-L, allowing the independent examiner to derive the OSU-TBI-ID summary indices. OSU-TBIID summary indices were calculated for each service member in our sample by a TRACTS examiner, using information gathered during the BAT-L interviews. This examiner had access to audiotapes of the interviews, as well as written notes, but did not have access to consensus diagnostic information. To determine the agreement in TBI severity ratings between the BAT-L and the OSU-TBI-ID, we then converted our method of grading TBIs to a scale that was comparable with the OSU-TBI-ID (see Table 4).

RESULTS

Primary findings

Approximately two-thirds of TRACTS veterans reported a lifetime (any time epoch pre-, during, or postmilitary service) history of 1 or more TBIs (*n* = 88; 1 TBI only: *n* = 47 (53%); >1 TBI: *n* = 41 (47%); mean incidence of lifetime TBIs = 1.35 (SD = 1.63); range of lifetime TBIs = 0-11). More than one-third of the sample experienced a military-related TBI (*n* = 51; mean incidence of military TBI = 0.56 (SD = 0.85); range of lifetime TBIs = 0-4). Of these individuals who were positive for military TBI, approximately 40% experienced 1 or more blast-related TBIs, 50% experienced a military TBI due to some other mechanism (eg, blunt force trauma), and 10% of the sample experienced both types of injuries (multiple TBIs of which there was at least 1 TBI secondary to blast and 1 TBI secondary to another mechanism).

Exposure to blasts

The vast majority of our sample participants (77%) were in relatively close proximity (within 100 m) to at least 1 blast during their military service (see Table 3). The mean number of total blast exposures within 100 m for each service member was 14.0 (SD = 49.0), whereas the median was 2. More than one-third of our sample was within 25 m of at least 1 blast, and one-third within 10 m of at least 1 blast. The range of blasts experienced by veterans varied widely from no exposure to 511 exposures within 100 m. Although this high level of exposures (>500) is somewhat of an outlier, we had a small number of veterans who reported very high-blast exposure. Seven individuals (5%) reported more than 50 blasts within 100 m. These were most often individuals with multiple tours of duty, often at peak points in the conflict, and who typically reported primary duties involving convoy, patrol, and/or explosive ordnance disposal.

Severity of TBIs

All blast-related TBIs were mild in severity. Twenty percent of veterans experienced a blast-related mTBI (*n* = 26). Of these blast-related mTBIs, more than half (54%; *n* = 14) were mild grade I injuries indicating no LOC, and AMS and PTA less than 15 minutes in duration (see Figure 1). Forty-two percent (n = 11) were mild grade II injuries indicating there was either LOC associated with the event of less than 5 minutes duration or PTA and/or AMS of more than 15 minutes (see Figure 1). There was an individual who experienced a grade III blast-related mTBI (see Figure 1). All nonblast military TBIs (military other) were also mild in severity and were similarly split between grade I, II, and III injuries (see Figure 1). Military-related injuries were thus all mild in severity and predominantly involved less than 15 minutes of AMS and LOC of less than 5 minutes (see Figure 2 and Table 2).

Predeployment TBIs occurring before military service were prevalent in our sample. Almost half of veterans reported a TBI before enlistment (45%). Almost all of these were mild in nature (see Figure 1). However, it is important to note that the only moderate and severe TBIs in our sample occurred before entry into the service (see Figure 1). After military discharge, 5% of veterans experienced a TBI (postmilitary). All of these were mild in severity (see Figure 1).

BAT-L Total score

The BAT-L Total score reflects a veteran's lifetime burden of TBI by summing the score (0-5 based on severity: see Table 4) for all TBIs in each category of injury (blast-related, military other, premilitary, and postmilitary: see BAT-L Supplemental Digital Content, available at: http://links.lww.com/JHTR/A70). Thus, a score of 0 reflects no lifetime TBI and the maximum score is 60. The mean BAT-L Total score for our sample was 1.85 (median = 1.00; SD = 2.09), and the range was 0 to 10. This not only reinforces the prevalence of a lifetime (any time epoch pre-, during, or postmilitary service) history of 1 or more TBIs in our sample but also reflects that TBIs that do occur are predominantly mild grade I or II injuries, yielding relatively low BAT-L Total scores.

Interrater reliability

Interrater reliabilities were extremely strong with substantial associations (all Cohen κs >0.80) between individual raters' diagnoses for each time period.

Correspondence between the BAT-L and the OSU-TBI-ID

To assess agreement between the BAT-L and the OSU-TBI-ID, the Cohen κ coefficient and the Kendall τ coefficient were calculated. Both measures indicated very strong consistency between the BAT-L and the OSU-TBI-ID (Cohen κ = 0.89; Kendall τ-b = 0.95; see Table 5). Disagreements between the 2 instruments were rare. The largest discrepancy involved 5 individuals classified with possible TBI according to the OSU-TBI-ID but were rated a grade II or III mTBI using the BAT-L. The discrepancy in diagnosis is due to the fact that the BAT-L defines an mTBI on the basis of AMS and/or PTA as well as LOC. More specifically, a TBI can be graded as more severe on the BAT-L (eg, grade II or III mTBI) on the basis of *any* of these 3 factors (see Table 2), whereas LOC is required on the OSU-TBI-ID to be classified as a definite mTBI (score of 3). AMS and/or PTA only (no LOC) are captured as a "possible TBI" on the OSU-TBI-ID. In the case of these 5 service members, all of them had AMS and/or PTA of more than 15 minutes without LOC (consistent with a grade II mTBI).

DISCUSSION

In this study, we demonstrated the validity of the BAT-L as a retrospective tool with which to probe for, characterize, and diagnose an individual's lifetime exposure to possible TBI. In particular, the BAT-L is designed to assess lifetime TBI in the complex OEF/OIF military population with particular attention to blast-related injuries. The BAT-L also guides the examiner in the distinction between the physiological disruption of consciousness and the psychological response to cooccurring traumatic events through detailed questioning and the consensus diagnosis process. A forensic approach involving tiered questioning and cueing is used to establish a timeline for each injury and approximate duration of AMS, PTA, and LOC. Attention is given to corroborating information available such as eyewitness reports, medic reports, injuries to other veterans present at the time of the event, and common procedures followed in combat situations. Particular attention is also given to factors that may complicate self-report and/or reports of available eyewitnesses, such as psychological response to injury/situation (combat adrenaline response, traumatic or stress response), changes in sensory abilities (hearing changes, vision changes), and substance use at the time of injury.

Among our sample, lifetime history of TBI was highly prevalent (approximately two-thirds of veterans experienced 1 or more lifetime TBIs). Many veterans experienced a TBI either in combat or during military service (more than one-third of the sample). History of TBI before military enlistment was also highly prevalent in this sample (almost half of veterans experienced at least 1 TBI before entering the service, most of which were mild in nature). Nonmilitary injuries most often occurred in childhood or young adulthood. Therefore, the OEF/OIF cohort may be considered a sample at high risk for TBI before and during military service. Occurrence of TBI before military engagement and contribution to current functional status must be considered when assessing OEF/OIF veterans. A TBI after separation from the military was less prevalent.

Approximately 40% of the individuals with military TBIs in our sample experienced 1 or more blast-related TBIs, 50% experienced 1 or more TBIs due to some other mechanism (eg, blunt force trauma), and 10% of the sample had both types of injuries (multiple TBIs of which there was at least 1 TBI secondary to blast and 1 TBI secondary to another mechanism). Interestingly, many of these military nonblast injuries occurred in settings that were not combat-related injuries. These noncombat injuries were most often related to falls, accidents (motor vehicle and other), training, assault, and sports-related injuries occurring in military or active-duty settings.

Blast exposure was a universal phenomenon among our sample, with almost 80% of veterans exposed to 1 or more blasts within 100 m. It is essential to differentiate blast exposure from blast-related TBI. Of this large number of veterans within close proximity to blast, only 20% of the events resulted in a blast-related TBI, indicating that many veterans in the vicinity of a blast do not experience a TBI or any notable disruption in mental status. Furthermore, in our sample, all blast-related TBIs that did occur were mild in severity. More than half of blast-related mTBIs were grade I, meaning that they involved only brief (<15 minutes) periods of AMS and/or PTA. Approximately 46% of the blast-related mTBIs involved LOC. All LOC events were less than 5 minutes in duration, by definition (see Table 2).

The BAT-L has excellent correspondence with the only currently validated TBI screening instrument (OSU-TBI-ID). The OSU-TBI-ID relies more on LOC in determining the presence and severity of TBIs, whereas the BAT-L uses a combination of AMS, PTA, and LOC to grade TBI severity.[22] As a result, an injury with reported AMS or PTA but no LOC may be classified as an mTBI on the BAT-L whereas LOC is required on the OSU-TBI-ID to be classified as an mTBI. Despite this difference in methodology, the 2 instruments show excellent agreement overall.

As we are beginning to understand, mTBI in OEF/OIF veterans is complex and variable. The high prevalence of blast-related munitions in the OEF/OIF conflict in particular and the co-occurrences of TBI and posttraumatic stress disorder necessitate a more refined assessment of head injury than previously required. Posttraumatic stress disorder and other psychiatric comorbidities/reactions must be carefully assessed and disentangled from physical injuries.

Limitations

The following limitations of this study are reported:

1. The TRACTS Center of Excellence research sample is a convenience sample in that participants are self-selected to be willing to participate in a research study conducted at a VA medical center. Veterans who respond to research inquiries may be more functional than veterans who seek treatment at VA medical centers. We believe our sample to be representative of US OEF/OIF veterans living in the community with multiple past or ongoing stressors related to their military service in a war zone. However, selection bias must be considered.
2. The BAT-L is based on self-report and is therefore subject to various biases such as embellishment due to recollection bias, potential secondary gain, or underreporting of symptoms due to military culture or stigma. Neuropsychological/psychological testing is important to address symptom validity.
3. Although the BAT-L structures and guides the interviewer to assess mTBI in the context of battle and other injuries, we note that clinical judgment and training are essential to successfully use this tool.
4. Convergent validity (military records, neuroimaging findings, helmet sensors, neuropsychological findings) must be established and is ongoing. In the absence of a “gold standard,” such as access to military records documenting TBI from the acute event, BAT-L validity remains limited to comparison with other interview methods.

SUMMARY

The BAT-L is the first validated postcombat semistructured clinical interview to characterize head injuries and diagnose TBIs throughout the life span. Findings from 131

OEF/OIF military veterans at the TRACTS Center of Excellence at the VA Boston Healthcare System highlight some key considerations in the research and clinical care of this cohort. First, head injuries before military service must be carefully assessed, given the high rates observed in our sample. Importantly, in this sample, childhood injuries were often more severe in nature than military-related injuries. Second, as has been demonstrated, TBIs acquired during OEF/OIF are far more likely to be mild in severity rather than moderate to severe. Third, blast exposure was a universal phenomenon among our sample with almost 80% of veterans exposed to 1 or more blasts within 100 m. However, TBIs occurring as a result of blast exposure were less frequent (20% of veterans experienced a blast-related TBI subsequent to blast exposure), and if a blast-related TBI did occur, it was mild in nature. The impact of blast exposure alone on health is not yet established.

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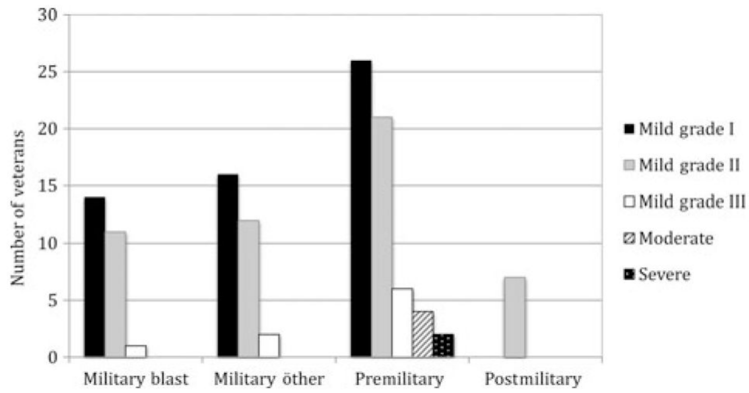

Figure 1.

Consensus diagnosis of most severe lifetime TBI by severity in 131 OEF/OIF veterans. The number of veterans who sustained a grade I mTBI, grade II mTBI, grade III mTBI, moderate TBI, or severe TBI for each category of injury is reported. mTBI indicates mild traumatic brain injury; OEF/OIF, Operation Enduring Freedom and Operation Iraqi Freedom.

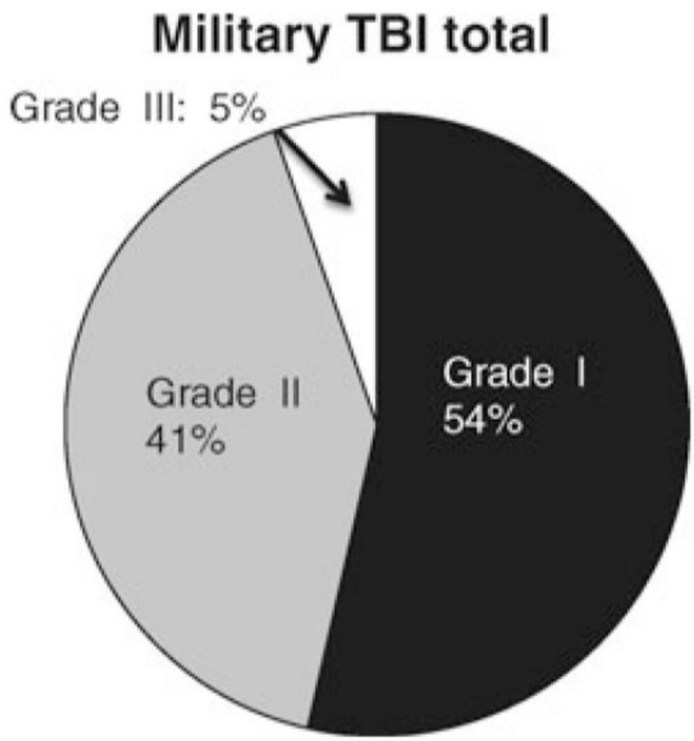

Figure 2.

Total number of military TBIs (blast and other mechanism combined) by severity in 131 OEF/OIF veterans. All military injuries were mTBIs. The percentage of veterans experiencing a military grade I, II, or III injury is reported. mTBI indicates mild traumatic brain injury; OEF/OIF, Operation Enduring Freedom and Operation Iraqi Freedom; TBI, traumatic brain injury.

TABLE 1

Basic demographics of the sample

Age, mean (SD)	33.9 (9.22) Range = 20-62
Education, mean (SD)	13.7 (1.80)[a] Range = 12-20
Gender, %	
Female	14.5
Male	85.5
Ethnicity, %	
White	74.8
African American	8.4
Asian	2.3
American Indian	1.5
Hispanic	11.5
Unknown	1.5
No. OEF/OIF deployments, mean (SD)	1.26 (0.48) Range = 1-3
OEF/OIF deployment duration, mean (SD), mo	13.4 (7.18) Range = 3-38
Time since last OEF/OIF deployment, mean (SD), mo	30.8 (24.3) Range = 1-99

Abbreviation: OEF/OIF, Operation Enduring Freedom and Operation Iraqi Freedom.

[a]There were 8 service members who received a GED and were assigned 12 years of education.

TABLE 2

BAT-L hybrid classification system for the diagnosis of mTBI into grade I, II, and III injuries and VA and DoD consensus criteria for TBI severity as defined in the Clinical Practice Guidelines: Management of Concussion—Mild Traumatic Brain Injury[a]

	Mild				
Criteria	**Grade I**	**Grade II**	**Grade III**	**Moderate**	**Severe**
Loss of consciousness	None	<5 min	>5 and <30 min	>30 min and <24 h	>24 h
Alteration of mental status	0-15 min	>15 min and <24 h	>24 h	>24 h; severity based on other criteria	
Posttraumatic amnesia	0-15 min	>15 min and <24 h	>24 h	>1 and <7 d	>7 d
Glasgow Coma Scale score		13-15		9-12	<9

Abbreviations: BAT-L, Boston Assessment of TBI–Lifetime; DoD, Department of Defense; mTBI, mild traumatic brain injury; VA, Department of Veterans Affairs.

[a]From Department of Veterans Affairs and Department of Defense[19] and adapted from Bailes and Cantu.[20]

TABLE 3

Blast exposure by distance in OEF/OIF service members (categories are not mutually exclusive)

	<10 m	**11-25 m**	**26-100 m**	**Total blast within 100 m**
Service members exposed, *n* (%)	42 (32)	50 (38)	91 (69)	101 (77)
Blasts per service member, mean (SD)	0.70 (1.50)	1.8 (4.74)	11.5 (47.7)	14.0 (49.0)
Blasts per service member, median	0	0	1	2
Blasts per service member, range	0-9	0-37	0-500	0-511

Abbreviation: OEF/OIF, Operation Enduring Freedom and Operation Iraqi Freedom.

TABLE 4

TBI diagnostic categories using the OSU-TBI-ID

OSU-TBI-ID diagnosis	OSU-TBI-ID criteria	BAT-L diagnosis	BAT-L TBI criteria
1 (improbable TBI)	No AMS, PTA, or LOC	No TBI	No AMS, PTA, or LOC
2 (possible TBI)	AMS or PTA but no LOC	Grade I mTBI	AMS or PTA <15 min but no LOC
3 (mTBI)	LOC >0 but <30 min	Grade II or III mTBI	LOC >5 but <30 min, or AMS or PTA >15 min but <24 h
4 (moderate TBI)	LOC between 30 min and 24 h	Moderate TBI	LOC between 30 min and 24 h or AMS or PTA >24 h
5 (severe TBI)	LOC >24 h	Severe TBI	LOC >24 h or PTA >7 d

Abbreviations: AMS, altered mental status; BAT-L, Boston Assessment of TBI–Lifetime; LOC, loss of consciousness; OEF/OIF, Operation Enduring Freedom and Operation Iraqi Freedom; OSU-TBI-ID, Ohio State University TBI Identification Method; PTA, posttraumatic amnesia; TBI, traumatic brain injury.

TABLE 5

Comparison of TBI diagnosis: OSU-TBI-ID as compared with BAT-L in 131 OEF/OIF service members[a]

	BAT-L (converted to OSU-TBI-ID scoring)				
OSU-TBI-ID	**1 (no TBI)**	**2 (grade I mTBI)**	**3 (grade II and III mTBI)**	**4 (moderate TBI)**	**5 (severe TBI)**
1 (improbable TBI)	42	1	0	0	0
2 (possible TBI)	1	32	5	0	0
3 (mTBI)	0	0	44	1	0
4 (moderate TBI)	0	0	1	1	0
5 (severe TBI)	0	0	0	1	2

Abbreviations: BAT-L, Boston Assessment of TBI–Lifetime; OEF/OIF, Operation Enduring Freedom and Operation Iraqi Freedom; OSU-TBI-ID, Ohio State University TBI Identification Method; TBI, traumatic brain injury.

[a]Cohen $\kappa = 0.89$, Kendall τ-b = 0.95.