Traumatic Brain Injury Among US Service Members, Veterans, and Their Families

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Introduction

Traumatic brain injury (TBI) has been defined as "an alteration in brain function, or other evidence of brain pathology, caused by an external cause" (Menon et al. 2010). Given that the vast majority of TBI injuries are considered mild in accordance with established TBI injury severity criteria, this chapter focuses on mild TBI (mTBI), a term used interchangeably with "concussion." For the veteran seeking treatment in this chapter's case study, it would be important for clinicians to consider that the myriad of presenting, distressing symptoms reported may or may not be etiologically related to the mTBI (or history of multiple mTBIs). Regardless of etiology, presenting symptoms should be considered within the veteran's overall psychosocial context and the meaning they attribute to their symptoms.

Case Study

Staff Sergeant (ret.) Jonathan Williams (pseudonym) is a 35-year-old male, honorably discharged service member who recently registered with the Veterans Health Administration and presented to the Primary Care Clinic with a history of multiple mild traumatic brain injury (mTBI) events during deployments to Afghanistan and Iraq. Specifically, he described exposure to three

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detonations of improvised explosive devices (IEDs) during combat situations, following which he felt "dazed and confused," and one detonation after which he experienced positive loss of consciousness and subsequent evacuation to a field medical tent. He reported persisting symptoms including headaches, tinnitus, light sensitivity, and dizziness. Additionally, he reported "panic attacks" and occasional passive suicidal ideation in the context of no history of suicidal gestures or behaviors. He revealed increased alcohol consumption in the evenings, delayed sleep onset, and intermittent awakenings throughout the night secondary to nightmares (resulting in daytime fatigue). He attributed recent marital separation to these aforementioned symptoms and shared a sense of isolation and that he missed his wife, children, and dog. He described generalized "stress" related to financial strain with simultaneous interpersonal conflicts occurring at his job as a store manager, placing his job in jeopardy. He expressed interest in returning to college using GI Bill benefits while simultaneously doubting that he could succeed academically due to cognitive problems with attention and concentration and forgetfulness. He requested medications to relieve headache pain and improve sleep. On screening measures, responses raised concern that history of mTBIs might be contributing to current symptom presentation and for possible diagnosis of posttraumatic stress disorder (PTSD). The primary care physician placed consultations to the Polytrauma Network Site (PNS) program, a specialty interdisciplinary outpatient program that assesses and treats veterans with a history of TBI. Separately, consults were placed to the Mental Health Service given concerns about potential comorbid psychiatric conditions including PTSD, depression, and alcohol abuse.

Phenomenology

What is known to clinicians working with veterans with a history of mTBI sustained in combat situations—but may not be fully appreciated by clinicians working with individuals with predominantly stateside injuries—is that the context of the combat situation matters in a very real way when considering the veteran's later phenomenological experience of emotional and cognitive symptoms. For the veteran, mTBI event(s) and resulting symptoms themselves can take on symbolic meanings and direct associations with the military culture, the deployment process, and/or the deployment or combat environment. As one specific example, a common post-concussive symptom is headache. For the veteran who sustained a mTBI in a life-threatening combat situation where he/she witnessed others in their unit badly injured or dying while simultaneously fearing for their own life, the headache symptom may become strongly associated with that distressing series of memories. The veteran may then try desperately through unconscious and conscious means to avoid headache onset because in so doing he/she would be avoiding the onset of sensory pain (due to headache) and simultaneously the onset of emotional distress (headache-triggering flashbacks of distressing combat situations). From a phenomenological perspective, what may get lost in a bulk of literature concerning combat-related TBI is that, for veterans, the post-concussive symptoms can themselves take on profound symbolic significance. It may be that addressing post-concussive symptoms superficially bypasses many of the less obvious (but powerful) symbolic drivers that may conspire to strengthen post-concussive symptoms over time.

In short, a symptom may represent much more than a symptom to a veteran who has been injured in a military context. The astute clinician may achieve a deeper and more enduring healing relationship with a veteran if he/she is able to empathically inquire about the contextual significance, or symbolic meaning, of a post-concussive symptom(s) for that veteran. For instance, asking

"Does the symptom of headache take on any additional significance for you, in that you are a veteran and the concussion occurred in a combat situation?" In this chapter's case study, the emotional, cognitive, and physical symptoms were occurring at a pivotal life juncture for Staff Sergeant (ret.) Jonathan Williams, wherein he was simultaneously experiencing marital and family separation, financial stress, occupational stress, the feeling of having let down comrades by being injured, and a deep concern about his ability to successfully move forward in light of distressing symptoms and self-doubt.

An additional phenomenological consideration is the relative impact of the presenting post-concussive symptoms and the meaning of these in the context of the family system. To a point, and to the extent that the individual's clinical symptoms begin to interfere with established premorbid family roles, the family system can begin to experience the veteran as physically present while emotionally absent. There is risk that the veteran can become so consumed and overwhelmed by clinical symptoms that a new identity is formed around clinical symptoms, thereby resulting in the family system experiencing an incremental "loss" of the veteran they knew before the injury. Pauline Boss, PhD, has written much about the experience of "ambiguous loss" and the tension created between the physical presence and simultaneous psychological absence, of an individual secondary to a host of neurologic and psychiatric conditions (Boss 2016). It can be argued that a similar set of tensions can surface for family systems when a veteran presents for clinical care with a historical mTBI(s), especially when co-occurring psychiatric and persisting post-concussive symptoms begin to account for a larger proportion of the veteran's identity (Landau and Hissett 2008).

Epidemiological Evidence

Traumatic brain injury is a significant health issue for US military service members and veterans especially, as they are at increased risk of sustaining a TBI during both times of peace and war. Compared to civilian peers, active duty and reserve service members are at increased risk for TBI partly due to demographics (young men between ages of 18 and 24 are at great risk for TBI) and partly because service members are deployed to areas where they are at high risk of experiencing blast exposures. Additionally, according to the Defense and Veterans Brain Injury Center (DVBIC), active duty service members participate in routine operational and training activities, and leisure activities, that place them at higher risk for TBI (DVBIC 2014). A total of 357,048 service members, across all components of the Army, Air Force, Navy, and Marine Corps, received medical diagnoses of TBI since 2000, with 82.3% of these being mTBI injuries. In 2015 alone, 22,681 diagnoses of TBI occurred in the military, with 18,666 (82.3%) classified as mTBI (DVBIC 2017).

Historical Overview

Head injury treatment was documented over 3,000 years ago. However, literature from that time describes moderate to severe TBI rather than mTBI. Trepanation (burr hole) was utilized to reduce pressure on the brain by draining hematoma; however, it was believed to drain "pus" rather than blood. The Hippocratic corpus makes the first mention of the term "concussion" in historical texts; interestingly, it does not distinguish between concussion and other types of brain injury (Hippocrates 1950). It was not until 900 AD that Muhammad ibn Zakariya al-Razi first documented concussion (*commotio cerebri*; McCrory and Berkovic 2001). He described concussion as a transient physiologic state, which represented a pivotal moment in the history of head injury treatment in that the term distinguished concussion from severe TBI.

In the fourteenth through seventeenth centuries, many European physicians continued to document concussion. In 1687, the College of Physicians in London described concussion in a range of ways, including a singing of the ears after the wound is received, falling after the blow, swooning for a time, slumber after the wound is received, dazzling of the eyes, and a giddiness which passes rapidly (Read 1687). Yet, beyond

the description of concussive symptoms, there was as yet no clear understanding of the pathophysiology of injury. A variety of hypotheses were posited to explain the pathology of concussion beginning in the sixteenth century. Early hypotheses suggested that the shaking of the brain resulted in brain tissue injury, secondary to damaging physical contact with the architecture of the skull. It was not until 1774, when Jean-Louis Petit documented that immediate loss of consciousness was attributable to concussion and subsequent loss of consciousness was due to brain tissue compression due to changes in blood, that a linkage of concussion to pathophysiology was posited (McCrory and Berkovic 2001). In 1792, Thomas Kirkland wrote that loss of consciousness from a blow is independent of any pathologic change in the brain (McCrory and Berkovic 2001). It was not until the late nineteenth century that the brain was examined under a microscope. In 1962 Symonds surmised that a concussive event could result in diffuse axonal injury (DAI), which was perhaps the first time this term was introduced in the medical literature (Symonds 1962). Later, in a review of extant literature, Gennarelli (1986) expanded upon this observation to conclude that many neuronal axons must be functionally impaired due to the wide range of symptoms after concussion.

During World War I, neurosurgical management strategies increased the rate of survival from severe TBI to approximately 35% (Boake 1989). Unfortunately, during WWI, morbidity rates attributable to concussion were poorly documented. Despite increased survival rates, there was only one TBI rehabilitation hospital in the USA (Boake 1989). The mortality rate from TBI dropped to 10–13% in World War II, thus requiring the creation of specialized TBI centers. Mortality rates continued to drop during the Korean and Vietnam wars (Cifu et al. 2013). With advanced weaponry used in the Persian Gulf War, 17% of fatalities were attributable to brain injury, and over 4,000 service members were admitted to military hospitals secondary to TBI. The Defense Veterans Head Injury Program (DVHIP) was created in 1992 to address the growing numbers of individuals surviving TBI with complex rehabilitative needs (Salazar et al. 2000). Later renamed the DVBIC, the organization represented a collaboration between Department of Defense (DoD), Department of Veterans Affairs (VA), and civilian partners, with the goals of providing clinical care, education, and research for TBI care across the three healthcare settings.

Since the late 1980s, a greater awareness and formal recognition of mTBI through war, and sports, has resulted in advances in research. OEF and OIF conflicts, along with legal cases in the National Football League, have brought an awareness of concussion into the home of the everyday, nonmedical person. As advanced equipment and sideline concussion evaluation protocols have been developed in the world of sports, similar parallel advances in battlefield protective equipment and concussion evaluation algorithms have developed in the post-9/11 combat theater. For example, in 2007, the DVBIC created the Military Acute Concussion Evaluation (MACE), which is an in-theater mTBI screening tool. Increased publicity and public awareness about concussion has resulted in large, national-level research efforts to characterize mTBI and successive mTBIs, as well as to advance treatment for TBI of all severities in both the military and civilian settings. One example of a national initiative is the 5-year, $62 million Chronic Effects of Neurotrauma Consortium (CENC), awarded in 2012 as part of a National Research Action Plan (NRAP). The Chronic Effects of Neurotrauma Consortium is a coordinated, multicenter collaboration linking basic science, translational, and clinical neuroscience researchers from the VA, military, and academia to establish a comprehensive understanding of the chronic sequelae associated with neurotrauma with a primary focus on mTBI/concussion.

TBI was designated the “signature wound” of OEF/OIF conflicts because over 60% of blast injuries resulted in TBI. In order to treat the large number of returning service members and separated veterans with TBI and comorbid complex, life-threatening injuries (e.g., burns, orthopedic injuries and amputations, infections), the US Congress allocated special purpose funding for VA to create the Polytrauma System of Care (PSC) in 2005. The Polytrauma System of Care is

comprised of four components that either directly provide or formally link the lifelong needs of service members and veterans with TBI/polytrauma (and their families) to healthcare options. The Polytrauma System of Care uses a tiered system of rehabilitation, with regional referral centers known as Polytrauma Rehabilitation Centers (PRC) and Polytrauma Network Sites (PNSs) that provide post-acute rehabilitation and coordination of polytrauma services within the Veterans Integrated Service Network (VISN), Polytrauma Support Clinic Teams that provide outpatient interdisciplinary rehabilitation, and Polytrauma Point of Contacts that facilitate referrals to higher-level interdisciplinary Polytrauma System of Care programs. Additional Polytrauma Transitional Rehabilitation Programs have been created, and co-located with the Polytrauma Rehabilitation Center sites, in order to serve veterans with TBI/polytrauma history, who are judged to benefit from a more structured residential setting in the service of optimizing community integration and participation.

Mechanisms of the Disease

A traumatic brain injury is by definition a historical event that can occur in any variety of contexts. More recently it has been conceptualized as a chronic disease process insofar as data, especially for moderate-severe TBI, implicate the injury as causative for increased rates of mortality and as a risk factor for other medical conditions including Parkinsonism and dementia.

For military personnel, TBI can occur in deployment and non-deployment contexts. While perhaps surprising to some unfamiliar with base rates of TBI in military populations, a greater percentage of TBI injuries requiring healthcare services occur in non-deployment settings, as a consequence of stateside motor vehicle accidents, falls, or training accidents.

In combat situations, TBI has most commonly been the result of blast detonations (e.g., improvised explosive devices (IEDs), rocket-propelled grenades, mortars), and these events have resulted in high rates of mTBI. The environment in which the blast occurs (mounted within a vehicle, dismounted out of a vehicle, near water, open space, etc.), the type of materials used in the explosive (amount of trinitrotoluene (TNT) equivalents), the mechanism used to deliver the blast (improvised explosive device, artillery, etc.), and the distance between the person and blast are all important when considering the clinical effects of blast-related mTBI.

Blast injuries often have multiple mechanisms of injury. Primary blast injury results due to a change in air pressure in which an overpressure wave is followed by an under-pressure wave. This change can result in injures to fluid- or gas-filled organs such as the intestinal tract, eyes, ears, and lungs. One hypothesis also is that pressure transmitted through the abdomen or thorax can result in increased intracranial pressure, thereby resulting in brain injury. Secondary blast injuries can result as a consequence of projectiles from the blast that hit or penetrate an individual. This type of injury can result in blunt head trauma or penetrating brain injury. Tertiary blast injury results from an individual being thrown against another object, which can also independently result in blunt head trauma. Quaternary injury occurs from toxins that can cause hypoxia or burns, and other environmental threats after the blast can compound the number of injuries.

Whether a veteran has suffered a blast injury; a vehicular, sports-related injury; or injury of a separate mechanism, the hallmark sign of mTBI is some alteration of consciousness which may or may not include a frank loss of consciousness. Although McCrory et al. (2013) defined concussion in the setting of sport, their definition can be used in any setting of mTBI (see Table 23.1).

The Status of Interventions and the Relationship Between the Latest Interventions and Clinical Care

In the case of mTBI and persistent post-concussive symptoms, it is important to note the high level of symptom overlap with other commonly occurring conditions among post-9/11 veterans. While PTSD is the prototypical comorbid condition in veterans with a history of concussion, other conditions also co-occur such as insomnia and

chronic pain—highly prevalent conditions that present with symptoms very similar to post-concussive disorder. As an example, post-concussive symptoms of attention and concentration problems, irritability, and fatigue also overlap with common symptoms of clinical depression or PTSD. This overlap creates a vexing differential diagnostic conundrum for clinicians who may feel compelled to attempt to delineate the etiology of presenting symptoms. While attempting to discriminate between comorbid conditions with largely non-specific symptoms presents an intimidating diagnostic challenge, Maguen et al. (2012) have identified symptoms that are specific to concussion history (i.e., dizziness/balance problems, light sensitivity, headaches, and memory problems) and PTSD (i.e., nightmares and avoidance) in veterans.

When working with veterans with a history of concussion, making accurate diagnoses regarding comorbid psychiatric conditions is critical to ensure that evidence-based treatments for these conditions are made available to these individuals, even if additional intervention for concussion-related symptoms is warranted. Aggressive management of comorbid conditions is ideal to reduce overall symptom burden in individuals with a history of concussion, as there is indication that the relation between history of concussion and negative health outcomes, including psychosocial and work-related difficulties, is mediated by the presence of co-occurring PTSD (Pietrzak et al. 2009). There is a strong case that the management of comorbidities, especially PTSD, may optimize a broad range of mTBI health-related outcomes.

Table 23.1 Definition of concussion (McCrory et al. 2013)

Cause	Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head
Underlying pathology	Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury, and, as such, no abnormality is seen on standard structural neuroimaging studies
Immediate sequelae	Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, symptoms and signs may evolve over a number of minutes or hours
Symptom resolution	Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course. However, it is important to note that in some cases symptoms may be prolonged

Due to the complex nature of these cases, frontline clinicians in the primary care environment are often confronted with the reality that the most prudent way forward, from a holistic perspective, is to refer the veteran to a specialty interdisciplinary team associated with the VA Polytrauma System of Care. These interdisciplinary teams are composed of medical specialists, rehabilitation nurses, care coordinators, and a variety of therapeutic disciplines that are well suited to identify the needs and implement treatment plans for veterans with a history of combat-related concussion. The level of coordinated care made available by interdisciplinary teams can help to overcome issues related to scope of practice and time constraints that might otherwise limit the effectiveness of providers working individually (Shultz et al. 2011).

Prior to OEF/OIF conflicts, treatment recommendations regarding the management of concussion-related symptoms were largely derived from the study of civilians recovering from motor vehicle collisions, falls, assaults, and sports injuries. Consistent with research indicating that expectation biases following concussion serve to magnify and perpetuate symptom report (e.g., Mittenberg et al. 1992), psychoeducational interventions were developed to normalize the presence of symptoms commonly reported in the weeks following concussion and to create an expectation of recovery and return to pre-injury social and role functioning. Following earlier success in reducing the prevalence of the abnormal persistence of symptoms after concussion

(i.e., post-concussional disorder), this psychoeducational strategy has successfully been adapted for use in emergency rooms and via telehealth.

While the development of these interventions represents important advances in the prevention and management of post-concussional symptoms, the application of such evidence-based strategies in the VA Healthcare System is complicated by the fact that veterans typically present for initial evaluation and treatment years—rather than hours or days—after the injury (Belanger et al. 2009). Rather than preventing the development of post-concussional symptoms in a population of individuals who are hours to days post-injury, clinicians working with veterans are faced with managing chronic symptoms (i.e., post-concussion syndrome) in individuals who have lived through a host of severe—and potentially life-threatening—stressors between the time of their concussion and the moment they present for evaluation and treatment. Furthermore, rates of physical and psychiatric comorbidities are extremely high in the VA population, further confounding the use of straightforward psychoeducational strategies developed to manage concussion in civilians.

Numerous rationally and empirically developed recommendations are available for treating the myriad of cognitive, somatic/sensory, and emotional/behavioral symptoms often attributed to a history of concussion in veterans, such as poor concentration, headache, and vestibular deficits (e.g., Shultz et al. 2011). While management of individual symptoms is important, especially when the symptoms are believed to contribute directly to activity limitations and participation restrictions, the wide range of symptoms attributed to post-concussion syndrome would make a comprehensive review of such treatments unwieldy and premature.

In 2009, the Department of Veterans Affairs and the Department of Defense (VA/DoD) released a set of clinical practice guidelines with the goal of promoting evidence-based management of veterans with a history of concussion based on review of available literature and on consensus derived from leading brain injury experts from the VA, Department of Defense, and the private sector (VA/DoD 2009). These were updated in Version 2.0, published in 2016. Patient-centered education and symptom management lie at the core of the treatment strategies.

The role of education is to provide veterans with empirically based information about recovery following concussion. In cases where the education can be delivered hours or days following the injury, the goal is to reduce the likelihood that early post-concussive symptoms will persist beyond the usual recovery period (post-concussive syndrome/disorder), by normalizing the early post-concussive symptoms and creating an expectation for recovery. Further research is needed to determine the effectiveness of such education with veterans, however, since they typically present for clinical evaluation years after the concussion event. Nevertheless, the goal of education in this context is presumably to reduce anxiety about health-related concerns that are actually common in community-dwelling individuals according to base rates while also exploring the possibility that symptoms are being misattributed to remote history of concussion rather than to other existing conditions that may be easily treatable.

When veterans continue to report significant cognitive, somatic, and emotional/behavioral symptoms thought to be related to concussion after the implementation of education-based treatment strategies, the clinical practice guidelines offer empirically based and consensus-driven guidelines regarding the management of these presumed post-concussive symptoms using pharmacological and non-pharmacological treatment. Follow-up referrals to appropriate specialists are encouraged for otherwise intractable symptoms. The clinical practice guidelines highlight the importance of care management, especially in cases where multiple specialty providers are involved, to ensure that patients are able to follow through with their individualized care plan.

While assessment and management of self-reported symptoms are encouraged in the clinical practice guidelines for concussion (VA/DoD

2009), it is important to note that there is wide agreement that post-concussive symptoms, especially those that persist years post-injury, are largely non-specific. Indeed, endorsement of "post-concussive symptoms" has been found to be higher among veterans diagnosed with PTSD relative to veterans with a history of mTBI (Soble et al. 2014). The overlap of post-concussive symptoms with psychiatric disorders is especially problematic, given that approximately one-third of service members and veterans with history of concussion also meet clinical diagnostic criteria for PTSD and depression (Hoge et al. 2008).

Through the challenges inherent to differential diagnosis, a way forward to the appropriate treatment of these individuals is to arrive at individualized treatment planning that addresses four overarching areas of health: physical, cognitive, psychological, and spiritual. Achieving such an individualized treatment plan ultimately requires inclusion of the family system to the extent possible. Not surprisingly, the complex and functionally impairing symptoms associated with mTBI can result in marked family strain. For families, adjustment to the veteran's symptoms is experienced in the context of their collective experience of the pre-, peri-, and post-deployment stages (e.g., Collins and Kennedy 2008). There is a recognized need to provide care and support to family members of veterans with mTBI; however, there is very little scientific literature on evidence-based interventions for military families. Multifamily Group Treatment for Veterans with TBI (Perlick et al. 2013) has demonstrated promising preliminary results, with veterans reporting reduction in anger expression and increased social support and occupational activity, while their caregivers have reported decreased burden and increased empowerment. Future research and clinical efforts should be geared toward increased understanding of family functioning related to persistent, post-concussive symptoms. Further attention to perspectives from various family members beyond only the caregiver, as well as to cultural differences, may help better inform the need for, and content of, family interventions.

Implications for the Future

As with many aspects of healthcare in the twenty-first century, technology is changing how TBI is evaluated and managed. The Veterans Health Administration (VHA) has started providing concussion evaluation and treatment to veterans at community-based outpatient clinics and at the homes of veterans through the use of clinical video telehealth technologies. While the use of telehealth will irrefutably improve access to care—especially for veterans who do not live close to large medical centers—research is still needed to determine whether outcomes associated with telehealth versus in-person visits are equivalent. Rehabilitation professionals should see the ability to provide care within a veteran's local community as an opportunity to augment skill transfer to real-life settings, a process that is typically challenging when therapy is provided only in a formal treatment setting.

Similarly, mobile applications are now available to assist veterans and their providers in managing post-concussive symptoms and comorbid conditions. These applications provide means not only to deliver real-time therapeutic strategies to veterans but also to collect information about the severity, intensity, and duration of symptoms that can be shared with therapists. Mobile applications such as the Concussion Coach, developed by the Department of Veterans Affairs in 2013, provide basic assessment tools that help direct the user to the most appropriate intervention strategies based on their self-reported problems—a tailoring of treatment that is essential given the large universe of symptoms and treatment strategies potentially available for those recovering from concussion.

While technology has created exciting new avenues for providing contextualized intervention in real-life situations, the role of vocational rehabilitation services in assisting veterans to transfer skills into real-life situations has never been more important. Early interventional strategies after TBI that focus on symptom reduction and maximizing independence should ultimately yield to specific community reintegration goals, the most important of which may be a return to

productive, meaningful activity regardless of disability severity (e.g., Wehman et al. 2009). The role of vocational rehabilitation, or specifically supported employment, has expanded rapidly in the VA healthcare system over the last 10 years. OEF/OIF veterans can benefit tremendously from these services, as they provide an important element of support for veterans who require additional assistance to adjust to the cognitive, emotional, or physical demands of a competitive workplace situation.

Lastly, there is broad consensus in the professional community that the vast majority of individuals suffering from a concussion experience should experience quantifiable cognitive changes within 3–12 months (Carroll et al. 2004). More recently, however, there has been increasing concern regarding the long-term health impact of concussion, especially repeated concussions. Theories have been put forth suggesting that repeated concussions may result in a unique neurodegenerative condition, called chronic traumatic encephalopathy (CTE), or that repeated brain injury may result in a reduction in cognitive reserve that allows for the earlier expression of age-related neurodegenerative disorders, such as Alzheimer's disease (Randolf and Kirkwood 2009). While the possibility that multiple concussions suffered in the line of duty may put veterans at increased risk of developing a neurodegenerative condition later in life is alarming, especially given rates of TBI in recent conflicts, multiple case studies have been published that do not draw a definitive causal link between concussions and neurodegenerative conditions (Karantzoulis and Randolph 2013). Prospective, longitudinal, multicenter studies of veterans are now underway to carefully explore the potential long-term consequence of multiple concussions. At present, however, clinicians should be cautious in discussing the potential relation between concussion (especially a single concussion) and neurodegenerative processes with patients and other healthcare professionals (Wortzel et al. 2013).

Large systems of care have been launched to address the complex assessment and treatment needs for service members and veterans who require specialized healthcare following TBI. In addition to the Polytrauma System of Care in the Department of Veterans Affairs, the National Intrepid Center of Excellence (NICoE) opened its doors in 2010 as a center designed to advance understanding of the "invisible wounds" from Iraq and Afghanistan. The NICoE has since this time established its role as a directorate within Walter Reed National Military Medical Center (WRNMMC) and as a key component within the Military Health System (MHS) TBI Pathway of Care. There is a collaboration between the NICoE and a developing network of "Intrepid Spirit Centers," localized TBI care facilities, to help address the continued challenge of TBI incidence in the MHS.

Conclusions

The incidence of concussion in military populations is well established. These rates have increased commensurate with increased recognition and awareness of the existence of mTBI, together with injuries sustained in combat and noncombat situations. The use of explosive devices through Operation Enduring Freedom/Operation Iraqi Freedom conflicts has further sensitized the medical community to the myriad physical and psychiatric sequelae of single or multiple mTBI events. Department of Defense, Veterans Health Administration, and university settings have developed interdisciplinary rehabilitation programs to provide comprehensive, lifelong care options for veterans with a history of TBI/polytrauma. The general consensus is that treating these individuals using a holistic, patient-centered approach requires some understanding of the context of the injury event and an appreciation for military culture and deployment-related mental health conditions. Team-based and early educational interventions hold promise in optimizing rehabilitation outcomes. Additional, scientifically informed intervention methods are needed to address the complexities of longer-term, persistent post-concussive symptoms, especially as these commonly present with comorbid psychiatric comorbidities. There is a need for the development of evidence-based interventions at both the patient and family

systems levels for individuals with persisting post-concussive symptoms with and without accompanying psychiatric conditions.

Key Concepts

1. The vast majority of military traumatic brain injuries (TBIs) are mild, with 82% of the approximately 23,000 military TBIs reported in 2015 being classified as such.
2. A TBI has traditionally been defined as a historical event, though it has more recently been reconceptualized as a chronic disease due to the increased risk for developing other medical conditions following moderate to severe TBI.
3. Blast exposure, the most common cause of combat-related mild traumatic brain injury (mTBI), can cause direct and indirect neurological injury through multiple mechanisms, including rapid changes in pressure (primary), projectiles set in motion by the blast (secondary), being thrown against another object (tertiary), and exposure to toxins (quaternary).
4. Post-concussive symptoms are largely nonspecific and difficult to differentiate from the symptoms associated with other medical conditions common in persons with a history of mTBI.
5. Diagnosis and aggressive management of comorbid conditions are necessary to optimize outcome when treating veterans with a history of mTBI.
6. Education focused on normalization of symptoms and on creating an expectation of recovery is considered best practice for mTBI management, though more research is necessary to determine how best to apply this treatment strategy to veterans who are often first evaluated years post-injury.
7. Coordinated interdisciplinary care, including the family system, is sometimes needed to effectively manage persisting somatic, cognitive, and affective post-concussive symptoms.
8. Technology-driven advances in TBI care, including clinical video telehealth and mobile applications, hold promise for maximizing reintegration through delivery of services in real-life settings.

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