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Management and Rehabilitation Strategies Following IED Related Mild Traumatic Brain Injury in Civilian Settings - What to Expect and How to Optimize Recovery From mTBI

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Review Article

Management and Rehabilitation Strategies Following IED-Related Mild Traumatic Brain Injury in Civilian Settings - What to Expect and How to Optimize Recovery From mTBI

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Abstract

The wide array of psychological and physical responses following an IED bombing may reduce the likelihood that appropriate assessment and recovery from mTBI occur. Such a situation is problematic as mTBI itself may negatively influence the recovery from the traumatic event or associated injuries if not diagnosed and managed properly. Consequently, the overall aim of this article isto better inform healthcare practitioners, patients, and patients' social support networkabout the nature of IED-related mild traumatic brain injuries. In so doing, we hope to facilitate enhanced assessment, management, and rehabilitation of this injury. In particular, the specific goals of the review include:

(i) a description of the nature of an IED-related mTBI in a civilian setting (section 2 to 2.3);

(ii) a description of the unique circumstances for mTBI survivors in regards to the signs and symptoms that may be anticipated (section 2.4);

(iii) what key stakeholders including: the rehabilitant, the managing health care team, and social support providers (e.g., family members) can expect in terms of the physical and emotional recovery process (sections 3 to 4.4.) Finally, general and specific lifestyle modifications to improve survivors' health are described in order to lay a clear foundation for patients' recovery from an IED-related mTBI.

ABBREVIATIONS

IED: Improvised Explosive Device; ACE: Acute Concussion Evaluation; ASD: Acute Stress Disorder; A-WPTAS: Abbreviated Westmead PTA Scale; BESS: Balance Error Scoring System; CBT: Cognitive Behavioral Therapy; CDC; Centers for Disease Control and Prevention; CT: Computed Tomography; e.g.: Exempli Gratia; GCS: Glasgow Coma Scale; HE: High Explosives; kPa: Kilo Pascal; LE: Low Explosives; MACE: Military Acute Concussion Evaluation; ms: Milli Seconds; mTBI: Mild Traumatic Brain Injury; PCS: Post-Concussion Syndrome; PTSD: Post-Traumatic Stress Disorder; TNT: Trinitrotoluene

INTRODUCTION

Mild traumatic brain injury (mTBI) is one of the leading causes of death and disability worldwide [1]. Among active duty military personnel, explosions by improvised explosive devices (IED) are the primary cause of mTBI [2,3]. Until recently, IED-related mTBI was seldom seen outside combat situations. However, with the ongoing global war on terrorism, this type of injury is becoming increasingly common among civilians surviving terrorist suicide bombings [4-6].

Unlike the military, the civilian medical community is typically ill-prepared in appropriate diagnostic and treatment procedures of IED-related mTBI [5,7]. Unfortunately, insufficient training in diagnosis and treatment of mTBI can have deleterious implications for those incurring such injuries as well as society at large. For instance, mis- or undiagnosed mTBI and improper treatment may lead to physical, cognitive, and long-term emotional symptoms that interfere with academic and job performance [8]. Although the majority of studies report recovery within 3-12 months [9], it has also been found that more than one third of patients did not resume work within three months post-injury [10]. Furthermore, lingering cognitive complaints have been reported by as many as 15% of patients, one-year post-injury [11]. Additionally, a trend of under-detecting or not reporting this type of injury has been documented [4,9,12-20].

With terrorist attacks on the rise, civilian medical personnel must understand the unique pathophysiology of IED-related mTBIs to effectively assess and treat injured individuals.

Our review is intended to provide key stakeholders including: civilian healthcare providers (e.g., first responders, primary care physicians, rehabilitation specialists, and psychologists), survivors, and social support providers (e.g., family members) with essential information for enhanced management (assessment and diagnosis) and rehabilitation of IED-related mTBI. In doing so, it is our hope that the current review will help improve the quality of patient care among those incurring IED-related mTBI. The review is divided into four sections. First, we examine the nature of IED-related mTBI, with a particular focus on the mechanics of the origin of the injury and the setting of a mass casualty. Second, state of the art knowledge regarding rehabilitation of mTBI from sports and military settings will be transferred to the context of an IED-related mTBI during a civilian mass casualty. Finally, we offer conclusions and take-home messages.

The value of this review is a synthesis of information for civilian healthcare providers who are involved in the chain of management and rehabilitation of IED-related mTBI. Furthermore, this review provides educational support for IED-related mTBI survivors and support providers (e.g., family members)regarding the nature of this traumatic injury and what to anticipate during recovery from it.Given that multiple stakeholders are necessarily involved in the assessment, management, and rehabilitation of an IED-related mTBI, our overarching goal in this review is to provide such stakeholders with relevant information to facilitate enhanced assessment and treatment of this injury.Although the information in particular sections may be of greatest interest to specific stakeholders, we have attempted to use clear, non-jargon language whenever possible, to maximize the accessibility of each section for each stakeholder.

THE NATURE OF AN IED-RELATED MTBI

As indicated, the consequences of mTBI for an individual's health and well-being have traditionally been underestimated [21]. To raise awareness of the short- and long-term effects of IED-related mTBI, we provide an overview of the nature of an IED-related mTBI in this section. In particular, terminological and definitional issues are first discussed, followed by information on the nature of improvised explosive devices (IED). This section of the review also includes discussion of the mechanics of an IED-related mTBI (impact versus blast) and injury symptoms.

Terminology and definition of mild traumatic brain injury

The term mTBI is often used interchangeably in the literature with "concussion", "mild head injury" (MHI) or "minor head trauma" (MHT) [22]. In the clinical medical literature, "mTBI" is typically the preferred term, whereas "concussion" is often invoked in the sports medicine literature [17,23,24]. A problem in using various terms to describe a single phenomenon is that some terms imply a greater or lesser injury severity with a tendency to underestimate or misinterpret the injury as less severe[25,26]. As such, it is important for healthcare providers and patients to understand that any of the terms above are considered to be an mTBI [17]. We suggest that the use of mTBI is most appropriate to use in the context of an IED situation, as all concussions are a subset of mTBIs [27].

Just as multiple terms have been used to describe an mTBI, so too various definitions have been offered. For example, a comprehensive definition of mTBI was released in 1993 by The American Congress of Rehabilitation Medicine (ACRM), where mTBI is defined as [28]: "

... atraumatically induced physiological disruption of brain function, asmanifested by at least one of the following:

1. *any period of loss of consciousness;*
2. *any loss of memory for events immediately before or after the accident;*
3. *any alteration in mental state at the time of the accident (eg, feeling dazed, disoriented, or confused); and*
4. *focal neurological deficit(s) that may or may not be transient; but where the severity of the injury does not exceed the following:*

- *loss of consciousness of approximately 30 minutes or less;*
- *after 30 minutes, an initial Glasgow Coma Scale (GCS) of 13–15; and*
- *Post traumatic amnesia (PTA) not greater than 24 hours.*

The definition by the ACRM includes incidences in regards to the head being struck, the head striking an object, and the brain undergoing an acceleration/deceleration movement (i.e., whiplash) without direct external trauma to the head [28]. However, this definition does not refer to blast events and thus, a definition referring to the military setting would be complementary. Helmick and colleagues stipulate that a mTBI is:

"... an injury to the brain resulting from an external force ... from an event such as a blast ... [29].

Improvised explosive devices

Although various terms may be used interchangeably to refer to a single injury type, it is important to recognize that the causes of an mTBI may have differing implications for individuals– both in mTBI symptomology and long-term prognosis. As such, it is instructive to examine the specific nature of IED's and their potential consequences for those suffering an IED-related mTBI.

To understand how an IED works, one must have information about the biomechanics of an explosion and the types of explosives. Explosives are categorized as either high explosives (HE) or low explosives (LE). HEs (e.g., TNT) produce a defining supersonic over-pressurization shock wave that transfers a sudden circular blast on the immediate environment and eject flying debris [6,30,31]. LEs (e.g., gasoline) are designed to burn and subsequently release energy relatively slowly. LE's do not form shock waves but create a subsonic explosion with a blast wind ejecting debris and bomb fragments as well [6,30]. IEDs can be composed of HE, LE, or both [30].

The mechanics of an IED-related mTBI

IED-related mTBIs can be caused by direct mechanical impacts to the head, by blast shock wave forces or both. The following sections (2.3.1) will describe the differences of the two types of injury mechanisms.

Impact-related versus blast-related mTBI: Impact-related mTBIs are caused by direct mechanical impacts to the head with sudden rotation causing skull/brain relative motion; combined linear, and rotational acceleration; or angular acceleration/deceleration forces [30,32,33].

Although an impact-related and a blast-related mTBI have similarities, differences do exist. First, blast shock wave forces cannot cause linear or rotational/angular acceleration as seen in impact-related mTBIs [33]. Furthermore, with a blast-related mTBI, the patient's entire body is exposed to the explosion. The exposure to a blast may involve a variety of interlinked local and systemic cerebral responses to blast exposure, which often occur simultaneously [34].

Symptoms

Symptoms following an mTBI are unspecific and may be prolonged, progressive, or even long-term. Symptoms may also be physiological, psychological, or behavioral in nature (Table 1). These dysfunctions could include abnormalities such as long-term gray and white matter atrophy, age-related neuro degeneration, or post-traumatic stress disorder (PTSD)-like traits with an increased risk for suicidality [3,35,36].

While some researchers suggest individuals may be symptom-free within days following mTBI [37], there is an indication that up to twenty percent of mTBI survivors continue to experience post-concussive symptoms long-term [18]. These estimate may be higher, as it becomes more and more apparent that there is an increasing rate of unreported mTBI injuries in the civilian as well as in the military population [9,15-20]. However, any individual who is experiencing any of the signs or symptoms following exposure to an IED explosion as listed in Table (1), should be evaluated further by a health care professional who is experienced in assessing mTBI [36, 38-41].

Table 1: Overview of unspecific signs and symptoms of an IED-related mTBI [36,38-41].

Physical	Cognitive	Affective	Sleep
Headache	Difficulties thinking clearly, confusion	Irritability, moodiness	Drowsiness
Loss of consciousness	Easily distracted	Inappropriate behaviour	Sleeping more or less than usual
Physical pain	Mentally "foggy"	Sadness, depression	Difficulties falling asleep
Nausea or vomiting	Difficulty concentrating	Anxiety	
Decreased physical ability, balance or coordination problems	Decreased processing speed	Heightened emotions (e.g., aggression, agitation)	
Dizziness	Difficulty memorizing new information	Nervousness	
Double or blurry vision	Difficulty memorizing events prior to the trauma	Alcohol and drug abuse	
Sensitivity to light	Difficulty memorizing events after to the trauma	Apathy	
Sensitivity to noise	Feeling "sluggish" or slowed down	Posttraumatic stress	
Tinnitus	Decreased verbal memory	Increased suicidality	
Fatigue	Aphasia, slow responses	Personality chance	
Does "not feel right" or "feeling down"			
Feeling "sluggish", or having no energy			
Numbness, tingling			
Describe "bell rung"			
Visual disturbances ("Seeing stars or double")			
"Glassy-eyed"			
Jaw pain			

Please note that these signs and symptoms a) may or may not appear immediately and b) may be overseen by the patient, healthcare providers, relatives, and friends.

MANAGEMENT OF IED-RELATED MTBI

Primary (emergency) triage

The management of IED-related mTBI begins at the scene of the emergency, where many injured victims with one or multiple concurrent injuries and co-morbid conditions may be present. Typically, the emergency medical personnel quickly evaluate the victims with "minimal acceptable care" to expedite treatment for the most severely injured and to avoid wasting resources on less seriously injured [42,43]. Depending on the number of victims, the average "one-on-one" time of medical personnel with a patient is less than a minute. Within this time, the patient is assigned to a triage category and receives very limited treatment (opening of airways and control of major bleedings) [44]. Accordingly, the performance of sophisticated tests to diagnose mTBI would be a depletion of scarce resources at the emergency scene. As mTBI typically not an acute life-threatening injury, this injury is likely to be overseen at this early stage. Here, the CDC simply suggests considering the proximity of the victim to the blast [45].

Secondary (in-hospital) triage

Following an IED bombing, patients who are evacuated from the emergency scene, as well as those suffering less severe injuries, or who bypass EMS triage, may enter secondary triage in a clinical setting for definitive care [46]. The follow-up care and procedures of the secondary triage that patients receive vary significantly and depends on the readiness of the clinic, the equipment, and the guidelines in place. Common clinical first measures for mTBI patients may include: patient identification, blood pressure measurement, lung capacity auscultation, assessment of the injury complexity and severity (e.g., by using Injury Severity Score), differential diagnosis to exclude hemorrhage (i.e., computed tomography),or a determination of the level of consciousness (e.g., by using Glasgow Coma Scale) [47].

Further application of sophisticated mTBI testing tools depends on the conditions and requirements of the particular clinic [48,49]. However, to achieve an accurate diagnosis of mTBI following an IED explosion, authors of the present paper support the use of the GCS in conjunction with the *Abbreviated Westmead PTA Scale* (A-WPTAS). The A-WPTAS should be routinely performed to assist with the monitoring, diagnosis, early management, and prognosis of IED-related mTBI. It is recommended that the A-WPTAS be used within 24 hours of injury for patients with a suspected closed head injury and a GCS 13-15. To be suitable for A-WPTAS, patients must be capable of opening their eyes spontaneously and obeying commands. The combined evaluation with both scales is an objective measure of post-traumatic amnesia [49,50]. Moreover, during initial evaluation and diagnosis of pediatric and adult patients, it is suggest using the *Acute Concussion Evaluation* (ACE), which is intended to provide an evidence-based clinical protocol to conduct an initial evaluation and diagnosis of pediatric and adult patients [49,51,52].The ACE is a validated clinical interview checking for injury characteristics, symptoms, risk factors, and other red flags, with the option of a follow-up action plan [49].

If the test mentioned above does not confirm an IED-related mTBI, the patient may be discharged with instructions for follow-up care, including written and verbal injury advice (e.g., Brain Injury Advice Card) [49]. The patient's readiness for clinical discharge can be further confirmed by the clinical criteria as outlined by Marshall et al., [53].

Tertiary (expert) triage

Depending on the clinical efficiency at the point of clinical discharge, IED survivors may or may not be symptom-free. Most mTBI symptoms typically resolve by three months [53,54]. However, a recent meta-analysis showed that in cases where the presence of cognitive deficits is still evident following the first two weeks post-MTBI, complete recovery may be prolonged [55].

Prolonged recovery following mTBI, is denoted post-concussion syndrome (PCS) [56]. Current findings stress the non-specificity of PCS (see 2.4)[53,56]. Accordingly, the differential diagnosis of PCS can include, but is not limited to, one more of the conditions listed below and requires further assessment [53,56].

• PTSD	• Sleep disorder
• Generalized anxiety	• Depression
• Post-traumatic headache	• Somatization
• Chronic fatigue	• Chronic pain
• Cervical injury (e.g., whiplash)	• Vestibular dysfunction
• Ocular dysfunction	• Substance abuse or polypharmacy
• Fibromyalgia syndrome	

Given the traumatizing circumstances, the patient is at higher risk for persistent symptoms and poorer outcomes following the IED-related mTBI compared to e.g., a sport-related mTBI [57-59]. Therefore, referral of an IED-related mTBI patient to a multidisciplinary treatment clinic is encouraged [60-64], particularly if symptoms persist until about one month post-injury [53,65]. Services, which are specialized on mTBI treatment, should feature the following:

- A team, which communicates well with each other (use of same common nomenclature in regards to the injury) and patients' environment (e.g., superiors and family members).
- Pharmacological and non-pharmacologic treatment options.
- Experiences with multiple settings (athlete, civilian, and military patients).
- Components of active rehabilitation (e.g., lifestyle modifications regarding stress management or nutrition or cognitive behavioural therapy).
- Individualized assessment (i.e., health history, occupational demands, social support resources, and facilitators and barriers to successful occupational re-entry)

Furthermore, neuropsychological tests can evaluate patients' cognitive, motor, behavioural, linguistic, and executive functioning to address patients' cerebral function or impairment levels [66]. In the following section, the common neuro physiological tests regarding mTBI assessment and management at an advanced stage of rehabilitation are presented [67].

Neuropsychological mTBI assessment: The Ohio State University TBI Identification Method (OSU TBI-ID) is a 5 minute standardized self-report to determine a patient's lifetime history of TBI [68-70]. This tool has been proven to be useful in many settings and to evaluate patient's current cognitive and emotional state.

The *Post-concussion Symptom Scale* (PCSS) is another assessment tool to gather self-reported information on a patient's status following potential mTBI. This 22-item questionnaire covers aspects of cognition, sleep problems, emotions, and physical factors. Responses are scored from 0 (no symptoms) to 6(severe symptoms) [71].

The *Balance Error Scoring System* (BESS) is a balance test developed to provide civilian and military clinicians with an inexpensive and practical tool for assessing postural stability, a common issue following mTBI [29,72,73].The test and the scoring are described in detail in Riemann et al. (1999) [74].

The *Military Acute Concussion Evaluation* (MACE), is another assessment tool that can be valuable in facilitating and IED related mTBI diagnosis. MACE is a medical screening and documentation measure to evaluate the severity of symptoms and cognitive deficits following mTBI [75].

REHABILITATION

In the section below, common steps involved in the recovery from mTBI, and strategies for facilitating patients' return to work are described. The present recommendations are based on publications which are rated in regards to their levels of evidence. According to the *Center for Evidence-Based Medicine,* the evidence level ranges between 1a (systematic reviews of randomized controlled trials) and 2a (individual cohort studies and low-quality randomized controlled trials). Consequently, the overall level of evidence is graded with a B (grade of recommendation; moderate evidence) out of a grade range between A (strong evidence) to D (conflicting evidence) [76].

Uncomplicated rehabilitation

Rehabilitation from an IED-related mTBI should ideally be based upon the diagnosis of an mTBI as described above. The first step towards an efficient rehabilitation following an IED-related mTBI is comprehensive rest (physically, cognitive, emotionally) [56]. Rest allows the injured systems to promote compensatory cerebral activation, characterized by increased cerebral blood flow and glucose metabolism [77]. Typically, patients with mTBI are advised to rest until all symptoms resolve, as high levels of physical and cognitive activity at an early stage following mTBI may delay recovery [78]. However, a general consensus among mTBI scholars is that rest beyond three days is not beneficial since too much rest may have adverse physiological and psychological consequences and could contribute to prolonged symptoms [56]. In the most recent consensus statement on sports-related concussion, a shorter initial period of rest in the acute symptomatic period (24-48 hours post-injury) was recommended [24,56]. The advice to rest also included sufficient sleep (see 4.3.1). Obtaining proper sleep hygiene (e.g., regular schedule, naps, avoiding caffeine and alcohol, sleeping in a dark room, a bedtime routine) is critical to the recovery process. General lifestyle modifications are described in section 4.3.1.

If the signs and symptoms of the IED-related mTBI improve and resolve [24], the second step towards recovery would be a gradual, symptom-free return to patients' previous occupation. The return phase should not result in an exacerbation of symptoms [24]. This phase may also include a substantial reduction (e.g., return-to-work programs) of the post-mTBI workload with only minimal to moderate cognitive activity. The points below are examples of activities that could be impaired and that may have to be simplified to facilitate patients' adaption:

- Activities for which reaction time is critical (e.g., driving in traffic, operating machines)
- Decision making (e.g., finances, household, partnership)
- Everything relying heavily on short-term memories (e.g., picking up kids after school)
- Focus (e.g., school)

However, a reduced post-mTBI workload or schedule does certainly not imply strict bed rest and a reduced work load. Findings from recent reviews on active rehabilitation of mTBI, support the idea of patients' time-appropriate, gradual, and active return to previous activities [24,53,56,79]. Examples of an active rehabilitation approach would include:

- Light to medium level of physical (e.g., walking, stationary cycling: <70% maximum permitted heart rate)
- Light cognitive activity (e.g., typical daily activities, such as preparing a simple meal)

Steps and procedures that would be beneficial in supporting recovery may include education or psychological interventions, such as cognitive-behavioral therapy to address maladaptive thinking and behavior. Furthermore, participation in physical, ocular or cervical spine manual therapy is recommended as well as treatment of symptoms not directly related to the mTBI, but concomitant injuries resulting from the IED bombing [56]. Also, sub threshold aerobic exercise, when asymptomatic at rest, may be beneficial during recovery from IED-related mTBI. Here, monitored exercise intolerance may serve as a physiological biomarker indicating physiological recovery. A safe and reliable test to examine exercise intolerance would be the *Buffalo Concussion Treadmill* test [80-84]. This standardized exercise test is based on a protocol imparting a gradual increase in workload. After the resolution of symptoms and following medical clearance, regular participation in daily activities and a full return to patients' occupation represents the completion of rehabilitation from the IED-related mTBI.

Rehabilitation of persistent symptoms

For the majority of mTBI patients, a full recovery is expected within three months, but about 15% of patients may experience persisting symptoms [24,53]. However, following trauma exposure, various impairments in physical health are to be expected [85,86]. Poor health behaviours are partially responsible for health problems following a traumatic event, such as an IED bombing. Thus, researchers have strongly recommended incorporating lifestyle modifications to improve general health [87,88]. The section below provides information on general and specific approaches to rehabilitating persistent symptoms following IED-related mTBI.

General lifestyle modifications

There is a bi-directional relationship between sleep, nutrition, physical activity and health [89,90]. A synergistic effect occurs when an optimal quantity of each component is applied daily [91].

Sleep: It is well-known that sleep deprivation and sleep inconsistencies can catalyze headaches among other health risks [92,93], and accordingly prevent improvement of mTBI recovery. Hence, educational input on the part of the health care provider is essential. For mTBI rehabilitants, evidence suggests the benefits of consistent sleep times avoiding daytime naps, and scheduling in rest or quiet periods, if feasible [53]. Furthermore, sleep habits, including exercise, stress management, noise reduction, sleep timing, and avoidance of caffeine, nicotine, and alcohol are integral in maintaining health and recovering from mTBI [94-97].

Nutrition: Missing out or delaying meals can trigger headaches in some individuals [132]. Ideally, patients with IED-related mTBI should consume a high-protein breakfast, lunch, and dinner and avoid delaying or skipping meals [98,99]. Also, antioxidant-rich foods (e.g., beans or blueberries) may promote protective anti-inflammatory mechanisms associated with mTBI

[100]. As part of nutrition, it is important to maintain hydration to support cognitive performance. Dehydration impairs tasks that require attention, psychomotor skills, and immediate memory skills and delays the recovery of the traumatized brain [101]. Marshall et al. (2013) recommend consuming 4-6 drinks per day of water, juice, milk or other non-caffeinated beverages [53]. Coffee and soft drinks as a measure to hydrate should be avoided as both caffeine and aspartame may trigger headaches [102]. Additionally, alcohol consumption should be completely avoided, as alcohol is a neurotoxin and may augment the effects of mTBI [103].

Exercise: In the initial period following mTBI, comprehensive rest (physical, cognitive, emotional) is often endorsed [56]. However, inactivity is frequently counter-productive, and a sedentary lifestyle without any cardiovascular exercise may, in some, perpetuate the headaches [56,79]. Accordingly, moderate physical activity (e.g., going for a walk, riding a stationary bicycle, or slow jogging on a treadmill) can be very supportive in headache management. Physical activity should be undertaken as tolerated and with a gradual increase in duration and intensity [24,104]. As a caveat, exercise may also trigger a headache. In that case, the intensity and/or duration of the exercise should be reduced or an alternative exercise should be trialed.

Specific lifestyle modifications for post-concussion syndrome: As indicated, most mTBI symptoms resolve in the majority of mTBI patients within days to months [53,54,73]. However, following trauma exposure, various impairments in regards to physical health are commonplace [85,86]. Hence, IED-related mTBI survivors are more prone to experiencing persisting symptoms [24,41,53,105]. Obstinate symptoms may delay or prevent a full recovery and thus a return to the individual's previous occupation, sports, or school.

- If symptoms persist (e.g., headache, fatigue, sleep disturbance, vertigo, irritability, anxiety, depression, apathy, and difficulty with concentration and exercise) beyond an acceptable time frame or more than a few weeks, the patient would be classified as experiencing post-concussion syndrome (PCS) [56]. In the case of PCS, specific lifestyle modifications and other measures should be adopted, depending on the type of symptoms. Active measures can be carried out by the patients themselves. For example, in managing a headache or tinnitus, the following treatments may be helpful [53]:Avoid triggers such as caffeine, heat, chocolate, or quinine

Adaptation of lifestyle (see 4.2.1)

Apply cold or heat to the neck or head

Headache bands to apply compression to the head

Foam roller applied to the neck and head

Stretching and (self-massaging) the head and/or neck and shoulders

Perform breathing exercises

Visualization or other mindfulness-based exercises

Locate a quiet place

Lie down

Go outside to get fresh air

NOTE: Avoid pain relievers such as ibuprofen (Advil, Motrin IB, others) and aspirin may increase the risk of both cerebral bleeding and tinnitus (i.e., ringing in the ears) already present.

In addition to physical symptoms such as a headache and tinnitus, IED-related mTBI survivors will likely experience some distress. Studies have demonstrated that survivors of traumatic events (e.g., accidents, natural disasters, assaults) reveal high rates of Acute Stress Disorder (ASD) [106-110]. ASD is predictive of subsequent posttraumatic stress symptoms, and a significant portion of individuals with ASD may develop PTSD [111,112]. A detailed list of the diagnostic criteria for ASD and PTSD can be found in a 2002 publication by Harvey and Bryant [113]. Both, ASD and PTSD, may impact survivors' lives significantly and can cause functional impairment and reduced success in larger life-course opportunities [114-118]. However, mTBI can increase the prevalence of both [119-121] which, in turn, can have a deleterious influence on the course of mTBI rehabilitation. For example, survivors of military-related mTBI exhibited a decreased ability to cope with PTSD symptoms, increased problems with physical health, and more pain complaints [122-125]. Accordingly, the likelihood, that IED-related mTBI survivors will develop concomitant stress disorders is high and should be considered during rehabilitation [121,126,127].

A few well-established and empirically-validated measures to assess ASD and PTSD are described below [128,129]:

- **Acute Stress Disorder Interview (ASDI).** A 19-item interview schedule based on criteria from the DSM-IV. It can be completed in approximately 5-10 minutes. Any appropriately trained person can administer the interview. It includes the five dissociative symptoms specific to ASD.

- **Acute Stress Disorder Scale** (ASDS). A 19-item self-report measure of ASD symptoms that correlates highly with symptom clusters on the ASDI.

- **Short Form of the PTSD Checklist - Civilian Version**. A 6 item screen with three components including re-experiencing, avoidance, and hyper arousal.

- **Primary Care PTSD Screen (PC-PTSD)**. An introductory sentence to cue respondents to traumatic events followed by a 4-item screen. This tool is used in primary care and other medical settings such as VA health care settings.

Further comprehensive expert interventions to support the recovery from post-concussion syndrome may include some the following therapies [53,56,130-132]:

Psycho-educational intervention to address concussion knowledge, symptom interpretation or recovery expectations.

Psychological intervention such as Cognitive Behavioural Therapy (CBT) to identify and change patterns of maladaptive thinking or behavior that exacerbates or even cause affective symptoms, including depression and anxiety.

Cognitive rehabilitation to develop compensatory strategies to address difficulties in regards to attention, memory, and executive functioning.

Manual therapy (e.g., massage therapists, physiotherapists, occupational therapists, chiropractors, osteopaths) to treat symptoms that may or may not be specific to the IED-related mTBI, such as pain, dizziness, a whiplash or spine injuries.

Vestibular therapy to treat common forms of vestibular dysfunction (inner ear/balance) following mTBI, such as vertigo, dizziness, visual disturbance, and/or imbalance.

Ocular therapy to address commonly reported eye problems such as accommodative disorders, convergence insufficiency, or saccadic dysfunction which may be reflected by blurry vision, double vision, near vision problems or headaches.

Sub threshold aerobic exercise therapy may improve autonomic nerve disorder which can include (but is not limited to): dizziness, fainting upon standing up or orthostatic hypotension. Sub threshold aerobic exercise consists of 80% of the heart rate at which an individual would begin experiencing PCS symptoms. Here, exercise intolerance is to be interpreted as a physiological marker of ongoing mTBI.

RETURN TO OCCUPATION

The process of returning to one's "normal" baseline functioning depends on the patients' current status quo in regards to the signs and symptoms associated with the mTBI. Accordingly, no single rehabilitation regimen can account for idiosyncratic differences in patients. That said, there are recovery models and recommendations which can be offered in regards to the management of mTBI. For example, McCulloch et al., recommend a progression in regards to the amount of physical activity, as displayed in Figure (1)[104].

The progression to return-to-normal

In addition to return to individual specific levels of physical activity, overall approaches to return to the workforce are helpful for organizing and managing IED-related mTBI recovery. The REAP model (Reduce, Educate, Accommodate, Pace) provides structured guidelines for the return to physical and cognitive activities following mTBI [133]. Although the community-based mTBI management program focuses on school settings, it offers an excellent template for implementing a team approach to successful return-to-school, -sports, -work, or -parenting responsibilities. Ideally, the "returner" can build a team in the early injury aftermath comprised of four components or members:

- **Family Team** (e.g., family, partner, colleagues, friends, student fellows)
- **Physical Team** (e.g., company doctors and nurses, medical officers, coaches, certified athletic trainers, physical education teachers, playground supervisors, school nurses)
- **Academic or Work Team** (e.g., managers, teachers, counselors, psychologists, social workers, occupational therapists)
- **Medical Team** (emergency department, primary care providers, nurses, specialists, neurologists, clinical neuropsychologists, physical therapists)

In an ideal scenario, team members from each of the four areas above can be recruited to build a customized, well-coordinated team around the mTBI rehabilitant. In so doing, the likelihood of facilitating a return to pre-injury function may be optimized from the onset of injury.

Based on the REAP model, four essential modules as listed below are recommended. However, as well as the team members,

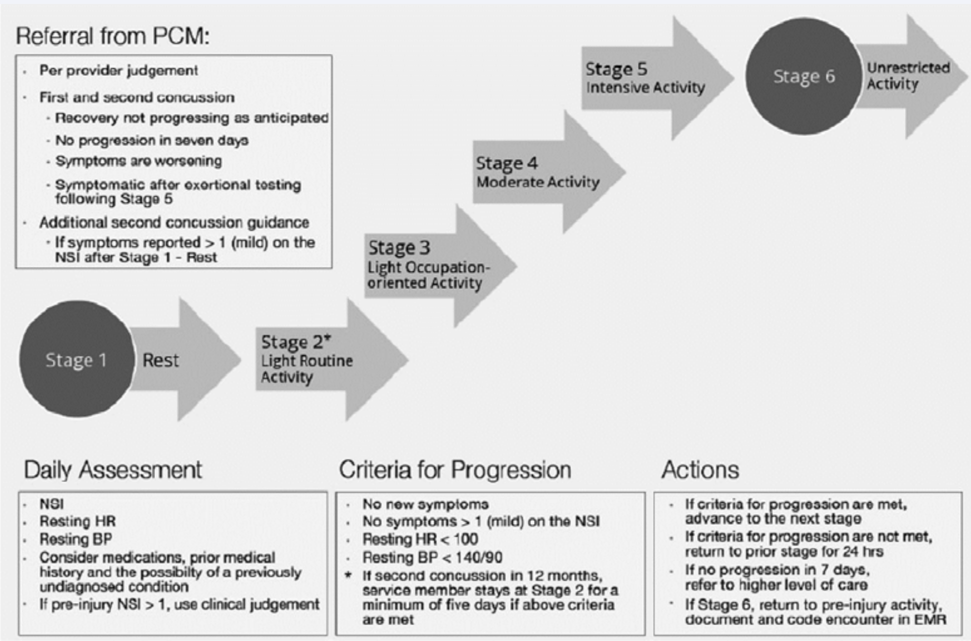

Figure 1 Rehabilitation provider diagram for mTBI physical rehabilitation according to McCulloch et al. (2015) [104]. Abbreviations: PCM, primary care manager; NSI, Neurobehavioral Symptom Inventory; HR, heart rate; BP, blood pressure; EMR, electronic medical record.

the modules have to be individually adjusted to meet patients' individual needs. The REAP modules are interdependent and include:

- Reduction: of the potential of further injury or stress to the brain by reducing physical and cognitive demands (e.g., modified duty and return-to-work/school programs; limited household chores; domestic aids).
- Education: of all team members including the rehabilitant. It is essential for all team members to know if and how the mTBI sufferer is recovering. Clear communication across the team members is key.
- Accommodation: Each area of concern may be accommodated in an individualized manner. Depending on the signs and symptoms, the environment, the time frame, the workload and the type of task may be modified as needed.
- Pace: The speed at which the rehabilitant returns is incremental. However, regressions and repeating steps should be expected in IED-related mTBI rehabilitants.

When composing the team and defining the modules, the following questions may be instructive: "What is the status quo in regards to rehabilitants' signs and symptoms, as well as the resources and the needs of the rehabilitant?", "Who will be on the team?", "Who will coordinate and manage the team?" "What tasks have to be solved by whom?" Such questions highlight the fact that managing a patient's recovery from an IED-related mTBI is a multifaceted, constantly changing process. Thus, each team member should be cognizant of the difficult challenges of managing the recovery from an IED-related mTBI and must remain fluid and flexible.

CONCLUSION

Following a traumatic event, such as an IED bombing, the patient may react with normal recurrent emotional and physical responses to the traumatic event. Emotional responses may include feelings of shock and disbelief, fear, sadness, helplessness, guilt, anger, shame, and relief [134]. Physical responses could be reflected by trembling, increased breathing and heart beat rate, the feeling of being choked up or a stomach tightening and cold sweats [135]. Psychological and physical responses following an IED bombing and possible concomitant injuries of various kinds may overshadow the recovery from mTBI. However, mTBI itself may influence the recovery from the traumatic event or from concomitant injuries in a deleterious manner if not diagnosed and managed properly.

Given, that the IED bombing survivor experienced the injury unexpectedly, likely in an emotionally charged manner, or possibly with concomitant, life-threatening injuries, the patient is at higher risk for persistent symptoms and poorer outcome following the IED-related mTBI [57-59]. Therefore, a multidisciplinary approach should be considered [60-64]. Multidisciplinary approaches can be organized in a twofold manner. First, an expert-based approach with a clinical focuses and second, a community-based approach with a focus on individual resource management [60-64,133,136]. Both approachescan be fruitfully applied in a combined manner to overcome unique challenges associated with the recovery and return to "normal" following an IED-related mTBI.

Limitations of the literature review

1. Despite the advances made in this review, it is not without limitations. First, although over 130 references were cited, we did not intend the review to be comprehensive in nature. Rather, we sought to provide a descriptive mini review of unique features characterizing IED-related mTBI injuries; to provide critical information for injury assessment and management among civilian health care providers, and to further delineate what rehabilitants and support providers may expect in terms ofthe recovery process. A second potential limitation is a methodological one and concerns recommendations about lifestyle modifications and rehabilitation measures to improve IED patients' recovery outcomes. To the best of our knowledge, this review was the first attempt to combine mTBI research in civilian, sports, and military settings and apply it to the specific situation of an IED-related mTBI in a civilian context. Although our recommendations were all based on evidenced-based findings, given the dearth of empirical work on IED-related mTBI, we necessarily had to base our recommendations on research findings taken from alternative – albeit related – contexts (i.e., military, competitive sport contexts, or non-IED civilian situations).Given the lack of empirical work on IED-related mTBI's in civilian settings, we are aware that caution is needed in making deductions about how best to manage and rehabilitate patients' incurring IED-related mTBI injuries based on findings from different contexts. As such, we advocate further scientific work on the optimal assessment and treatment strategies for IED-related mTBI injuries among civilians.

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