Introduction and Overview

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EXTRACTED FROM THE HFM-193 FINAL REPORT
WRITTEN BY ALL AUTHORS OF THE REPORT

2.1 NEED FOR A NATO STANDARD DEFINITION OF MILD TRAUMATIC BRAIN INJURY (MTBI)

2.1.1 Purpose

To present the need for a standard definition of MTBI among NATO countries.

2.1.2 The Challenge

Different consensus definitions of MTBI have been developed and published in the literature, including those by: the American College of Rehabilitation Medicine [6]; the Centers for Disease Control and Prevention (CDC) [7]; the World Health Organization (WHO) [8]; the National Athletic Trainer's Association [9]; the VA/DoD Clinical Practice Guidelines (2009) [5]; and, the Prague Sports Concussion Guidelines [10].

The WHO and CDC MTBI definitions have been most commonly used in research. The Unites States VA/DoD Clinical Practice Guidelines [5] adheres to these, and utilizes the characteristics of loss or alteration of consciousness, post-traumatic amnesia, and the absence of neuroimaging abnormalities. The Canadian Armed Forces has adopted a similar definition [4].

These definitions all endorse biomechanical forces as a cause of MTBI that result in an acute alteration of consciousness that includes: being dazed and confused, Loss Of Consciousness (LOC), or post-traumatic amnesia. All definitions provide maximum lengths of unconsciousness and post-traumatic amnesia in order to distinguish mild from moderate or severe TBI.

2.1.3 Relevance for NATO

In order to ensure optimal clinical care of military personnel who have sustained a MTBI whenever they are evaluated at any NATO medical facility, a common definition with agreed-upon clinical criteria is necessary. Having a common operational definition of MTBI is the basis of consistent case ascertainment, development of shared diagnostic assessment tools, clinical management strategies, and the ability to compare findings from scientific investigations.

2.2 BLAST-INDUCED INJURIES AND MTBI

2.2.1 Purpose

To present an overview of blast injuries and MTBI.

2.2.2 The Challenge

The relationship between explosive detonations and alterations in brain function has been a concern since World War I. Concerns have been raised about the ability to attribute symptoms to psychological reactions versus physical injuries.

The use of Improvised Explosive Devices (IEDs) by enemy combatants has resulted in a growing number of military service members and civilians having been exposed to blast waves and who suffer from the secondary, tertiary or quaternary effects of blast, in addition to injuries that are result of direct exposure to blast waves. Recent improvements in body and vehicle protection have resulted in decreased mortality but greater morbidity, including Traumatic Brain Injury (TBI).

MTBI accounts for the vast majority of documented TBI cases in the operational environment, and is often accompanied by stress and psychological trauma from the causative event. Most cases of MTBI have limited detectable structural brain lesions identified. However, advanced imaging techniques have detected structural brain lesions in more MTBI cases than earlier imaging techniques, and are promising. Some with MTBI have functional effects that last for a considerable amount of time; the underlying factors associated with chronic effects remain to be established. The physics of blast injury are different compared to non-blast trauma reported in the civilian setting [38].

One way to understand the effects of a blast wave is to divide the mechanism into:

- **Primary Effects of Blast:** The blast wave involves supersonic pressure changes over a very short time frame. The threshold for injuries is determined by factors such as peak pressure, duration and shape of the blast wave (reflections, underpressure, etc.). The effects of blast on organs such as the lungs and ears are well known, but the potential effects on the central nervous system are still being studied.
- **Secondary Effects of Blast:** The blast wave can generate flying objects, such as shrapnel fragments, which can cause penetrating and blunt force injuries.
- **Tertiary Effects of Blast:** The blast wave can cause the individual to be physically moved. Such acceleration movements can result in tissue shearing and diffuse injuries within the brain, such as Diffuse Axonal Injuries (DAI) in nerve fiber tracts.
- **Quaternary Effects of Blast:** Quaternary effects are due to heat, smoke (involving toxins) or emission of electromagnetic pulses. There is no evidence for negative effects of electromagnetic pulses on the central nervous system at present.

2.2.3 Relevance for NATO

The majority of battlefield MTBI cases are due to one or more of these blast injury mechanisms, e.g., blast wave pressure combined with flying objects or acceleration movements. However, data on the characteristics of blast exposure are usually not available. Blast-related TBI resulting in brain edema and vascular spasm should be assumed to be the result of a combination of more than one blast injury mechanism.

There is not enough information to determine whether a primary blast alone can induce MTBI or if other blast injury components are required. Experimental studies have revealed functional changes in animals, but the translation of experimental research is not yet sufficient to conclude that similar functional changes result in the development of clinical symptoms of MTBI, post-traumatic stress disorder or other clinical conditions in humans.

2.3 CONSEQUENCES OF MTBI ON MILITARY OPERATIONS

2.3.1 Purpose

To present an overview of the consequences of MTBI on operational readiness, individual and family functioning, and health-care delivery systems.

2.3.2 The Challenge

MTBI is a military relevant issue due to its incidence and prevalence both in deployed and non-deployed settings. Although blast is frequently the precipitating event resulting in TBI in current NATO conflicts, other mechanisms such as falls, falling debris, sports injuries and motor vehicle crashes also occur and must be taken into account.

Acutely, symptoms from MTBI may impact operational readiness of the individual or unit. In most cases, the acute effects are of short duration, but an important minority of individuals with MTBI have a prolonged course of recovery. Consequences of MTBI impact the health of individuals in the short term, can affect their ability to remain in theatre, and potentially affect their ability to deploy in the future if symptoms fail to resolve.

Failure to identify or recognize individuals who are impaired as a result of MTBI can have serious consequences for them, their comrades, and the mission. Programs and policies that are implemented to manage MTBI have the potential to impact the military operation in a positive or negative way. Positive impacts include appropriate early identification of injured personnel. Potential negative effects include unnecessary removal of personnel from operational duties.

From a societal perspective, the way the military deals with MTBI may influence public perception of the military commitment to the care of service members. This, in turn, may influence public and individual resolve to remain in the fight.

2.3.3 Relevance for NATO

There is considerable variability in how NATO Nations have chosen to approach this issue. To some extent, this may be due to national variability in the nature and duration of deployments as well as the number of service members deployed. Ultimately, a sound approach should be informed by evidence relevant to each Nation's forces. Decisions about the implementation of programs, policies and guidelines should be guided by such results and aided by the use of sound public health organizing frameworks.

Evidence-based public health policy is best served by the use of an evaluation framework such as Population Impact Analysis [39]. Such organizing frameworks can be used to apply evidence when estimating the impact of program and policy implementation.

2.4 RETURN-TO-DUTY CONSIDERATIONS IN THOSE WITH A CLINICAL DIAGNOSIS OF MTBI

2.4.1 Purpose

To present an overview of the need to establish objective Return-To-Duty (RTD) criteria.

2.4.2 The Challenge

MTBI is increasingly recognized in sports medicine where significant focus has been placed on evaluation of injured athletes with specific criteria for return to play. Evidence-based RTD criteria are essential for injured military personnel in deployed environments. MTBI affects both mission readiness and individual health. Consideration of the cumulative impact of multiple concussions should be included in the RTD decision-making process.

2.4.3 Return-to-Duty Considerations

There is no single established objective criterion for RTD, nor validated tools with which to guide RTD decision making in military operational settings. The following factors may be considered in RTD decisions:

- **Symptoms –** The absence of symptoms is widely accepted as minimal criteria for RTD.
- **Physical Examination –** Physical examination, which includes a neurological exam, should be normal prior to RTD.
- **Concussion History –** The number, severity, and recency of prior concussions should factor into RTD considerations.
- **Exertional Testing –** Exertional testing [4], [5] with symptom monitoring can inform RTD determination:
  1) Exert to 65 – 85 % of target heart rate (THR = 220-age) using push-ups, sit-ups, running place, step aerobics, stationary bike, treadmill and/or hand crank;
  2) Maintain this level of exertion for approximately 2 minutes;
  3) Assess for symptoms (headache, vertigo, photophobia, balance, dizziness, nausea, visual changes etc.); and
  4) If symptoms exist with exertional testing, stop testing, and allow additional time for rest and recovery until asymptomatic.
- **Cognitive Testing –** Quick assessment tools (Standardized Assessment of Concussion [SAC], Military Acute Concussion Evaluation [MACE]) and/or more detailed neurocognitive testing in the appropriate settings may aid in RTD determinations.

Other technologies, such as neuroimaging, biomarkers, etc., have yet to demonstrate sufficient sensitivity and specificity for routine use in RTD determinations.

2.4.4 Relevance for NATO

The development of comprehensive policies and practices regarding RTD determination after MTBI is essential to promote mission readiness and enforces a standard and consistent approach to RTD.

At a minimum, those policies should consider criteria identified above.

2.5 TOWARDS A GOLD STANDARD FOR MTBI DIAGNOSIS

2.5.1 Purpose

To present an overview of the need for gold standard clinical and biomarker assessments for MTBI diagnosis.

2.5.2 The Challenge

The diagnosis of MTBI currently relies on clinical characteristics at the time of injury. In a military operational setting, acute evaluation at the time of injury is not always feasible and therefore the diagnosis is often made based on retrospective self-report or witness report of those clinical characteristics. In addition, polytrauma or acute stress associated with a life threatening combat event may confound the diagnosis of a MTBI.

Early identification and diagnosis of MTBI allows for early intervention and improved outcomes. Therefore, objective diagnostic tools, particularly those that can be used near the point of injury, are of great interest.

A gold standard diagnostic tool is one of known validity and reliability which is generally accepted to be the best available, against which new tests or results and protocols are compared [40]. The current approach to MTBI diagnosis relies on a comprehensive history of the injury event and immediate symptoms that follow, and physical examination including neurologic and cognitive assessments. There are currently no validated tests to objectively diagnose MTBI.

Potential objective diagnostic tools may be categorized as follows:

- Advanced neuroimaging techniques (such as MRI diffusion tensor imaging, PET-CT, high-resolution fiber tracking, etc.);
- Blood biomarkers;
- Electrophysiologic markers (such as quantitative EEG, event-related potentials);
- Measures of cerebral blood flow and intracranial pressure;
- Neurocognitive assessments; and
- Sensory assessment tools (olfaction, auditory, vestibular).

2.5.3 Relevance for NATO

Currently, the gold standard for making a diagnosis of MTBI relies exclusively on clinical characteristics and clinical evaluations. Objective diagnostic tools such as advanced neuroimaging techniques, blood biomarkers, electrophysiologic markers, neurocognitive assessments, and sensory assessment tools hold promise singularly or in combination, but require additional research to validate their sensitivity, specificity, and reliability, and demonstrate practicality before they can be considered a standard of care.

An agreed-upon diagnostic strategy among NATO Nations would allow for a common understanding and would help coordinate future research, surveillance, and evaluation of deployment health outcomes.

2.6 ASSESSMENT AND MANAGEMENT OF MTBI IN MILITARY OPERATIONAL SETTINGS

2.6.1 Purpose

To present issues related to the assessment and management of MTBI in military operational settings.

2.6.2 The Challenge

There is a paucity of scientific evidence related to the assessment and management of MTBI. Most of the available literature is based on civilian cohorts that were not randomized, controlled studies. There are many ongoing research studies being conducted within military populations. Policy and clinical guidance about MTBI assessment and treatment vary considerably among NATO Nations. Early detection facilitates successful resolution of symptoms and optimal management [41]-[43]. Therefore, the need for validated assessment tools and effective treatments remain a priority.

Common assessments used after MTBI in the deployed setting include the following:

- History, physical and neurological examination, symptom screening;
- Military Acute Concussion Evaluation (MACE);
- Neurobehavioral Symptom Inventory (NSI);
- Automated Neuropsychological Assessment Metrics (ANAM);
- Immediate Post-concussion Assessment and Cognitive Testing (ImPACT); and
- Glasgow Coma Scale (GCS).

2.6.3 Relevance for NATO

Adopting a NATO standardized approach to assessment and management will optimize care. The mainstay of treatment remains early education and rest until recovery. The use of validated assessment tools and effective treatments for MTBI will support best care practices known at this time. In addition, this information can be leveraged to help further the development of validated assessment tools used in MTBI, as well as effective treatments.

2.7 THE RELATIONSHIP BETWEEN MTBI AND POST-TRAUMATIC STRESS DISORDER

2.7.1 Purpose

To address the relationship between MTBI and PTSD.

2.7.2 The Challenge

The relationship between MTBI and PTSD is not fully understood. There is no universally accepted objective diagnostic standard for either condition, although there is significant overlap in symptom presentation. Due to this overlap in symptoms, there is ambiguity about attribution of persistent symptoms to MTBI or PTSD.

The majority of people (approximately 85 – 90 %) in civilian sports populations who experience MTBI fully recover with no residual symptoms within 3 months [44]. However, a small portion of patients experience Persistent Post-Concussive Symptoms (PPCS) lasting more than six months. This sub-set often has co-occurring mental health conditions, such as anxiety, depression, or PTSD, that may delay recovery and require specific treatment. Exposure to a life threatening event (i.e., combat) may pre-dispose individuals to developing acute stress reaction, PTSD, or other mental health disorders.

Post-concussive symptoms are not specific to MTBI. These symptoms occur as part of various conditions, including PTSD, although it should be noted that flashbacks are not a symptom of MTBI, and neurocognitive problems are not a common symptom of PTSD.

PTSD is commonly diagnosed in military populations following combat deployments. PTSD is defined as a stress-related disorder that may develop after an individual experiences a traumatic event, such as threat of death to oneself or to someone else, or damage to one's own or someone else's physical, sexual, or psychological integrity.

It is manifested by frequent re-experiencing of the trauma, through flashbacks or nightmares, avoidance of stimuli associated with the trauma and increased arousal (resulting in sleep problems and irritability) that last longer than 1 month.

Early identification and treatment for PTSD leads to better outcomes. Current scientific evidence supports trauma-focused Cognitive Behavioral Therapy (CBT) and eye movement desensitization reprogramming therapies, and may be supported by medication.

2.7.3 Relevance for NATO

Given the overlap between PTSD and MTBI symptoms, an interdisciplinary team evaluation may be considered an essential component of a comprehensive clinical evaluation for anyone who has PPCS. Knowledge of both diagnoses is critical to ensure appropriate health-care for military personnel.

It should be stressed that the majority of people who sustain a blow or jolt to the head do not develop PTSD. The majority of people who develop PTSD have not sustained a blow or jolt to the head.

Military health-care providers need to be aware of and should consider screening for the presence of PTSD in patients with a history of MTBI who present with persistent symptoms.

Numerous studies are under way to elucidate the neuropathological, neuropsychological, and neurochemical changes that may distinguish between these two military relevant conditions.

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