Persistent Symptoms Following Mild Traumatic Brain Injury (mTBI) – A Resource for Clinicians and Staff

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Executive Summary

Persistent and even disabling symptoms may occur in some Veterans who report prior concussion (mTBI, minor traumatic brain injury). Although mTBI is not a new concept, the recognition, assessment and treatment of persistent symptoms can be challenging and require a coordinated approach. The Research Directorate prepared this report as a resource for clinicians and staff developing services for Veterans with persistent symptoms after concussion.

1. "mTBI" means "mild traumatic brain injury" or concussion. mTBI occurs in mild head injury where there is transient altered mental status ranging from being briefly stunned to a few minutes of loss of consciousness. mTBI and concussion are used interchangeably to describe the initial event, not subsequent symptoms.
2. Concussion (mTBI) is not a new medical problem.
3. mTBI (concussion) is caused by <u>physical</u> trauma, not psychological trauma.
4. Military mTBI is topical because (1) The risk of concussion is more common in Afghanistan and Iraq than everyday life, typical of all wars; (2) Limited evidence from the U.S. suggests that 10-20% of their combat troops experienced mTBI during deployment; (3) There is unproven concern that pure blast energy from ambush weapons common in the Middle East may cause mTBI; (4) Persistent symptoms long after concussion are controversial, can be very disabling in an important

minority, can be difficult to recognize, and require coordinated assessment and treatment; and (5) More people have become aware of long-standing concerns about concussion.

5. Based on civilian experience, most people recover from concussion within 7-10 days and the majority by three months. At one year, a minority report variable persistent symptoms causing various degrees of disability. In those with persistent symptoms, healing continues long after.
6. Persistent symptoms that may be reported after mTBI are of three types: somatic (physical), psychological (emotional and behavioural) and cognitive (thinking).
7. Persistent symptoms are not specific to brain injury, meaning they could be caused by a variety of mental and physical health conditions.
8. It is not known to what degree symptoms reported long after an mTBI are due to the brain injury. Since shell shock in the First World War, researchers have been trying to figure out whether psychological symptoms after an mTBI are caused by the brain injury, or by psychological mechanisms not related to brain injury, or some combination.
9. Diagnosis is based on a credible timeline of clinical findings from the point of the mTBI. No diagnostic test proves with certainty that brain injury is the cause of late symptoms after an mTBI. CT and MRI scanning typically are not required in the assessment of stable persistent symptoms. Neuropsychological testing may be indicated when cognitive deficit is suspected.
10. Unlike civilians, battlefield soldiers are more likely to be exposed to significant psychological stress at the time of concussion. Symptoms of OSIs (operational stress injuries[1]) and psychiatric conditions overlap with symptoms that may be reported after mTBI.
11. Research into new tools for examining the brain at the cellular level where axonal injury and damage occurs are improving our understanding of concussion and may lead to development of better diagnostic tests. Such tools include advanced neuroradiology, electroencephalography and biochemical markers, however they are not ready for routine clinical use.
12. Regardless of whether concussion is proven to be the cause of subsequent disabling symptoms, standard symptom treatments appear to be effective.
13. Assessment and treatment of persistent symptoms may be best provided by a primary care provider working with an integrated team capable of managing the somatic, psychological and cognitive symptoms that are characteristic of persistent disability following concussion.

[1] "An Operational Stress Injury (OSI) is any persistent psychological difficulty resulting from operational duties performed while serving in the Canadian military. It is used to describe a broad range of problems which include diagnosed medical conditions such as anxiety disorders, depression and post traumatic stress disorder (PTSD) as well as other conditions that may be less severe, but still interfere with daily functioning." http://www.vac-acc.gc.ca/clients/sub.cfm?source=mhealth/definition

Introduction

"TBI" means traumatic brain injury, a form of ABI (acquired brain injury). "mTBI" means mild traumatic brain injury, or concussion. mTBI (concussion) is not a new condition. All forms of TBI including concussion have long been familiar to physicians and other health care providers. mTBI is more common than moderate or severe traumatic brain injury in civilian and military settings.

Early in the 20th century it was thought that concussion was largely benign, though some clinicians did wonder whether it could cause persistent symptoms (Peerless and Rewcastle 1968). Civilian mTBI research intensified in the 1960s, particularly related to sports concussion (Hugenholtz and Richard 1982). Although the majority who suffer a concussion recover without persistent disability, there is valid concern that the consequences of concussion may not be benign for some (Iverson 2005, Holm et al 2005, IOM 2006). Research is under way to resolve questions about mTBI epidemiology, diagnosis, treatment and life course management, especially for military populations.

Clearly, there is increased risk of concussion in the Afghanistan and Iraq wars, as in all wars (IOM 2006). Other issues surrounding mTBI are less clear. Symptoms reported after an mTBI are not specific to a brain injury, making it difficult to be certain that brain damage is the cause. Heavy use of explosive ambush weapons in the Middle East is leading to more soldiers being exposed to blast mechanisms of injury (Warden 2005). There is controversy about the degree to which blast energy may cause brain injury in the absence of other injuries (Bell 2008). Some victims, families and health care providers may not be familiar with the recognition and treatment of symptoms that may arise after an mTBI (IOM 2006). Fortunately, experienced clinicians feel that enough is known to provide effective treatment for symptoms that may persist after concussion, whether or not it can be proven that an mTBI is the cause in every case.

Canadian researchers have been at the forefront of brain injury research since World War I (e.g. Evans 1966, Iverson 2005, Teasell et al 2007). Health care providers have been concerned about the public health impact of brain injury since at least the 1960s. Civilian brain injury rehabilitation treatment and research centers are well established in cities across Canada. Lay brain injury societies and associations have organized in all Canadian provinces, most cities and many towns.

This document is about persistent disability following an mTBI in Veterans. The Veterans Affairs Canada Research Directorate offers this information to assist development of services responding to the needs of Veterans who may have persistent symptoms after concussion.

Evidence Base

In 1950, Richardson summarized what was known about the effects of brain injury, telling a psychiatric conference in Halifax that "*…late effects of head injury present very common problems of diagnosis and treatment and we are often hard pressed to give*

satisfactory accurate opinions to workmen's compensation boards, pensions commissions, lawyers (and) … the patients themselves" (Richardson 1951). Up to that point, most effort had been on understanding moderate to severe brain injury. Since then more has been learned about moderate to severe brain injury (Teasell et al 2007), and there has been increased attention on mild traumatic brain injury (concussion).

In 2005, Iverson (2005) reported that the mTBI literature was large, complex, methodologically limited and controversial, a caution reported by others (Carroll et al 2004b, Cassidy et al 2004, Holms et al 2005, French and Parkinson 2008). The World Health Organization's Collaborating Centre for Neurotrauma Task Force on Mild Traumatic Brain Injury critically analyzed the world's scientific literature on mTBI during the four years prior to the 2003 Iraq invasion (Holm et al 2005, Peloso et al 2004b). Their systematic search of the literature produced 38,806 references. Of the 743 studies found to be relevant, only 313 were scientifically acceptable. They found important gaps in peer-reviewed published scientific knowledge for many aspects of mTBI, including pathophysiology, proof that post concussive symptoms are due to mTBI, utility of diagnostic tests, and evidence for treatments. In spite of intense research effort spanning decades, many theories about mTBI (concussion) remain unproven.

There is consensus from several lines of evidence that cellular-level cascades lead to brain tissue damage in moderate to severe head injury (Park et al. 2008, Lux 2007). Whether or the degree to which this occurs in mild head injury and may account for persistent symptoms after concussion remains unproven (Iverson 2005, French and Parkinson 2008, U.K. MoD 2008). Limited evidence for pure blast energy as a primary cause of mTBI appears sufficient to support further research and prudent clinical care but insufficient for proof (Taber et al. 2006). Broad clinical experience suggests that recovery after brain injury continues for years if symptoms persist, however the pathophysiology of this late phase remains unproven.

Well-designed, prospective epidemiological studies of the natural history of concussion are still needed, especially in military populations. Symptoms reported after mTBI are non-specific, and techniques for diagnosing whether mTBI may be the cause are still being developed. Many treatments are not based on peer-reviewed published evidence, owing to research difficulties (Holm et al 2005). Less evidence is available about interventions for families affected by a member with acquired brain injury (Boschen et al 2007). In the absence of sufficient evidence, expert opinion fills many gaps. Experienced clinicians believe that effective treatments are available when disabling symptoms persist after an mTBI, whether or not concussion can be proven as the cause.

This analysis is based on rapid critical appraisal of key scientific publications; consensus opinions of expert panels convened by the Canadian, U.K. (U.K. MoD 2008) and U.S. (DVBIC 2006) military; professional meetings attended by the author in Baltimore, Washington DC, Australia, Winnipeg, Halifax and Montreal during 2007-08; ongoing correspondence with experts in several countries; and the author's clinical experience managing head injuries.

Why is mTBI Topical Right Now?

- mTBI (concussion) is not a new thing. TBI has been a public health concern for decades. As did sports concussion in the 1990s, the war in Afghanistan and Iraq has again brought mTBI into public awareness, so many who were previously unfamiliar with the term are searching for more information.
- mTBI (concussion) has long been a challenging public health issue. The following points are discussed in more detail later in this report:
    - Many who suffer from a concussion do not seek medical help at the time of injury.
    - The definitions of “mTBI” and “concussion” continue to be controversial.
    - After an mTBI, an important minority of persons report subsequent symptoms and difficulties with jobs, relationships, community life and recreation.
    - Symptoms reported after mTBI are nonspecific, meaning other physical and mental health causes could explain them.
    - Symptoms may be subtle, especially cognitive problems.
    - Some persons may have symptoms that are not easily recognized by themselves or others as possibly being due to an mTBI.
    - No diagnostic test confirms with certainty that mTBI-induced brain damage is the cause of post-mTBI symptoms.
    - Treatment of persistent symptoms after concussion is more effective when provided by a health care provider team capable of managing the full range of somatic, psychological and cognitive issues that may be reported after brain injury, but organizing such teamwork is challenging.
- As in past wars, the risk of TBI is more common among combat troops in Afghanistan and Iraq than among civilians at home. This is not unexpected, given exposure to mechanisms of head injury in combat theatres.
- Blast is an uncommon mechanism of injury in peacetime civilian trauma. Conversely, blast from ambush explosives is a common mechanism of injury among combat troops in the Middle East. There is controversial concern that pure blast energy may cause an mTBI without associated injuries in other body parts, raising concern that soldiers may be experiencing undiagnosed mTBI as a result of blast exposure (Warden 2006, U.K. MoD 2008, DVBIC 2006).
- Unlike a civilian experiencing concussion, a combat solider is more likely to be affected at the same time as concussion by exposure to high psychological stress (Holm et al 2005, Lew et al. 2008). Operational Stress Injuries such as PTSD (post traumatic stress disorder) have symptoms that also may be experienced after an mTBI, making it difficult to determine whether an mTBI or a psychiatric condition is the cause of persistent symptoms (Lew et al 2008).

Definitions

- There are several definitions for both mild traumatic brain injury and concussion, none universally accepted (Cassidy et al 2004).
- Peerless and Rewcastle (1968) noted that Bell described "concussion or commotion of the brain" this way in 1801: "*Every affection of the head attended with stupefaction … consequence of external violence … no mark of injury … supposed to proceed from commotion or concussion of the brain … derangement of this organ as obstructs its natural and usual functions, without producing such obvious effects on it …*". The concept appears to predate Bell, perhaps by centuries.
- Since the 1960s, head injury has been categorized as mild, moderate or severe depending on the degree of altered mental status, amnesia and other symptoms and signs present at the time of injury. This categorization does not necessarily predict subsequent complications or degree of disability for all individuals, but in general it works to estimate risk in a general way. There has been no clear consensus for a single set of criteria.
- Not all head injuries cause a brain injury. If there are clear signs or symptoms that the brain was affected at the time of the head injury, there is consensus that the brain was at least transiently injured. Not all brain injuries cause significant persistent brain damage. Not all symptoms after brain injury are necessarily due to brain damage.
- TBI may occur as a result of closed or penetrating head injuries. "Concussion" (mTBI) usually refers to closed head injuries, which are more common than penetrating head injuries in civilian and military populations.
- Concussion is used interchangeably with mTBI (Iverson 2005).
- In 1993, the American Congress of Rehabilitation Medicine published this definition of mild traumatic brain injury (ACR 1993):
    - Traumatically induced physiological disruption of brain function manifested by at least one of:
        - Any period of loss of consciousness;
        - Any loss of memory for events immediately before or after the accident;
        - Any alteration of mental state at the time of the accident (eg, feeling dazed, disoriented or confused; and
        - Focal neurological deficit(s) that may or may not be transient.
    - But where the severity of the injury does not exceed:
        - 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.

- Reporting on the 2nd International Conference on Concussion in Sport held in Prague during 2004 McCrory et al (2005) wrote that the consensus was to define sports concussion this way:
    - Complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces (physical forces).
    - Typically results in rapid onset of short-lived impairment of neurologic function that resolves spontaneously.
    - May result in neuropathological changes where the acute symptoms largely reflect functional disturbance rather than structural injury [meaning, I think, that structural CT and MRI may not detect abnormalities occurring at the cellular level – JT].
    - Results in acute syndromes that may or may not include loss of consciousness.
    - Resolution follows a sequential course.
    - Structural neuroimaging studies typically are normal.
    - In some cases, post-concussive symptoms may be persistent.

  The Conference further defined sports concussion as "simple" when symptoms resolved fully in 7-10 days, and "complex" when the person had persistent symptoms, prolonged cognitive impairment, or certain specific features such as convulsions or loss of consciousness greater than one minute.

- The World Health Organization (Holm et al 2005, UK DoD 2008) uses this definition:

  (a) An acute brain injury resulting from mechanical energy to the head from external physical forces. Operational criteria for clinical identification include:
  (1) One or more of the following:
  - Confusion or disorientation,
  - Loss of Consciousness for 30 minutes or less.
  - Post-traumatic amnesia for less than 24 hours, and /or
  - Other transient neurological abnormalities such as focal signs, seizures and intracranial lesion not requiring surgery;

  (2) GCS score of 13-15 after 30 minutes post injury or later upon presentation for health care
  (b) These manifestations of mTBI must not be due to drugs, alcohol, medications, caused by other injuries or treatment for other injuries (eg systemic injuries, facial injuries or intubation), caused by other problems (eg psychological trauma, language barrier or co-existing medical conditions) or caused by penetrating craniocerebral injury.

- The Defense and Veterans Brain Injury Center (DVBIC) at the Walter Reed Army Hospital Medical Center defined mTBI this way (DVBIC 2006):

  Mild TBI in military operational settings is …

  - Injury to the brain;

- Resulting from an external force and/or acceleration/deceleration mechanism including blast, fall, direct impact, or motor vehicle accident;
- Causing alteration in mental status including:
    - Loss of consciousness (LOC),
    - Amnesia (memory loss), either for the event, or post-traumatic amnesia (PTA), or retrograde amnesia (RGA),
    - Or being dazed or confused;
- Resulting in temporally related onset of symptoms such as headache, nausea, vomiting, dizziness/balance problems, fatigue, insomnia/sleep disturbances, drowsiness, sensitivity to light/ noise, blurred vision, difficulty remembering, and/or difficulty concentrating.

The DVBIC brain injury categories are:

- (Note: Minimal head injuries would be those where no discernible brain injury occurred, i.e. no LOC, no PTA and normal GCS.)
- Mild: LOC < 1 hr, PTA < 24 hrs, GCS 13-15.
- Moderate: LOC 1-24 hrs, PTA 24 hrs - 7 days, GCS 9-13.
- Severe: LOC > 24 hrs, PTA >= 7 days, GCS 3-8.

- As can be seen in these definitions, complete loss of consciousness is not required for concussion (mTBI).
- ICD (International Classification of Diseases) criteria for Post Concussion Syndrome and DSM (Diagnostic and Statistical Manual) criteria for Postconcussional Disorder are still being validated and researched. The etiology (cause) of these conditions has not been proven (Iverson 2005).
- ICD criteria have a lower threshold for defining mTBI that may cause post concussion states than do DSM criteria. The DSM criteria require loss of consciousness, but the ICD criteria more generously allow for transient altered mental status. There is consensus that transient altered mental status at the time of head injury signals brain injury. The ICD criteria also allow for symptom preoccupation to point of hypochondriasis.
- There is inconsistency in how the terms “concussion”, “brain injury”, “mTBI” and “brain damage” are used in informing patients and the public owing to concerns about iatrogenic stress and symptom attribution (Iverson 2005). Some experts argue that concussion and mTBI should be reserved for the acute event, and that “concussion” is a better term to use because it is more familiar to most and is less like to carry connotations of permanent damage.

mTBI Causes

- mTBI (concussion) is caused by <u>physical</u> trauma, <u>not psychological</u> trauma.
- Because the brain is jelly-like, it is prone to injury when it jiggles inside the skull during trauma.

- In both the civilian world and military service, TBI most commonly occurs when the brain is affected by an object striking the head, the head striking an object, or sudden deceleration/acceleration (IOM 2006, Pickett et al 2001). Motor vehicle accidents and falls are the most common mechanisms (Cassidy et al 2004).
- As in the U.S. (IOM 2006, AFHSC 2006, Warden 2006),TBI occurs among members of the military in Canada and overseas, and in training, recreation, off duty and combat. It is more common among the military than among civilians (Warden 2006).
- Damage to brain tissue may occur from a variety of acquired brain injury causes other than physical trauma, including stroke, infection, toxins, lack of oxygen, nutritional deficiency, substance abuse, lack of sufficient blood supply, and other factors.
- There is concern that multiple mTBI exposures may be additive, although proof is lacking (French and Parkinson 2008).

mTBI Pathology

- Brain injuries may be “focal” meaning only specific areas of the brain are affected, or “diffuse” meaning broad areas are affected.
- Examples of focal injuries include brain hemorrhages (bleeds), lacerations, contusions (bruises), but these are more likely in more severe head injuries than in concussion. Acute structural injuries that may occur in mTBI include bleeding (hemorrhages), contusions (bruises), abrasions, and lacerations (Lux 2007). These are much more likely with more severe head injury than concussion.
- In a concussion (mTBI), the most common injury is thought to be diffuse axonal injury, meaning simultaneous injury to many axons at once (Fleming 2004, Lux 2007). Axons are thin communicating projections from one brain cell to another.
- Although axonal injury is diffuse, it is not necessarily homogeneous, meaning different parts of the brain may be affected (Lux 2007). Some parts of the brain seem to be more susceptible in concussion than others, for example frontal and temporal areas of the cortex (Ptito et al 2007).
- Just as when a person injures their arm by bumping into a door, a mild traumatic brain injury usually heals with no apparent ill effects (Lux 2007). The question is whether and to what degree persistent damage occurs that may explain persistent symptoms after concussion (Iverson 2005, Park 2008).
- Although it is accepted that moderate to severe brain injury is associated with a complex cascade of biochemical changes that may lead to axon breakage (Park et al 2008), and it is suspected that this also occurs in concussion (Iverson 2005), it has not been proven (McCrory et al 2005).
- The hypothesis is that sometimes injured axons eventually break, persistently disrupting cell-to-cell communication, affecting brain function (Park et al 2008, Lux 2007, Iverson 2005).

- Since shell shock in the First World War, researchers have been trying to figure out whether psychological symptoms after an mTBI are caused by tissue damage, or by psychological mechanisms not related to brain injury, or some combination (Jones et al 2007, Jones 2008). New tools allow researchers to peer into TBI at the brain cell level, for example by measuring blood and cerebrospinal fluid chemicals in days and weeks after brain injury, and by using advanced neuroradiological techniques such as functional magnetic resonance imaging (fMRI), PET and SPECT.
- In sport concussion, functional magnetic resonance imaging is demonstrating changes whether or not structural abnormalities are apparent (Chen et al 2008). This new type of evidence may be beginning to support the long-standing clinical impression that some symptoms following concussion may have a structural basis.
- Persistent symptoms after concussion are not forever. Experienced clinicians and head-injured patients note that recovery seems to go on for years after moderate to severe brain injuries, and there have been similar reports for post concussion symptoms (Rees and Bellon 2007). The hypotheses are that perhaps some nerve cell regeneration might occur, and/or that undamaged parts of the brain are able to compensate for damaged neurons.
- Contrary to popular belief, the brain may be able to heal. Adult brain contains stem cells shown in the laboratory to be capable of generating into the brain's three major cell types: astrocytes, oligodendrocytes and neurons (http://stemcells.nih.gov/info/basics/basics4.asp). University of Calgary researchers are among those credited with discovering brain stem cells in the 1990s (Weiss et al 1996).
- Neurological healing starts soon after the acute brain injury (Iverson 2005). Healing appears to continue even in those with long-lasting symptoms, though the cause of persistence and therefore healing remains unclear (Iverson 2005).
- Worsening any time after a brain injury triggers a search for a new problem.

Blast Injury

- Blast is a rare mechanism of injury in civilian life, but is common in Afghanistan and Iraq owing to the use of explosive ambush weapons (Nechaev et al. 1991, Warden 2005, DePalma et al 2005).
- Blast produces supersonic high pressure waves, heat, and wind related to underpressurization after passage of the blast waves (DePalma et al 2005). Blast may damage a person in five ways (U.S. DoD 2006):

  Primary – Direct tissue damage from supersonic shock wave passage through the body of the high pressure blast wave.
  Secondary – Blunt and penetrating force effects from primary and secondary fragments.
  Tertiary – Blunt and penetrating force effects as the body is struck or thrown by underpressurization air movements (wind).

Quaternary – Burn and inhalation injuries.
Quinary – Post-blast environmental contaminants: infection, toxins, radiation.

- Blast energy dissipates exponentially (rapidly) with distance (DePalma et al 2005). Blast dose is highly variable owing to distance from the detonation, height above ground, body position, the presence of barriers between the person and the detonation, and other factors.
- Very severe blast exposure typically causes damage to multiple organs (polytrauma), including transient apnea and cardiac arrhythmia, blast lung, delayed gastrointestinal tract injury, tympanic membrane rupture, eye injury, and multiple blunt force injuries to the head, thorax, abdomen and extremities, sometimes leading to extremity amputation (DePalma et al 2005).
- Brain injury experts who work with blast victims think that lesser but sufficient pure blast energy may cause mTBI without other injuries, however proof is lacking (Bell 2008, Taber et al 2006). Evidence favouring the hypothesis comes from animal studies, a few human case reports, and biological arguments. This question is being actively researched in Canada, the U.S. and elsewhere.
- In the absence of contrary evidence, it is prudent to presume that primary blast may cause concussion similar to blunt force concussion.
- The U.S. Centers for Disease Control posted information on blast for professionals at this website: http://www.bt.cdc.gov/masscasualties/blastinjuryfacts.asp.

Symptoms

- Based largely on civilian experience with sports injuries (McCrory et al 2005, Iversen 2005), a person may look blank and confused at the time of concussion. Some may lose consciousness completely for a short time. They may stumble around for a short time, seem uncoordinated, and appear confused. These initial signs usually pass rapidly. The person may later describe concussion as a momentary feeling of being stunned, dazed, “having their bell rung”, “having their computer reboot” or blacking out, or they may not remember the event. They may have headache, balance problems, ringing in the ears, flashing visual lights (“seeing stars”), irritability, or brief nausea. These symptoms usually pass quickly (McCrea 2008). Many persons with concussion feel better in 2-3 days, but in simple concussion symptoms may be provoked by exertion, typically until resolution in about 7-10 days (Iverson 2005).
- Based on civilian studies, the cognitive and neurobehavioral consequences of concussion are self-limited in most (Carroll et al. 2004, Iverson 2005). Symptoms and cognitive impairment fully resolve in the majority of people by 7-10 days (McCrea 2008, Iverson 2005). A minority report persistent symptoms after concussion, but most are resolved in 1-3 months (Carroll et al 2004). Symptoms may persist after a concussion in some persons, however the cause is unclear (Carroll et al 2004, Lux 2007, Iverson 2005). A small number may have

symptoms for longer periods, and fewer are very affected (Iverson 2005, Holm et al 2005, U.K. MoD 2008).

- The effects of an mTBI vary from person to person, though there is a fairly predictable course and common set of symptoms (IOM 2006, Iverson 2005).
- Potential post concussion symptoms group into three categories. These symptoms do not all occur to the same degree in all patients:
    1. Somatic (physical): Headache, dizziness, hearing problems, visual disturbances, sensitivity to noise or light, sleep disturbance and emotional or mental fatigue. While those are the most common, certain brain injuries might cause specific (focal) problems depending on the part of the brain injured, such as limb or facial paralysis, speech problems and a variety of other central nervous symptom disorders.
    2. Cognitive (thinking): Problems with thinking, making decisions, memory, attention and concentration, abstract reasoning and information processing.
    3. Psychological (emotional and behavioural): Depression, anxiety, mood swings, irritability, impulsiveness, loss of interest, agitation and relationship difficulties.
- The brain appears to have abilities to heal from acute mTBI, but it is hypothesized that in some cases its healing ability can be overwhelmed, leading to brain changes that may result in functional problems and take longer to heal (Lux 2007, Iverson 2005).
- The degree to which persistent symptoms are due to an mTBI remains controversial (Carroll et al 2004, Iversen 2005, Holm et al 2005, Willer and Leddy 2006), but clinicians have long been suspicious (Richardson 1951, French and Parkinson 2008). Estimates of longer term prevalence of post concussion symptoms reported after concussion range from as high as 20% or more to as low as 5% or less, depending on definitions and research methodology used (IOM 2006, McCrea 2008). Most reviewers report that the proportion with poor outcome is less than 5% (Iverson 2005, McCrea 2008). Post concussion symptoms are common in injured people without head injuries, and in the general population (Meares et al 2008, Iverson 2005). The WHO mTBi Task Force could not rule out injury-related pain and distress playing a role in cognitive deficits observed after mTBI (Carroll et al 2004).
- Persistent symptoms after concussion are not specific to brain injury, meaning they can occur in many other psychological and physical conditions. For example, there is overlap between post concussive symptoms and symptoms characteristic of OSIs and psychiatric disorders, including sleep disturbance, irritability, memory and concentration difficulties, fatigue, nausea, depression and headache (King 2008, Iverson 2005). These symptoms also occur in a large number of medical conditions.
- Worsening after the initial concussion phase is over prompts investigation for new causes or complications.

- The WHO (World Health Organization) mTBI Task Force found evidence for no risk of brain tumours after an mTBI, and a very low risk of seizures within four years (Holm et al 2005). They found insufficient evidence to determine whether mTBI is a risk factor for dementia later in life: this hypothesis is still being studied by researchers.

Post Concussion Syndromes

- Post Concussion Syndrome (ICD classification) and Postconcussional Disorder (DSM classification) are clusters of symptoms sometimes reported by persons after concussion. They have slightly different criteria, but share common symptoms such as headache, dizziness, fatigue, irritability, impaired memory and concentration, insomnia, and lowered tolerance for noise and light.
- ICD and DSM definitions for post-mTBI symptom syndromes are still being validated. For example, a recent Australian study looked at 90 patients with mTBIs and 85 controls with trauma but no head injury (Meares et al 2008). They diagnosed Post Concussion Syndrome (PCS) using a checklist, neuropsychological testing and psychological testing. The diagnosis of acute PCS was not specific to mTBI: 43% of those with an mTBI were diagnosed with PCS, as were 44% those with trauma but no head injury. This finding of nonspecificity has been reported in other studies (Iverson 2005). The causes of these conditions have not been proven and appear to be multifactorial. Possibilities include pre-existing life stress, psychiatric conditions, comorbid conditions such as chronic pain, depression, PTSD or substance problems, and misattribution of symptoms with pre-occupation (Iverson 2005).

Numbers of Troops Affected by Concussion (mTBI)

- Studies of civilian populations report annual rates of concussion ranging 0.5-6/1,000 population (Gordon et al 2006, IOM 2007, Cassidy et al 2004, Pickett et al 2001). Given that people under-report their concussions, the WHO mTBI Task Force estimated the rate could be as high as 6/1,000 (Holm et al 2005, Gordon et al 2006). TBI has been recognized in civilian health care as an important public health issue since at least World War II.
- TBI has long been an issue for military forces in all countries. The overall incidence of TBI in the U.S. Armed Forces during 1997-2006 was 8/1,000 members per year (AFHCS 2008). As in civilian studies, this may be an underestimate, since it is based on documented medical system contacts. Motor vehicle accidents and falls were more common causes than combat injuries.
- Soon after OIF/OEF (Operation Iraqi Freedom/Operation Enduring Freedom) began in 2003, clinicians at the Defense and Veterans Brain Injury Center (DVBIC) at the Walter Reed Army Hospital Medical Center in the United States noticed both head injuries and blast exposure were common among moderate to severely wounded soldiers repatriated to Walter Reed for further care. They did an audit on the first 433 wounded troops repatriated from Iraq and Afghanistan

with head injuries. They reported on their audit at a medical conference in 2005 (Warden et al 2005), finding that:

  - Just over half were injured in blasts.
  - The majority had closed rather than penetrating head injuries, which is typical for civilian settings and other wars.
  - The majority (79%) fit the DVBIC definition of having had an mTBI (at least some altered mental status at injury but loss of consciousness < 1 hr, post traumatic amnesia < 24 hrs).
  - A majority (91%) had nonspecific symptoms and signs characteristic of post concussion syndrome and mental health problems.
  - Head injury was thought to be relatively more common among wounded troops repatriated to Walter Reed, owing to new body armour and heavy use of blast weapons by enemy forces.

While it was not unexpected that TBIs would occur, because head injuries are common in war, these clinicians raised a red flag to alert everyone to the pattern of injuries among wounded combat troops in OIF/OEF: head injuries, blast, and mTBI.

- The true incidence of mTBI remains uncertain. The proportion of U.S. troops returned from Iraq and Afghanistan who self-reported mTBI after returning from deployment was at 12% (Schneiderman et al 2008), 15% (Hoge et al 2008) and 20% (RAND 2008). These estimates are based on three studies with important limitations. They were retrospective, and subject to bias related to self reporting. The study by Hoge et al. (2008) was confined to two combat brigades from Iraq, a study population that may have differed in important ways from Canadians in Afghanistan. The RAND (2008) study used self-reported mTBI and random-dialling telephone survey of 1,921 persons who reported they had been in U.S. military service among the 1.6 million deployed to Iraq-Afghanistan, with a response rate of only 44%.
- Based on the RAND study, the public heard that 320,000 troops had returned from Afghanistan and Iraq having had mTBI episodes during deployment. Evidence for this estimate is not strong, and it does not mean that 320,000 had persistent symptoms: the study authors noted that “Most individuals who screen positive for having experienced a probable mTBI are likely to have full cognitive functioning” (RAND 2008 page 93), consistent with civilian data showing that the majority of people with concussion are completely better within a few weeks.
- Some have described mTBI as the “signature injury” of Iraq/Afghanistan. While blast exposure and mTBI are more common in Iraq and Afghanistan than among civilians at home, labelling mTBI as the “signature injury” may backfire. Both blast and TBI have occurred in all wars. Such labelling may distract from the usual range of important in-theatre injuries and health issues such as those described in Iraq by Rosenfeld et al (2006) and others: amputation, penetrating wounds, burns, musculoskeletal injuries, hearing loss, infections and psychological stress. It may create distorted social beliefs similar to shell shock and gassing in World War I, where a variety of symptoms were attributed to exposures in spite of

insufficient evidence (Jones et al 2007a and b, Jones 2008, Richardson and Engel 2004).

Diagnosis

- No one health care provider has “the rights” to diagnose and treat mTBI-related symptoms. Some suggest that a primary care provider working with a multidisciplinary team is the most effective way to ensure that somatic, psychological and cognitive symptoms are recognized, diagnosed and treated in context, while others advocate comprehensive assessment and treatment by specialized teams (French et al 2008).
- It is reasonable to ask about prior head injuries when a Veteran presents with symptoms typical of those reported after concussion. A past history of mTBI is suspected when a person had one or more head injury accompanied by transient altered mental status and/or brief amnesia (see Definitions).
- Screening for mTBI is not diagnosis. Screening may increase the risk of premature symptom attribution. Screening requires adequate follow-up to rule in or rule out the diagnosis in positive mTBI screens.
- At the time of concussion, CT and standard MRI infrequently may show signs of bleeding, contusion and diffuse axonal injury, but more often show nothing abnormal (Borg et al. 2004). MRI is more likely to show abnormalities than CT, but CT may be adequate to check for surgical indications at the time of injury. These tests are not always required either at the time of an mTBI (Stiell et al 2001) or subsequently (Willer and Leddy 2006, Lux 2007).
- If a sufferer presents a considerable time after the mTBI event when disabling symptoms are already well established, then it may be difficult to diagnose prior mTBI events as the cause of the symptoms (Iverson 2005).
- No test proves brain injury as the cause of persistent, nonspecific symptoms. At present, the diagnosis relies on determining whether characteristic symptoms and findings follow a credible timeline from the time of injury. The diagnosis is one of exclusion (Iverson 2005).
- When symptoms persist after mTBI events, assessment includes a neurological history and physical examination, mental status examination and, when indicated by specific reasons or to investigate other causes, neurocognitive testing, bloodwork, neuroradiology, or electroencephalogram (Willer and Leddy 2006). Prior medical records may be helpful in recreating the timeline.
- Standard radiology (Computed Tomography and structural Magnetic Resonance Imaging) and EEG may infrequently show changes that suggest, but do not prove, remote mTBI as the cause of persistent symptoms. Structural neuroimaging is not required in the investigation of stable symptoms following concussion, unless specific indications are present such as certain types of worsening, or symptoms and signs suggesting an undiagnosed structural lesion (McCrory et al 2008, Lux 2007).

- Neuropsychological testing is not specific for brain injury effects. standardized testing is indicated when cognitive impairment is suspected in persons with persistent post-concussion symptoms because it may be more sensitive and precise than other clinical assessments, and quantifies cognitive function (McCrory et al 2008, McCrea et al 2008, Lux 2007). Neurocognitive test results can be helpful to teams planning symptom treatment, and in the assessment of degree of disability. Veterans Affairs Canada may pay for neuropsychological testing for eligible clients, with pre-approval.
- The term “differential diagnosis” means alternative diagnoses that might explain a person’s presenting symptoms and signs. Post-mTBI symptoms often are non-specific, meaning the differential diagnosis is wide, including a number of physical and mental health conditions (Willer and Leddy 2006, McCrea et al 2008). For example, depression may be caused by certain drugs, infectious agents, cancers, neurological disorders, heart diseases, hormone disorders, blood disorders, nutritional deficiencies, metabolic disturbances, life events and psychiatric states.
- Differentiating between traumatic brain injury and psychological trauma such as an OSI as the cause of psychological and cognitive symptoms can be difficult (Bryant 2008, Lux 2007, Iverson 2005).
- Promising research prospects include biochemical markers of acute brain injury, advanced radiological imaging such as functional magnetic resonance imaging (fMRI), quantitative electroencephalography (EEG), and ongoing research into the role of neurocognitive testing (Borg et al. 2004, Iverson 2005). These tools eventually may provide clinicians with routine diagnostic tools allowing them to non-invasively look into the living brain at the cellular/biochemical level where brain injury is thought to cause functional problems.

Treatment

- The WHO mTBI Task Force found 41 practice guidelines with conflicting recommendations (Holm et al 2005). Only one adult guideline met criteria for being rated evidence-based (Peloso et al 2004). There were no high-quality studies of mTBI interventions (Borg et al 2004b).
- In spite of lack of research answers for many questions, clinical experience in treating post-mTBI symptoms suggests that effective treatments are available for persistent symptoms, whether or not prior concussion can be proven as the cause or a contributing factor (Iverson 2005).
- In the acute and subacute phases of concussion, there is some evidence for the efficacy of non-intensive education, support and reassurance, graded asymptomatic return to activity, and cognitive behavioural therapy for persistent symptoms (Willer and Leddy 2006, Holm et al 2005, Willer and Leddy 2006).
- Even though it may not be possible to prove whether concussion is the cause of persistent symptoms, standard treatments for all three symptom spheres are recommended (Iverson 2005, Willer and Leddy 2006).

- The challenge is to develop comprehensive, integrated treatment services to manage all three spheres of symptoms that may persist after concussion: somatic, psychological and cognitive (French and Parkinson 2008, Lew et al 2008, Willer and Leddy 2006, IOM 2006). Specialized civilian brain injury rehabilitation centers across Canada have considerable experience in the assessment and treatment of TBI sequelae, but in the past they specialized in moderate to severe brain injury rather than mTBI (ERABI Research Group 2006), although this is changing. Civilian brain injury centers may have limited experience with blast injury and the military context of TBI. Military and Veterans' mental health services have expertise in assessing and treating psychological problems, but may have had less experience treating brain-injured persons (Lew et al 2008).
- It is recommended that the term "concussion" be used with patients instead of "mTBI", "brain injury" or "brain damage", since concussion is a more familiar concept, may be less threatening, and better conveys the likelihood of improvement over time.
- Although research evidence is not yet complete, cornerstones for managing persistent symptoms in the setting of mTBI history appear to include (Iverson 2005, IOM 2001, Barsky and Borus 1999, Richardson and Engel 2004):
    - Strong independent relationship with a primary care provider.
    - Hearing all the patient's concerns and view of the diagnosis.
    - Attention to all three symptom spheres (somatic, cognitive and emotional/behavioural).
    - Attention to the military, family and social contexts.
    - Successful collaboration between clinician and patient to consider physical and psychiatric differential diagnoses and all treatment options.
    - Symptom treatment, starting with pain and sleep difficulties, if present.
    - Education, support and reassurance for patient and family.
    - Cognitive behavioural therapy.
    - Anticipate return to active life.
    - Early referral to mental health providers for cognitive, emotional and behavioural problems.
    - Referral for somatic problems as required.
    - Integration of health care providers to ensure continuity of care.
    - Consideration of personality factors when symptoms persist.
    - Limited attention to new symptoms to ensure no new condition develops.

Veterans Affairs Canada Benefits

Veterans Affairs Canada offers a variety of services for eligible Veterans who may have disabling symptoms following mTBI (concussion) events. Find information on available benefits at http://www.vac-acc.gc.ca or by calling Veterans Affairs Canada at 1-866-522-2122 (English) or 1-866-522-2022 (French).

Compensation

- Traumatic brain injury and therefore concussion is not uncommon in military service. Eligible Canadian Veterans have been entitled for disability pensions or awards for health conditions related to TBI acquired in most deployments since WW I, and other types of service. The most common entitled disability diagnosis is Post Concussion Syndrome.
- Alternative diagnoses may be considered for entitlement. Post-mTBI symptoms usually are non-specific and may be due to alternative diagnoses including mental health conditions such as Post Traumatic Stress Disorder, depressive disorders, anxiety disorders and a variety of physical conditions.
- Assessment is assisted by neuropsychological tests, which may be paid for eligible clients by the Department, with pre-approval.

Treatment Services

- An operational stress injury (OSI) is any persistent psychological difficulty resulting from military service (http://www.vac-acc.gc.ca/clients/sub.cfm?source=mhealth/definition). Operational Stress Injury (OSI) clinics provide standardized assessment, treatment, and support services. A team of health professionals, including a psychiatrist, addiction consultants, psychologists, nurses, and clinical social workers work together to develop treatment plans to meet individual needs. Individual, group, couples or family counselling and educational programs are also available. Veterans can access an occupational stress injury clinic by obtaining a referral from a Veterans Affairs Canada District Office. Contact the District Offices by calling 1-866-522-2122 (English) or 1-866-522-2022 (French).
- A Peer Support Network has also been established by the Operational Stress Injury Social Support (OSISS) program to help Canadian Forces members, Canadian Forces Veterans and their families. The Peer Support Network is made up of Veterans and family members from across the country who know first hand what it is like to live with an OSI. Confidential support is available by contacting the nearest Peer Support Coordinator at 1-800-883-6094 or at www.osiss.ca.
- Multidisciplinary client service teams in Veterans Affairs Canada District Offices provide case management and coordination services when required. The team includes a District Medical Officer and a District Nurse. Case management is coordinated by the Area Counsellor.
- Rehabilitation programs assist eligible Veterans whose service-related health problems interfere with transition to civilian life. The program includes one-on-one case management, rehabilitation, financial benefits, group health insurance, job placement assistance, the lump sum disability award, other allowances, and support to families.
- Veterans may have access to a variety of health benefits, depending on their eligibility and coverage status.

Further Research

Concern about the rate of traumatic brain injury exposures among U.S. military members deployed to Iraq and Afghanistan, long-standing concerns about TBI in civilian public health, and the many questions remaining about mild traumatic brain injury in particular has dramatically accelerated research. TBI research is ongoing in Canada, the U.S., the U.K. and elsewhere (UK MoD 2008, Carroll et al 2004b). We expect this increased activity to produce much new information in the near and medium terms. Veterans Affairs Canada will re-evaluate the new information as it becomes available.

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