

Care of the Patient with Mild Traumatic Brain Injury

AANN and ARN Clinical Practice Guideline Series



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Preface

In 1997, the American Association of Neuroscience Nurses (AANN) created a series of patient care guidelines, the AANN Reference Series for Clinical Practice, to meet its members' needs for educational tools. To better reflect the nature of the series and the organization's commitment to developing each guideline based on current literature and evidence-based practice, the name was changed in 2007 to the AANN Clinical Practice Guideline Series. This guideline represents a milestone in the series as AANN has now partnered with the Association of Rehabilitation Nurses (ARN) in the development of this guideline. This is the first of several guidelines to be developed collaboratively between the organizations and promotes evidence-based practice across the continuum of care.

Traumatic brain injury (TBI) is a leading cause of disability worldwide. It is caused by a bump or blow to the head that affects how the brain normally works (National Center for Injury Prevention and Control, 2008). Because nurses are frequently the professionals who see the full impact of TBI and have the skills that can alter the course of a patient's recovery, it is important for nurses to have a valuable resource to help them achieve the best possible outcomes. This guideline helps translate the latest research into an easy-to-use reference. The purpose of this document is to provide recommendations based on current evidence that will help registered nurses, advanced practice nurses, and institutions provide safe and effective care to injured patients with a mild traumatic brain injury (MTBI). The goal of these guidelines is to offer evidence-based recommendations on nursing

activities that have the potential to maximize outcomes for persons following MTBI. Not all recommendations concern activities independently performed by registered nurses, but nurses are responsible for implementing and monitoring the outcomes of these activities. The evidence presented here may help nurses make appropriate choices when caring for patients with MTBI. Dependent on the scope of practice regulations, advanced practice nurses may have independent or collaborative responsibilities for activity performance, thus this guideline may assist them in the management of patients with MTBI.

As a result of the high profile of TBI—particularly injuries that are blast-related—new medical, nursing, and rehabilitation treatments are frequently emerging. Resources and recommendations must describe the best practices that can enable nurses to provide optimal care for persons following MTBI. Accordingly, adherence to these guidelines is voluntary, and the ultimate determination regarding their application must be made by practitioners in light of each patient's individual circumstances. This reference is an essential resource for nurses providing care to persons following MTBI. It is not intended to replace formal learning but rather to augment clinicians' knowledge base and provide a readily accessible reference tool. AANN, ARN, and the nursing field are indebted to the volunteers who have devoted their time and expertise to this valuable resource, created for those who are committed to excellence in the care of brain-injured patients.

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I. Search Strategy and Levels of Evidence

A. Search strategy

A computerized search of MEDLINE, The Cochrane Collaboration, EMBASE, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) was performed using mild head injury, mild traumatic brain injury, and concussion as keywords. The search was restricted to works in English published from 2005 through November 2010. The reference lists of identified articles were also searched for additional relevant references including books, guidelines, and articles. A panel of nursing experts determined the level of evidence for each study included under every recommendation, summarizing the level of evidence for each recommendation.

B. Levels of evidence supporting the recommendations

- Class I: Randomized controlled trial without significant limitations or meta-analysis
- Class II: Randomized controlled trial with important limitations (e.g., methodological flaws or inconsistent results), observational studies (e.g., cohort or case control)
- Class III: Qualitative studies, case study, or series
- Class IV: Evidence from reports of expert committees and expert opinion of the guideline panel, standards of care, and clinical protocols.

The Clinical Practice Guidelines recommendations for practice are established based upon the evaluation of the available evidence (AANN, 2005, adapted from Guyatt & Rennie, 2002; Melnyk, 2004):

- Level 1 recommendations are supported by class I evidence.
- Level 2 recommendations are supported by class II evidence.
- Level 3 recommendations are supported by class III and IV evidence.

II. Scope of the Problem

A. Definition of mild traumatic brain injury (MTBI)

1. The Glasgow Coma Scale (GCS) was introduced in 1974 (Teasdale & Jennett, 1974). A GCS score of 13–15 quickly became considered a minor injury, but the scale was not designed to diagnose mild injury (Jagoda et al., 2009).
2. The American Congress of Rehabilitation Medicine was the first organized interdisciplinary group to advocate four specific criteria for MTBI in 1993 (Ruff et al., 2009). The diagnostic criteria specified MTBI as a traumatically induced physiological disruption of brain function manifested by at least one of the following:

- a. loss of consciousness
 - b. loss of memory for events immediately before or after the accident
 - c. alteration in mental state at the time of the accident (feeling dazed, disoriented, or confused)
 - d. focal neurologic deficit(s) that may or may not be transient.
3. The terms MTBI and concussion are used synonymously. The American Academy of Neurology (Ruff et al., 2009) defines the spectrum of concussion related to sports injury to include the following symptoms:
 - a. Grade 1 concussion
 - transient confusion
 - no loss of consciousness,
 - duration of mental status abnormalities on examination that resolve in less than 15 minutes.
 - b. Grade 2 concussion
 - transient confusion
 - no loss of consciousness
 - concussion symptoms or mental status abnormalities on examination lasting more than 15 minutes
 - c. Grade 3 concussion
 - any loss of consciousness (seconds to minutes)
 4. The World Health Organization (WHO) defines MTBI as an acute brain injury resulting from mechanical energy to the head from external physical forces.
 - a. Criteria include 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
 - transient neurological abnormalities such as focal signs, seizure, and intracranial lesion not requiring surgery
 - GCS score of 13–15 after 30 minutes post-injury or later upon presentation for healthcare.

MTBI manifestations must not be due to drugs, alcohol, or medications; caused by other injuries or treatment for other injuries (e.g., systemic injuries, facial injuries, or intubation); caused by other problems (e.g., psychological trauma, language barrier, or coexisting medical conditions); or caused by penetrating craniocerebral injury (Carroll, Cassidy, Holm, et al., 2004).

Nursing recommendation: Currently there is no definition for MTBI that is agreed upon internationally and across disciplines. For the most part, MTBI and concussion are used synonymously (**Level 3**), including in this guideline. Nurses should take an active part in the consensus work needed to continue to work toward a common definition of MTBI.

B. Epidemiology

1. Between 1 and 1.5 million emergency department (ED) visits occur in the United States annually for TBI (Jagoda et al., 2009) and approximately 80% of these are MTBI (Ruff et al., 2009). Population-based estimates of MTBI are between 1% and 2% of the U.S. population (Bruns & Jagoda, 2009).
2. The incidence of clinician-confirmed TBI in U.S. soldiers returning from Iraq and Afghanistan is reported to be approximately 23%, where the majority are MTBI (Terrio et al., 2009). There is a need for increased collaborative research to investigate effects of repeated MTBI from blasts, treatment for events that may have occurred 1 year or more in the past, and approach with comorbid presentations (Helmick & Working Group Members., 2006; Hoge et al., 2008; Sayer et al., 2009; Lew et al., 2008; Jagoda et al., 2009).
3. An estimated 300,000 sports-related concussions occur annually in the United States (Lew, Thomander, Chew, & Bleiberg, 2007). Incidence of concussion in Canadians is estimated at 110 per 100,000 of the population (Gordon, Dooley, & Wood, 2006).
4. Incidence is thought to be high in most developed countries, but exact incidence worldwide is unknown as the injury may be unrecognized (Shuttleworth-Edwards et al., 2008). Patients may not be seen in an immediate care center, are most likely seen in a doctor's office, and are thus excluded from epidemiological databases (Garrick, 2005). Because current TBI databases use international classification of disease (ICD) codes to capture TBI from hospital and emergency department databases, the true incidence may also be influenced by this coding.

Nursing recommendation: The true incidence of MTBI is not known due to the lack of an agreed upon definition that is accepted internationally and across disciplines for the purposes of case finding. Well-designed multidisciplinary research is needed for a more complete understanding of the epidemiology of MTBI (**Level 3**).

C. Mechanisms of injury

1. Classic biomechanical mechanisms of injury in TBI include the following three components (March & Hickey, 2014; see section III. Pathophysiology):
 - a. contact
 - b. acceleration-deceleration
 - c. rotational acceleration-deceleration
2. Mechanisms of injury
 - a. Falls
 - Fall-related injuries are highest in the elderly (Jagoda et al., 2009; Sarmiento, Langlois, & Mitchko, 2008)
 - b. Motor vehicle crashes (Alexander, Shelton, Fairhall, & McNaughton, 2007; Jagoda et al., 2009)
 - c. Sports-related (Alexander et al., 2007; Casson, Pellman, & Viano, 2008; Collins, Lovell, Iverson, Ide, & Maroon, 2006; Cusimano, 2009; Garrick, 2005; Gessel, Fields, Collins, Dick, & Comstock, 2007; Hollis et al., 2009; Hynes & Dickey, 2006; Lew et al., 2007; Yang et al., 2008).
 - Males predominate in certain sports (i.e., rugby [Hollis et al., 2009], American football [Guskiewicz et al., 2005], fighting sports, and ice hockey [Holm, Cassidy, Carroll, Borg, & Neurotrauma Task Force on Mild Traumatic Brain Injury of the WHO Collaborating Centre, 2005]).
 - In the United States, females are experiencing more concussions in high-school sports than males (Gessel et al., 2007; Gregory, 2007).
 - d. A relationship between whiplash-associated disorders and concussion in professional hockey players has been reported (Hynes & Dickey, 2006).
 - e. Since Operation Enduring Freedom/ Operation Iraqi Freedom, there has been an increased prevalence in blast injury/blast-induced neurotrauma related to increased exposure to explosive devices (Hoge et al., 2008; Cernak & Noble-Hauesslein, 2010).

D. Prevention

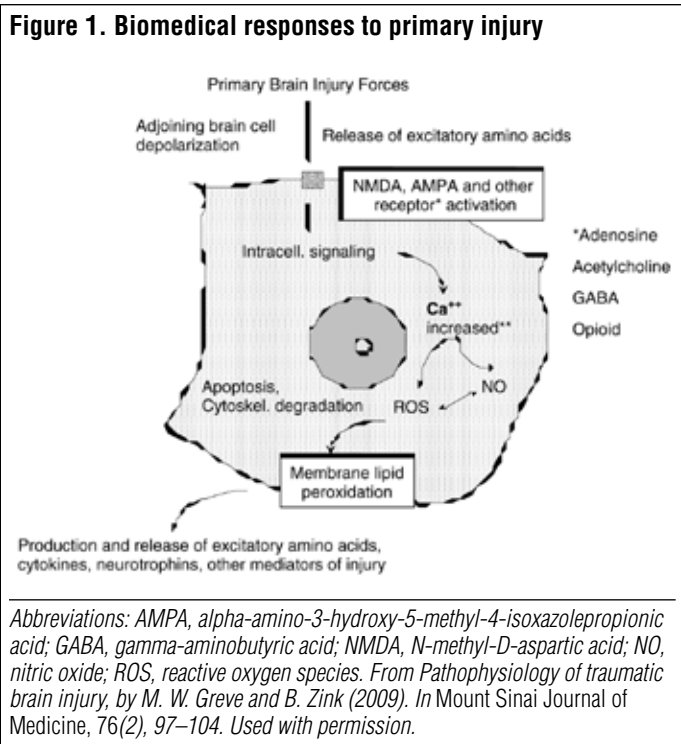
1. Nurses are key in preventing MTBI using health promotion efforts specific to adults or children.
2. Health promotion efforts to prevent MTBI in adults include (but are not limited to):
 - a. Provide advice to drivers that they should avoid distracted driving, obey traffic laws, avoid speeding, and avoid

- driving when under the influence of drugs or alcohol.
 - b. Encourage motor vehicle drivers and passengers of the need to wear seat belts and shoulder harnesses.
 - c. Warn passengers of the dangers of riding in the back of pickup trucks.
 - d. Instruct motorcyclists (Liu et al., 2008; Holm et al., 2005), scooter riders, bicyclists (Thompson, Rivara, & Thompson, 1999; Holm et al., 2005), skateboarders, roller skaters, and rollerbladers to wear helmets.
 - e. Promote and support educational programs directed toward violence and suicide prevention in the community.
 - f. Make water safety instruction available.
 - g. Educate patients, particularly the elderly, about steps they can take to prevent falls (Opalek, Graymire, & Redd, 2009; Sarmiento et al., 2008). Interventions to reduce falls in older adults include exercise, medication review, regular eye examinations and home safety assessment to reduce tripping hazards and improve lighting (Centers for Disease Control and Prevention [CDC], 2010).
 - h. Train athletes to use protective devices such as helmets (Collins et al., 2006; Gessel et al., 2007), mouth guards (Singh, Maher, & Padilla, 2009), and other protective clothing appropriate to the sport. Recommend that coaches be educated in proper techniques including the appropriate use of the most up-to-date protective devices and mechanisms (Hollis et al., 2009). Coaches, parents, and athletes of all ages should be provided information about preventing, recognizing, and responding to concussion (Giza et al., 2013; See CDC "Heads Up" resources, available at www.cdc.gov/concussion/index.html).
 - i. Encourage soldiers to use helmets, protective clothing, and appropriate reinforced vehicles.
3. Health promotion efforts for children include (but are not limited to) the following:
- a. Place motor vehicle passengers younger than 12 years of age in restraint systems in the back seat appropriate for their age, size, and weight (Farmer, Howard, Rothman, & Macpherson, 2009; Sun, Bauer, & Hardman, 2010).
 - b. Encourage children engaged in sports to follow their coach's rules for safety and rules of the sport.
 - c. Teach children engaged in sports to practice good sportsmanship at all times.
 - d. Ensure that children wear the appropriate protective equipment for the activity (i.e., helmets, padding, mouth guards).
 - e. Encourage coaches to ensure protective equipment fits properly, is well maintained, and has most up-to-date design.
 - f. Teach children playground safety (i.e., keeping two hands on swings at all times, refraining from pushing and shoving, and allowing one person at a time on playground equipment)
 - g. Educate parents and families about the potential stresses of parenthood and primary prevention activities to successfully manage stress. Hospital-based parental education has been shown to decrease the incidence of shaken baby syndrome (Dias et al., 2005).
- Nursing recommendation:** Health promotion efforts have been shown to successfully reduce the incidence of TBI (**Level 2**). Well-designed nursing research is needed to compare and test efficacy of translating these health promotion efforts to prevent MTBI (**Level 3**). For example, a comparison of face-to-face and online teaching methodologies has not been done.
- E. Repetitive injury
1. Known to occur in certain sports (i.e., boxing, American football [Guskiewicz et al., 2005], rugby [Hollis et al., 2009], ice hockey).
 2. If an individual has suffered from more than one concussion at any point in time, this is known as a "repeat concussion." The effects on the brain are more serious compared to the effects of the first concussion (Hayden, Jandial, Duenas, Mahajan, & Levy, 2007). Effects of repeat concussions include symptoms lasting longer than with a single injury, chronic headaches, slower response times, and decreasing academic test scores (Guskiewicz et al., 2003).
 3. There has been some initial evidence of pathologic brain changes in adults with repeat concussions, called chronic traumatic encephalopathy (McKee et al., 2009).
 4. Individuals with the Apolipoprotein E (APOE) 4 genotype may be at increased risk for chronic cognitive impairment following concussion (Giza et al., 2013).
- Nursing recommendation:** Nurses should include the effects of repeat concussions in discharge teaching following concussion (**Level 2**). Better designed nursing research is needed to compare and test methods of preventing repetitive injury (**Level 3**).

III. Pathophysiology

A. Biomechanical

1. Primary injury: Concussion is always a primary injury as is initial neurological insult (**Figure 1**). While the primary event cannot be changed, steps can be taken to prevent secondary injury.



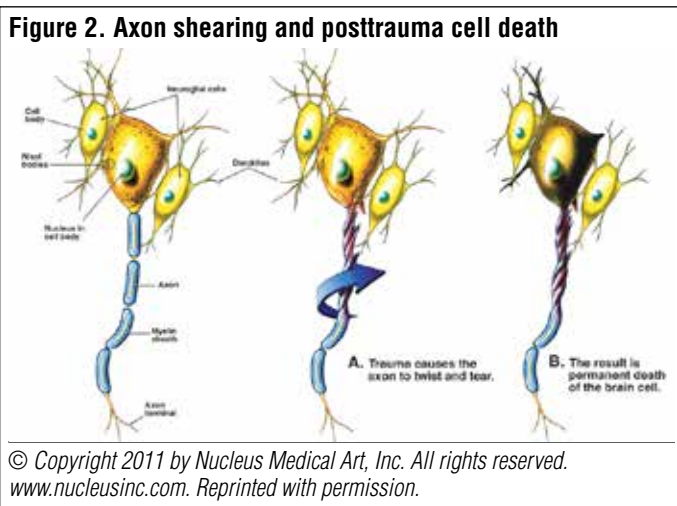
a. Classification

- i. Direct: Impact-loading occurs when contact is made while the head is at rest, causing it to move. Contact injuries result in focal damage.
 - ii. Indirect: Force at a point of impact that is an anatomical location other than the head, producing a transfer of energy to the spine and skull, causing injury to the brain. The brain dysfunction related to MTBI is altered brain metabolism rather than damage to the structure.
2. Mechanisms of injury
 - a. Linear acceleration and deceleration
 - i. Coup and contrecoup: Sudden acceleration or deceleration causing the brain to move within the skull
 - Coup: head impacts stationary object causing injury to cranial tissues at the point of external contact of neuronal tissue, including neurons and glial cells at site of impact

- Contrecoup: the remaining force presses the brain against the opposite side (180 degrees) of the skull resulting in a second impact and injury
- Tissue closest to the surface, grey matter, is most affected by linear forces (Greve & Zink, 2009).
- Coup or contrecoup may also occur without impact as a result of sudden acceleration or deceleration alone (e.g., stopping suddenly in an automobile causing a forward motion with resistance and seatbelt recoil). There is no direct external head impact but the brain may still be in motion.

b. Rotational

- i. Rotational forces result in shearing on cerebral axons, causing damage (**Figure 2**).



- ii. Stress/strain brain tissue, vasculature, and other neural elements beyond structural tolerance (Kirkwood, Yeates, & Wilson, 2006)
 - iii. Concussion is mild form of traumatic axonal injury (mechanical injury of deeper cortical white matter by rotational forces) and may lead to functional neuronal disturbances (McCrorry & Berkovic, 2001).
- c. Blast (Cernak & Noble-Haesslein, 2010; Bridges, 2006)
 - i. The primary blast injury is the blast wave itself.
 - ii. The secondary blast injury is related to penetrating injuries caused by projectiles.

- iii. The tertiary injury is related to acceleration and deceleration of the body and impact with other objects.
- iv. Some features of blunt head injury (i.e., diffuse axonal injury, cytoskeleton degradation, neuronal injury, cell death) are also seen in experimental models of blast-related neurotrauma (Cernak & Noble-Hauesslein, 2010).

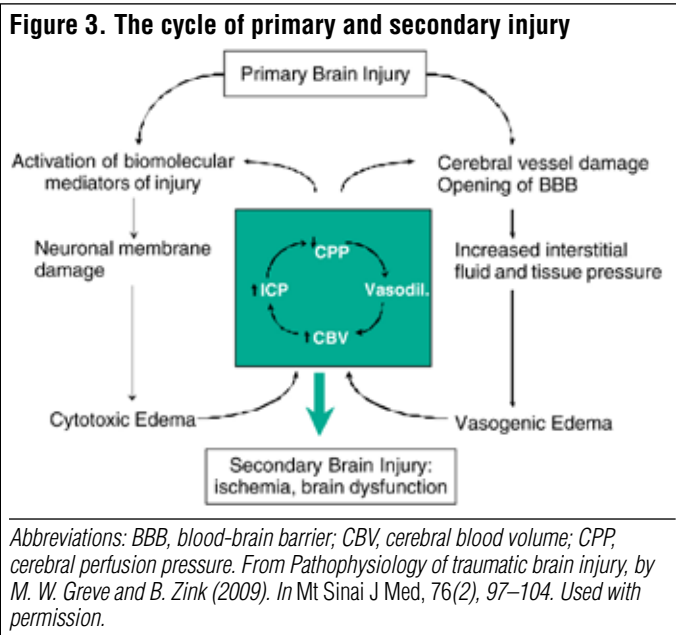
B. Biomolecular

1. Secondary injury includes that which occurs immediately, hours, or days after primary injury related to the complex neuroinflammatory response (cascade) following TBI (Figure 3).
2. The cascade is triggered after impact causing abrupt, massive depolarization of neuronal, glial, and endothelial cells of the cerebral vessels, release of excitatory neurotransmitters, ionic shifts, altered glucose metabolism, and cerebral blood flow and impaired axonal function (Kirkwood et al., 2006; Greve & Zink, 2009).
3. Biomolecular responses: excitatory amino acids (EAA) → widespread depolarization of neurons, glial, and endothelial cells of vessels → oxygen radical reactions → nitric oxide → calcium influx → unstable cell environment → cellular damage → cell death either directly via apoptosis or indirectly by loss of adenosine triphosphate (ATP) production (Greve & Zink, 2009)

- (Deutschman et al., 1986; Yoshino, Hovda, Kawamata, & Katayama, 1991, Barkhoudarian, Hovda, & Giza, 2011).
- 5. The brain is hypersensitive to decreased and inadequate blood flow (Giza & Hovda, 2001). The brain requires a large amount of oxygen and glucose to function even under homeostatic conditions. Following TBI, the brain needs extra nutrients (Giza & Hovda, 2001).
- 6. The excitotoxicity continues to accumulate leading to calcium increases and damage to the axonal cytoskeleton and axonal disconnection (Kochanek, Clark, & Jenkins, 2007).
- 7. The extent of neuronal apoptosis, programmed cell death, correlates with the patient's prognosis (Greve & Zink, 2009).
- 8. Second impact syndrome can occur if another impact to the brain occurs in the immediate period (hours to few weeks) following initial injury, which has been primarily been reported in children and young adults. A minor blow triggers the neuroinflammatory response resulting in cerebral edema and rapid rise of intracranial pressure.

C. Physiologic differences related to age

1. Children
 - a. Brains in children are very different from those in adults. The greatest percentage of brain maturation occurs from birth through age 5. Differences between developing and mature organisms include brain water content, cerebral blood volume, level of myelination, skull geometry, and suture elasticity (Kirkwood et al., 2006).
 - b. The immature brain is more vulnerable to injury (Aloi & Rumpe, 2008).
 - c. The developing brain is 60 times more sensitive to NDMA (glutamine-mediated N-methyl-D aspartate) and excitotoxic brain injury (Field, Collins, Lovell, Maroon, 2003).
 - d. With excitotoxic response cerebral blood flow falls. MTBI causes glycolysis, which decreases ATP, the substance that provides energy to the brain. This may result in depleted energy and loss of brain tissue (Hovda, 2003).
 - e. The metabolic changes present in the injured brain may alter child development. Aloi and Rumpe (2008) reported that MTBI in preschool children may lead to their inability to read.
 - f. Incidence of brain swelling after moderate brain injury is higher in children than adults.



4. The brain remains in a state of hypermetabolism for 7–10 days following injury

- g. The immature musculoskeletal systems in young athletes influence injury dynamics. Less developed neck and shoulder muscles create an inability to transfer energy directed at the head throughout the body and may increase risk of concussive injury (Kirkwood et al., 2006).
 - h. Children commonly experience more severe symptoms of post-concussion syndrome than adults (McCrory et al., 2009).
2. Older adults
- a. The brain decreases in size by approximately 10% and brain weight decreases 6%–7% between ages 30 and 70, although intelligence is not affected (Guttman, 2009). An increase in “free space” within the skull may result in greater secondary injury and a delay symptoms of intracerebral hemorrhage (ICH).
 - b. There is a gradual decline in the number of neurons in the cortex of the cerebellum and hippocampus.
 - c. Nerve conduction slows up to 15%.
 - d. Cerebral blood flow declines 15%–20%.
 - e. Bridging veins are more susceptible to injury.
 - f. Higher incidence of coagulopathies and anticoagulation therapy can result in ICH.
 - g. Changes can occur in neurotransmitter systems, including dopaminergic, cholinergic, catecholamine, and glutamatergic. When the neuroinflammatory response is initiated, increases in these substances may cause a greater inflammatory response, leading to more severe damage with less injury. Animal studies on older rats suggest that cellular excitotoxicity following MTBI results in earlier onset and areas of wider damage than in younger animals (Dawodu, 2009).

IV. Review of Diagnostic Studies

A. Nursing responsibilities

- 1. Though it is not within the registered nurse scope of practice to order diagnostic studies, the nurse should be familiar with each diagnostic modality and its mechanism and indication, and be able to provide education and guidance to the patient regarding the procedure. Care should be taken to obtain an interpreter to facilitate the assessment and teaching process (Sasso, 2008).
- 2. The nurse should obtain a past medical history, and allergy and medication list, and inform the ordering provider of any possible

contraindications to the examination. For procedures requiring injection of a contrast material, the nurse will need to assess the patient’s renal function and notify the ordering provider if the glomerular filtration rate is decreased. The nurse will need to insert an intravenous (IV) line for the injection of the contrast material and make frequent assessments of the IV site and look for possible allergic reaction to the dye (Sasso, 2008).

- 3. Patients undergoing magnetic resonance imaging (MRI) scans should be assessed for the presence of ferromagnetic foreign bodies such as metal in the orbits, pacemakers, aneurysm clips, coils and ventricular shunt (VPS) catheters, and implanted pumps or stimulators. The radiologist should be made aware of any of these findings as they may contraindicate the MRI or require posttest reprogramming in that patient. Skull X rays should be obtained for any patient with possible exposure to metal fragments in the orbits prior to obtaining an MRI. Patients with pacemakers may not undergo an MRI as the pacemaker leads may heat the surrounding cardiac tissues and cause damage to the myocardium. Aneurysm clips and coils, besides creating artifact on the image, may be contraindicated depending on the manufacturer. VPS valves will need to be reset after undergoing an MRI if the valve contains an adjustable magnetic spring device (Sasso, 2008).
 - 4. The nurse should assess for anxiety and treat patients appropriately with anxiety-reducing tactics, such as visualization techniques and deep-breathing exercises. In addition, sedatives may be necessary to alleviate anxiety and promote tolerance of the examination. Ear plugs or earphones can be offered to the patient to increase their tolerance (Sasso, 2008).
 - 5. The nurse should prepare the patient for the timing on results of the study and encourage the patient to contact their provider for follow up (Sasso, 2008).
- B. Computed tomography (CT)
- 1. Mechanism
 - a. CT, developed in 1972, uses X-ray beams, which are transmitted through a patient’s skull and brain at many different angles. The degree of radiation absorption by the different tissues (e.g., bone, blood, tissue, fluid) is analyzed by the computer program to develop a series of images (Yousem, Grossman,

& Zimmerman, 2010). Several forms of CT can be performed depending on the information being sought.

2. Modalities and use in MTBI

a. Noncontrast CT

- First-line radiographic modality used in TBI
- Quickly and easily detects the presence of acute intracranial hemorrhages (Yousem et al., 2010); usually takes less than 10 minutes to perform; can detect the presence of contusions, subdural hemorrhages, epidural hemorrhages, and, less sensitively, cerebral edema.
- Several studies report up to 15% of adult patients with a mild head injury that report to the ED will have positive findings on CT scan and up to 1% of those will require neurosurgical intervention (Fabbri et al., 2005; Haydel et al., 2000; Ibanez et al., 2004; Mack, Chan, Silva, & Hogan, 2003; Smits et al., 2005; Stiell et al., 2005). The incidence of intracranial injury seen on CT increases with adults 65 years old or older. Studies reported positive CTs from 12% to 34% with age increasing the odds ratio to 2 and 3 (Fabbri et al., 2005; Haydel et al., 2000; Ibanez et al., 2004; Mack et al., 2003; Stiell et al., 2005). The results for children are slightly lower, with <4%–8% of all noncontrast CTs showing positive intracranial lesions and <0.5% requiring neurosurgical intervention (Schnadower, Vazquez, Lee, Dayan, & Roskind, 2007).

b. Indications for imaging

- i. In 2008, a clinical policy paper was published outlining the recommendations for neuroimaging in adult MTBI patients in the acute setting (Jagoda et al., 2008).
- ii. CT is not diagnostic for concussion but is obtained to rule out more serious TBI (Giza et al., 2013).

Nursing recommendation: A non-contrast head CT is indicated in head trauma patients with loss of consciousness or posttraumatic amnesia only if one or more of the following is present: headache, vomiting, age greater than 60 years, drug or alcohol intoxication, deficits in short-term memory, physical

evidence of trauma above the clavicle, posttraumatic seizure, GCS score less than 15, focal neurologic deficit, or coagulopathy (**Level 1**; Jagoda et al., 2008).

A noncontrast head CT should be considered in a head trauma patient without loss of consciousness or posttraumatic amnesia if there is a focal neurologic deficit, vomiting, severe headache, age 65 years or greater, physical signs of a basilar skull fracture, GCS score less than 15, coagulopathy, or a dangerous mechanism of injury, including ejection from a motor vehicle, a struck pedestrian, and a fall from a height of more than 3 feet or 5 stairs (**Level 2**; Jagoda et al., 2008).

ii. Children: A noncontrast CT scan is not without some risk. The radiation exposure from a head CT is equal to about 20 chest X rays (two rems; Bazarian, Blyth, & Cimpello, 2006). In children, whose brain cells are rapidly growing, this exposure presents a life-long risk of developing cancer and a decrease in cognitive function (Schnadower et al., 2007). In addition, prediction models have been developed in an attempt to identify the children most at risk for developing a clinically significant intracranial lesion (Schnadower et al.). In 2006, Dunning and colleagues published the Children's Head Injury Algorithm for the Prediction of Important Clinical Events (CHALICE) to predict the need for a CT scan in children with 98% sensitivity and 87% specificity (**Table 1**). The rule-predicted CT frequency was 14% (Dunning et al., 2006). In 2009, Maguire and colleagues evaluated eight clinical prediction rules used in predicting the need for a head CT in the pediatric population for quality and performance. They deemed CHALICE the top-performing rule with the second highest quality. The highest quality rule was found to have a 100% sensitivity with a 5% specificity but increased the CT frequency to 56%, which would require more CTs to be performed (Oman et al., 2006). Unfortunately, neither one of these rules has been validated in different populations

Table 1. CHALICE criteria

A CT scan is required if any of the following criteria are present:

History

- Witnessed loss of consciousness of >5 min duration
- History of amnesia (either antegrade or retrograde) of >5 min duration
- Abnormal drowsiness (defined as drowsiness in excess of that expected by the examining doctor)
- >3 vomits after head injury (a vomit is defined as a single discrete episode of vomiting)
- Suspicion of nonaccidental injury (NAI, defined as any suspicion of NAI by the examining doctor)
- Seizure after head injury in a patient who has no history of epilepsy

Examination

- Glasgow Coma Scale (GCS) <14, or GCS <15 if <1 year old
- Suspicion of penetrating or depressed skull injury or tense fontanelle
- Signs of a basal skull fracture (defined as evidence of blood or cerebrospinal fluid from ear or nose, panda eyes, Battles sign, hemotympanum, facial crepitus, or serious facial injury)
- Positive focal neurology (defined as any focal neurology, including motor, sensory, coordination, or reflex abnormality)
- Presence of bruise, swelling, or laceration >5 cm, if <1 year old

Mechanism

- High-speed road traffic accident, either as pedestrian, cyclist, or occupant (defined as accident with speed of >40 mph)
- Fall of >3 m in height
- High-speed injury from a projectile or an object

If none of the above variables are present, the patient is at low risk of intracranial pathology.

From Dunning, J., Daly, J. P., Lomas, J. P., Lecky, F., Batchelor, J., Mackway-Jones, K., et al. (2006). Derivation of the children's head injury algorithm for the prediction of important clinical events decision rule for head injury in children. Archives of Disease in Childhood, 91(11), 885–891.

and a high-quality, high-performing rule for children under 2 years old has not been developed (Table 1).

Nursing recommendation: CT scans should be protocolized to minimize the exposure of children to radiation (**Level 2**). Follow CHALICE criteria for pediatric patients 2 years of age or older (Table 1); further work is needed to develop evidence-based criteria for CT scans for children under 2 years old (**Level 2**).

- c. Repeat imaging
 - i. In adults with MTBI (GCS 13–15) who are not receiving anticoagulation therapy, several studies have shown that in the absence of neurological deterioration a repeat CT is not indicated regardless of the presence of intracranial hemorrhage (Brown et al., 2004, 2007; Sifri et al. 2006).
 - ii. In adults with MTBI (GCS 13–15) who are receiving anticoagulation

therapy, one study found that a repeat CT was not indicated if the original CT showed no intracranial abnormality and there was no neurological deficit (Kaen et al., 2010).

- iii. Children with MTBI with abnormal initial CTs or neurologic deterioration should undergo a repeat head CT (Givner et al., 2002). Currently, there are no recommendations for children who do not need a repeat head CT.
- d. Other forms of CT imaging
 - i. Xenon-133 CT: Used to evaluate regional cerebral blood flow (rCBF).
 - ii. CT with perfusion: Used to measure cerebral perfusion by calculating the mean transit time (MTT), cerebral blood volume (CBV), and cerebral blood flow (CBF = CBV/MTT; Wintermark, Sincic, Sridhar, & Chien, 2008).
 - iii. Single photon emission computed tomography (SPECT): Estimates rCBF.
 - iv. Positive emission tomography (PET): Detects cerebral blood flow, oxygen metabolism, and glucose metabolism.
 - v. Use of these studies for MTBI patients has been limited primarily to investigational purposes. They have shown alterations in cerebral blood flow, perfusion, and metabolism after a MTBI (Bazarian et al., 2006; Metting et al., 2009; Nariai et al., 2001).

C. MRI

- a. Mechanism
 - i. MRI uses the response to strong magnets and radiofrequency pulses of hydrogen molecules contained within brain tissues to produce detailed 3-D and 2-D images. The magnet is the center of MRI technology. They are graded in Tesla. The average MRI scan used in medical imaging ranges from 1.0 to 3.0 Tesla (Yousem et al., 2010).
 - ii. Special attention needs to be given to items that contain metal since they can become projectile missiles inside of an MRI scanner. A patient with metallic fragments in the eye, a pacemaker, some aneurysm clips, or dental implants cannot have an MRI. Patients with ventriculoperitoneal

Table 2. Magnetic resonance technology use in concussion

Technique	Mechanism	Studies
MT imaging	Increases the resolution between CSF and brain tissue by differentiating between mobile water molecules and bound water molecules.	Two studies have shown improved detection of parenchymal lesions using this type of MRI in patients with post-concussion syndrome after MTBI (Hofman et al., 2002; McGowan et al., 2000).
DWI	Detects the linear flow of water in the brain in three planes; detects small areas of edema that cannot be seen in routine T2 imaging (Johnston, Ptito, Chankowsky, & Chen, 2001); allows differentiation between cytotoxic and vasogenic edema (Suskauer & Haufman, 2009).	DWI performed early after concussion demonstrates a decrease in diffusion, whereas studies done later in the course of recovery show increased diffusion (Bazarian et al., 2006).
DTI	More specific to white matter tracts, detects linear flow of water in six planes to produce 3-D images (Bazarian et al. 2006); evaluates structural connectivity; fractional anisotropy (FA) index = representation of the uni-directional diffusion; integrity of white matter tracts = FA of 1; disrupted white matter tracts = FA of 0 (Van Boven et al., 2009).	Multiple studies have shown a correlation between low FA values and poor cognitive testing and persistent post-concussive symptoms, especially in the pediatric population. In addition, longitudinal studies in children have shown increasing values of FA, suggesting a functional recovery of the white matter tracts over time (Suskauer & Haufman, 2009).
SWI	Detects extracellular and extravascular blood products early after injury; able to detect larger numbers and volumes of microhemorrhages (Suskauer and Haufman 2009).	Most studies were performed on severe TBI patients but were found that the number and volume of lesions negatively correlated with IQ and neuropsychological test scores.
MRS	Detects signals from neurometabolites contained within brain tissue; two significant signals include n-acetylaspartate (marker of neuronal integrity) and choline (marker of neuronal damage).	Increased levels of choline and decreased levels of N-acetyl aspartate found in concussion patients; indicates neuronal damage.
fMRI	Detects brain function by tracking blood flow to activated areas of the brain during a cognitive task; detects the change in ratio of hemoglobin to oxyhemoglobin (Van Boven et al., 2009).	Increased activation in areas of the brain to perform tasks may represent a recruitment of neurons to bypass damaged areas.
<p><i>Abbreviations: MT, magnetization transfer; DWI, diffusion-weighted imaging; DTI, diffusion tensor imaging; SWI, susceptibility weighted imaging; MRS, magnetic resonance spectroscopic, imaging; fMRI, functional magnetic resonance imaging. Sources: Bazarian et al., 2006; Jagoda et al., 2008; Suskauer & Haufman, 2009; Van Boven et al., 2009</i></p>		

shunts that use a magnet within the valve will need to have their valves readjusted after having an MRI.

- b. Current use of MRI in MTBI (Table 2)
 - i. Traumatic axonal injury (TAI) may occur with MTBI. These lesions are small and tend to group in various areas of the brain. They are located in the lobar white matter, especially at the junction of gray and white matter; 80% of these lesions are nonhemorrhagic. MRI has been found to be much more sensitive (up to 30%) than CT in detecting the small changes that occur after a TBI such as TAI, and while these studies show promise to date, MRI is not currently standard of care in the management of MTBI and is generally used for research purposes (Doezema et al., 1991; Mittl et al., 1994; Orrison et al., 1994).
 - ii. The common technique used in MRI are T1 (spin-lattice relaxation time) and T2 (spin-spin relaxation time) weighted imaging.
 - a) The terms T1 and T2 refer to relaxation time of the hydrogen

molecule to return to its normal position in different planes. Clinically speaking, T1 weighted images are used to visualize the tissues. Tissues are bright on T1 weighted images. T2 weighted images are used to visualize the cerebrospinal fluid (CSF) and cerebrospinal (Yousem et al., 2010).

- b) In MTBI, four studies revealed a prevalence of 10%–57% abnormal findings on MRI scanning (Doezema et al., 1991; Hofman et al., 2001; Hughes et al., 2004; Voller et al., 1999). These lesions included extra-axial hematomas, hemorrhagic and nonhemorrhagic contusions, and TAI. In regards to surgical interventions, none of these lesions were found to be of clinical significance. However, some studies have found a clinical significance to post-concussive symptoms and the development of post-concussion syndrome (Bazarian et al., 2006).

- c) In children, the location of intracranial lesions has been associated with psychiatric outcomes such as the development of attention deficit disorder, post-traumatic attention deficit hyperactivity disorder, personality disorder, anxiety disorder, and obsessive compulsive disorder. In addition, neuropsychological testing has shown dysfunction in memory and executive functioning (Suskauer & Huisman, 2009).
- c. MRI techniques used in MTBI
- i. The development of specialized pulse sequences has led to new techniques in MRI scanning. These include magnetized transfer (MT) imaging, fluid-attenuated inversion recovery (FLAIR), fast field echo (T2-weighted) imaging, gradient-echo imaging, susceptibility weighted imaging (SWI), diffusion-weighted imaging, diffusion tensor imaging (DTI), magnetic resonance spectroscopy (MRS), functional MRI (fMRI), and magnetic source imaging (Jagoda et al., 2008). Some of these sequences are described in Table 2.

Nursing recommendation: With the development of new MRI techniques, earlier diagnosis of patients with clinically significant lesions could lead to earlier implementation of new medical and neuropsychological interventions for the prevention and treatment of post-concussive symptoms, learning disorders, and psychiatric conditions (**Level 3**).

D. Biomarkers

1. After TBI, proteins are released into the bloodstream after crossing the blood-brain barrier, which can be detected by laboratory testing. Research surrounding biomarkers has focused on their correlation with CT findings and clinical outcomes.
2. Some studies have shown that S-100B could reduce the number of CT scans performed on MTBI patients by as much as 30%, resulting in reduced healthcare costs. However, further validation needs to be performed before this can be universally accepted and FDA approval has not been given (**Table 3**).

V. Assessment and Monitoring

A. Initial and sideline evaluation

1. Completed by a trained professional (Professionals who often perform sideline evaluations include athletic trainers, emergency medical technicians, nurses, and physicians.)

Table 3. Biomarkers in concussion

Biomarker	Cell	Clinical Significance
S-100B	Astrocyte	<ul style="list-style-type: none"> • Most studied • Detected 30 mins after injury • Half-life of 97 mins • At levels <0.1 mcg/L within 4 hrs of injury, S-100B levels are a sensitive predictor of CT abnormality • Also contained within adipose, skin, and cartilage, therefore, not as specific in patients with significant extracranial traumatic injuries, which leads to a low specificity • Weak to moderate correlation with long-term outcome
Glial fibrillary acidic protein	Astrocyte	<ul style="list-style-type: none"> • Only studied in severe TBI
Creatine kinase BB isoenzyme	Astrocyte	<ul style="list-style-type: none"> • Weak correlation with CT • Weak correlation with long-term outcome
Myelin basic protein	Oligo-dendrocyte	<ul style="list-style-type: none"> • Moderate correlation with CT findings in two studies but researchers combined severe and mild TBI patients (Bazarian et al., 2006)
Cleaved-tau	Neuron	<ul style="list-style-type: none"> • Studies mixed with severe TBI patients
Neuron-specific enolase	Neuron	<ul style="list-style-type: none"> • Not studied in correlation with CT • Studies grouped with severe TBI patients • In MTBI, showed low sensitivity
α II-spectrin breakdown products	Neuron	<ul style="list-style-type: none"> • Studied in severe TBI patients and animal models • Obtained from CSF • Current studies focusing on development of antibodies to breakdown products that can be detected in serum

Abbreviations: CSF, cerebrospinal fluid; CT, computed tomography; MTBI, mild traumatic brain injury; TBI, traumatic brain injury

2. Components of this evaluation include
 - a. mental status and cognitive testing to address orientation, concentration (e.g., adding by 7s, reciting months backwards), and memory (e.g., details of events leading to concussion, 3-item recall)
 - b. symptoms at the time of injury as well as exacerbation of symptoms with activity.
 - c. neurologic tests such as checking pupils, coordination (finger-to-nose test and tandem gait testing), and sensation should be assessed by a trained professional (AAN, 1997; McCrory et al., 2009; Whiteside, 2006).

B. Initial nursing assessment of patient following MTBI

1. Injury characteristics
 - a. History of the events leading to the concussion.
 - Nurses should ask questions about events leading to the concussion that will indicate whether assault or abuse were involved in the incident.
 - b. Mechanism of injury
 - c. Duration and severity of alteration in consciousness
 - d. Immediate and current symptoms (level of consciousness, posttraumatic amnesia, headache, dizziness, memory difficulties, balance disturbance, etc.)
 - e. History of prior concussions (number, age at occurrence, etc.)
 - f. This information will assist in making treatment and imaging decisions as well as recommendations for returning to work and play (Department of Veterans Affairs & Department of Defense [DVA], 2009).
2. Obtain a thorough patient history to evaluate for confounding or comorbid conditions that may exacerbate concussion symptoms or complicate the concussion recovery process. Current or prior use of alcohol or drugs, psychiatric conditions, and medications that may exacerbate symptoms should be reviewed. Also assess if assault or abuse were involved including domestic violence, child abuse, and elder abuse (DVA, 2009).

C. Timing

1. Frequency of assessment and monitoring following concussion has not been addressed in the literature. There is occasional mention of serial or repeated assessments to track neurologic decline or progress, but the suggested timing or frequency of such

assessments following concussion is not reported.

Nursing recommendation: The guideline panel recommends an initial assessment, repeated hourly until the patient returns to baseline. Any decrease in neurologic status should prompt more frequent neurologic assessment and notification of the physician. Symptoms may not be resolved at the time of discharge from the ED or hospital; however, neurologic status should have returned to baseline prior to discharge. For most, this will be GCS 15, full motor strength, and being alert and oriented with no focal deficits. Further research is required to establish a clear timing frequency of assessments for concussion (**Level 3**).

D. Components of assessment

1. Neurologic examination, including items described in the section on initial and sideline evaluation on page 13 should be assessed in order to compare the initial assessment to future neurologic examinations.

Nursing recommendation: Nurses should be alert for “red flags”: altered consciousness, declining neurologic examinations, abnormal pupil response, seizures, vomiting, vision changes, worsening headache, disorientation, confusion, irritability, slurred speech, balance disturbance, and numbness or weakness in arms or legs (**Level 3**; DVA, 2009).

- a. Assessment of balance to identify postural stability deficits is recommended (**Level 3**; McCrory et al., 2009). This testing is an advanced practice assessment; however, registered nurses should be aware of balance disturbances, observe patients getting up and walking, and ensure safety. Formal assessment of balance by advanced practice nurses, physicians, or rehabilitation specialists can be performed at the bedside and monitored with serial examinations when difficulties with balance are identified.
2. Symptom assessment includes a report from the patient, or family member if the patient is unable, of physical, cognitive, and emotional or behavioral symptoms.
 - a. Fatigue and sleep difficulties as well as pain level and severity should be assessed (Bazarian, McClung, Cheng, Flesher, & Schneider, 2005; Blinman, Houseknecht, Snyder, Wiebe, & Nance, 2009; Lundin, De Boussard, Edman, & Borg, 2006; McCrory et al., 2009).
 - b. Establishing the baseline symptoms and monitoring for resolution of symptoms is

- helpful for monitoring treatment efficacy (DVA, 2009).
- c. See section on post-concussion syndrome on page 20 for assessment of long-term or persistent symptoms.
 - d. Assessing the perceived affect of the symptoms will help identify potential difficulties that may be encountered for returning to work, school, and sports and may indicate a need for referral to rehabilitation specialists.
 - e. Pediatric assessment includes a symptom report from the child as well as parent. Teachers' reports of ongoing symptoms can also be helpful. Parents' reports of symptoms should not replace the child's report but should be an additional source to better understand the symptomatology (Ayr, Yeates, Taylor, & Browne, 2009).

Nursing recommendation: Fatigue and sleep difficulties as well as pain level and severity should be assessed on an ongoing basis (**Level 2**). Establishing baseline symptom experience and monitoring for symptom resolution is helpful for monitoring treatment response (**Level 3**).

E. Assessment tools

Use of a single assessment measure for MTBI is not supported in current literature. The following tools may be used in combination and should be examined for utility in individual clinical practice settings. Diagnosis of concussion cannot be made solely by these measures, but these assessment tools may be helpful for monitoring progress or decline in status.

1. GCS is a widely used measure of level of consciousness in the trauma populations. Its components include eye opening, verbal response, and motor response. Although the overall scale ranges from 3 to 15, it is recommended that individual items be reported separately in addition to the total score (Teasdale & Jennett, 1974). The scale is often used to classify severity of injury, such as severe TBI for scores of 8 or less, moderate TBI for scores of 9–12, and mild TBI for scores of 13–15. GCS as a measure of severity of concussion has been used to assist with the clinical decision to perform CT scans or not. Specifically, GCS 15 with no clinically significant findings was deemed a “low risk” category in a large prospective study. This group was able to be discharged from the ED without a CT scan with a favorable outcome (Fabbri et al., 2004).

2. Acute Concussion Evaluation (ACE) is a tool created for assessing concussion in primary care and emergency medicine settings. Its components include 1) characteristics of the injury including mechanism, level of consciousness, and posttraumatic amnesia; 2) signs and symptoms; and 3) risk factors for prolonged recovery. The tool is intended for serial assessment to monitor progress or decline over time. In addition to the evaluation, there is a care plan for making treatment recommendations including return to work, school, and play. This scale has been validated with adult and adolescent concussion patients within 3 months of time since injury and its reliability is supported (Gioia, Collins, & Isquith, 2008).
3. Military Acute Concussion Evaluation (MACE) is used for assessment and documentation of mechanism of injury, acute characteristics of the injury, and cognitive deficits. It is primarily used in military operational settings. This scale has not yet been validated although the concussion evaluation section is based on the Standardized Assessment of Concussion (SAC), which is a validated tool for concussion. Without evidence to support its psychometric properties including use with the general population, this may not be the optimal measure for use at this time in the acute care or rehabilitation settings.
4. SAC is a test used to document the presence and severity of neurocognitive impairment associated with concussion. It tests for impairment in orientation, immediate memory, concentration, and delayed recall. This tool was developed as a quick (6 minute) assessment of concussed athletes as a sideline evaluation, and baseline scores can be obtained before the start of an athletic season. The SAC had been shown to be a valid and reliable tool for use with concussed athletes for concussion assessment and tracking of recovery (McCrea, Kelly et al., 1998; McCrea, 2008; Giza et al., 2013). In addition, the SAC has been reported as a useful tool for assessment of concussion in the ED (Naunheim, Matero, & Fucetela, 2008).
5. The Rivermead Post-Concussion Symptom Questionnaire has been validated as a measure to assess symptoms following MTBI (King, Crawford, Wenden, Moss, & Wade, 1995). This measure includes somatic,

cognitive, and emotional symptoms as well as a severity rating for each of the 16 items (**Appendix A**).

6. Glasgow Outcome Scale Extended (GOS-E) is an eight-item scale ranging from “death” to “upper good recovery.” The GOS-E has been shown to be more sensitive to change with mild and moderate brain injury compared to the GOS (Sander, 2002).
7. Neurocognitive or neuropsychiatric examinations, such as the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) tests, are supported in the literature for evaluating concussions; however, their use in acute care settings can be complicated by costs of test, time to administer and score, and noise associated with hospital settings. Rehabilitation facilities commonly offer these types of examinations and can tailor treatments to specific areas of difficulties identified during testing.
 - a. ImPACT is a computerized concussion evaluation system. Components of this battery include health history, symptoms report, neuropsychological tests (e.g., attention, memory, response time, problem solving, and response variability), and injury characteristics. These tests take approximately 20 minutes to complete, and results are interpreted by the testing center and reported back to the test administrator. ImPACT has been used as a preseason test for athletes, with return to baseline being a requirement following a concussion. If no pre-injury test is available, results following concussion can be compared to age-appropriate norms. Validity and reliability are reported on concussed athletes (Schatz, Pardini, Lovell, Collins, & Podell, 2006). One small study reported using the ImPACT in the ED setting, where they were able to obtain computers and quiet settings for testing (Peterson, Stull, Collins, & Wange, 2009). They were able to detect subtle neurocognitive deficits when compared to a control group, which may be helpful in determining follow up needs. Although this tool is used extensively in the outpatient setting, because of the system requirements (computer equipment and purchasing the program) and logistic needs of a quiet testing area, it may be difficult to implement in the acute care settings.
8. Assessment of rehabilitation needs
 - a. Most patients with MTBI have symptoms that are self-limiting, with a natural history of recovery occurring within minutes to several weeks following injury. Approximately 5%–15% of persons have persistent symptoms or limitations following MTBI (Ruff, Camenzuli, & Mueller, 1996); therefore, instructions should include to follow up with their healthcare provider if their symptoms do not improve by 1 week after their injury (**Level 3**; Jagoda et al., 2009).
 - b. Healthcare providers should be aware of the resources available in their community for post-acute management of concussion, such as
 - concussion clinics
 - neurologists
 - neuropsychologists
 - rehabilitation specialists
 - vocational rehabilitation
 - c. Screening for cognitive rehabilitation needs can be performed by primary care providers experienced in the care of persons with TBI. If cognitive symptoms are present or other symptoms are severe (such as depression, posttraumatic stress disorder [PTSD], and pain), consider referral to a specialty clinic. Patients should be seen in the specialty clinic within 4 weeks, and if cognitive symptoms resolve should be followed monthly to ensure they are symptom free for 6 months (**Level 3**; Helmick & Members of Consensus Conference, 2010).
- i. Two meta-analyses of neuropsychological functioning with MTBI report that neuropsychological and cognitive functioning returns to near baseline soon after injury (7 days–1 month; Babikian & Asarnow, 2009; Frencham, Fox, & Maybery, 2005). Use of neuropsychological tests at follow up may be helpful in making decisions to return to work, school, and play following concussion (**Level 3**; Gioia, Isquith, Schneider, & Vaughan, 2009).

Nursing recommendation: Nurses caring for persons with concussion should be proficient at performing neurologic examinations, with reevaluations as indicated to detect improvement or decline in neurologic status following a concussion. Nurses should assess for post-concussive symptoms and

educate patients and family about their presence and expected trajectory. Use of a single assessment measure for MTBI is not currently supported, but these assessment tools may be helpful for monitoring progress or decline in status. No specific symptom assessment tool is supported in the literature at this time; however, incorporating a standardized measure into practice may be helpful to not miss subtle symptoms during assessment. Nurses should be aware of neuropsychological and neurocognitive testing that is available in order to educate patients about resources that are available should the patient need further testing and treatment (Level 3).

VI. Patient Problems

A. Acute problems

1. Posttraumatic headaches

- a. Headache is the most commonly reported symptom following MTBI. Acute pain in the ED has been associated with persistent symptoms at 3 months post-injury (Sheedy, Harvey, Faux, Geffen, & Shores, 2009).
- b. Because headaches, as well as other concussion symptoms, are often experienced by the general population, it is important to understand the pre-injury occurrence of headache as well as the acute post-injury complaints.
- c. As with other symptoms, headaches are expected to resolve within days to weeks post-injury, and prolonged headache complaints may be related to other variables (e.g., stress, anxiety, depression).
- d. Elkind (1992) surveyed persons following MTBI and found that 30%–80% developed posttraumatic headaches and that the milder the head injury, the more headaches occurred. In a sample of U.S. soldiers with MTBI, after adjusting for PTSD and depression symptoms, posttraumatic headaches remained a significant problem (Elkind, 1992; Hoge et al., 2008).
- e. The type of headache has been associated with mechanism of injury. Blunt force trauma is usually associated with tension-type headache while blast injury is associated with a higher rate of migraine-type headache (Lew et al., 2006; Terrio et al., 2009; Walker et al., 2010).
- f. Posttraumatic headaches correspond with the International Society of Headache diagnostic criteria (Headache Classification Subcommittee, 2004) and can

be divided into the following types:

- i. Migraine-type (29%; Ferri, 2010)
 - a) Migraine without aura (common migraine) attacks last 4–72 hours and have at least 2 of the following characteristics: unilateral, pulsating pain; moderate to severe intensity of pain, worsened with or causing avoidance of usual physical activity. In addition, at least one of the following symptoms must be present: nausea, vomiting, photophobia, and phonophobia (Headache Classification Subcommittee, 2004).
 - b) Migraine with aura attacks fulfill the same criteria as common migraine; in addition, the aura presents within 60 minutes of onset of headache. Aura consists of one of the following fully reversible features: visual changes, sensory changes, or dysphasic speech (Headache Classification Subcommittee, 2004).
 - c) Treatments
 - Acute abortive treatment: should begin as soon as possible for maximum efficacy and includes Triptans (rizatriptan [Maxalt], eletriptan [Replax], and almotriptan [Axert]) via subcutaneous (SC), oral (PO), or intranasal administration; antiemetics; ergotamines; and dihydroergotamines (DHE).
 - Prophylactic treatment: begins with headaches occurring more than once per week or when other treatments have failed; a 3-month medication trial should occur before changing medications. Classes of drugs used for this purpose include Beta-blockers, calcium-channel blockers, antidepressants (amitriptyline [Elavil] and selective serotonin-reuptake inhibitors), and antiepileptics (e.g., valproic acid [Depakene], gabapentin [Neurontin], and topiramate [Topamax]).
- ii. Tension-type headache, also called stress, muscle contraction, or essential headaches (37%; Ferri, 2010)
 - a) Characterized by headache

- lasting 30 minutes–7 days without nausea or vomiting
- b) Bilateral pressing or tightening pain quality (nonthrobbing), mild or moderate in intensity.
- c) Not precipitated by usual physical activity
- d) Treatment
 - Non-narcotic medications for acute headaches used periodically to prevent rebound headaches
 - Tricyclic antidepressants, muscle relaxants, indomethacin (Indocin) trial; limit nonsteroidal anti-inflammatory drugs (NSAIDs) for chronic headaches
 - There is no universal posttraumatic headache (PTH) treatment protocol to date. However, most care providers utilize the primary headache guideline (www.icsi.org/headache/headache__diagnosis_and_treatment_of_2609.html; Voller et al., 1999)

Nursing recommendation: Nursing assessment or patient headache log should include (**Level 3**; Lew):

- Site of head injury and location of headache pain
 - Pain radiation
 - Type of pain (e.g., pulsating, dull, aching, sharp, etc.).
 - Severity
 - Duration
 - Pain levels (e.g., Visual Analog Scale)
 - Precipitating factors.
2. Fatigue, exhaustion, or lack of energy, is common following MTBI as nearly one-third of persons suffering with MTBI demonstrate severe fatigue 6 months post-injury (Stulemeijer et al., 2006). Studies have shown that post-injury fatigue can persist for years and has been documented up to 5 years following injury (Bushnik, Englander, & Wright, 2008a; Bushnik, Englander, & Wright, 2008b).
- a. Fatigue has been shown to be associated with limitations in daily functioning and quality of life (Cantor et al., 2008; Stulemeijer et al., 2006).
 - b. Fatigue is not related to injury severity. Severe levels of fatigue are associated with limitations in physical and social functioning.
 - c. Fatigue may or may not be associated

- with sleep disturbance following MTBI (see section 3. Sleep disturbances).
- d. Initially, in the acute stages, nurses should monitor drowsiness and fatigue as possible signs of CNS deterioration (**Level 3**; Formisano, 2009). In the later stages, fatigue may result from injury, comorbid symptoms, or side effects of medications, and assessment and monitoring is warranted.
- e. There are two types of fatigue after a MTBI—physical and mental.
 - i. Physical fatigue
 - After increased physical exertion, if the person with MTBI experiences increased symptoms or symptoms that were not initially experienced, then the person’s recovery is not complete (CDC, 2010).
 - Quality-of-life studies demonstrate that after experiencing TBI, physical fatigue is more prevalent and severe than for those whose fatigue is based on depression, pain, or sleep disturbance (Cantor et al., 2008).
 - ii. Mental fatigue
 - Performance of cognitively demanding tasks may lead to mental fatigue, which may in turn impact task performance (Lenaerts, 2008). This is commonly experienced by persons following MTBI.
 - Mental fatigue can last for several years (Chaput, Giguere, Chauny, Denis, & Lavigne, 2009).
- f. Treatment options
 - Periods of rest may be beneficial for both physical and mental fatigue.
 - If fatigue continues, a psychostimulant or amantadine may be ordered (Arciniegas, Anderson, Topkoff, & McAllister, 2005).
 - Graded aerobic exercise with cognitive-behavioral therapy has demonstrated improvement in physical functioning in fatigued persons (Ferri, 2010; Wearden et al., 1998).

Nursing recommendation: Nurses should monitor drowsiness and fatigue in the acute period following injury as possible signs of CNS deterioration (**Level 3**; Formisano, 2009). Nurses should also be aware of and assess for secondary causes of fatigue, including sleep disorders, pain, depression, anxiety, lifestyle, and medication side effects, all of which have been associated with

a reduced tolerance for physical and mental activity (**Level 2**; Bushnik et al., 2008b).

3. Sleep disturbance

- a. TBI patients experience a spectrum of sleep disturbances following injury at rates higher than that of the general population. The lack of quality sleep in patients recovering from TBI can exacerbate symptoms such as pain, irritability, and cognitive deficits (Ouellet & Morin, 2007).
- b. Typical diagnoses include insomnia, hypersomnia, narcolepsy, obstructive sleep apnea, and circadian rhythm sleep disorder.
- c. MTBI is more likely to be associated with insomnia symptoms such as initiation and maintenance of sleep due to the type and location of injuries (Mahmood, Rapport, Hanks, & Fichtenberg, 2004; Gasanov, Gitlevich, Lesnyak, & Levin YaI, 1998).
- d. There is inconsistency in the polysomnographic changes in sleep architecture seen in patients with a history of TBI and reported sleep disturbances. Changes in rapid eye movement (REM) sleep seems to be the most effected by TBI; however, the changes reported are inconsistent and include both increases and decreases in amount of REM sleep (Parcell, Ponsford, Redman, & Rajaratnam, 2008). Reported changes in sleep architecture include a prolongation of stage 1 and an increase in sleep spindle activity seen in nonREM sleep (NREM; Ouellet & Morin, 2007; Parcell et al., 2008).
- e. Treatment options
 - i. Pharmacologic
 - a) Trazadone (Desyrel) is the first-line therapy for sleep disturbance (Arciniegas et al., 2005).
 - b) Other medications may include tricyclic antidepressants or modafinil (Provigil).
 - c) Melatonin has also shown potential benefit for improving sleep in TBI patients (Kemp, Biswas, Neumann, & Coughlan, 2004).
 - d) Use of benzodiazepine hypnotics and antipsychotics are undesirable in TBI patients due to potential interference with neuronal recovery (Rao & Rollings, 2002; Zasler, 1992).

ii. Nonpharmacologic

- a) Includes cognitive behavioral therapy for insomnia (CBT-I) and sleep hygiene education (Babson, Feldner, & Badour, 2010; Siebern & Manber, 2010). In a small pilot study of patients with TBI and insomnia ($n=11$), CBT-I has been found to improve sleep quality (Ouelett & Morin, 2007).
- b) Sleep hygiene education
 - maintain regular bedtime and awakening schedules, including weekends
 - establish usual bedtime routine
 - sleep in quiet, dark, cool room
 - use bedroom only for sleep and sex
 - avoid eating, caffeine, stimulants, smoking, alcohol, and exercise prior to bed
 - if unable to sleep after 15 min in bed, rise and go to another room until sleepiness returns
- c) Preliminary studies of hyperbaric oxygen treatment demonstrate it may improve sleep quality and headaches (Wright, Zant, Groom, Schlegel, & Gililand, 2009).

Nursing recommendation: Nurses should assess for sleep disturbance following MTBI (**Level 2**). Nurses can play a critical role in providing sleep hygiene education and, when appropriately trained, may be providers of CBT-I as indicated.

4. Posture and balance

- a. There is a statistically significant relationship between acute balance deficits and ongoing concussion symptoms at 3 months post-injury.
- b. Postural stability may be an indicator of recovery as postural stability was shown to be statistically worse in a group of persons with MTBI assessed in the ED, compared to controls. Although the MTBI group showed balance errors, all participants could eventually be discharged from the ED when they could mobilize safely (Sheedy et al. 2009).

Nursing recommendation: Nurses should assess and document postural stability in the ED and on an ongoing basis post-injury (**Level 2**).

5. Post-injury symptoms reported in pediatric patients
 - a. The most common symptoms reported in children after MTBI are headache, fatigue, and balance problems.
 - b. The most severe problem is sleep disturbance (too much or too little) (Blinman, Houseknecht, Snyder, Wiebe, & Nance, 2009).
- B. Chronic problems and rehabilitation issues
1. Post-concussive symptoms (PCS)
 - a. The term PCS is more a more accurate term than post-concussion syndrome because symptoms are not orderly in presentation or predictable. Further, the outcome of MTBI may include moderate to moderately severe symptoms leading to cognitive, functional, and emotion-behavioral deficits (Arciniegas et al., 2005; Cantor et al., 2008).
 - b. Initial symptoms begin a few days after the acute concussion, last well beyond 3 months, and may last longer than 1 year.
 - c. 15% of patients will have a complex set of problems.
 - d. Symptoms may be influenced by pre-existing conditions, psychiatric conditions, and other expectations.
 - e. Symptoms include (Ferri, 2010; Al Sayegh, Sandford, & Carson, 2010)
 - headaches
 - fatigue
 - dizziness
 - visual disturbances
 - memory deficits
 - concentration deficits
 - sleep disturbances
 - irritability
 - anxiety
 - poor tolerance to stress, emotion, noise, bright lights, and alcohol
 - neck pain
 - paresthesias
 - personality changes, including argumentativeness, suspicion, and stubborn behaviors
 - audiology (Dennis, 2009).
 - f. PCS affects the patient in behavioral, cognitive, physical, and social aspects.
 - g. Treatment of PCS is challenging because of the varied symptomatology relating to the dysfunction following MTBI. No particular management strategy has been shown to be superior in regard to recovery and prevention of long-term sequelae (Giza et al., 2013). Treatment may include referral to neurology, psychiatry, physiatry, pain management, neuropsychology, and physical and occupational therapy specialists (Ferri, 2010).
 2. Memory
 - a. Neurobiological effects on the central nervous system cause ongoing memory impairment and brain dysfunction in more than one area of the brain (Arciniegas et al., 2005).
 - b. Memory impairment is common, but this could reflect deficits in other cognitive domains such as attention or processing speed, which is interpreted as memory impairment.
 - c. Mental fatigue or PCS can impact long-term memory (Johansson, Berglund, & Romback, 2009).
 - d. A referral to a specialist, including a neuropsychology specialist, should be made if significant symptoms persist after 4–6 weeks.
 - e. At this time, there is no consensus on the treatment for memory impairment secondary to PCS.
 - f. Cognitive rehabilitation is a central component of rehabilitation for TBI; memory interventions include both restorative (i.e., word-list learning, paragraph listening) and compensatory approaches (i.e., memory aids designed to assist with recall and activities of

- daily living, such as memory books or calendars, electronic memory aids [e.g., personal digital assistants], and pager systems; Tsaousides & Gordon, 2009).
- g. Pharmacologic management includes the use of cholinesterase inhibitors (donepezil) for memory, attention, and monitoring the effects of stimulant medications as may exacerbate PCS symptoms.

Nursing recommendation: When completing the assessment, the nurse should screen for potential risk factors that can cause ongoing memory impairments (**Level 3**; Evans, 1992), such as

- previous head injury
 - multiple trauma
 - age 40 years and older
 - alcohol and drug abuse
 - lower socioeconomic level
 - lower intellect level.
3. Vestibular symptoms (Shepard, Clendaniel & Ruchenstein, 2007)
 - a. Benign paroxysmal positional vertigo is characterized by brief periods of dizziness, falls, or lightheadedness induced by head movement and is generally related to displacement of otolith crystals into the semicircular canal. Treatment includes referral to a healthcare provider for crystal repositioning maneuvers (Epley maneuver) or for vestibular and balance rehabilitation therapy.
 - b. Balance disturbance and dizziness from central origin will frequently present with more continuous symptoms of gait imbalance and require vestibular and balance rehabilitation therapy referral.
 - c. Patient history and assessment should include hearing loss or other auditory symptoms with onset of dizziness, posture, and balance assessment.
 - d. Medications used for short-term vestibular suppression therapy include meclizine, promethazine, scopolamine, prochlorperazine, and clonazepam.

Nursing recommendation: Nurses should monitor and assess for the presence of vestibular symptoms following MTBI and provide appropriate referrals for additional treatment (**Level 3**). Nurses should also monitor patients on vestibular suppression therapy for therapeutic and potential adverse effects (**Level 3**).

4. Seizures and epilepsy
 - a. Conventional epilepsy is a rare occurrence following MTBI.

- b. An epileptic syndrome or partial seizure may occur as a result of unusual electrical burst in the brain. This phenomenon may explain “memory gaps, hearing an imaginary voice or feeling a burst of happiness” (Roberts, 2008).

VII. Patient or Family Caregiver Education

A. Assessment and implications for providing education regarding MTBI

1. Consensus of medical MTBI literature projects safe patient discharge to home with adequate patient and family education.
 - a. Caregivers are able to monitor the neurologically normal MTBI patient with a potentially significant intracranial injury (Bruns & Jagoda, 2009).
 - b. Provide education regarding expected symptoms, natural history, and the expectation of recovery (Ponsford, Draper, & Schonberger, 2008).
 - c. Educate the patient and family on atypical MTBIs that do not follow the usual short, quick return to baseline cognitive and functional status (Bruns & Jagoda, 2009).
 - d. Expectations of caregivers following education include
 - ability to monitor patient’s daily neurological status
 - ability to identify any deteriorating neurological conditions (Fung, Willer, Moreland, & Leddy, 2006).

B. Implementing education

Implement education prior to ED discharge, during provider’s office visit, or during in-theater situation.

1. Provide education with family or responsible adult present.
2. Multimodal education
 - a. verbal, written, video, and audio instructions
 - b. literacy recommendations: sixth- to seventh-grade level
3. Formatting of written information should include minimum of 12-point font size, wide margins, and left justification to increase white space for enhanced readability (Bruns & Jagoda, 2009; Jagoda et al., 2008), and 1.5-line spacing to accommodate the visually impaired (Fung et al., 2006).
4. Utilize the “teach back” method, where the patient repeats the educational instructions (Uniformed Services University of the Health Sciences, 2010).

5. Facilitate learning with “dual discharge” approach.
 - a. The physician, nurse practitioner, or physician’s assistant provides instructions.
 - b. The nurse provides reinforcement education (www.usuhs.mil).
6. Provide material in short blocks of information.
 - a. Frequent repetition to patient and family, due to memory limitations
 - b. Electronic and paper memory aides (e.g., calendar, alarm watch, digital phone organizers, or personal digital assistants; DVA, 2009; Uniformed Services University of the Health Sciences, 2010)
7. Military combat situation
 - a. Distribute educational material to the patient and the commanding officer.
 - i. Communicate specific duty assignments and limitations.
 - ii. Emphasize expectations of full recovery (Helmick & Working Group Members, 2006).
 - iii. Provide early education and treatment for alleviating symptoms to decrease potential for prolonged post-concussive syndrome.
 - b. Unique military education challenges for MTBI
 - i. Co-morbidity issues
 - ii. Prolonged delay in seeking treatment
 - iii. Belief that illness equals weakness
 - iv. Potential career implications
- C. Education for adults who have sustained MTBI (CDC, 2010; DVA, 2009)
 1. Follow treatment recommendations to aid recovery.
 2. Get plenty of sleep at night and rest during the day.
 3. Avoid physically demanding activities or those requiring extensive concentration.
 4. Avoid activities such as contact or recreational sports.
 5. Ask the healthcare professional when to resume activities such as driving, bike riding, and operating heavy machinery.
 6. Avoid airplane travel initially as it may worsen symptoms.
 7. Talk to employer about injury diagnosis and limitations, and gradually return to work and activities.
 8. Avoid alcohol and caffeine as they can worsen symptoms.
 9. Follow instructions regarding over-the-counter medications as they may slow recovery and impair memory.
 10. Maintain a healthy diet; exercise routinely.
 11. Create usual daily routines.
 12. Limit distractions and noise, and complete one task at a time.
 13. Avoid sustained use of computers or video games.
 14. Document appointments, phone numbers, and names in a notebook.
 15. Use a calendar or daily planner to aid memory.
 16. A take-home resource for patients is “What to expect after a concussion,” available from CDC at www.cdc.gov/concussion/pdf/TBI_Patient_Instructions-a.pdf (See also **Appendix B**).
- D. Education for the patient and family related to childhood MTBI injuries
 1. Contact the primary care provider if the following occur after discharge: listlessness, continued irritability, sleep, eating and play changes, regression in developmental skills, and balance problems (BIAA, 2007; U.S. Department of Health and Human Services, 2010).
 2. Children who have sustained trauma to the head should always be taken to the ED for examination.
 3. Children may have difficulty comprehending what has occurred and how to express their needs and fears.
 4. Rest is a major component of the recovery process. Patients need to maintain rest and avoid high-risk, high-speed activities.
 5. Administer only medications approved by the healthcare provider.
 6. Subsequent changes related to injury may become evident as child grows and develops.
 7. Hold the expectation that errors will occur and provide gentle correction in a blameless environment.
 8. Maintain a consistent routine and minimize distractions (BIAA, 2007; CDC, 2010; USDHHS, 2010).
 9. Educate the patient and family on potential consequences of a premature return to sports in those suffering sport-related concussion.
 - a. Risk of repetitive concussion
 - b. Risk of second-impact syndrome and death
 - i. The brain has not fully recovered from the initial trauma.
 - ii. Adequate rest for brain healing has not occurred.
 - iii. The impact from a second injury can be catastrophic (McCrea, 2008).

10. Teachers, coaches, counselors, siblings, and babysitters should be alerted to the concussion incident.
 - a. Educate on second-impact syndrome
 - b. The athlete diagnosed with a concussion should not be allowed to return to play the same day (Harmon et al., 2013)
 - c. Discuss poorer prognosis (i.e., difficulty with concentration, memory, headache, and balance) with repetitive trauma (CDC, 2010).
- E. Education for all patients following MTBI
1. Communicate the expectation for full recovery and the potential timeframe; impart expectation for rapid complete recovery for a first-time concussion is usually within 1 week–3 months (Hoge et al., 2008; Lew et al., 2008; McCrea, 2008; Michigan TBI Services and Prevention Council, 2008).
 2. Normalize symptoms as part of a routine recovery; symptom recovery generally requires no treatment.
 3. Recovery will vary by individual.
 4. Young patients recover more quickly with little evidence of residual cognitive, behavioral, or academic deficits.
 5. Recovery takes longer for those over 40 years old or those with other preexisting conditions (McCrea, 2008; Michigan TBI Services and Prevention Council, 2008).
 6. Refrain from physical and strenuous mental exertion for 2–3 days following concussion.
 7. Maintain home monitoring and observation for 24 hours.
 - a. Frequent awakening and pupil monitoring in conjunction with negative head CT or patient at negligible risk for imaging in ED is not supported by the literature (Jagoda et al., 2008).
 - b. Current literature is mixed on support for need to awaken MTBI patients for monitoring and further assessment. One group recommends awakening twice the first night (Fung et al., 2006). According to another group, because deterioration of MTBI patient condition can be rapid, occurring over minutes to hours, monitoring was considered to be crucial, even though its efficacy remains in question, acknowledging that the literature does not recommend awakening the patient nor the frequency that it should be done (Fung et al., 2006). A third group indicated no need for observation when the CT scan was negative and no other signs or symptoms were present at discharge (Fung et al., 2006).
8. The following symptoms necessitate an immediate return to ED (Bruns & Jagoda, 2009; Fung et al., 2006; Jagoda et al., 2008):
 - repeated vomiting
 - jerking of body or limbs (seizures)
 - inability to remember new events
 - increased sleepiness or confusion
 - inability to move parts of body
 - loss of vision or speech, changes in behavior (acting strange, saying things that do not make sense)
 - worsening headache.
 9. Potential development of post-concussive symptoms prior to discharge
 - a. PCS education should be presented verbally and in written format, addressing physical, cognitive, and emotional symptoms.
 - i. Physical symptoms
 - a) Include headache, sleep difficulties, dizziness or balance problems, feeling tired all the time, increased sensitivity to noise or light, nausea
 - b) Educate regarding the following interventions for physical symptoms: rest, quiet, nonstimulating environment, regular sleep routines, light exercise as permitted, relaxation, and stress management techniques (e.g., meditation, visualization, deep breathing), well-balanced diet, protection from bright light, and avoiding rapid position or head changes to dampen dizziness (may require vestibular rehabilitation)
 - ii. Cognitive symptoms
 - a) Include difficulty paying attention or concentrating, memory problems
 - b) Educate regarding the following interventions: assistive strategies with personal digital assistants, calendars, notes, aerobic exercise, and refreshing sleep and rest
 - i. Emotional symptoms
 - a) Include anxiety, irritability or mood swings, depression
 - b) Educate regarding the following interventions: family support, exercise, nutritious meals, relaxation and stress management

- techniques, good sleep hygiene (Bruns & Jagoda, 2009; Jagoda et al., 2008; Lew et al., 2008; McCrea, 2008; Michigan TBI Services and Prevention Council, 2008; Sayer et al., 2009; DVA, 2009; Hunt et al., 2006)
- b. Appearance and duration of PCS varies widely in the literature, may last days or weeks to a few months, and the prognosis is generally positive.
 - c. Persistent symptoms may indicate need for referral to a specialist (Bruns & Jagoda, 2009; McCrea, 2008).
10. Medications
- a. There is no specific drug indicated to treat MTBI or PCS.
 - b. As medications can impede neuronal recovery of the brain and negatively impact cognitive abilities, it is important for patients to fully disclose to health-care providers all current medications, including over-the-counter medications, herbal supplements, illicit drugs, and blood thinners.
 - c. Aspirin or anticoagulants and alcohol may exacerbate symptoms or prolong recovery time.
 - d. Brain-injured patients have a heightened sensitivity to medication with increased risk for side effects (Cifu, Steinmetz, & Drake, 2010; Comper et al., 2005; Rose, 2005; V A National Center, 2007).
 - e. Medications may be ordered to treat headache, sleep problems, depression, emotional issues, dizziness, memory problems, fatigue and musculoskeletal pain. Follow prescribed dosages.
 - f. Instruct the patient and family on potential side effects, drug interactions, and the need for immediate reporting of either to prevent detrimental cognitive impact (Cifu et al., 2008; Comper, Bishop, Carnide, & Tricco, 2005; DVA, 2009; Rose, 2005). Symptom-specific medication recommendations may be referenced in the VA/DoD Clinical Practice Guideline Management of Concussion/Mild Traumatic Brain Injury (DVA, 2009).
11. Recommendations for resumption of activity (e.g., school, work, sports, driving, combat, leisure) should be provided as written instructions.
- a. Military
 - Initial period of rest, if symptomatic;
 - b. Athletes—suggested to refrain from sports until physician authorization
 - Return when symptom free at rest and with exertion (Cifu et al., 2008; Fung et al., 2006)
 - Progressive activity protocols may guide RTP (May, Marshall, Burns, Popoli, & Polikandriotis, 2014)
 - Educate athletes, parents, and coaches regarding cumulative trauma prognoses and second-impact syndrome, which can be fatal due to brain edema (Bruns & Jagoda, 2009).
 - c. Pediatric patients
 - Notification of teachers, coaches, and counselors of the concussion upon return to play or school
 - Modified work load, nonstrenuous play, rest periods, repetitive instructions
 - Frequent communication with parents
 - Increased assistance for assignment completion (BIAA, 2007)
 - d. Adult return to work
 - Consideration for a modified work schedule
 - Provide services of a vocational rehabilitation counselor as needed
 - Reassignment of duties during recovery period for hazardous occupation, complex cognitive pressures, multitasking, and deadlines
 - Return to work should not derail the recovery process or exacerbate PCS
 - Fitness for duty statement from the physician may be needed (Jagoda et al., 2008; Rose, 2005)
12. Prevention of MTBI recurrence
- a. Educate patients, families, providers, and the public on the importance of preventing recurrent MTBI due to the impact and serious implications of cumulative trauma.
 - b. Athletes and pediatric patients
 - Adhere to child safety seat criteria.
 - Wear seatbelts.
 - Wear helmets for risky sports.
 - Exercise good sportsmanship.
 - Follow healthcare providers'

instructions for rest, activity, and prescribed medications.

- Refrain from premature resumption of sports and usual activities.
- Refrain from alcohol consumption (BIAA, 2007; U.S. DHHS, 2010).

c. Military

- Utilize protective equipment.
- Adhere to screening and treatment.
- Return to full duty in graduated steps (Helmick & Working Group Members, 2006).

d. Middle and older adults

- Avoid throw rugs in home.
- Wear seatbelts in cars and and helmets on motorcycles.
- Ladders should be used safely and within capability.
- Implement siderails on stairs and grab-bars in bathrooms.
- Drive when conditions are safest.
- Refrain from driving impaired.
- Obtain regular eye examinations.
- Utilize alternatives to driving.
- Limit distractions (CDC, 2010).

F. Evaluation of learning effectiveness

1. Utilize the “teach back” method.
2. Provide opportunities for questions or clarification.
3. Print and explain graphics from the patient education library.
4. Ask open-ended questions to elicit the patient’s and family’s comprehension, fears, and anxiety related to coping strategies.
5. Include written contact information for follow up (DVA, 2009).

G. Documentation

Document in the medical record materials who provided education, who received the education, what modes of education were used (e.g. verbal, print, pictures, demonstration), and the patient’s and family’s response to the education.

VIII. Expected Outcomes

A. Initial recovery

Following concussion, nurses should assess the patient’s neurologic status to determine a post-injury baseline. Neurologic status should improve over the course of the initial visit, with the GCS improving or remaining at 15, normal pupil responses, and no evidence of focal neurologic deficits (March & Hickey, 2014). Nurses should not expect symptoms to resolve during the initial evaluation period (typically in the ED) as the expected trajectory is for gradual symptom resolution over days to weeks following injury (Carroll, Cassidy, Peloso, et al., 2004;

Lannsjo, Geijerstom, Johansson, Bring, & Borg, 2009; Lundin, De Boussard, Edman, & Borg, 2006).

Nursing recommendation: Any decline in neurologic status should prompt more frequent assessments as well as a medical evaluation (**Level 2**).

B. Symptoms

Outcomes for patients with concussion have been described from a variety of perspectives, including symptom resolution, cognitive, behavioral, or physical functioning. Mortality is rare among the MTBI population (Carroll, Cassidy, Peloso, et al., 2004), and outcomes are more commonly discussed in terms of disability or difficulties with returning to pre-injury roles.

1. A decline in symptom number and severity is expected for most patients and occurs days to weeks post-injury (Carroll et al., 2004; Lannsjo et al., 2009; Lundin et al., 2006).
2. Sports concussion is expected to resolve within 7–10 days post-injury (McCrea et al., 2009).
3. A small percentage of persons with concussion continue to experience symptoms 3 months after injury (5%–30%; Lannsjo et al., 2009; Lundin et al., 2006). For some cases, persistent symptoms may be related to pre-injury factors—such as depression, anxiety, and pain—and symptoms should be managed accordingly considering the comorbid conditions.

C. Functional outcomes

1. Final outcomes are typically reported in terms of successful return to work, school, and sports. Although symptoms are expected to resolve in a short period of time (McCrory et al., 2009), living with the symptoms for even a short time can be disabling.
2. Patients with MTBI are typically expected to return to their pre-injury roles within days of their injury, which can be problematic because they may still be experiencing physical, cognitive, or psychosocial difficulties. In a study of return to work after mild to moderate brain injury, Gilworth and colleagues (2008) found that post-TBI patients described that, although they were able to return to work, they were questioned on the reality of their difficulties because the brain injury is not outwardly visible. Referral to vocational rehabilitation or social services may be indicated.
3. Studies indicate that cognitive deficits (e.g., inability to pay attention, use short-term and long-term memory, and use executive function) are common soon after injury.

Frencham and colleagues (2005) conducted a meta-analysis of factors such as memory, attention, perceptual organization, processing speed, and executive functioning, and found that time since injury was a significant moderating variable. This large study supports that, while cognitive outcomes may be problematic soon after injury, patients with MTBI should regain cognitive function with time. By 12 months, patients with MTBI scored equal to those in non-TBI groups on tests of cognitive function (Dikmen et al., 2009). Appropriate referral for cognitive therapy may be indicated.

4. Persons with MTBI are more likely than controls to experience new onset of depression, anxiety, PTSD, and agoraphobia (Bryant et al., 2010). Negative expectations regarding injury and recovery can affect post-MTBI outcome. Mittenberg and colleagues (1992) describe this phenomenon as “expectation as etiology,” where people are more likely to experience symptoms if they expect to do so. Referral to neuropsychologist may be appropriate.
5. Pediatric outcomes are similar to those for adults with an expected gradual decline in symptoms. Because children and adolescents are more prone to the devastating effects of second-impact syndrome, special consideration must be given to this population when making return-to-play recommendations (McCrary & Berkovic, 2001). Children should be symptom free prior to returning to sports, including during rest, exertion, and cognitive exertion, and should never be allowed to return to play on the same day as the injury. Children may also require cognitive rest if they are expected to perform academically and are unable to do so because of the symptoms they experience or if symptoms worsen during school or academic activities.

Nursing recommendation: Nurses should provide support and advocate for patients following MTBI as they return to usual activities (**Level 2**). Nurses should provide education regarding the trajectory of recovery and expectations in order to promote optimal recovery (**Level 2**).

D. Risk factors for poor outcome

1. Pre-injury: Increased age, female (Dischinger, Ryb, Kufera, & Aumon, 2009), less education, mental health disorders (e.g., depression, anxiety), stress, substance abuse (U.S. Department of Veterans Affairs, 2010)
2. Peri-injury: Lack of support system, symptom presentation (e.g., headache, dizziness, nausea) in the ED, context of injury (e.g., stress, combat, traumatic; DVA, 2009); injury severity measures such as level of consciousness, post-traumatic amnesia, and injury severity scores are not predictors of outcome following MTBI (Kashluba, Paniak, & Casey, 2008).
3. Post-injury: Compensation, litigation, psychiatric disorder, chronic pain, lack of support, low education level (U.S. Department of Veterans Affairs, 2010); the World Health Organization taskforce, as well as a meta-analysis of MTBI, identified litigation as a predictor of prolonged symptom complaints and delayed return to work (Belanger, Curtiss, Demery, Lebowitz, & Vanderploeg, 2005; Carroll, Cassidy, Peloso, et al., 2004).

Nursing recommendation: Nurses should be aware of and assess for risk factors for poor outcome following MTBI (**Level 2**). In cases where there is a modifiable risk factor (e.g., pain, lack of support), nurses should provide appropriate intervention in order to mediate their effect on outcome (**Level 3**).

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Appendix A

The Rivermead Post-Concussion Symptoms Questionnaire*

After a head injury or accident some people experience symptoms which can cause worry or nuisance. We would like to know if you now suffer from any of the symptoms given below. As many of these symptoms occur normally, we would like you to compare yourself now with before the accident. For each one, please circle the number closest to your answer.

- 0 = Not experienced at all
- 1 = No more of a problem
- 2 = A mild problem
- 3 = A moderate problem
- 4 = A severe problem

Compared with before the accident, do you now (i.e., over the last 24 hours) suffer from:

Headaches.....	0	1	2	3	4
Feelings of Dizziness	0	1	2	3	4
Nausea and/or Vomiting	0	1	2	3	4
Noise Sensitivity,					
easily upset by loud noise	0	1	2	3	4
Sleep Disturbance.....	0	1	2	3	4
Fatigue, tiring more easily.....	0	1	2	3	4
Being Irritable, easily angered	0	1	2	3	4
Feeling Depressed or Tearful	0	1	2	3	4
Feeling Frustrated or Impatient	0	1	2	3	4
Forgetfulness, poor memory	0	1	2	3	4
Poor Concentration	0	1	2	3	4
Taking Longer to Think	0	1	2	3	4
Blurred Vision	0	1	2	3	4
Light Sensitivity,					
Easily upset by bright light.....	0	1	2	3	4
Double Vision	0	1	2	3	4
Restlessness	0	1	2	3	4

Are you experiencing any other difficulties?

- | | | | | | |
|----------|---|---|---|---|---|
| 1. _____ | 0 | 1 | 2 | 3 | 4 |
| 2. _____ | 0 | 1 | 2 | 3 | 4 |

*King, N., Crawford, S., Wenden, F., Moss, N., and Wade, D. (1995) J. Neurology 242: 587-592

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Appendix B: Resources

Online Resources for Clinicians

1. CDC (www.cdc.gov/traumaticbraininjury)

This is a government sponsored resource. Acute Concussion Evaluation (ACE) for Physician/Clinician Office Version, as well as additional resources for clinicians such as the Heads Up for Clinicians, are available here.

2. Brain Injury Association of America (BIAA, www.biausa.org)

BIAA is the leading national organization serving and representing individuals, families, and professionals who are touched by a life-altering, often devastating, TBI.

3. BrainLine (www.brainline.org) BrainLine.org is a website of WETA Public Television and Radio funded by the Defense and Veterans Brain Injury Center (www.dvbic.org) through a contract with the Henry M. Jackson Foundation. Government funding support is not an endorsement of WETA or any of its products, including this website.

4. Defense and Veterans Brain Injury Center (www.dvbic.org)

This is a government-based resource for veterans from the Department of Defense with an emphasis on education, treatment, and research.

5. Centre for Neuro Skills (CNS, www.neuroskills.com)

This site provides medical- and rehabilitation-related content, and CNS is strongly involved in advocacy and support.

6. Deployment Health Clinical Center (www.pdhealth.mil/TBI.asp)

This is a government site with information for clinicians, families, and service members.

7. National Guideline Clearinghouse (www.guideline.gov)

This is a government site from the U.S. Department of Health & Human Services Agency for Healthcare Research and Quality that is searchable for clinical practice guidelines on TBI and its related symptoms.

8. National Injury Prevention Foundation (www.think-first.org)

This foundation is aimed at reducing traumatic injuries in children, teens, adults, families, and communities. It promotes and provides activities to increase awareness and knowledge about risk of injury and use of good safety habits.

9. Society for Neuroscience (<http://web.sfn.org>)

This is an advocacy group that works actively to increase federal support for biomedical research and to convey to policymakers the importance of sustained research funding. It engages membership and chapters in advocacy efforts both in Washington, D. C. and at the local level.

10. U.S. National Library of Medicine and National Institutes of Health (www.nlm.nih.gov/medlineplus/traumaticbraininjury.html)

The library collects materials and provides information and research services in all areas of biomedicine and health care.

11. Clinical Practice Guideline: Management of Concussion/mild Traumatic Brain Injury (www.healthquality.va.gov/MTBI/concussion_MTBI_full_1_0.pdf)

This resource is available from a government site.

12. Cognitive Rehabilitation for Traumatic Brain Injury and Stroke: Updated Review of the Literature from 1998 through 2002 with Recommendations for Clinical Practice (www.acrm.org/BI-ISIG/docs/Cognitive_Rehabilitation_Update_ACRM.pdf)

This report is available from the American Congress of Rehabilitation Medicine.

13. American Academy of Neurology (AAN), Practice Guidelines & Tools (www.aan.com/go/practice/guidelines)

AAN developed these guidelines as a resource for clinical decision-making related to the prevention, diagnosis, treatment, and prognosis of neurologic disorders.

Other Resources for Clinicians

Brain Injury Association of America. (2007). *The Essential Brain Injury Guide* (4th ed.). McLean, VA: Author.

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Online Resources for Patients and Families

- Brain Injury Association of America (www.biausa.org)
- Brain Injury Association of America/State Affiliates (www.biausa.org/state-affiliates.htm)
- Brainline Organization (www.brainline.org)
- Brain Rehabilitation (www.brainrehab.org)
- Defense and Veterans Brain Injury Center (www.dvbic.org)
- Mayo Clinic (www.mayoclinic.org)
- National Centers for Disease Control, National Center for Injury Prevention and Control (www.cdc.gov/ncipc/tbi); Concussion resources (800.232.4636)
- Pain Foundation Organization (www.painfoundation.org)

Other Resources for Patients and Families

- American Pain Foundation. (2009). Pain management for service members and veterans. Canada: QuickSeries Publishing.
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