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Mild Traumatic Brain Injuries

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MILD TRAUMATIC BRAIN INJURIES

by

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This independent study submitted by Martha Jo McCart in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisor under whom the work has been done, and is hereby approved.

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Name of Advisor

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Degree Master of Science

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ABSTRACT

Mild traumatic brain injury (mTBI) or concussion is a serious health problem. Brain injuries can occur due to a variety of impacts and can occur at any age. While concussions are currently in the news, information regarding recognition, response, and management are frequently out of date.

Literature was reviewed in relation to current research in the pathophysiology of mTBI and focused in the area of cerebral blood flow, metabolic demands, and neuronal damage. Additionally, current recommendations relating to identification and response were reviewed in relation to athletics and in the military setting. Nursing knowledge was also addressed by a review of the literature, assessment of two nursing programs, and evaluation of several text books used in nursing education.

In response to current information available to school nursing in this community, a presentation was developed. This presentation reviewed current research in the pathophysiology of mTBI and the recommended guidelines in response and management.

There are many areas in which additional information for mTBI is needed. This is true in nursing text books, nursing programs, and for nurses currently in practice. One of the ways change will occur is the increasing number of laws that are being enacted relating to mTBI and student athletes. This will create a more immediate need for nurses to have comprehensive knowledge of mTBI, in both educational and community settings.

Introduction

The clinical question in relation to this independent study is: Do nurses have adequate training in the pathophysiology, recognition, and appropriate management of mild traumatic brain injury (mTBI)? The number of cases of mTBI is increasing due to a combination of factors. This includes more competitive sports at younger ages, military personal exposed to longer periods of deployment and increased exposure to improvised explosive devices (IED's), aging population at risk of falling, and promotion of physical activity at all ages.

Nurses are the community promoters of health, whether it is through work, schools, or community activities. In addition, they are frequently sought out as a health care resource by individuals and families. In practice they are typically responsible for providing accurate, evidence-based, educational information. Nurses need to have current information regarding concussions. This includes complications and outcomes relating to lack of recognition and appropriate management. This paper reviews the important aspects of mTBI in relation to nursing education and nursing practice.

Purpose

The purposes of this independent study are to review current information in relation to mild traumatic brain injury (mTBI), to assess the knowledge nurses have in the clinical setting, and survey information available for students in pre-licensure nursing programs. To accomplish this, the pathophysiology of mTBI, the current guidelines, recognition, assessment, and appropriate responses were reviewed. In addition, this author created and resented an educational program for school nurses which included each of these components.

Significance

The importance for nurses to have an understanding of mTBI continues to grow. In the United States the number of traumatic brain injuries (TBI) is estimated to be 1.7 million a year (CDC, 2012, March 23). Of these, between 75-90% are classified as mild. All athletes, not just professional, but those at the collegiate, high school, and even middle school levels are at risk of sustaining a mTBI. The Brain Trauma Research Center at the University of Pittsburgh (2012), reports there are over 300,000 sports-related concussions each year, with 62,000 occurring at the high school level. Collegiate football players are at significant risk, with 34% having one mTBI or concussion, while 20% have sustained multiple concussions.

The wars in Iraq and Afghanistan have produced a record number of TBI's secondary to IED's. The Department of Defense's Military Health System (2012) reports of the 31,407 traumatic brain injuries sustained in 2010, nearly 25,000 were defined as mild.

Recreational activities and unorganized sports also contribute to these numbers. Activities such as bicycling, skateboarding, and swing set injuries all have significant risk for concussions. The Center for Diseases and Prevention reports the greatest number of TBI's occurring in those under 19 years old are related to bicycle accidents, followed by football and playground activities (2011, October 7).

The health care cost and the loss of productivity are in excess of $76.5 billion a year (CDC, 2012, March 23). This does not include lost time at school for students or impaired learning as a result of the injury. These numbers include all forms of TBI's but are reflective of the economic and social burden of mTBI.

In addition to the numbers of mTBI, legislation addressing sports-related concussion in youth is occurring in many states. Currently 34 states have enacted laws relating to TBI while 14 others have legislation introduced relating to TBI. These laws vary from state to state but typically require the need for medical professionals to clear a student athlete before

he or she can return to play. As these laws continue to be enacted through the country, health care providers must have current knowledge relating to identification, response, as well as current knowledge about the legal responsibilities relative to TBI.

Theoretical Framework

The theoretic framework of this paper is the pathophysiology of mild traumatic brain injury. In order to recognize and respond to a mTBI, nurses need to have an understanding of what physiologic changes occur following this type of trauma, and its significance. Understanding of the pathophysiology allows nurses and other health care professionals to correlate the patient's symptoms to their injury. This knowledge is the basis for appreciating the need for appropriate recognition, response, and treatment of mTBI.

Research in this area is ongoing, and ranges from metabolic process to cerebral blood flow, as well as changes in the structure of the brain. Autoregulation and cerebral blood flow (CBF) are an important area research related to TBI and mTBI. Rangel-Castilla, Gasco, Nauta, Okonkwo, and Robertson (2008) studied CBF following TBI and found significant impact on autoregulation, which then produces instability within the brain. Maugans et al. (2012) studied the changes in CBF that occurred in children following a sports related concussion. The author's conclusions related to the importance of compromised CBF in explaining the symptoms presented by children following a concussion. These studies are important as they provide an increase in the understanding mTBI has on cerebral homoeostasis.

Neuronal cell changes following concussion is another area of research. Kane et al. (2011) and Eakin and Miller (2012) looked at the impact of injury on nerve cells. Kane et al. (2011) included single injury, secondary, and then multiple injuries. These injuries created significant damage in structure and function, while the study by Eakin and Miller (2012) found the cells had significant functional impairment. These studies are important as they

provide a physiologic reason for the symptoms of mTBI, as well as the potential complications that can occur. In other words, negative imaging may rule out injuries such as a subdural hematoma, but they do not identify injuries that have occurred at a cellular level.

An injury that creates a concussion also involves metabolic changes to the brain. Signoretti, Vagnozzi, Tavazzi, and Lazzarino (2010) looked at the reduction of adenosine triphosphate (ATP) and N-acetylaspartate (NAA) reduction following a mTBI, and its impact on the brain. This reduction created metabolic instability and vulnerability within the brain. Leddy, Kozlowski, Fung, Pendergast, and Willer (2007) discussed the significance of metabolic changes following a TBI in the clinical setting. Cognitive and physical activity frequently creates symptoms post-injury and may be reflective of the insufficient metabolic reserves that occur with this type of injury.

Mild TBI is frequently seen as a self-limiting, relatively benign event. Understanding the pathophysiology behind the symptoms provides the nurse with the knowledge to effectively respond to patients and their symptoms, both immediately post injury and in follow-up. This includes providing information to the patient and the families to help them understand the importance of rest, both cognitive and physical, based on current evidence.

Definitions

Concussion and mild traumatic brain injury are used interchangeably. A specific definition of a concussion or mTBI is illusive and part of the difficulty in research. There are two definitions currently considered the standard: one by the CDC, the other as a result of the 2008 Zurich Conference for Concussion in Sports.

The CDC (2011, October 6) defined concussion as "A concussion is a type of traumatic brain injury, or TBI, caused by a bump, blow, or jolt to the head that can change the way your brain normally works." McCrory et al. (2009) defined concussion more extensively. Their definition is

> Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathologic and biomechanical injury constructs that may be utilized in defining the nature of a concussive head injury include:
>
> 1. Concussion may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an "impulsive" force transmitted to the head.
> 2. Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously.
> 3. Concussion may result in neuropathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury.
> 4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however it is important to note that in a small percentage of cases however, post-concussive symptoms may be prolonged.
> 5. No abnormality on standard structural neuroimaging studies is seen in concussion. (p. 76)

In relation to athletes, a student athlete is defined as one who is playing in a competitive sport sponsored by their educational facility. A collegiate athlete competes in tertiary education centers, while professional athletes are defined as those paid for participation in their sport.

Process

The literature search this author used was the CDC and several search engines including PubMed, Google Scholar and Cumulative Index to Nursing and Allied Health Literature (CINAHL). The date range was limited to 2007 to 2012, and in searches related to pathophysiology the range was 2010-2012. Specific terms depended on what portion of the literature was being searched. In pathophysiology using CINAHL, the terms concussion and pathophysiology between 2007 and 2012 were used and returned a total of 11 results. In searching for literature in relation to nurses and their education, CINAHL was used with these three terms: concussion and nurses and education. This resulted in nine articles; the second one was the basis for part of the paper: *Mild traumatic brain injury: a survey of perceived knowledge and learning preferences of military and civilian nurses*.

PubMed was also used extensively in searches, specifically in relation to pathophysiology. The use of the two terms, concussion and pathophysiology, returned 177 results with seven since 2010. In addition to this, a specific search of the neurosurgical journals was done using sports concussions, and the results were then sorted by date. This resulted in around 50 results, but with the date limitation it yielded around 20 articles. This provided a set of articles in the November, 2010 Neurosurgical Focus reporting a series of studies done by neurosurgeons on hockey players and recognition of mTBI.

As more information was accessed this author utilized references within articles to extend the search in specific areas of research. This related to the pathophysiology, recognition, and management of mTBI. The 2008 Zurich Consensus in Sport Statement by McCrory et al. (2009) is the foundation for many studies and reports. This statement assisted in providing basic information relating to the strengths and gaps in relation to mild TBI, and concussion. In an attempt to gain information and understanding of TBI, this author attended a grand rounds presented by pediatric neurosurgeon Dr. Laurie Ackerman in the fall of 2011,

and a presentation for advanced practice nurses and physicians by a community sports medicine physician Dr. Jeremy Hunt in January of 2012. In addition to this, in March of 2012, the author attended an annual lecture series featuring Geoffrey Manley, M.D., Ph.D., in which he presented current research in relation to mTBI. In reviewing both content and format throughout this project, this author consulted Julius A. Silvidi, M.D., a board certified neurosurgeon and Mary Kay Cramer, Ph.D. in education.

Improving the understanding nurses have regarding mTBI in clinical practice, and in education, is an important component of this study. As information becomes available in all areas of mTBI, and as the numbers of injuries, especially in the military setting, continue to increase, educating nurses to TBI is imperative. Within nursing education this can be done by assuring the inclusion of mTBI as part of the baccalaureate essentials, and ensuring that questions relating to mTBI are included in the National Council Licensure Examination (NCLEX) exam.

At the community level, education programs, such as one done for school nurses, would be a starting point. Providing workshops for primary care providers, athletic trainers and coaches, as well as practicing nurses are an additional steps that could be taken. It is important to provide information to schools, so playground supervisors, as well as those involved in athletics, have current knowledge in recognition and response to concussions.

Assessing the available information in relation to what occurs during mTBI and how this is reflected in the symptoms exhibited as a result of the injury was a significant focus of the research. Once this was accomplished, assessing the importance of the ability of individuals to recognize and manage TBI was addressed. Finally, the level of knowledge and comfort nurses had regarding mTBI was examined to assess the need for education at both the community level and in nursing programs. Establishing these three areas determined the focus of the literature review.

Introduction for Literature Review

Traumatic brain injury (TBI) has come to the forefront of health care providers, athletics, the military, and the media. While initial information and concern was within the National Football League, the impact on athletes at all levels, from little league, through high school, and collegiate level, has been significant. Additionally, the wars in both Iraq and Afghanistan have produced significant numbers of TBI for our military. According to the Department of Defense (2012), the number of TBI's sustained in the military for 2010 was 31,407 cases, with 24, 989 identified as mild. The Centers for Disease and Prevention (CDC) estimates the annual number of TBI's is 1.7 million. Of those, there were 173, 285 emergency department (ED) visits for mTBI's following sports and recreation injuries in children under 19 years old (CDC, 2012, March 23).

The toll TBI causes physically, emotionally, economically, and on health care resources, is significant. Recognizing and identifying mild TBI (mTBI), having basic knowledge of the pathophysiology related to mTBI, responding and managing mTBI, as well as providing education to patients and families are important. Traumatic brain injury, especially mild TBI, while becoming more recognized, remains an issue due to lack of understanding within health care.

Mild traumatic brain injury (mTBI) does not have an accepted, standardized definition. This lack of a clear definition can create difficulty for coaches, athletic trainers, clinicians, and researchers. The Concussion in Sport Group (CISG) in a consensus statement put forth the following definition of mTBI (McCrory et al. 2009): "Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical pathologic and biomechanical injury constructs that may be utilized in defining the nature of a concussive head injury" (p. 756). Len and Neary (2011) in evaluating this definition note that it does not contain

objective criteria. They go on to suggest, that until there is a better understanding of the pathophysiology of mTBI, a definitive definition will be illusive. This review of literature will look at the pathophysiology of mild TBI, the importance of standards in recognition and management, as well as the knowledge and education of health care providers, specifically nurses, relating to mild TBI.

Pathophysiology

The pathophysiology of mild traumatic brain injury is poorly understood. Research in this area is ongoing, and new information is available on a continuing basis. Many areas of pathophysiology in relation to mTBI are being addressed. Ainslie and Duffin (2009) noted that each researcher looks at specific areas related to mild TBI, such as auto-regulation and cerebral blood flow, rather than taking a systematic approach. In addition, much of the research has been related to moderate and severe TBI, rather than mild (Kan & Ling, 2012). This author will limit pathophysiology review to three areas: cerebral blood flow, changes in the neuron, and metabolic changes at a cellular level.

Cerebral Blood Flow

Cerebral perfusion pressure (CPP) is defined as the mean arterial pressure (MAP) minus intracranial pressure (ICP), or MAP-ICP= CPP. Auto-regulation in the brain is the ability to maintain steady blood flow, even with varying degrees of CPP (Marieb & Hoehn, 2008). In a normal state, cerebral blood flow (CBF), CPP, and consequently auto-regulation, are constant. In trauma the mechanism of injury is the brain's inability to auto-regulate (Marieb & Hoehn, 2008). Metting et al. (2009) looked at a group of 74 head injured individuals with no abnormalities on CT, and utilized a control group of 25 non-injured individuals. Using perfusion computerized tomography, the researchers found significant decreases in cerebral perfusion. This study used subjects that had transient posttraumatic amnesia, which implies slightly higher level of injury, but with a negative CT scan, they were

still be defined as mild TBI. Additionally the study was limited by the number of subjects. Even with these limitations, the study found significant reduction in CBF within the frontal area of the brain (Metting et al., 2009).

Maugans, Farley, Altaye, and Cecil (2012) completed a study that evaluated children with sports related concussions (SRC). Evaluation was initially done within 72 hours of injury, then at 14 days, with final evaluation at 30 days or greater. The 12 children included in the study were between 11 and 15 years of age. The criteria for participation were specific, and included a single concussion as defined by the Third International Conference on Concussion in Sport with the diagnosis of concussion made by a licensed health care provider. Children with additional injuries, as well as those receiving medication for neurologic or psychiatric conditions, were excluded from the study. Once the cohort was set, a control group was compiled that mirrored the participants in age and gender. Cerebral blood flow was measured by magnetic resonance phase contrast angiography (MR-PCA). In the immediate post injury evaluation of CBF the differences in mean totals were 38ml/100 grams per minute, compared to the non-concussed CBF of 48.0 ml/100grams. The researchers noted that all but one child had CBF change of >10% in comparison to the control. In looking at the overall results, the mean was 21%, with a maximum change in CBF of 60%. While improvement occurred, at the final testing, CBF values were still statistically significant, with a mean of 39.2 compared to 48.0 in the control (Maugans et al., 2012).

While this study finds that there is a decrease in CBF, it does not explain the pathophysiologic mechanisms which cause this. Additionally, while the mean showed a decrease in CBF, two of the children with SRC did not test for any reduction in CBF. As with other studies, the number of participants is limited, but those selected did meet very specific criteria. The researchers conclude there is a need for further investigation, which has both a larger number of subjects, and follows the injured for a longer periods of time.

Metting et al. (2009) and Maugans et al. (2012), while looking at different subject groups, both found CBF to be a component of the pathophysiology of SRC.

Rangel-Castilla et al. (2008) looked at CBF and the impact on autoregulation, with all areas of TBI, including mild. Cerebral blood flow following TBI, and the impact on autoregulation, identifies there is a significant reduction in CBF. This reduction creates hemodynamic instability. If mean arterial blood pressure (MABP) changes during this time of instability, the risk for secondary injury occurs. Hypotension can lead to ischemia, where an increase in MABP can transmit to microcirculation, creating edema, infarction, or hemorrhage (Rangel-Castilla et al., 2008). The authors acknowledge that cerebral autoregulation and the impact of further injury is unknown; additionally, they state that it is only one of the factors related to the pathophysiology of TBI. This study addresses cerebral blood flow through the context of cerebral autoregulation, rather than directly studying CBF. The study also focuses on severe TBI and its treatment, rather than mild, although some aspects of mTBI are addressed.

As Rangel-Castilla et al. (2008) alluded to, the mechanisms that lead to the changes in CBF are not completely understood; however the study by Maugans et al., (2012) showed significant decrease occurring, even following a mTBI. Research further confirmed that a decrease in CBF has an impact on auto-regulation. When this occurs, the brain is susceptible to either continued injury, or additional injury, even when negative imaging is present. While CBF and the resulting auto-regulation are only one aspect of mTBI, it is an important component of understanding, not just in what is occurring at the time of injury, but the potential cascade that can follow.

Changes in the Neuron

The two studies this author used to assess the impact of mild traumatic brain injury on neural cells were by Kane et al. (2011), and Eakin and Miller (2012). Both of these studies

looked at the impact of TBI on neuronal cells. Kane et al. (2011) used nerve cells to look at neuron impact, rather than an intact nervous system. This allowed the researchers to focus the study on cellular response. The authors created mild repetitive injury by using biaxial stretch injury in the cells. The research, which was sponsored in part by the Department of Veteran's Affairs, attempted to establish a model for studying the pathophysiology of repetitive traumatic brain injury which would reflect what occurs clinically with a TBI. In this study, Kane et al. (2011) looked at initial injury, secondary, and then, repetitive injury. While this was an in vitro study, the results showed significant impact on neurons. This included a decrease in the number and length of neurites, either the axon or dendrite, as well as a decrease in cell viability. Cysteine protease, an enzyme, and caspase, a protein, are important components in cellular function. In this study the injury produced an activation of these components, which lead to cell apoptosis, or programed cell death.

Eakin and Miller (2012) studied neural activity in rats to assess the impact of mTBI on cellular physiology. The researchers created memory tasks for the rats, and then implanted electrodes to analyze single neuron activity from 30 to 90 days following injury. The injury was a lateral percussion with fluid. The results showed no neuronal loss, but showed significant impairment in function. Eakin and Miller (2012) concluded that, while there were no structural defects, the impairment was due to changes in activity of the individual neurons. Additionally, in looking at single neuron activity, there was not a difference in firing rates between the two groups; rather the number of cells with activity was diminished. This study did not look at immediate effect of mTBI, rather on longer term impact.

Each of these studies shows that TBI, even mild, has an impact on individual neurons within the brain. Eakin and Miller (2012) showed no loss in the number of neurons in their study of rats, while the study by Kane et al. (2011) showed a decrease in the number of

neurons. While both of these studies have limitations, Kane et al. (2012) provides an effective model for additional research to be done.

Metabolic Changes

In reviewing literature in relation to metabolic changes occurring during mTBI, Signoretti, Vagnozzi, Tavazzi, and Lazzarino (2010) studied the relationship between N-acetylaspartate (NAA) synthesis, and neuronal health. As with many aspects of brain injury, the exact role of NAA is unknown. It is a significant brain metabolite, and reductions in the levels reflect the severity of injury to neuronal tissue. The authors explain the most important aspect of NAA is its relationship to energy metabolism. Signoretti, Marmarou, Tavazzi, Lazzarino, Beaumont, and Vagnozzi (2001) looked at the impact of mTBI on adenosine triphosphate (ATP) levels within the brain, as well as the relationship to NAA. The study found that the changes of ATP and NAA were mirrored. Signoretti et al. (2010) found that following an injury, the reduction in ATP was gradual, and reached statistical significance by two hours post injury. A net reduction in ATP of 40% was recorded at this point in time with a high of 57% at six hours, with recovery occurring over the next five days. At this point there was no significant difference in ATP levels between control animals, and injured animals (Signoretti et al., 2001, 2010). This decrease in ATP is reflective of mitochondrial dysfunction, and structural changes related to TBI (Leddy, Kozlowski, Fung, Pendergast &Willer, 2007). The mitochondrial dysfunction creates a situation where an increase in metabolic demands, whether through physical or cognitive activity, can create significant metabolic consumption, and therefore, vulnerability within the brain.

Signoretti et al. (2010) discussed the lack of research relating to mTBI, in part, due to the difficulty to have effective laboratory models. The authors discuss the current information available and the implications for clinical practice. In this, Signoretti et al. (2010), note the importance of metabolic insufficiency following mTBI, which creates

significant vulnerability. In an additional study, Signoretti et al. (2010) looked at a second mild injury during the window of decreased ATP. During this time, it was found the injury increased mitochondrial malfunction, and created a metabolic environment consistent with a severe TBI.

Leddy et al. (2007) discuss the clinical implications related to metabolic insufficiency and mTBI. Increasing metabolic demand, through physical or cognitive activity, puts stress on a vulnerable brain, producing symptoms such as headache and dizziness. In addition, Signoretti et al. (2010) found that an injury occurring during this time of metabolic depression creates the potential for a severe TBI. These studies offer a possible explanation for the pathophysiology of catastrophic second impact syndrome.

Discussion

Research relating to the pathophysiology of TBI and mTBI is ongoing. As previously discussed, studies have looked at different aspects of injury, such as metabolic and neuronal damage, when each of these aspects are actually interrelated. One of the hallmarks of mTBI is negative neuroimaging (McCrory et al., 2009), which is frequently interpreted as lack of injury. Research in these areas provides an explanation for the symptoms related to mTBI, as well as the potential complications for unrecognized, or improperly treated mTBI. In the studies discussed, the researchers show that in multiple areas, metabolic, neuronal and CBF, the brain is significantly impacted, and vulnerable following even a mTBI. Increasing understanding of these concepts by health care providers will improve management of individuals who sustain a mTBI, and decrease their risk of additional injury, or prolonged recovery. Providing a pathophysiologic explanation for presenting symptoms in mTBI, even with negative imaging, provides a foundation for understanding the importance of implementing cognitive and physical care.

Recognition and Management

Multiple studies have looked at the recognition of mTBI, as well as the most appropriate guidelines for management. The 3rd International Conference on Concussion in Sport (McCrory et al., 2009), provided guidelines in identification and in relation to return to play. While the guidelines are not strictly evidence-based, they are a consensus of experts in the field of concussion in sports, and are accepted by such organizations as the American Association of Neurological Surgeons (Echlin et al., 2010), the National Athletic Trainers (McCrory et al., 2009), and the CDC (2011, January, 6).

Recognition

Identification of a mild TBI is the first step toward appropriate management. Mild TBI can occur in many areas, such as sports, military, and with accidents, both recreational and motor vehicle. In a pivotal study, Valovich McLoed, Schwartz, and Bay (2007) studied understanding of concussion in youth coaches. The researchers created seven case studies, and presented them to coaches to assess their willingness to return youth athletes to play. The study included 156 active coaches who were between 23 to 60 years old, with an average of 5 years' experience. Players being coached were from 8-14 years old. While the majority of coaches were able to identify certain symptoms of mTBI, 42% thought loss of consciousness was required for a diagnosis of concussion. In addition to this, 32% did not feel a mild or a grade one concussion required removal from play, and 26% would allow a symptomatic child to return to play (RTP). This study helped launch the CDC's Head Up in youth sports campaign, and is reflective of the lack of knowledge about concussions especially by those who are overseeing the youth players. Valovich McLoed, Schwartz, and Bay (2007) also found that education related to concussion had a significant impact on both identification of symptoms, and willingness to return to play immediately following injury.

The ability to recognize mild TBI in athletes is multi-factorial. While understanding the types of impact and the signs and symptoms of mTBI are important, two additional factors in recognition are essential. First, is the player's willingness to self-report an injury, and second, the ability of the supervising adult (coach, athletic trainer, or parent) to recognize impacts which are capable of causing a mTBI. In a prospective study, Echlin et al. (2010) looked at the impact of physician observed concussions, and the implications for recognition. Echlin et al. (2010) used the 2008 Zurich Consensus Statement from the Third International Conference on Concussion in Sport as their criteria for concussion. The diagnosis of concussion was done through the following means: observation or self-reporting impact, neurological signs and symptoms (either delayed or immediate), and abnormal Sport Concussion Assessment Tool 2 (SCAT2) (Appendix A) or ImPACT test. The SCAT 2 test provides assessment guidelines for concussion, while the ImPACT test provides evaluation of cognitive function through a computer testing program. Those players who self-reported concussions were directed to the physician for similar diagnostics.

Pre-study assessment was done by the use of the Scat 2 and ImPACT, as well as after each observed and physician diagnosed concussion. The study participants were two teams of male hockey players, ranging from 16-21 years old. Team A was observed in 34 of 36 games, Team B was observed in only the first 21 scheduled games then dropped, due to lack of compliance to testing. Observers were independent (no association with the team), and consisted of one physician, and one to three non-physician observers, per game. Each observer had a 20 minute verbal instruction on observation and reporting responsibilities. In addition to this, there was a descriptive form that was completed to document when a concussion occurred. In the event of a non-911 emergency, the player was removed from game and assessed by the physician, while observers remained in place. Scat 2 tests were administered immediately, with follow up sequential ImPACT testing in a medical office.

Return to play decisions were made by the lead investigator, and were based on clinical assessment. The use of SCAT 2 results, as well as ImPACT scores, were evaluated. Once clearance was obtained, the player was required to complete the six-step RTP guidelines (Appendix B), as defined by the Zurich Consensus Statement by McCrory et al. (2009).

There were 52 observed games, with concussions occurring in 19 of those games. Of the 34 potential concussions identified, 17 or 53% were confirmed by physician diagnosis (Echlin et al., 2010). Of the 17 observed concussions, five of those players suffered a repeat concussion, with a mean interval between the first and second of 78.6 days. Of interest, the numbers of documented concussions in this study is seven times higher than previously highest reported rates (Echlin et al., 2010). This is the first study where physician observers were used to identify concussions and the researchers felt this may have had an impact on the higher rates. Another possible component, the observers noted that, even when not involved in other tasks, the team trainer or first responder did not see and/or react to possible impacts. In addition, this study used the Zurich guidelines which could provide a more sensitive threshold than in previous research, and finally player recognition may be improving reflective in the three self-reported injuries.

In a frequently referenced study, Gerberich, Priest, Boen, Straub, and Maxell (1983), found the risk of second concussion was four times higher than in those without a history of concussion. In a study by Guskiewicz et al. (2003) the authors found that of the 12 repeat concussions, 11 occurred within ten days of injury, and nine within seven days of injury.

Recurrent concussions were also discussed by Echlin et al., (2010). The authors hypothesized this increased risk of repeat concussion was due to premature RTP. The study was also effective in looking at the impact of trained observers, and physician diagnosis in identifying mTBI. The study did not include observations during practice, and was limited to

this specific group of players. Echlin et al. (2010) discuss the need for larger studies, and in addition, to this look at different sports, and incorporate different ages and both genders, as well as different skill levels.

Discussion

Identification is the first step in management of mTBI, and protection against further injury both in the short and long term. In the two studies reviewed, it is clear the more education and training, the greater the recognition of mTBI. In evaluating the evidence, Echlin et al. (2010) found that having individuals whose sole responsibility is to watch for potential impacts which can result in concussion, followed by an immediate ability to diagnosis, provides the most accurate means of identification. In addition to this, Echlin et al. (2010) point out the importance of having standardized guidelines, for both assessment and RTP, which are provided by the Consensus in Sport statement, and used for the study.

Management

There are three standards available relating to management of mTBI. These are: The Third International Conference on Concussion in Sport in 2008, the CDC's Heads Up Campaign: Facts for Physicians about Mild Traumatic Brain Injury (MTBI), updated in 2011, and the Defense and Veterans Brain Injury Consensus Conference (2008).

The Consensus Statement on Concussion in Sport defined RTP guidelines for athletes. These guidelines address cognitive and physical rest with specifics relating to incremental increases in physical activity, based on time and the player's symptoms. The basic concept in these guidelines is, with any return of symptoms, the player must rest until symptom free, and then return to the previous level of activity. These guidelines for managing sports related concussions were the criteria for the neurosurgical study on hockey players, as well as recommended by the CDC for organized athletics.

The CDC provides a Heads Up for physicians, relating to mTBI. These guidelines include immediate treatment and follow-up. Following a mTBI, the CDC recommends office monitoring for patients who have progressive resolution of TBI symptoms within three to five days. For those patients who continue to be symptomatic past five days, the CDC's recommendation is to refer to a health care professional who specializes in mTBI (2011, January 6). Diagnostic testing is addressed, but no specific symptoms are provided as guidelines. The CDC (2011, January 6) addresses the need for physical and cognitive rest as essential for recovery, specifically avoiding high-risk behavior such as bicycling, when any symptoms are present. Additionally, the recommendations include increased rest with return of symptoms, and well-defined guidelines for returning to school. Return to play guidelines are summarized as using caution; any recurrence of symptoms would require a decrease in activity. For competitive sports the CDC recommends using the Concussion in Sport protocol. In addition to cognitive and physical activity, the guidelines also address return to work, again, restricting activity in relation to symptoms.

The Department of Defense consensus (Post Deployment Health, 2008) addresses evaluation and treatment of mild TBI. The consensus statement specifically addresses the lack of randomized trials and specific studies relating to the treatment of concussions. As with the Zurich statement, the recommendations are based on available literature, and input for specialists from multiple disciplines (Post Deployment Health, 2008). The treatment is addressed through four areas: symptom management, rest/return to duty guidance, educational initiatives, and supportive therapies. Education provides instructions outlining recommendations and restrictions. An interesting aspect of these guidelines is it is not just to the patient, but also to squad leaders and their commanders who are provided instructions and restrictions. Management of headache is addressed, noting the avoidance of non-steroidal anti-inflammatory drugs (NSAIDS) and narcotics, and with prolonged symptoms, the use of

amitriptyline in limited amounts. Return to duty is very specifically addressed stating that the patient remains on restricted duty until asymptomatic. Exertion testing guidelines are included, and state that if there is any return of symptoms, including cognitive impairment, that occurs with activity, continued observation is needed. In addition to this, algorithms are included for both identification and management (Post Deployment Health, 2008).

The three guidelines for management of mTBI have similarities. The Zurich consensus has the most specific guidelines for RTP, and only touches on the importance of cognitive rest. The CDC addresses multiple aspects of mild TBI such as returning to work and school, but are very nonspecific, leaving the health care provider with a great deal of discretion. The Department of Defense provides the most specific guidelines, while acknowledging the lack of evidence-based information in relation to management. In addition to this the DoD addresses what types of medications should be used and avoided. The CDC addresses the need for school officials to be informed about a student with a mTBI, while the military requires individuals who work with the patient to be informed. Though there is no standard, these three sets of guidelines are very inclusive to provide safe management of mTBI, in the athletic, community and military setting.

Knowledge of mTBI

The study by Watts, Gibbons, and Kurzweil (2011) looks at perceived knowledge of nurses in relation to mTBI. The study includes military and civilian nurses who potentially have contact with patients experiencing a mTBI. Nurses included were those who had direct patient care; those who were advanced nurse practitioners or managers were excluded from the study. Following exclusion criteria 1224 respondents were used. Along with demographics and work setting, the study evaluated nurses' contact with patients having sustained a mTBI, continuing education for mTBI, and importance of mTBI knowledge in current practice.

Knowledge levels of mTBI were evaluated using a Likert type scale. Areas addressed included: treatment options, patient and family education, physiology of mTBI, and recovery. The study showed that most nurses were comfortable with their knowledge level in relation to the types of impact that causes mTBI. In all other areas of mTBI, there was a lower level of knowledge and confidence. This included interviewing techniques, understanding of posttraumatic stress disorder, the pathophysiology, treatment options, as well as education, for both the patient and the family.

In addition, the researchers looked at preferred methods of expanding the nurses' knowledge base of mTBI. It was found that shadowing was the most preferred, and continuing education units using the internet was the least preferred. The authors note, that the survey overrepresented military nurses, and evaluated perceived knowledge rather than actual knowledge. The conclusion was the need for bedside nurses to have accessible and affordable continuing education, which would provide them the ability to care for this patient population (Watts, Gibbons & Kurzwell, 2011).

While Watts, Gibbons, and Kurzwell (2011) identified many aspects of mTBI in their paper, this author, was unable to determine what types of questions were asked of the respondents. There was no discussion in relation to management and return to activity, an area continually overlooked. This study also addressed only practicing nurses and did not assess curriculum in pre-licensure programs. This is the only study this author found that specifically addressed nursing knowledge in relation to mTBI, and is an important first step in identifying the educational needs of nurses and mTBI.

Interpretation

The most important aspect of this review is the lack of understanding regarding the symptoms associated with mTBI, and their pathophysiological origin. Health care providers, nurses, and coaches generally feel that a negative imaging equates to lack of injury. This

misinterpretation provides the foundation for many of the difficulties relating to mTBI in patients, whether it is recognition, response, or education.

An assessment of two nursing programs, a two-year associate degree program in a community college, and a private four year baccalaureate program, found the educational components of mTBI were limited. The two-year program did not include instruction or assessment relating to mTBI (personal communication, Sharon Adams, February, 2012). The pre-licensure Bachelors of Science in Nursing program in a senior level, medical surgical unit covered mTBI with a portion of the lecture and four questions on that unit's exam (personal communication, Judith Carter, January, 2012).

In a presentation to school nurses in Muncie, Indiana none of the 17 nurses who attended had continuing education relating to mTBI. Additionally, communication between athletic trainers and school nurses concerning student athletes who have sustained a mTBI, is limited (personal communication, Muncie Community School nurses, January, 2012).

In assessing nursing text books, the amount of information is minimal. In Ignatavicius and Workman's (2010): *Medical-Surgical Nursing, Patient-Centered Collaborative Care,* closed head injury is covered but there is nothing specific to mild traumatic brain injury or concussion. In *Foundations in Nursing* by Potter and Perry (2010) there is no information relating to mTBI or concussion. In the undergraduate book, *Human Anatomy and Physiology* by Marieb and Hoehn, 8th Edition, discussion of concussion is limited to one paragraph.

A current review book, *Mosby's Comprehensive Review of Nursing for the NCLEX-RN® Examination,* published in November, 2008 has a section relating to traumatic brain injuries. Within this section, one statement is related to concussion. It is: "Concussion: temporary disruption of synaptic activity; brief loss of consciousness (less than 5 minutes)" (Nugent, Green and Hellmer, 2011, p. 212). Historically, loss of consciousness was needed

to meet the criteria of a concussion. In the 2009 Consensus Statement on Concussion in Sport, the criteria for concussion does not mandate loss of consciousness (McCrory et al., 2009). This description in a current review manual for NCLEX is inaccurate according to current guidelines, and is symptomatic of the misleading information in relation to mTBI for students, educators, and practicing professionals.

Part of the challenge in addressing curriculum and education in relation to mTBI, is the limited time available in nursing education. While a patient with a subarachnoid hemorrhage can quickly have a catastrophic event, a patient with a mTBI is seen transiently in a clinic, emergency department, or on a playground; this makes it difficult to devote education time to what is frequently seen as a benign, self-limiting injury. Assessing and then finding an appropriate amount of time to dedicate to the physiology and recognition of mTBI will be difficult.

In-service for School Nurses: Mild Traumatic Brain Injury

In developing the presentation for mTBI for school nurses, this author first created the learning objectives or goals for the presentation. These were:

- Defining TBI
- Current information relating to Pathophysiology of TBI
- What Types of Impact Cause TBI
- Signs and Symptoms of TBI
- Importance of Return to Activity Guidelines
- School Nurses and TBI

A power point presentation (Appendix C) was used, and a folder was given to each nurse that included: the power point, Sport Concussion Assessment Tool 2 (SCAT2) and the Acute Concussion Evaluation (ACE) (Appendix D) forms, as well as a copy of the recently passed Indiana law (Appendix E) relating to concussion. In addition to this, a copy of the

Statement on Concussion in Sport – the 3rd International Conference on Concussion in Sport held in Zurich, November 2008 was provided. A pre-test (Appendix F) and post- test (Appendix G) were given, and a demographic questionnaire that included education level and experience/education in relation to mTBI (Appendix H). Following the presentation, a short evaluation form was given to the nurses to complete (Appendix I).

During the presentation there was a significant amount of discussion about the types of injuries the nurses had experience in relation to mTBI and communication. This included communication between the nurses and athletics, parents, teachers, administration, and medical personal. The post-test provided information in relation to what this author felt was important.

Implications for Nursing

There are several implications for nursing; the one with the greatest impact may be the number of laws that are being created by state legislators in relation to recognition and response to mTBI and concussion, specifically in the student athlete. The importance of nurses having a working knowledge of mTBI has a direct impact, not just on the care of patients, but also on providing information and education. This is especially true with the pediatric population. Explaining what is occurring to both the child and his or her parents, the limitations that need to be followed, not just physically but cognitively, are important guidelines for nurses to provide.

As referenced previously, mTBI is the signature injury of the Iraq and Afghanistan wars, and nurses who care for members of the military need to have education relating to mTBI, either in nursing school or through continuing education. Community health nurses need to implement mTBI information programs. This would include club sports which are typically coached by parents, and have little oversight, as well as recreational activities associated with mTBI, such as skateboarding and bicycling.

Nursing education is reflective of the requirements of accreditations, NCLEX, and the State Boards of Nursing. Nurse educators need to incorporate this into the curriculum. The difficulty can be both the lack of information in frequently used texts, as well as time constraints. Understanding the importance of mTBI is the first step; once this is done educators can bring the most current information into their classroom, integrating it into the curriculum.

Manley, (2012) is currently researching mTBI, including how to more effectively define mTBI using criteria similar to cancer and cardiology diagnoses, rather than the nearly 30 year old Glasgow coma scale. As this information becomes available, adding the pathophysiology of mTBI, and correlating it in relation to symptoms, may be an effective way for this information to be integrated in nursing programs.

Research in nursing is limited in relation to mTBI. Looking at the lack of communication between school nurses and the athletic department is one area that should be researched, as well as further studies relating to nurses knowledge and confidence in caring for patients with concussion. Nurses need to be aware of their state's policy and legislation regarding concussion, especially in student athletes. Being active in the local chapters of the ANA or other nursing groups, to promoting public education for concussion, is important. Writing opinion pieces or letters to the editor about the need for all coaches to be trained in mTBI, as well as attending school board meetings ,or talking with athletic directors in the community schools, can provide an effective forum for nurses to provide information to the community.

Discussion

Mild traumatic brain injury is a significant public health concern. With the current number of 1.7 million in the civilian population and large numbers in the military, all areas of health care need to be current in their knowledge relating to concussion. The economic costs

to health care and lost hours of school and work are also high. As the public awareness continues to increase, state legislators are addressing the risk to students by creating laws which govern coaches, athletic trainers, schools, and health care provides.

Research in the pathophysiology is just now showing a relationship between symptoms and physiologic changes. In addition to this, researchers are looking at more appropriate models for TBI, such as grading similar to cancer, rather than the subjective terms mild, moderate and severe terms that are decades old. As more research is done, the more information will become available to health care professionals, including nurses and nursing educators.

Nursing knowledge of mTBI is limited. In part this is a reflection of the previously held belief that concussions were simply dings or having your bell rung, and were of little or no consequence. In addition to this, some of the current text books used by nursing schools either lack information, or the information is not up to date and inaccurate. Research has shown that nurses in practice do not have a comfort level in caring for, and providing education to patients and families. Mild TBI research is continuing to provide new information, and nursing has a responsibility to provide courses and educational material that has the latest and most accurate information available.

Recognition, response, and management of mTBI is imperative; this includes student athletes, military personal, injuries due to altercations, motor vehicle accidents, as well as recreational injuries. School nurses, nurses who work in offices such as pediatrics and primary care, need to understand the risks associated with primary and secondary injuries, as well as return to activity guidelines.

Traumatic brain injuries, even mild ones, can impact an individual and family, immediately and in the long term. It is incumbent on nursing to have knowledge of the risks

associated with mTBI, the types of treatment recommended, and to understand the importance of educating patients and their families.

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