Understanding Traumatic Brain Injury: An Introduction

By Tina M. Trudel, PhD, Marcia J. Scherer, PhD, MPH, FACRM, and Eileen Elias, M.Ed

The following article is the first of a multi-part series on traumatic brain injury (TBI). Historically, TBI has received very limited national public policy attention and support. However since it has become the signature injury of the military conflicts in Iraq and Afghanistan, TBI has gained the attention of elected officials, military leaders, policymakers, and the public.

This series is being published by the Traumatic Brain Injury—Resource Optimization Center (TBI - ROC) and its Advisory Group, which is facilitated by JBS International, Inc. The TBI–ROC aims to be a recognized source and leader for advancing national attention to the myriad of policy, research, practice, and service needs supporting both civilian and military individuals who incur TBI and their families.

Traumatic Brain Injury (TBI) is one of the leading causes of death and disability among children, adolescents, and adults. While we do not know the numbers of people with TBI who receive no medical care, of the approximately 1.4 million who go to the hospital, 50,000 die, 235,000 are admitted for medical stabilization and treatment, and 1.1 million are treated and released annually in the United States. Often called the 'Silent Epidemic,' millions of American families have had to face the challenges raised by brain injury. The Centers for Disease Control and Prevention define traumatic brain injury as, "craniocerebral trauma associated with neurological or neuropsychological abnormalities, skull fracture, intracranial lesions or death." TBI leads all causes of death for Americans under age 44, and one-third of injury-related deaths are associated with TBI. The term TBI is a subset of "acquired brain injuries," a larger and similar group of conditions that also include disease processes such as stroke or tumor. While each brain injury is unique, all forms of brain injury have a range of impact on the ability to succeed in educational, community, vocational and family roles, with symptoms potentially affecting diverse life activities given the importance of the brain in all that we do.

The below illustration identifies the location of each part of the brain to help understand the impact of a TBI.

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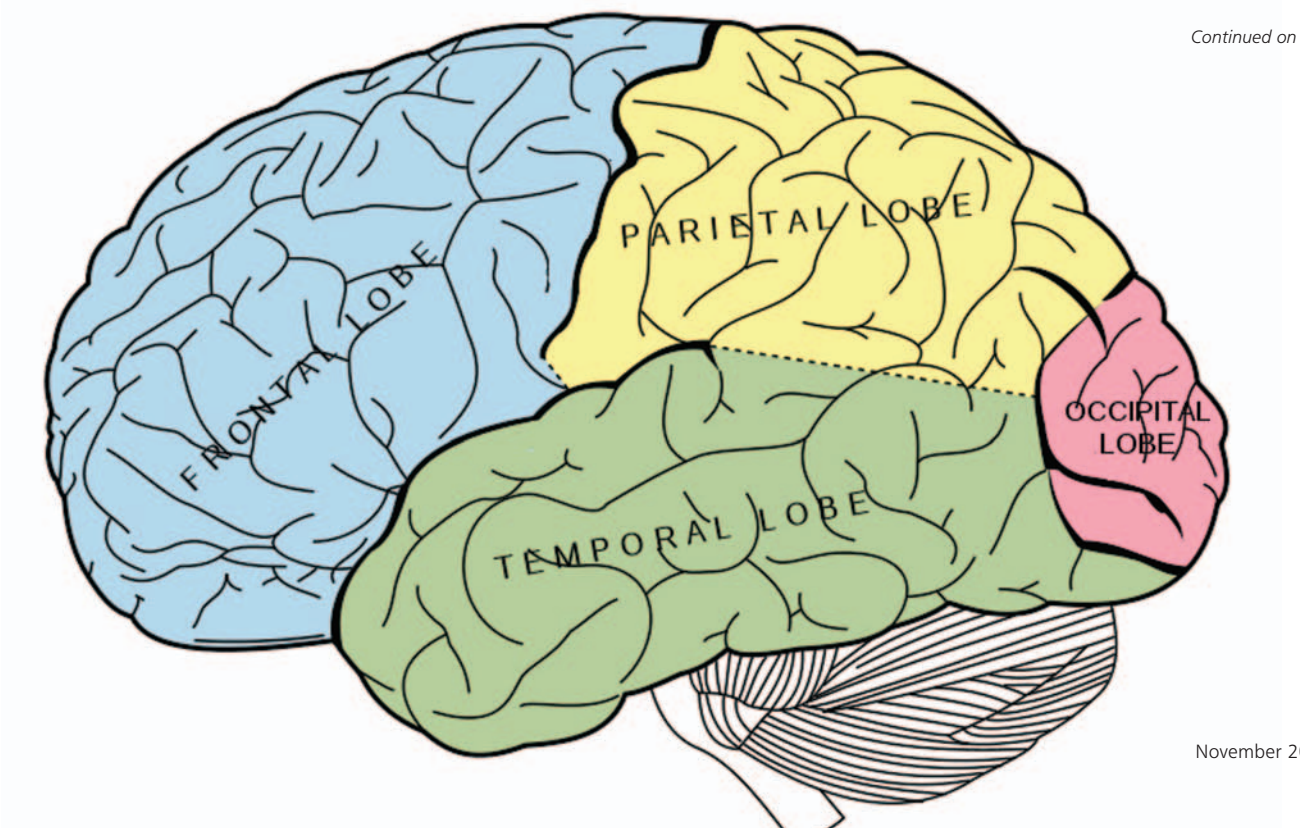

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The most frequent causes of TBI differ based upon gender and age at injury. The age groups at highest risk are the very young (0-4 years old), teenagers, and elderly persons. Firearms and motor vehicle collisions are the leading causes of TBI in those under 75 years of age, and falls are the leading cause for those 75 and older. Males are about 1.5 times as likely as females to sustain TBI. Further, firearms-related TBI occur 6 times more frequently among males than females and 9 of 10 are fatal. Overall the leading causes of TBI are: falls (28%); motor vehicle-traffic crashes (20%); impact injuries (struck by/against) (19%); and assaults (11%). Sports activities, workplace injuries, domestic violence, child abuse, and active military duty are all potential causes of TBI. Blasts are presently the leading cause of TBI for active duty military personnel in war zones in Iraq and Afghanistan, with well over 30,000 affected. Risk for repeat TBI is three times greater for a second injury; and after second injury, risk is eight times greater for a third injury. Unfortunately, injury effects may be cumulative resulting in increasing symptoms and worse outcome after repeated injuries, as seen in blast related concussion in wartime, and athletes in contact sports. Guidelines are presently available through the Brain Injury Association of America to assist parents, coaches, and trainers in better managing sports concussion. The military continues to develop enhanced methods of in theater and post-deployment screening to check for TBI to reduce risk of cumulative injury from repeated recurrence of blast concussion.

The symptoms of traumatic brain injury fall into three broad areas—physical, cognitive, and psychosocial or behavioral challenges. Physical symptoms include seizures, motor control and coordination problems, paralysis, spasticity, tremor, dizziness, balance/vestibular problems, sensory deficits (e.g. vision, hearing), swallowing problems, difficulty speaking, fatigue, pain headache and incontinence. Pituitary and endocrine functions may be affected in some instances. Physical recovery often responds to rehabilitation and stabilizes first, whereas the cognitive and psychological changes contribute to more lasting problems. Cognitive symptoms include adversely affected skills in areas such as attention, concentration, learning, memory, processing speed, visual perception, language (aphasia), motor planning and time perception. Advances in cognitive rehabilitation and increased scientific and funding support for cognitive treatments continue to improve TBI outcomes.

The most troubling cognitive symptoms are those that emerge with injury to the frontal lobe of the brain, the region directly behind the forehead and eye sockets, which is the most commonly injured region in car crashes and falls. The frontal lobe does not fully develop until after puberty, warranting repeat and thorough assessment in adolescence for youngsters who sustained childhood TBI. The cognitive functions of the frontal lobe are referred to as 'executive functions,' as they reflect the kinds of activities that an executive would need to be successful. These executive functions are also necessary for achieving adolescent and young adult developmental milestones and independence in the community. Executive functions include working memory (the ability to multi-task), initiating, organizing, planning, prioritizing, goal setting, problem solving, abstract reasoning, delaying gratification, managing drives (inhibition), managing motions and most critically, self-awareness (the ability to accurately assess one's strengths and weaknesses in different circumstances). Frontal lobe related cognitive problems, especially impaired awareness, can make rehabilitation and recovery much more difficult. Whether after TBI or in other life situations, if someone does not know how to play to their strengths, spot their weaknesses and know when to ask for help, loss of jobs and relationship failures may occur, leading to anger, irritability, and depression.

While anger, irritability, and depression may be common reactions after brain injury, such psychosocial problems are far broader and more complex. Behavioral symptoms are in some instances caused by the TBI itself, as regions of the brain may be directly damaged or have disruption in patterns of electrochemical activation. Other times, psychosocial symptoms emerge from the person's reaction to having the injury, and the confusion and change that ensues. TBI may also cause pre-existing psychological or substance abuse problems to recur or increase. Impaired self-awareness has roots in frontal lobe injury, but may mimic a psychological reaction called denial. When psychological denial occurs, the person with TBI cannot come to terms with their new 'self' and needs more extensive therapy. In most instances a period of adjustment and acceptance occurs after TBI. In this adjustment process, it is critical through rehabilitation to establish new hopes and

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goals based on an accurate understanding of post-TBI strengths and weaknesses, thus reducing depression and risk of suicide.

After TBI, pain and fatigue can contribute to behavioral problems. Mood swings, personality changes, anxiety, sleep problems, temper outbursts, impulsivity, and inflexibility are also common residual TBI issues. Therapies and/or medication may provide symptom relief and support the rehabilitation process. More severe TBI and frontal lobe injury often lead to egocentrism – the excessive focus on one's self, and difficulty appreciating the perspective of others. This egocentrism contributes to difficulties in interpersonal relationships and intimacy. Although TBI is a risk factor for drug and alcohol abuse, published studies of TBI have found that alcohol intoxication plays a role in 37-51% of TBI, and substance abuse of any kind is associated with worse outcome, demonstrating the complications of this common pre-existing condition.

The American Congress of Rehabilitation Medicine and other groups have established criteria to define levels of TBI as mild, moderate, or severe. These levels are based on medical symptoms at the time of injury. Approximately 80% of reported TBI's are mild, with the remainder split between moderate and severe. One of the most confusing aspects of TBI is that the level of injury at the time of the TBI only partially predicts the long term outcome for any particular person. At times there are cases of remarkable recovery after extended loss of consciousness (coma) as reported by the press. Other times, individuals with TBI defined as 'mild' based on initial physical symptoms, face major challenges from cognitive, mood and personality changes. Additionally, terminology such as mild TBI, concussion and minor head injury, have been used interchangeably over the years, creating confusion. Most professional groups generally define mild TBI as having a disruption of or loss of consciousness less than 30 minutes, moderate TBI with loss of consciousness over 30 minutes up to 24 hours, and severe TBI as loss of consciousness over 24 hours. Mild TBI may also be diagnosed when a person has disruption of brain function characterized by loss of memory for events immediately before or

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after the accident, any alteration of mental state at the time (e.g. dazed, confused, disoriented) and any focal neurologic deficits (e.g., balance, word retrieval) that may be transient. But as stated, severity of injury is not the best indicator of prognosis.

The constellation of problems that may continue after mild TBI is called post-concussive syndrome or disorder (PCS or PCD). These are a constellation of symptoms caused or worsened by TBI and persisting after 3 months (most mild TBI symptoms usually clear within three months). Hallmark PCS/PCD features include a history of head trauma that has caused a significant cerebral concussion, manifestations of concussion that include loss of consciousness, post-traumatic amnesia, and less commonly, post-traumatic onset of seizures, evidence of difficulty in attention (concentrating, shifting focus of attention, performing simultaneous cognitive tasks) or memory, and symptoms developing shortly after the trauma and lasting at least 3 months such as becoming fatigued easily, disordered sleep, headache, vertigo or dizziness, irritability or aggression on little or no provocation, anxiety, depression, or affective liability, changes in personality (e.g., social or sexual inappropriateness) and apathy or lack of spontaneity.

The brain is a complex organ that operates as a delicate and remarkable electrochemical system, where chemical messengers move between cells called neurons. Through the chemical changes that occur, patterns of electrical activity are formed, creating our thoughts, feelings and actions. This brain electrical activity is what the neurological test called the electroencephalogram (EEG) measures, a test often used in the diagnosis of seizures. The typical human brain is a three-pound universe with 100 billion neurons, each of which has the potential to connect to thousands of other neurons, passing their information through electrochemical messengers. Much of the 'thinking' part of the brain that performs our highest intellectual functions is in the outer layer of tissue known as the grey matter. Underneath this grey matter is the white matter, cellular information superhighways that speed transmission of information in the brain by having a fatty insulation covering (myelin), similar to the electrical insulation covering on wires. The insulated projections from neuron cell bodies that relay electrochemical impulses are called axons, and together bundles of axons form tracts. These white matter tracts vary in thickness, and are often finer than a human hair, making them vulnerable to injury.

The brain is viewed not only in terms of grey or white matter, but also by the functions of various regions or lobes. As previously mentioned, the frontal lobe is most vulnerable, and oversees the executive duties of life, allowing us to be successful, independent and able to adjust to our changing world and life demands. The rearmost part of the frontal lobe is responsible for movement, taking our intentions and sending out the motor plan so that we can reach, jump and run. On each side of the brain, just above the ear area rest the temporal lobes. They are also very vulnerable to TBI, and injury in this region is associated with higher risk for seizure and subsequently, psychological problems. The temporal lobes are critical in learning and memory, as well as understanding language and sequencing. Above the temporal lobes and further back in the brain are the parietal lobes. The parietal lobes control, pull together and comprehend our experience of the sensory world. Parietal lobes play a critical role in touch sensation, spatial abilities as well as academic skills. Surprisingly, our vision happens in the occipital lobe in the very back of the head. Injury to this region of the brain may cause cortical blindness, where the eyes work perfectly well, but the occipital lobe cannot process the images.

The brain can be injured in many different ways. Initial causes of injury include the pushing and pulling of tissue where there is rapid acceleration-deceleration injuring the white matter tracts (such as car crashes), the brain smashing into the rough regions of the skull causing bruising and swelling, tearing of tissue causing bleeding, and loss of oxygen (anoxia) causing neuron death. Secondary causes of injury include increased pressure on the brain, infection, chemical changes and other medical complications. Initial timely medical management is critical. Given the effects of TBI may last a lifetime, initial care and rehabilitation sets the stage for long term outcome.

There is no cure for TBI, thus the importance of optimal care every step of the way. The continuum of care starts in the ER, where diagnosis of mild to severe TBI involves a variety of tests such as CT scans, MRI, EEG or PET scans, allowing physicians to see the architecture and activity within the brain. With severe TBI, advances in management of pressure due to brain swelling (intracranial pressure) have saved thousands of lives. Most people with mild TBI are sent home with follow-up instructions for aftercare. Others with mild TBI, and many with more severe TBI, are admitted to the hospital for medical stabilization and treatment. This treatment may result in transition to an inpatient rehabilitation setting or long term acute care hospital where various professionals are involved in providing treatment. Many medical specialties (physiatry, neurology, psychiatry, pulmonology, nursing, etc.) and allied health providers (neuropsychology, case management, occupational, physical, recreation, and speech therapies, etc.) may be involved, with care. Usually care is delivered through a team model centered on the person with TBI and their unique needs.

Ideally, outpatient and community based services for the person with TBI continue in a person-centered model, although frequently shortages in funding and resources are identified as obstacles to accessing post-acute rehabilitation and community re-entry services. Advocacy organizations such as the Brain Injury Association of America and National Association of State Head Injury Administrators, provide directories, on-line, telephonic and in vivo resources to assist in identifying local and regional options. Supports and services should be made available to all family members, as TBI affects a family unlike any other injury. Aside from the traumatic nature of the injury, TBI may result in personality and role changes, long term rehabilitation needs, on-going disability and financial hardship. Parents, spouses,

siblings and children are all potentially changed by this experience, and often extra help is needed to manage the family's transformation post-TBI. Unfortunately, family strain, child behavior problems and divorce are all too common. The only 'cure' for TBI is prevention. Reducing risk through everyday prevention behavior is an opportunity for personal and family wellness. Consistent use of seatbelts and properly fitted helmets for sports activities, proper use of equipment and training in work settings, and enhanced concussion screening (to avoid re-injury risk) and improved helmet design in the military and contact sports are all key components of a familial, community, and cultural commitment to TBI prevention. •

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JBS International is facilitating the Traumatic Brain Injury–Resource Optimization Center (TBI–ROC), under the direction of Eileen Elias (TBI-ROC) Director and Senior Policy Advisor on Disability and Mental Health and the TBI–ROC Advisory Group. The Center was created to ensure comprehensive expert input and recommendations from its supporting Advisory Group consisting of representative stakeholders including corporations, foundations, national and State trade organizations, providers, payers, and other private and public experts on this growing health issue. TBI–ROC aims to be a recognized source and leader for advancing national attention to the myriad of policy, research, practice, and service needs supporting both civilian and military individuals who incur TBI and their families. It identifies and facilitates multifaceted actions resulting in coordinated TBI health and human services and supports.