TRAUMATIC BRAIN INJURIES

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Executive Summary *The World Health Organization states that traumatic brain injury (TBI) will surpass many diseases as the major cause of death and disability by 2020, and is a significant source of disability and morbidity. TBI is brain dysfunction caused by a blow to the head which may cause bruising, bleeding, swelling or torn nerve fibers. Causes of TBI are blasts, falls, vehicle accidents, sports injuries, abuse and gunshot wounds. Diagnostic methods involve neurological exams, scans, other medical tests and interviews. The degree of damage depends on the extent and part of the brain affected, and these are underwriting considerations as well. The goal of TBI treatment is to restore the highest level of independence and degrees of recovery can vary. Research reveals that multiple TBIs, even mild concussions, may have long-term impacts on patients, so underwrite carefully.*

The Centers for Disease Control (CDC) estimates more than two million emergency room visits each year in the US and some 280,000 hospitalizations are due to traumatic brain injury (TBI), either alone or in combination with other injuries. According to the National Institutes of Health, a population of some 3.2 to 5.3 million people live with long-term physical, cognitive and psychological health disabilities related to TBI, at an estimated cost of more than $60 billion annually in direct and indirect costs. More than 50,000 deaths are attributed to brain injuries each year.

These numbers do not include injuries at military or Veterans Health Administration facilities. Approximately 357,000 TBIs have been reported since 2000, when the VHA began tracking TBI. This includes brain injuries sustained during military training, deployment, or during daily activities such as recreational activities or playing sports. Only one TBI per service member is counted, so multiple brain injuries to one soldier are not included in these numbers.

The World Health Organization estimates 10 million people are affected annually by TBI, stating it will surpass many diseases as the major cause of death and disability by 2020, particularly in low and middle income countries, which have a higher incidence of risk factors leading to TBI and less prepared medical facilities to address brain injury treatment.

TBI is undoubtedly a significant source of disability and morbidity. By definition, a traumatic brain injury is brain dysfunction caused by an outside force, usually a violent blow to the head or an object penetrating the skull. When the brain collides with the inside of the skull, it may be bruised or begin bleeding, or nerve fibers may be torn. Injured brain tissue often swells following trauma, and increasing pressure inside the skull may create secondary injuries.

Causes

While blows to the head are most frequently associated with TBI, brain trauma may also be caused by sudden and rapid acceleration or significant deceleration of the body. Common causes for TBI include falls, particularly in young children and older adults, vehicle-related collisions and violence -- shaken baby syndrome, domestic abuse and gunshot wounds.

Unintentional blunt trauma, such as collisions during contact sports such as football and hockey, account for about 15% of TBI, according to the CDC. Athletes in extreme individual sports such as snowboarding or skateboarding, as well as highly competitive sports such as cheerleading and gymnastics, also are at risk for TBI.

Explosive blasts are a common cause of TBI in active duty military personnel. Risks of explosive blasts include shrapnel causing head trauma, as well as the pressure wave created by the explosion damaging the brain. Head and neck injuries including severe brain trauma have been reported in 1 of 4 military person-

nel who were evacuated from conflicts in Afghanistan and Iraq.

Diagnosis

A neurological exam as well as brain and spinal imaging via a number of medical tests -- CT (computed tomography), CAT (computed axial tomography), MRI (magnetic resonance imaging), SPECT (single photon emission), PET (position emission tomography), EEG (electroencephalogram) and others – may be used to diagnose brain injuries. CT scans, for example, create a detailed view of the brain with a series of X-rays to produce a three-dimensional image. Physicians can quickly see fractures, evidence of bleeding, blood clots, bruises and swelling in the brain with a CT scan. MRI creates a brain view using radio waves and magnets. MRIs are typically performed once an injured person's condition has been stabilized, as they are better able to show subtle differences in soft tissue as opposed to CT scans. Because TBI patients are at risk for a second brain injury due to increased intracranial pressure, doctors may insert an intracranial pressure monitor through the skull to track brain tissue swelling.

In addition to physical screening, doctors may ask questions of a TBI patient to gauge the severity of injury. The Ranchos Los Amigos Scale is a series of questions to measure awareness, cognition, behavior,and interaction with the environment in eight levels, from no response (Level I) to purposeful and appropriate responses (Level 8).

A 15-point scale for estimating and categorizing the outcomes of brain injury, the Glasgow Coma Scale scores TBIs on overall social capability or dependence on others. The test assesses responses to commands regarding motor, verbal and eye opening responses. Scores in each area are added, with lower scores indicating a more severe injury and poorer outlook for full recovery. GCS scores of 3 to 8 are classified as severe TBI, scores of 9 to 12 are classified as moderate, and scores of 13 to 15 are classified as mild TBI.

Symptoms

As command central for the body, the brain controls behaviors, thoughts, movements and sensations. Injury to the brain, therefore, may create a spectrum of cerebrovascular dysfunction involving any or all of these. The degree of dysfunction depends greatly on which part of the brain has been affected, whether it occurred in a specific location or over widespread area, and how extensive the damage.

How a TBI develops following an injury is not fully understood, and a wide range of findings and clinical manifestations may be displayed simultaneously. Symptoms may appear immediately after trauma or develop after several days or even weeks. Direct trauma injures tissues of the brain's cortex, but hematomas damage sub-cortical tissues and cause constriction in the brain's blood vessels and decreased blood flow. Sudden movement of the skull on its vertical axis (acceleration, deceleration or rotation) damages long axons which interconnect regions of the brain.

Classification

TBIs are classified as mild, moderate or severe based on the extent of symptoms, which may be as mild as momentary confusion, nausea or headache, to more serious and permanent presentations such as seizures, memory loss, coma, disability or death.

TBIs are classified as mild when the Glasgow Coma Scale score is higher than 12 and loss of consciousness is less than 30 minutes. Brain imaging tests are often normal with mild TBI, and common symptoms include headache, fatigue, sleep cycle interruption, loss of balance, visual disturbances and post-traumatic amnesia for less than an hour following injury. Some people may look well and even report feeling well in cases of mild TBIs, but family and friends may notice unusual behaviors such as moodiness, easy confusion, or distraction or lethargy.

Concussions are the most frequent type of mild TBI and were once given little consideration beyond the pain associated with them. During the past few years, however, increased attention has been paid to studying the effects of multiple concussions; new research and more sensitive diagnostic testing such as diffusion tensor imaging have shown long-term risks associated with repeated mild TBIs. A 2015 report by Frontline, for example, found chronic traumatic encephalopathy (CTE) in 96% of the NFL players examined and in 79% of football players at various levels of play. The Mayo Clinic defines CTE as "brain degeneration likely caused by repeated head traumas" that is "a diagnosis only made at autopsy." It has also been recently recognized that while females tend to have fewer concussions than males, the effects can be more severe even with the same severity of the blow to the head.

Moderate brain injuries, rated 9 to 12 on the Glasgow Coma Scale, may result in loss of consciousness from 1 to 24 hours and post-traumatic amnesia for up to 24 hours. Severe brain injuries, rated 3 to 8 on the Glasgow Coma Scale, are characterized by more than 24 hours of unconsciousness or coma and more than 24 hours of post-traumatic amnesia. Imaging scans for moderate and severe TBI will show abnormal

results, and patients with moderate to severe TBI may exhibit any number of symptoms shown in the chart (next page).

TBI may also have profound impacts on the endocrine system because the injury may disrupt function of the pituitary gland, which makes hormones that direct other glands such as thyroid and adrenal gland to make other kinds of hormones. TBI also may affect the hypothalamus, which controls release of hormones made by the pituitary gland. Dysfunction of one or both of these areas of the brain may cause problems such as adrenal insufficiency, production of too much prolactin, disruption of the salt-to-water balance in the body, hypothyroidism, hypogonadism and growth hormone deficiency.

Children may lack the communication skills to explain their physical, sensory or other impairments related to brain injury. Signs of TBI in children include a change in eating or sleeping habits, persistent crying with inability to be consoled, unusual or easy irritability, inability to pay attention, or loss of interest in favorite toys or activities.

Treatment

The goal of TBI treatment is to restore the highest level of independence in daily living activities, capitalizing on strengths and learning new skills or strategies to compensate for deficits, making accommodations to the physical environment as needed to remove barriers, and enhance participation. Because TBI causes numerous and widely varied neurological deficits, treatment protocols are typically aimed at specific issues related to the injuries.

People who sustain mild brain injuries may need nothing more than non-prescription pain relievers and rest, though the patient should be monitored closely at home for any new or worsening symptoms. Treatment for moderate to severe TBI, however, requires emergency intervention so that oxygen and blood flow to the brain is monitored and secondary injuries are prevented.

Therapeutic interventions such as lab tests, medications, surgery and hormone therapy address physical needs while rehabilitative programs are focused on improving speech, cognitive, behavioral and social/emotional deficits. Supportive care includes monitoring breathing, heart rhythm, blood pressure, pulse,and intracranial pressure.

A review of recent studies illustrates the use of focused approaches to treatment for TBI. For example:

- A study published in the *American Journal of Occupational Therapy* (April 2016) concluded direct attention training contributes to improvement in executive functioning and memory compensation strategies in adults with TBI.
- Clinical research sponsored by the National Institute of Neurological Disorders and Stroke includes brain tissue oxygen monitoring, medical therapies for children with TBI, stem-cell based therapy, and dynamic pressure autoregulation strategies among others.
- Mnemonic studies, particularly visual imagery training, help TBI patients improve memory, according to a study sponsored by the Academy of Neurologic Communication Disorders and Sciences.
- Results of a study published online in the journal *Neurology* on December 21, 2016, show monitoring sleep-wake cycle may be a possible tool for assessing recovery from TBIs. Researchers found patients slept better as they became more alert, which suggests commonality may underlie brain recovery and sleeping cycles.

For soldiers returning from active military zones, the Department of Defense has implemented an exposure screening program as a complement to the screening program previously established by the Department of Veterans Affairs. Identifying mild TBIs which previously may have been missed should lead to better outcomes.

Prognosis and Recovery

Estimates of recovery from TBI are as individualized as treatment options and are described in terms of probabilities rather than certainties. Attempts to predict the degree of recovery and timeline for recovery are rudimentary. Age, duration of coma, duration of post-traumatic amnesia and results of imaging studies are used to evaluate prognosis.

Premature mortality is a potential risk in patients who survive the brain trauma itself. Risks of mortality from external causes (suicide, injury and assault) were increased. Psychiatric or substance abuse comorbidity also increased mortality risk. A study in Sweden examined 41 years of data and found patients who survived 6 months after TBI had three-fold increased odds of mortality compared with general population controls.

Results of a study performed on data from 1988 to 2010 in the US were similar. Mortality of people who experienced a moderate to severe brain trauma was higher than that of the general population. Researchers found that life expectancy reduced by 3 years to 11 years, depending on age, sex and severity of disability in walking and feeding.

	**Cognitive difficulties with:** • Attention • Concentration • Distractibility • Memory • Speed of processing • Confusion • Perseveration • Impulsiveness • Language Processing • Executive functions
	**Speech and Language** • Difficulty understanding the spoken word • Difficulty speaking and being understood • Slurred speech • Speaking very fast or very slowly • Problems reading • Problems writing
	**Vision** • Partial or total loss of vision • Weakness of eye muscles and double vision • Blurred vision • Problems judging distance • Involuntary eye movements • Intolerance of light
	**Social-Emotional** • Dependent behaviors • Emotional ability • Lack of motivation • Irritability • Aggression • Depression • Disinhibition • Denial/lack of awareness
	**Physical Changes** • Physical paralysis/spasticity • Chronic pain • Control of bowel and bladder • Sleep disorders • Loss of stamina • Appetite changes • Regulation of body temperature • Menstrual difficulties • Convulsions that may involve disruption in consciousness, sensory perception or motor movements
	**Sensory** • Difficulties interpreting touch, temperature, movement, limb position and fine discrimination • Loss or diminished sense of taste • Loss or diminished sense of smell • Decrease or loss of hearing • Ringing in the ears • Increased sensitivity to sounds

Source: Traumatic Brain Injury Association (www.traumaticbraininjury.com/symptoms-of-tbi/severe-tbi-symptoms/).

Patients over age 2 and under age 60 are thought to have better prognosis even if they suffer the same injury as the youngest and oldest TBI patients. The shorter the coma and the shorter the amnesia, the better the prognosis. Imaging results, particularly from computed tomography (CT) and intracranial pressure scanning, reveal the extent of the brain injury, which is also a consideration of recovery.

Underwriting Considerations

Life Insurance

The primary considerations for life insurance depend on the extent and type of traumatic brain injury, any complications, other related impairments and prognosis.

If a single limited concussion is involved, a favorable decision may be appropriate if there is full recovery and this is within the scope of a company's guidelines. The same applies to minor head injuries with no skull fracture and no residuals, where the loss of consciousness was less than 6 hours.

Multiple concussions may result in complications such as seizures or CTE even many years later, so mortality considerations need to be taken into account.

For major head injuries, with or without skull fractures and a loss of consciousness of greater than 6 hours, it may be prudent to wait a period of time to allow for an adequate assessment of possible complications. Post-traumatic epilepsy may have a mild to moderate mortality impact if controlled, but an excess effect on mortality if seizures are frequent. Ongoing neurological symptoms or cognitive impairment may affect daily functioning. Prolonged loss of consciousness, coma or amnesia lasting greater than 2 weeks would require a thorough review to assess for any residual effects.

Disability Insurance

This type of coverage is generally more problematic for TBI than life insurance, especially for injuries that have lasting neurological effects such as paralysis, seizures and so on. Some patients may require multiple treatments including surgery or speech, physical, behavioral and occupational therapies and may never fully recover despite these interventions.

Similar to life insurance, however, with a single limited concussion, the impact to morbidity may be minimal. For more involved TBI, an unfavorable outcome or an exclusion rider may be appropriate, depending on the design of the product and the nature of the residuals. If full recovery is achieved, these decisions may be reconsidered.

Conclusion

Incidence of TBI around the world is rising. Research increasingly reveals that multiple TBIs, even mild concussions, may have long-term impacts on patients. Given the broad spectrum of potential dysfunction with TBI, some of which may emerge only after a significant period of time, underwriting TBI risks must be considered carefully.

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Terry Feeney, FALU, FLMI, ACS, joined Transamerica Reinsurance in March 1995 as a Senior Underwriter, transitioning to the role of Underwriting Director in 2000, and continuing in that position as part of SCOR Global Life Americas. She assists the International area with auditing and training. Terry served on the Underwriting Procedures and Cost Committee, on the AHOU Program Committee 2016-2017 and as AVP of the Carolina Underwriters Forum. Prior to reinsurance, Terry was a Senior Underwriter at United Services Life Insurance Company and Garden State Life Insurance Company in the Washington, DC, area.She attended the University of Maryland and worked as a bilingual teacher after graduation. She learned Spanish growing up in Latin America, moving every 2 years due to her father's position as a diplomat. Terry lives in Concord, N C.