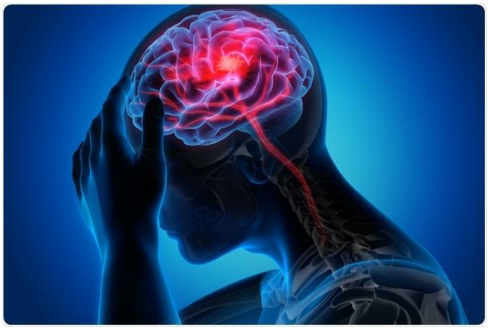
Traumatic brain injury

Introduction:



Definition and Overview:

Traumatic brain injury (TBI), a form of acquired brain injury, occurs when a sudden trauma causes damage to the brain. TBI happens when a sudden, external, physical assault damages the brain.

Historical Context:

The oldest known mention of brain injuries dates to 1600 BCE (before common era). These mentions come from an ancient Egyptian text known as the Edwin Smith Papyrus, which is thought to be a copy of an even older text. This text is so old that it goes as far as mentioning magic as a last resort in terminal cases.

Epidemiology:

This disease is divided according to the seriousness level of the injury. The incidence of mild TBI (easiest complication level) is about 131 cases per 100,000 people, the incidence of moderate (the medium level) TBI is about 15 cases per 100,000 people, and the incidence of severe (the most serious level) TBI is approximately 14 cases per 100,000 people. The inclusion of prehospital deaths increases the last figure to 21 cases per 100,000 people.

Etiology:

Causes and Risk Factors:

Traumatic brain injury, typically resulting from head or body trauma, can be severe and influenced by various factors such as injury nature and impact force. The following common events cause TBI:

Falling: Traumatic brain injuries are the most common result from falling, especially in older adults and young children, resulting from simple various sources such as bed, ladder, stairs, and bath.

Vehicle-related collisions: Car, motorcycle, or bicycle collisions, along with pedestrians involved, are a common cause of traumatic brain injury.

Violence: Common causes of gunshot wounds, domestic violence, and child abuse include assaults, while shaken baby syndrome is a traumatic brain injury in infants caused by violent shaking.

Sports injuries: Traumatic brain injuries, often resulting from high-impact sports like soccer, boxing, football, and skateboarding, are common in youth.

Explosive blasts and other combat injuries: Explosive blasts are a common cause of traumatic brain injury in active-duty military personnel, with researchers suggesting pressure wave is the primary mechanism.

The people most at risk of traumatic brain injury include Children especially newborns to 4-year-olds, young adults especially those between ages 15 and 24 and adults age 60 and older.

Genetic and Environmental Influences:

Each TBI patient presents unique symptoms and outcomes, necessitating a comprehensive assessment of brain health and function from multiple perspectives to understand cellular and molecular mechanisms and genetic predispositions,

So yes, molecular and genetic changes influence TBI severity and recovery. Besides, hundreds of babies are born with brain damage from a birth injury each year.

Clinical Features:

Signs and Symptoms:

Traumatic brain injury can cause significant physical and psychological effects, with symptoms appearing immediately or days or weeks after the event. This injury is divided into levels:

Mild traumatic brain injury:

The signs and symptoms of mild traumatic brain injury may include:

Physical symptoms: Headache, nausea or vomiting, fatigue or drowsiness, problems with speech, dizziness or loss of balance

Sensory symptoms: Sensory problems, such as blurred vision, ringing in the ears, a bad taste in the mouth or changes in the ability to smell and sensitivity to light or sound,

Mental symptoms: Loss of consciousness for a few seconds to a few minutes, no loss of consciousness, but a state of being dazed, confused or disoriented, memory or concentration problems, mood changes or mood swings, feeling depressed or anxious, difficulty sleeping and sleeping more than usual.

Moderate to severe traumatic brain injuries

Moderate to severe traumatic brain injuries may exhibit mild symptoms within the first few hours to days after a head injury, having the following symptoms:

Physical symptoms: Loss of consciousness from several minutes to hours, persistent headache or headache that worsens, repeated vomiting or nausea, convulsions or seizures, dilation of one or both pupils of the eyes, clear fluids draining from the nose or ears, inability to awaken from sleep, weakness or numbness in fingers and toes and loss of coordination.

Mental symptoms: Profound confusion, agitation, combativeness or other unusual behavior, slurred speech and coma and other disorders of consciousness.

Disease Stages and Progression:

Traumatic brain injuries are classified as mild, moderate and severe. Most people progress through the stages of coma, vegetative state, minimally conscious state (is a disorder of consciousness in which patients with severe brain damage are in a state of partial arousal rather than true awareness**),** emerged from minimally conscious state, and post-traumatic confusional state. To sum up more serious TBI can lead to severe and permanent disability, and even death.

Complications:

Traumatic brain injuries can lead to numerous complications, with severe injuries increasing the risk of more severe ones. TBI can lead to significant, long-term changes in a person's consciousness, awareness, or responsiveness. Different states of consciousness include:

Coma: A coma is a state of unconsciousness due to brain damage, which can either be re-exposed or reverted to a vegetative state after a few days to weeks.

Vegetative state: Damage to the brain can lead to a vegetative state, allowing individuals to be unaware of their surroundings but still able to respond to reflexes.

Minimally conscious state: A minimally conscious state is a severely altered consciousness with some self-awareness, often transitioning from coma or vegetative to greater recovery.

Brain death: Brain death occurs when there is no measurable brain activity, leading to cessation of breathing and eventual heart failure, and is considered irreversible.

The Physical complications include**:**

Seizures: Post-traumatic epilepsy is a recurrent condition where seizures occur in the early stages or years after a traumatic brain injury.

Fluid buildup in the brain (hydrocephalus): Traumatic brain injuries can cause cerebrospinal fluid buildup in the brain's ventricles, resulting in increased pressure and swelling.

Infections: Skull fractures can tear brain protective tissues, allowing bacteria to enter and cause meningitis, potentially spreading to the rest of the nervous system if untreated.

Blood vessel damage: Traumatic brain injuries can damage blood vessels, potentially leading to strokes or blood clots, and other brain-related issues.

Headaches: Frequent headaches are common following a traumatic brain injury, often starting within a week and potentially persisting for several months.

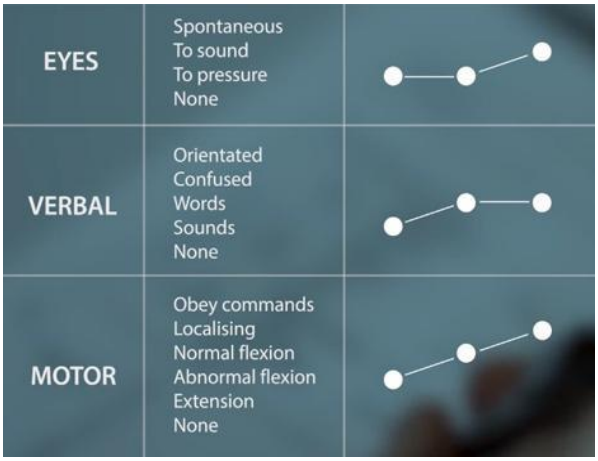
Vertigo: Many people experience vertigo, a condition characterized by dizziness, after a traumatic brain injury.

Brain injuries can cause cognitive changes, including difficulty focusing, memory issues, learning difficulties, judgment issues, attention issues, executive functioning issues, problem-solving difficulties, multitasking, organization, planning, decision-making, and task completion.

Diagnosis

Diagnostic Criteria:

TBI is diagnosed by loss of consciousness, posttraumatic amnesia, disorientation and confusion, and. neurologic signs. The **Glasgow Coma Scale** is a clinical tool designed to assess coma and impaired consciousness and is one of the most used TBI severity scoring systems.



Diagnostic Tests and Procedures:

A CT scan is a crucial test in emergency rooms for suspected traumatic brain injuries, using X-rays to create a detailed view of the brain. It can quickly detect fractures, bleeding, blood clots, bruised tissue, and swelling. MRI, on the other hand, uses powerful radio waves and magnets to create a detailed view of the brain, often used after the person's condition stabilizes or if symptoms don't improve soon after the injury.

Differential Diagnosis:

Doctors may attribute mood problems to a chemical imbalance or situational factors, but they can stem from a blow to the head. ADHD—The sudden appearance of attention deficit disorder symptoms can be TBI-related.

Furthermore, Traumatic brain injury must be differentiated from other disease that causes headache, seizures and loss of consciousness such as subdural hemorrhage, meningitis, encephalitis, brain tumor, hemorrhagic stroke, neurosyphilis, migraine, hypertensive encephalopathy, Wernicke's encephalopathy, brain abscess, drug toxicity and so on.

Pathophysiology

Mechanisms of Disease Development

TBI can result from direct trauma to the head (e.g., blunt, penetrating) or from forceful head movements resulting in acceleration–deceleration and rotational forces. Acceleration–

deceleration forces cause mechanical strains that operate in a centripetal sequence moving from the surface to deeper areas of the brain.

TBI can further develop by violent blow or jolt to the head or body. An object that goes through brain tissue, such as a bullet or shattered piece of skull, also can cause traumatic brain injury. Mild traumatic brain injury may affect your brain cells temporarily.

Cellular and Molecular Changes:

The cellular response to TBI is the when the immune response in brain: After TBI, parenchymal, vascular, and blood-brain barrier damage results in the production of DAMPs. These DAMPs activate resident brain cells (microglia, astrocytes) that initiate the intracerebral inflammatory response.

When brain injury occurs at high speed, the brain rotates inside the skull. This type of rotational movement damages axons (part of the nerve cell), and blood vessels by stretching and tearing them.

Impact on Body Systems:

Although traumatic brain injuries involve brain-related symptoms, other organs including the immune system, GI system, lungs, and heart may also be compromised. These injuries can result in changes throughout the body that can increase morbidity and even mortality.

Management and Treatment

Medical and Surgical Treatments:

Treatment of TBI is based on the severity of the injury.

Mild traumatic brain injuries typically require rest and pain relievers, but they require close monitoring and follow-up appointments. Relative rest is recommended for the first few days or until the doctor advises resuming regular activities. Moderate to severe injuries require emergency care to ensure adequate oxygen and blood supply, maintain blood pressure, and prevent further head or neck injuries. Severe injuries may also require additional treatments in the hospital to minimize secondary damage due to inflammation, bleeding, or reduced oxygen supply to the brain. Most people return to normal routines gradually.

After a traumatic brain injury, medications may be used to limit secondary damage. Anti-seizure drugs may be given to prevent seizures during the first week, while coma-inducing drugs are used to temporarily coma people with a comatose brain. Diuretics are given intravenously to reduce fluid in tissues and increase urine output. Severe injuries may also require additional treatments to address other injuries, such as inflammation, bleeding, or reduced oxygen supply to the brain. These treatments aim to minimize secondary damage and ensure proper functioning of the brain.

Emergency surgery is often necessary to prevent further damage to brain tissues, including removing clotted blood (hematomas), repairing skull fractures, stopping bleeding in the brain from head injuries, and opening a window in the skull to relieve pressure by draining cerebrospinal fluid or creating more room for swollen tissues. These procedures can help minimize further damage to brain tissue and prevent further brain damage.

Pharmacological Therapies:

Pharmacologic therapies are an essential part of TBI care, and several agents have well-established effects in TBI care. In the acute phase, tranexamic acid, antiepileptics, hyperosmolar agents, and anesthetics are the mainstay of pharmacotherapy, which have proven efficacies.

Lifestyle and Dietary Modifications:

Some studies have shown that a Mediterranean diet rich in fruits, vegetables, whole grains, beans, nuts, olive oil and fish may be beneficial after brain injury.

Rehabilitation and Supportive Care:

Cognitive rehabilitation therapy focuses on restoring cognitive function through interventions or tools designed to improve memory, focus, and other cognitive skills. Neuropsychological assessments can be used to identify treatment targets and strengths that can be leveraged to optimize function.

To support someone with TBI you can help them break down their tasks, monitor their overstimulation, make home a friendlier place, help them slowly expand their comfort zone, assume ownership of tasks they can't handle for now and support them during treatment.

Prevention and Control:

Since this disease is mostly caused by accidents so you can prevent TBI by simple tips such as wearing a seat belt every time you drive or ride in a motor vehicle. Never drive while under the influence of alcohol or drugs. Choose a sports program that enforces rules for safety and avoids drills and plays that increase the risk for head impacts. Prevent head injuries in children and it is preferred to use a child safety seat or a seat belt when the child is in a motor vehicle. And prevent texting or calling while driving.

Primary, Secondary, and Tertiary Prevention Strategies:

For preventing TBIs (at its primary stage) caused by falls include improved in-home lighting, use of stair handrails, and assessments of balance and gait in older persons.

For the secondary TBI is specifically through avoiding and treating aggravating factors, such as hypotension, hypoxia, inadequate cerebral perfusion pressure (CPP), and intracranial hypertension. Tertiary prevention refers to maximizing patients' functional abilities and restoring their daily life following an established brain injury. These include various approaches to neurorehabilitation as well as symptom management.

Public Health Interventions:

Educate the public about TBI risks, stages and prevention ways, enforce helmet laws for motorcycle drivers and for sports. Encourage school programs about TBI prevention. Provide support services for individuals with TBI and their families.

Vaccination and Screening Programs:

There is no vaccine for TBI, otherwise ACL's TBI Technical Assistance and Resource Center helps TBI State Partnership Program grantees promote access to integrated, coordinated services and supports for people who have sustained a TBI, their families, and their caregivers. The BIST is a tool that can facilitate clinical decision making through identification of people who are at low, medium or high risk of longer-term difficulties. This tool should be used in addition to clinical judgment and other assessments such as the Vestibular/Oculomotor Motor Screening (VOMS), King-Devick or the Romberg's test.

Prognosis

Disease Outcomes and Survival Rates:

Among 169 (50.0%) TBI patients diagnosed with severe TBI (GCS ≤ 8) based on their GCS score at admission, the cumulative survival was 36.92% (95% CI: 27.09–46.77%). In other words the overall survival rate estimated survival rate for TBI patients in the study was 47.53%.

Factors Influencing Prognosis:

Other important prognostic factors included hypotension, hypoxia, glucose, coagulopathy, haemoglobin and category of CT characteristic, such as midline shift, mass lesion, basal cistern. In other words, gender and intraventricular haemorrhage did not have predictive value. Men more often participate in higher risk behaviors that can cause injury, worsen the effects of previous injury, or increase the risk of repetitive injury.

Quality of Life:

It was found 67.9% of subjects reported that TBI negatively impacted their QoL. Patients' reported their TBI impacted their QoL (The Traumatic Brain Injury Quality of Life measurement system (TBI-QOL) is a TBI-specific extension of the PROMIS and Neuro-QoL measurement systems that includes 20 item banks across physical, emotional, social, and cognitive domains.) by affecting their independence (60.4%), relationships (73.6%), hobbies (61.2%), and careers (54.7%).

Furthermore, the brain affects how you think; how you feel; how you act. So, a TBI can affect your physical functions, thinking abilities, behaviors, and more. The injury can range from mild to severe, and it may increase your risk for mental health conditions such as anxiety and depression, as well as sleeping problems.

Current Research and Future Directions:

Recent Advances and Discoveries:

A team of Medical University of South Carolina researchers, led by Onder Albayram, Ph. D., reports in PNAS Nexus that they have discovered a novel protective response by which the brain naturally repairs itself after traumatic brain injury.

Ongoing Clinical Trials:

Longitudinal Assessment of Traumatic Microvascular Injury (LATMI) The LATMI study uses functional MRI scans to characterize the response of neural blood vessels to increased CO2 levels. TBI patients will undergo assessments and follow up to determine the healing capacity of cerebral vasculature after TBI.

Future Research Needs:

Future treatment of TBI will require a far more detailed understanding of normal cerebral anatomy and physiology as well as the pathological and recuperative responses that result from trauma than is currently known. It is need to know that some types of TBI can cause temporary or short-term problems with brain function, including problems with how a person thinks, understands, moves, communicates, and acts.

Case Studies

Example Cases:

Chris Nowinski is a famous WWE wrestler, Nowinski experienced multiple concussions during his wrestling career, which led to persistent cognitive issues such as memory loss, headaches, and difficulty concentrating, he hade several symptoms which led to end his wrestling career.

After his retirement, Nowinski went to medical help and was diagnosed with TBI, Nowinski has been instrumental in pushing for changes in sports policies to better prevent head injuries.

Furthermore, after retiring, Nowinski’s initial treatment was resting and managing his symptoms such as his headaches and cognitive difficulties, he underwent Neuropsychological Assessment, he had received therapy to manage symptoms of depression, anxiety, and other psychological effects associated with TBI. His lifestyle now is avoiding dangerous activities.

Finally, Chris Nowinski's case highlights the importance of medical treatment and behavioral therapy. He has influenced public awareness and research into effective treatment and prevention strategies for TBI.