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Traumatic Brain Injury (Review Article)

Samir F. Hassan

Department of Anatomy, College of Medicine – Warith Al-Anbiyaa University
E-mail address: - Samir.F@uowa.edu.iq

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Abstract

Traumatic brain injury (TBI) can be caused by anything from a minor head injury to a catastrophic brain injury. In the United States, 1.7 million people are at risk of experiencing a traumatic brain injury, with seniors 65 and older and teens between the ages of 15 and 19 having the highest risk. Mild traumatic brain injury (mTBI), often known as a brain concussion, was formerly assumed to be a non-life-threatening disorder. Mild traumatic brain injury has gained a lot of attention, however, because of some of the negative neuropsychological repercussions it has on people who serve in the military and those who participate in contact sports. This activity emphasizes the importance of interprofessional team members working together to offer well-coordinated therapy and improve patient outcomes. Its primary focus is on the examination and treatment of traumatic brain injuries.

Introduction

Traumatic Brain Injury (TBI) can result from moderate concussions to serious brain-penetrating traumas. TBI affects 1.7 million Americans, with older teens (15-19 years) and elderly (65+ years) at higher risk. The frontal and temporal lobes are often damaged. Once considered harmless, mild TBI increasingly draws attention due to its cognitive repercussions, especially in civilians like sportspeople and military personnel. Around 500 per 100,000 Americans suffer moderate to severe TBI, which causes injury-related deaths and disability. Mild head traumas account for 80% of TBI cases.[1]

Any blunt force, such as a blow, bump, jolt, or penetration, can cause brain injury. Falls cause the majority of traumatic brain injuries (49%) in children (0-17 years) and an astounding 81% in the elderly (65 and over). Other typical sources of injury include being hit by an object, being involved in a car accident, purposely injuring oneself, and being hit by an object. Falls (52%) and car accidents (20%) are hospitalised patients' most common causes of traumatic brain injury.[2]

Males are twice as likely as females to suffer from traumatic brain injuries (TBI) in terms of gender distribution. Notably, a study of 1,084 TBI patients found that the injury was a substantial risk factor for post-traumatic stress disorder (PTSD) and other mental illnesses. According to the Centers for Disease Control and Prevention (CDC), over 1.5 million TBI cases occur in the United States each year, with approximately 230,000 needing hospitalisation. TBI diagnoses grew from 10,958 in 2000 to

344,030 in 2015. Estimates of TBI-related mortality range from 3% to greater levels of difficult-to-quantify morbidity.[3]

Pathophysiology of Traumatic Brain Injury (TBI)

The Monro-Kellie theory, which asserts that the hard cranial container maintains a consistent intracranial volume, including brain tissue, cerebrospinal fluid, and venous and arterial blood, might help us better understand the pathophysiology of traumatic brain injury (TBI). When an extra compartment, such as a hematoma, is created, a comparable reduction in another compartment must be made to prevent intracranial pressure. The most important element is cerebral perfusion pressure (CPP), which is computed by subtracting mean arterial pressure (MAP) from intracranial pressure (ICP). Ischemia and infarction in the brain may occur due to reduced CPP caused by an increase in ICP. The primary goal of TBI treatment is to avoid this secondary insult**.**[4]

Types of TBI

Concussion: A moderate TBI without significant structural damage is caused by nonpenetrating head trauma, most typically caused by acceleration/deceleration forces from a direct strike—concussion results in temporary changes in mental status, ranging from bewilderment to loss of consciousness. Routine CT or MRI scans make diagnosis difficult; however, specialist MRI sequences such as diffusion tensor imaging and functional MRI can aid in early detection.[5]

Second Impact Syndrome (SIS): Second impact syndrome occurs when a patient, generally an athlete, returns to play before fully recovering from a concussion and gets another injury; this can quickly progress to malignant cerebral oedema.

Chronic Traumatic Encephalopathy (CTE): CTE, a common disorder in athletes caused by recurrent mild TBI, is a delayed effect that can lead to mental health concerns, suicidal thoughts, difficulty paying attention, and memory and executive function impairments.

Extra-axial Hematoma: Extra-axial hematomas include epidural and subdural hematomas (EDH and SDH). EDH is frequently a life-threatening illness caused by fractures or bleeding in the middle meningeal artery. SDH, caused by bridging vein hemorrhage, can be acute or persistent. [5]

Contusion: Contracoup injuries occur on the side of the impact opposite coup contusions and often affect the basis-frontal lobe and anterior temporal lobe.

Traumatic Subarachnoid Hemorrhage (SAH): Blood enters the subarachnoid space due to tiny capillary breaking, the most common cause of SAH. Although aneurysmal rupture causes SAH in the basal cisterns, convexity causes SAH more frequently.[6]

Diffuse Axonal Injury (DAI): DAI, a common cause of mild to severe TBI, is caused by shearing, stretching, or twisting of the neuronal axons at the grey-white matter junction. These tensions produce axonal stretching, disrupting the cytoskeleton and resulting in axonal swelling, increased permeability, calcium influx, separation, and axonal death, with autopsy revealing extensive laminar necrosis. [7]

History and Physical Examination in Traumatic Brain Injury (TBI)

Most mild to severe traumatic brain injuries (TBI), particularly those received while participating in sports or recreational activities, are unreported to medical experts. Concussions from sports and leisure activities were the leading cause of TBI in children under the age of 18, according to a study published in the Journal of Pediatrics. TBI affects up to 80% of military personnel and veterans not on active duty due to training or leisure activities**.** [8]

Neuropsychiatric Symptoms and Post-Concussion Syndrome

Besides physical symptoms, neuropsychiatric problems can be disproportionate to TBI severity. Neuropsychiatric symptoms like anxiety, irritability, sadness, and sleep difficulties may accompany physical complaints like headaches, dizziness, and cognitive impairment in post-concussion syndrome

patients. Labile affect, poor social judgment, aggression, and perseveration are common symptoms of frontal lobe syndrome. Adult TBI patients may have these symptoms up to 23%. Mild TBI patient working memory is significantly damaged, and drug misuse and PTSD symptoms are up to 18% and 22% greater, respectively.[9]

Psychotic Disorder Following Traumatic Brain Injury (PDFTBI)

PDFTBI occurs in 0.7% to 8.9% of TBI patients. This disease causes deficits in executive function and psychotic (executive and semantic) functioning. Even though auditory hallucinations are infrequent, they may be disastrous and arise 4-5 years after a TBI. Psychotic symptoms after a TBI might vary, but frequently include auditory hallucinations and paranoid delusions. It is unusual to experience unpleasant responses or visual hallucinations. PDFTBI exacerbates executive dysfunction in TBI patients, resulting in substantial executive dysfunction.[10]

Comorbidity Among Soldiers

According to a 2015 study published in the American Journal of Psychiatry, the prevalence of comorbid disorders among soldiers who had a major depressive episode, PTSD, generalized anxiety disorder, or suicidality increased from 12.9% to 16.8% at 9 months post-deployment (T3) compared to 3 months post-deployment (T2); this demonstrates the complex interplay of mental illnesses in TBI patients, requiring extensive examination and therapy. [11]

Evaluation of Traumatic Brain Injury (TBI)

The severity of a traumatic brain injury (TBI) is assessed utilizing a variety of key signs and methods that can aid in diagnosis and long-term prognosis. The Glasgow Coma Scale (GCS), the level of consciousness (LOC), the altered mental state (AMS), posttraumatic amnesia (PTA), and the individual's level of consciousness (LOC) are all important components of this examination; each of which provides critical insights into the severity of impairment.

Levels of Cognitive Functioning Evaluation [12]

Ranchos Los Amigos Scale Levels	Description
Level I:	No response
Level II:	Generalized response
Level III:	Localized response
Level IV:	Confused-agitated
Level V:	Confused-inappropriate
Level VI:	Confused-appropriate
Level VII:	Automatic-appropriate
Level VIII:	Purposeful-appropriate

Tools for Comprehensive Evaluation

A thorough review needs the use of a variety of methods and assessments, including:

Evaluation Component	Description
Clinical Presentation and History	**The initial examination includes a full neurological test, a GCS score, and a mental evaluation focusing on cognitive performance.** [13]
Laboratory Examinations	Serum analysis for glial fibrillary acidic protein (GFAP) and ubiquitin C-terminal hydrolase (UCH-L1) biomarkers provide information about brain injury. GFAP, which is more dependable, is especially beneficial in the first seven days after injury because these proteins leak from injured astrocytes and neurons.
Neuroimaging	Many imaging modalities are employed to assess TBI's anatomical and physiological anomalies. Although CT and MRI are routinely used to search for abnormalities associated with vascular injury, intracranial pressure, haemorrhage, and oedema, they may not show abnormalities in many mild TBI patients. Diffusion tensor imaging (DTI) can detect axonal damage in mild to severe TBI. TBI patients are distinguished from control groups using functional MRI (fMRI), which is also used to examine TBI patients' activation patterns. Single Photon Emission Computed Tomography (SPECT) assesses cerebral blood flow and activity patterns even when structural abnormalities are absent, which may aid in TBI diagnosis and rehabilitation.
Sleep Research	Sleep studies, using power-spectral analysis provide useful information about brain impairment following moderate TBI. Delta and alpha power fluctuations in the first non-rapid eye movement (NREM) phase and beta power variations in the NREM periods are notable findings. These findings imply that sleep tests have the potential to act as a sensitive marker for brain injury, perhaps assisting in assessing the anatomical amount of brain damage.

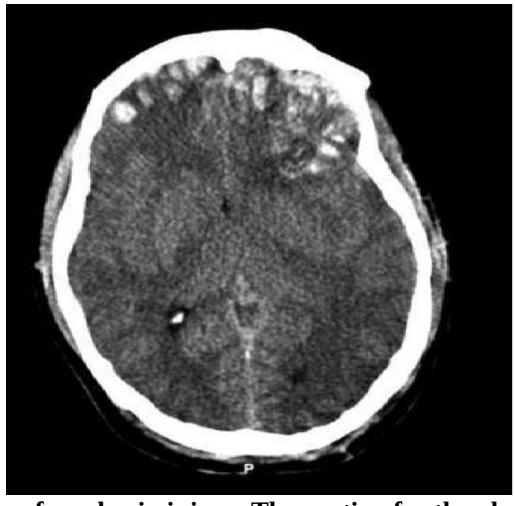

Figure 1 A CT scan of a patient suffering from brain injury. The caption for the photograph says, "Preoperative CT scan of the patient while he had a GCS of 14." According to the report's accompanying language, "emergent CT imaging revealed a sagittally oriented skull fracture extending from the vertex to the foramen magnum, as well as a transverse parietal and temporal bone fracture." Frontal, parietal, and temporal lobe contusions, interhemispheric bleeding, and a 1.7-mm-deep subdural hematoma on the left side were all present. After the basilar cisterns were removed, the midline construction remained unchanged.

Treatment and Management of Traumatic Brain Injury (TBI)

Treating psychiatric symptoms after a concussion or mild traumatic brain injury (mTBI) requires a customised approach depending on individual variables and the form and degree of symptoms. The management strategies include physiotherapy, psychological therapies, and pharmaceutical treatment techniques.

- **Physical Rehabilitation**

TBI may substantially influence the physical and behavioural components of a person's short- and long-term overall health. As a result, there is a greater risk of disability, suffering, trouble obtaining work, and difficulty sustaining social relationships. Patients can be strengthened and given greater daily activity skills through assistive technology, assistive devices, physical therapy, occupational therapy, speech-language therapy, and other treatments**.**[14]

- **Psychotherapy**

Initial training, continuous support groups (focused on symptoms and processes), family education, and addressing societal problems such as financial, legal, and transportation issues are all part of psychotherapeutic therapy. In larger clinical investigations, innovations such as virtual reality and video game-based treatment are being investigated to address balance, coordination, and cognitive issues such as attention and focus. **[15]**

- **Medications**

Medication may treat specific TBI symptoms such as headaches, depression, emotional instability, and cognitive deficits. Triptans, nonsteroidal anti-inflammatory medications (NSAIDs), and Depakote can all be used to alleviate headaches. Depression can be treated with selective serotonin reuptake inhibitors (SSRIs) such as Citalopram and Sertraline**.**[16] Atypical antipsychotics are widely used in conjunction with beta-blockers in severe cases to address agitation and irritability. Anticonvulsants are medications that are used to modulate mood and prevent seizures. Dopaminergic medicines can improve attention and focus, whilst cholinesterase inhibitors or cognitive enhancers can help with memory problems. Atypical drugs such as Modafinil and Buspar are being studied for their capacity to improve attention and emotional stability. When utilizing pharmaceuticals, a "start low, go slow" technique is usually used, coupled with careful consideration of social contexts, avoiding potentially harmful substances, and completing whole treatment trials to confirm efficacy.

- **Managing Sleep Dysfunction**

Sleep disorders are frequent after a TBI, with distinct patterns reported in the acute and chronic periods. Education on sleep length and quality changes is critical during the acute phase (less than three months). There are recommendations for optimal sleeping habits, such as a regular bedtime. If necessary, short-term sleep aids such as prazosin and zolpidem may be attempted. A review of current drugs and health conditions is required to establish the reasons for sleep disruptions in the chronic phase (more than three months). Sleep-specific cognitive behavioural therapy is an effective treatment option**.**[17]

- **Hyperbaric Oxygen Therapy (HBO2) and Hypothermia**

The potential benefits of hyperbaric oxygen therapy (HBO2) in treating TBI, particularly in mild and moderate instances, are being investigated. HBO2 has been found in studies to impact cerebral oxidative metabolism and reduce intracranial pressure. Hypothermia, obtained by lowering the body to systemic temperatures of 34 to 35 degrees Celsius, has been proposed to decrease secondary injury and enhance results by suppressing post-traumatic inflammation.[18]

- **Medical and Surgical Measures for Intracranial Pressure**

Elevating the head end of the bed to 30 degrees, brief hyperventilation, hyperosmolar treatment, therapeutic cooling, and medically induced comatose states are all methods used to regulate intracranial pressure. Intracranial pressure monitoring may be required for some patients. In some circumstances, surgical procedures such as draining cerebral hematomas or performing a decompressive craniectomy may be needed**.**[19]

Complications

Traumatic brain injuries (TBI) have both immediate and long-term consequences. In the acute phase, TBI often occurs alongside other injuries, potentially causing cognitive impairment, sensory processing issues, or even comatose states in severe cases. Patients may also face complications like cerebrospinal fluid leakage, vascular or neuronal injuries, seizures, and increased intracranial pressure, leading to potential herniation and, in extreme cases, brain death. Longitudinally, neuropsychiatric issues, including post-concussive syndrome, are common and influenced by factors like pre-existing neurological and psychiatric conditions, substance abuse, inadequate social support, and injury severity. These complications can manifest as difficulties with sleep, concentration, memory, mood disturbances, and increased risk of psychiatric disorders and substance abuse. Cognitive impairments, particularly in executive functions, may arise, along with behavioural issues, short-term memory problems, and sleep disturbances, often linked to sleep-disordered breathing.[20]

Discussion

Traumatic brain injuries (TBIs) present a complex and multifaceted landscape with implications that span from mild concussions to severe penetrating traumas, affecting a significant portion of the American population. This study highlights the critical need for an in-depth understanding of the factors contributing to TBI and its wide-ranging implications, encompassing both acute and long-term outcomes.[1]

One striking revelation from this research is the increasing recognition of mild TBI, which might have been previously underestimated but is now gaining prominence due to its cognitive repercussions. Particularly, populations like athletes and military personnel are vulnerable, and this study emphasizes the importance of acknowledging the cognitive consequences and long-term implications associated with this prevalent form of brain trauma. [3,22]

Exploring the aetiology of TBIs, the study underscores fall as the leading cause of TBI-related emergency department visits in children and elderly individuals; this highlights the need for preventive measures and safety awareness, especially within these age groups. Furthermore, the study reveals that other causes, such as motor vehicle collisions, blunt force injuries, and self-inflicted harm, contribute significantly to the diverse scenarios leading to TBI. [4]

Gender distribution is another notable aspect, with the study revealing that TBI disproportionately affects males. Additionally, the association between TBI and post-traumatic stress disorder (PTSD) and other psychiatric conditions underscores the intricate interplay of these comorbidities, emphasizing the necessity for comprehensive evaluation and management strategies.

=Moreover, the epidemiological data provided by the Center for Disease Control and Prevention (CDC) indicates a substantial burden of TBI on the American population. Millions of individuals suffer from TBIs annually, with thousands requiring hospitalization. These numbers underscore the critical need for effective prevention, management, and rehabilitation strategies to mitigate TBI's impact effectively.

Understanding the pathophysiology of TBI is pivotal. The study elaborates on the Monro-Kellie

hypothesis, emphasizing the significance of intracranial volume and cerebral perfusion pressure (CPP). This knowledge guides TBI management by preventing secondary insults and further cerebral damage, underscoring the importance of maintaining adequate CPP to avoid ischemia and infarction.

Furthermore, the study delves into various TBIs, including concussions, second impact syndrome (SIS), chronic traumatic encephalopathy (CTE), extra-axial hematomas, contusions, subarachnoid haemorrhages, and diffuse axonal injuries. Each type presents unique challenges and implications, emphasizing the need for tailored approaches to diagnosis and management based on the specific TBI type.

The underreporting of mild to moderate TBIs, particularly in sports and recreational activities, poses challenges in effectively identifying and addressing these cases. Increased awareness and reporting mechanisms are crucial, especially in high-risk populations.[21]

Additionally, the neuropsychiatric symptoms and post-concussion syndrome associated with TBI are discussed. These complications can be disproportionate to the severity of the initial injury, significantly impacting an individual's quality of life and functionality; this highlights the need for comprehensive evaluation and management, including psychotherapeutic and pharmacological interventions.

Psychotic Disorder Following Traumatic Brain Injury (PDFTBI) is identified as a relatively rare but significant complication, emphasizing the importance of recognizing and addressing this disorder, which can manifest as devastating auditory hallucinations and other psychotic symptoms.

The study's insights into comorbidity among soldiers experiencing major depressive episodes, PTSD, generalized anxiety disorder, or suicidality further underscore the complex interplay of psychiatric conditions in TBI patients and the importance of holistic assessment and management.
In conclusion, this study provides a comprehensive overview of traumatic brain injuries, ranging from epidemiology to pathophysiology, types, associated complications, and severity evaluation. The findings underscore the importance of a multidisciplinary approach to TBI management, focusing on prevention, timely diagnosis, and tailored interventions to mitigate cognitive and neuropsychiatric consequences. Future research should continue to explore the intricate relationships between TBI and its associated psychiatric conditions and further refine diagnostic and therapeutic strategies to enhance the quality of life for TBI patients.

Conclusion

In conclusion, this study offers valuable insights into the epidemiology, aetiology, and diverse consequences of traumatic brain injuries (TBIs). It underscores the increasing recognition of mild TBI's cognitive repercussions and its prevalence among athletes and military personnel, emphasizing the need for a comprehensive understanding of this common form of brain trauma. The findings illuminate the complex interplay between TBIs and psychiatric conditions, particularly post-traumatic stress disorder, highlighting the importance of holistic assessment and management. Despite its strengths, including a broad scope and insightful pathophysiological explanations, this study also faces limitations, such as potential biases and the underreporting of mild to moderate TBIs in sports and recreation. Overall, this research calls for continued efforts in TBI prevention, timely diagnosis, and tailored interventions to mitigate cognitive and neuropsychiatric consequences, guiding future investigations into refining diagnostic and therapeutic strategies for enhanced patient care in the medical field.

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