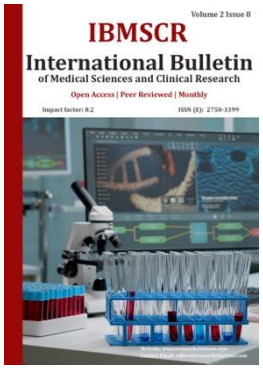


# PATHOGENETIC ANALYSIS OF TRAUMATIC BRAIN INJURIES AND THE STUDY OF THEIR PREVALENT COMPLICATIONS

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**Abstract:** Traumatic Brain Injury (TBI) is a condition that occurs more frequently than commonly perceived. Due to its complex clinical manifestations and long-term sequelae, it serves as a primary factor leading to widespread disability.[1;1] While the fields of neuropathology and psychiatry focus on the treatment and prevention of post-traumatic changes, the fundamental task of pathophysiology is to investigate the mechanisms of destructive and disintegrative disturbances following brain injury, identify previously unexplored aspects, and propose novel therapeutic solutions.[2;445]

**Keywords:** Mitochondrial dysfunction, energy deficit, headache, dizziness, early and late complications of traumatic brain injury.

**Relevance of the Topic:** Traumatic Brain Injury (TBI) leads to motor and cognitive impairments.[5;1] Complications of TBI can persist from several days to a lifetime. Over a period of 20 years post-injury, improvements and deteriorations are observed, during which time various neurological diseases are likely to manifest.[1;2] Many scientists emphasize that this is caused by mitochondrial dysfunction due to inflammation, leading to cell death. This article investigates cellular-level changes precisely to understand the pathogenesis of neurological diseases, which also aids in comprehending the essence of functional alterations.[6;5394]

**Objective of the Study:**To investigate the changes within the nervous system following traumatic brain injuries, ranging from molecular and cellular structures to various structural and functional organizational components. Additionally, the study aims to examine both post-traumatic and long-term pathologies, and to become acquainted with diagnostic criteria for their assessment.

**Materials and Methods:** Based on the conducted literature analysis, the brain is functionally structured in such a way that it can generate pathological excitation without additional stimuli. [2;446] This implies that changes arising after traumatic brain injury can persist for a long time and lead to new types of diseases. Due to the plasticity (fragility) of the nervous system, pathological processes can become chronic, remain for extended periods, and even re-develop. [2;447] By studying the following prevalent diseases, it is possible to investigate the mechanisms of traumatic brain injury development and identify their interconnected aspects. Early and common long-term diseases after traumatic brain injury include: Post-traumatic headache, asthenic syndrome (drowsiness, decreased attention), vestibular disorders (dizziness and balance disturbance), post-traumatic epilepsy [5;1] (the most common complication after injury, characterized by seizures resulting from scar tissue formation in the brain). Late-onset diseases that emerge after a long period include:Post-traumatic encephalopathy (decrease in intellectual activity due to general degeneration of brain tissue), chronic traumatic encephalopathy (resulting from repeated injuries), cognitive

impairments and dementia (increased risk of Alzheimer's disease), psychopathological conditions (depression, anxiety disorder), neuroendocrine disorders (hormonal problems due to pituitary dysfunction). These can be studied by dividing them into the following groups: pathogenetic, functional, structural, clinical and etiological. If a commonality among these diseases, specifically their development mechanism and slightly differing aspects, can be identified, I believe it would be possible to halt any type of disease at any stage, develop treatment measures, and achieve targeted intervention.

**Results:** A cellular-level examination of the pathophysiology of traumatic brain injuries reveals that neuronal death is observed. In this process, mitochondrial dysfunction occurs in the cell after the injury. A large amount of Ca++ begins to enter the mitochondria of neurons, and due to the increased burden on mitochondrial function, energy production (ATP) decreases, leading to the formation of free radicals, i.e., reactive oxygen species that damage lipids, proteins and even the mitochondria's own DNA, consequently disrupting cellular metabolism. Since mitochondria can no longer supply the cell with energy, brain tissues enter a state of energetic starvation. This leads to cell death. [3;4] Changes in cells can be detected by conducting biochemical analyses. Specifically, dead neurons release substances into the blood. The higher the concentration of proteins in the blood, the more damaged the brain tissue is. This condition, on one hand, can lead to increased intracranial pressure and headache. The mechanisms of post-traumatic headache are diverse, and it can be said that the above-mentioned condition occurs after almost all types of injuries, as it is a symptom arising from cellular-level changes. The next common pathological condition is dizziness. This results from the dysfunction of the vestibular apparatus. To confirm this condition, numerous examinations must be carried out, as diagnosing true dizziness is somewhat difficult. Dysfunction of the vestibular apparatus can be both central and peripheral. In this case, small particles formed from the destruction of otolith membranes begin to move freely in the labyrinthine vestibule, then adhere to each other, and when they acquire sufficient mass, they stimulate the organ of balance. [4;4;5] This aforementioned condition is one cause of brain dizziness, though several other causes have been noted. Considering that these changes can be both structural and functional, we can understand the necessity of conducting a series of examinations to identify them and assess the condition. Coordination can be checked with the Romberg test.

If we consider the common aspects of the early-stage diseases mentioned above, from a pathogenetic perspective: the initial mechanical impact led to neuronal and glial damage, the onset of inflammatory processes, blood-brain barrier disruption, and metabolic disturbances. Functionally: the damaged neurons resulted in a temporary or permanent impairment of information transmission, which in turn led to disturbances in cognitive (learning-related), emotional, and motor functions. Structurally: sometimes clear macroscopic changes (hematoma, contusion) are often observed microscopically. Clinically: headache manifests as a symptom of all the above diseases, along with fatigue-asthenia, and dizziness. From an etiological viewpoint: the force and mechanism of the injurious impact, and its localization (frontal, temporoparietal – if the same area is injured, it is possible to determine the severity of various clinical symptoms even when the structures in that area manifest different symptoms due to the same impact). General diagnostic tests for all these diseases: anamnesis collection, neurological examination, cognitive tests, EEG (to identify epileptic foci), vestibular examinations like posturography, laboratory tests (toxicology if needed, neurospecific

proteins, C-reactive protein, vitamin B12, complete blood count), and PET. Common aspects of late-stage diseases following traumatic brain injury. From a pathogenetic perspective: Mechanical insult, severe trauma, or repetitive impacts lead to neuronal-glial damage and diffuse white matter injury. Secondary injuries include: neuroinflammation (cytokines), oxidative stress, glutamate excitotoxicity, mitochondrial dysfunction, and retro-grade mitochondrial disruptions. The chronic stage involves: gliosis, synaptic loss, myelin loss, pathological protein aggregation and activation of neurodegeneration processes. Functional aspects: Cognitive functions (memory, attention deficit), executive functions, slowed processing speed, and decreased efficiency. Emotionally, depression, impulsivity, apathy, and aggressiveness are observed. Motorically: parkinsonian signs, altered muscle tone. Vegetatively: asthenia, sleep disturbances, fatigue.Structural aspects: Contusions, subdural, epidural hematomas, large vascular injuries. Post-traumatic atrophies include lobar, global, and cortical atrophies, with temporal and frontal types being common, and a reduction in hippocampal volume. Neuroendocrinological changes involve alterations in pituitary structures such as cysts, microadenomas, and infarcts. Clinically, each of the above-mentioned diseases can have its specific characteristics.From an etiological perspective, considering the type of injury: a single severe traumatic brain injury (which may lead to coma, contusion, oxygenation disturbance) can result in clear post-traumatic epilepsy and a high incidence of dementia. Injury localization: temporal lobe (memory/epilepsy), frontal (behavioral, executive dysfunction), diencephalon/pituitary atrophy (neuroendocrine disorders). Biological factors: advanced age results in poorer outcomes from impact, and cognitive decline occurs after traumatic brain injury. Comorbid factors: alcohol consumption, drug use, metabolic and vascular diseases worsen the condition. The standard approach to assessing the severity of these diseases includes: 1.Initial assessment: clinical and functional, GCS 2.Cognitive screening: MMSE; if impairment is found, broader neuropsychological tests (IQ, verbal/visual memory, executive tests). 3. For dementia: CDR or Global Deterioration Scale. 4.Imaging level: FDG-PET, DTI/FA decrease indicates white matter damage. 5. EEG: if seizures are suspected or to assess subclinical activity. 6. Neuroendocrine evaluation: basal and dynamic tests; pituitary MRI. 7.Psychiatric evaluation. 8.Biomarker analysis.

**Conclusion:** It can be noted that traumatic brain injuries are not merely conditions that manifest in the short term and quickly recover. Nerve cells require a significant amount of time for regeneration; furthermore, restoring the disability arising after the injury (such as inability to perform certain movements, or walk) requires years of rehabilitation. It falls into the category of diseases demanding great patience from both the treating physician and years of rehabilitation. Despite extensive research on some aspects of traumatic brain injuries, there is very limited information available regarding functional complications that emerge in the long term. One such area is motor function. Therefore, more prolonged investigations and an accurate understanding of motor recovery will aid in developing better rehabilitation strategies. [1;2]

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