

Cognitive Functioning in TBI Patients: A Review of Literature

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Abstract: Traumatic brain injury (TBI) is a major public health problem. Patients with mild, moderate and severe brain injuries suffer from physical, behavioral emotional and social problems. Beside these problems persons with TBI experience serious long enduring problems with cognitive functioning. In the present study an attempt was made to review the literature on cognitive functioning in mild moderate and severe TBI patients. The aim of the study was to review the literature related to whether cognitive functioning is affected in mild moderate and severe TBI patients and if affected what are the areas of cognitive functioning affected in mild moderate severe TBI patients. Studies conducted on cognitive functioning with respect to TBI suggest that there is a decline in the cognitive functioning of TBI patients. On reviewing the available literature pertaining to cognitive functioning in mild, moderate and severe TBI patient It was found that studies lacks consensus and further research is needed to resolve the contradiction.

Key words: Traumatic brain injury • Cognitive functioning

INTRODUCTION

Traumatic Brain Injury (TBI) is caused by an external trauma to the head or violent movement of the head, such as from a fall, car crash or by being shaken. TBI may or may not be combined with loss of consciousness, an open wound or skull fracture. [1]

The Brain Injury Association (BIA), a leading national advocacy group for people with brain injuries, defines TBI as an insult to the brain, not of degenerative or congenital nature, caused by an external physical force that may produce a diminished or altered state of consciousness and which results in an impairment of cognitive abilities or physical functioning. It can also result in the disturbance of behavioral or emotional functioning. [2]

TBI is a leading cause of deaths, hospitalizations, disabilities and socio-economic losses. At the national level, nearly 2 million people sustain brain injuries, 0.2 million lose their lives and nearly a million need rehabilitation services every year.

Road traffic injuries were reported as a leading cause (60%) of TBI followed by falls (20%-25%) and violence (10%) by Gururaj (2002) [3]. Road traffic injuries occurred predominantly in the age group of 15 - 40 years. The ratio of male to female occurrences of Road traffic injuries is 2:1.

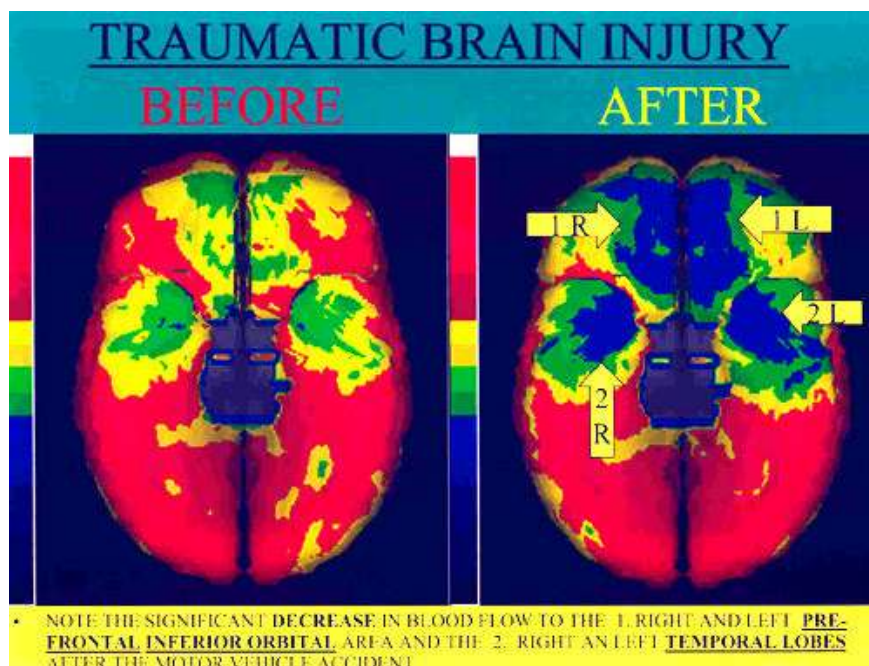
As shown below decrease in the blood flow in different areas of brain can be seen after TBI caused after motor vehicle accident which was reported as a leading cause of TBI.

Classification of TBI: TBI can be classified into categories of mild, moderate and severe brain injury.

Mild traumatic Brain Injury (mild TBI): Is defined as a traumatically induced physiologic disruption of brain function, as manifested by at least one of the following:

- a. brief loss of consciousness (less than 30 min);
- b. Loss of memory for events occurring immediately before or after the accident;
- c. Temporary change in mental state at the time of the accident (e.g., feeling dazed, disoriented, or confused);
- d. Temporary focal neurologic deficits;
- e. Post-traumatic amnesia not greater than 24 h and
- f. An initial Glasgow Coma Scale score of 13-15

This definition includes all injuries in which the head is either struck by, or strikes an object, or in which the brain undergoes acceleration/deceleration movement without actually striking the head. It excludes trauma resulting from stroke, anoxia, tumor, encephalitis .



A mild TBI means the brain's functions are upset by some kind of insult. Nerve fibers can be stretched and torn in the brain when one is hit by or is "jolted" on one's head. Brain cells may not function or communicate as they once did. This damage generally does not show up on the CT scan but patient's signs and symptoms tell that they have a concussion or mild TBI (Fig. 1). These signs and symptoms are as follows: Headache, Difficulty controlling your emotions, taking longer to do regular activities, Forgetfulness, Difficulty organizing your day, easily tired, Dizziness, Sensitivity to light or noise, Difficulty paying attention, Irritability or personality changes, Disrupted sleep. In most cases, the brain can heal itself. These symptoms may take some time to resolve.

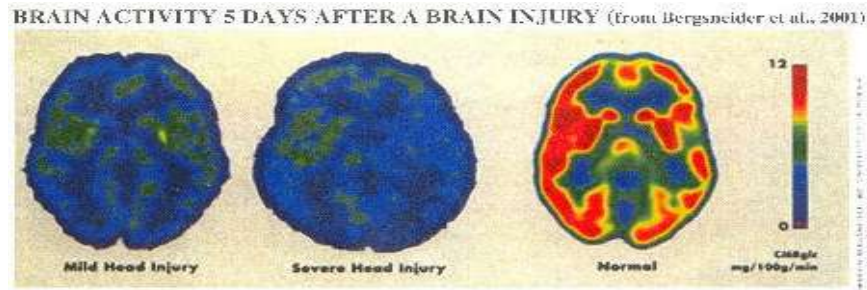
Moderate Brain Injury: Results in a loss of consciousness lasting only a few minutes to a few hours, followed by days and or weeks of confusion. People who sustain moderate TBI usually have physical, cognitive and behavioral impairments that can last for many months and may become permanent. The other criteria include a Glasgow Coma Scale (GCS) score of 9-12; abnormal CT scan findings, operative intracranial lesion and length of hospital stay is at least 48 h. There may be long-term physical or cognitive deficits as a result of a moderate brain injury. Much depends on the type and location of the specific insults to the brain. Rehabilitation helps to overcome some deficits and help provide skills to cope with any remaining deficits.

Severe Brain Injury: Usually results in coma, a loss of consciousness. When in a coma, the patient's eyes are closed and he or she shows no reaction when spoken to, touched, or pinched. Some patients demonstrate a reflexive movement, such as a hand grip, when an arm or leg is touched or squeezed. A coma can be brief or can persist for hours, days, weeks, months, or even years. The longer a person is unconscious, the more severe the injury and the greater the chance for permanent neurological damage. The Traumatic Coma Data Bank (TCDB) reveals that severe TBI is indicated when the GCS score is below 9 within 48 h of the injury and more than 48 h of hospitalization. Individuals who suffer a severe TBI are at risk for long-term disability. Their behavior can be inhibited and at times they may disregard social conventions. Some have difficulty remaining employed, maintaining pre-injury relationships and establishing new social contacts.

Changes in brain metabolism can be observed after mild and severe head injury in the figure given below.

PET scan after mild head injury, left, compared with severe head injury (middle) and normal, uninjured brain (right). Red (light shading) indicates high brain metabolism, which is a sign of high brain activity, whereas blue (dark shading) indicates low brain metabolism or low activity. Picture from Bergsneider, 2001 [4]

Consequences of TBI: Rarely are the consequences after TBI limited to one set of symptoms, clearly delineated



impairments, or a disability that affects only one part of a person's life. Rather, the consequences of TBI often influence human functions along a continuum from altered physiological functions of cells through neurological and psychological impairments, to medical problems and disabilities that affect the individual with TBI, as well as the family, friends, community and society in general. When other, more urgent medical problems are apparent at onset, mild TBI may be masked, even though it can result in impairments. In many cases, the consequences of TBI endure in original or altered forms across the lifespan, with new problems likely to occur as a result of new challenges and the aging process.

The neurological consequences of TBI are many and complex, occurring throughout the neural axis. Any sensory, motor and autonomic function may be compromised. Most of these complications are apparent within the first days or months following injury, depending on the severity of initial trauma. Some long-term effects include a variety of movement disorders, seizures, headaches, ambient visual deficits and sleep disorders. Non-neurological medical complications include, but are certainly not limited to, pulmonary, metabolic, nutritional, gastrointestinal, musculoskeletal and dermatologic problems.

Research on outcome following TBI indicates that people can suffer from impairment in all aspects; physical, cognitive, emotional, behavioral and social, functioning [5]. The consequences of TBI can be life long for some people, while others may be able to recover and resume activities they enjoyed before the injury occurred. The person may experience paralysis of one side of the body (hemi paresis), paralysis involving both legs and both arms (Quadra paresis), poor balance and lowered endurance, a loss of ability to plan motor movements (ataxia) and abnormal tone and muscle stiffness (spasticity). The individual may also lose the ability to stabilize his trunk even though his limbs are functional (proximal instability). Direct damage to muscular and bony tissue may be sustained.

All senses may be affected, producing changes in hearing, vision, taste, smell and touch. Changes may involve an increase, decrease or loss of sensitivity. This could result in the inability to see items on one side of the visual field, (visual field deficit), sensitivity to movement (vestibular deficits) or difficulty in understanding where his limbs are in relation to his body.

The person may have difficulty understanding what is said to him (receptive aphasia), or difficulty expressing his thoughts (expressive aphasia). Some people have a specific difficulty recalling nouns or names, or pronouncing or articulating words (dysarthria). Cognitive impairments due to traumatic brain injury (TBI) are substantial sources of morbidity for affected individuals, their family members and society. Disturbances of attention, memory and executive functioning are the most common neurocognitive consequences of TBI at all levels of severity. Disturbances of attention and memory are particularly problematic, as disruption of these relatively basic cognitive functions may cause or exacerbate additional disturbances in executive function, communication and other relatively more complex cognitive functions [6].

People with brain injuries often are confused about the current time, where they are, who they are and who the people around them may be (disorientation). In addition cognitive problems following TBI include lack of concentration, reduced processing speed, word finding difficulties, altered academic abilities (i.e., errors in simple math computation, spelling difficulties and difficulties understanding what one reads) decreased learning abilities and impaired executive functioning (i.e., reduced ability to plan, sequence, prioritize, think flexibly, abstract or problem solve). Since a high percentage of individuals with TBI sustain damage to the frontal lobes or to the frontal system, impairments of higher level thinking or executive functioning are common. In addition to executive dysfunction, memory problems are almost always present following TBI, either due to direct effects on memory systems or secondary to disrupted attention

and concentration. Often, the severity of cognitive deficits does not become apparent until the individual tries to resume the activities of preinjury life, such as return to work. Besides physical and cognitive symptoms, many individuals with TBI experience various types of behavioral dyscontrol (e.g., impulsivity, aggression, amotivation, apathy) and emotional dysregulation (e.g., moodiness, irritability, apathy), which can disrupt the individual's social interactions and employability. Fatigue is also frequent and disabling in patients with traumatic brain injury (TBI) and it can have a tremendous impact on an individual's quality of life. Impaired interpersonal communication and social cognition (e.g., an inability to follow conversations, being rude, interrupting people, talking too fast or too slowly) also impact the person's ability to develop and maintain meaningful relationships.

Review of Literature

Cognitive Functioning in TBI Patients: Studies conducted on cognitive functioning with respect to TBI suggest that there is a decline in the cognitive functioning of TBI patients. De Guise, Feyz, Le Blane, Richard and Lamoureux (2005) [7] assessed 348 TBI patients using Glasgow Coma Scale score and neurobehavioral rating scale score and found the cognitive deficits most frequently observed on the neurobehavioral rating scale were in the areas of attention, memory and mental flexibility as well as slowness and mental fatigability.

Similar result were found when Ciaramelli, Serino, Santantonio and Ladavas (2006) [8] administered neuropsychological battery to evaluate cognitive functioning on 37 TBI patients and results showed severe deficits in speed processing, divided attention, working memory, executive function and Long term memory.

In another study conducted on 97 TBI patients it was found deficit in intelligence, memory, attention, speed of processing and cognitive flexibility [9].

Curtiss, Vanderplog Spencer and Salazar 2001 [10] conducted a study on 150 TBI patients by using specific indexes of memory processes and found patterns of memory dysfunctions.

Studies Comparing the Cognitive Functioning of Mild, Moderate and Severe TBI Patients Are However Very Few and Full of Contradictions: Some studies conducted on mild TBI reported decline in cognitive functioning. Blankenship (1988) [11] reported that each individual with mild TBI will present unique difficulties relative to the particular locations, type and extent of injury. Binder

(1986) [12] stated that poor concentration is the most commonly reported functional limitation in mild TBI patients. Poor concentration can be attributed to reduced information processing capacity or reduced capacity for the brain to carry on a number of different operations at the same time [13]. Fatigability is another common functional limitation which has been frequently observed in individuals with mild TBI. Mental and physical fatigue can result from the increased amount of effort that is required to attend and concentrate. Rimmel *et al.* [14] observed that a majority of the patients with mild TBI that they studied still suffered from persistent headaches and memory problems three months post-injury. One third of these individuals who were working prior to their injury had not resumed employment. Despite apparent complete physical recovery and lack of positive neurological findings, persistent headaches and memory problems may seriously impede the ability to function on the job.

Ponsford, Willmott, Rothwell, Cameron, Kelly Nelms and Curran (2000) [15] conducted a study on 84 adults with mild TBI patients and reported that at 1 week post injury patients reported headaches, dizziness, fatigue and visual disturbance and memory difficulties. They exhibited slowing information processing on neuropsychological measures. By 3 months the symptoms reported at 1 week had largely resolved and no impairment were evident on neuropsychological measures. In contrast Kemp, Goulding, Spencer and Mitchell (2005) [16] found in a case study that cognitive functioning was impaired immediately post injury and remained impaired and neuropsychological examination at 8 months post injury showed severe cognitive deficits.

There continues to be debate about the long-term neuropsychological impact of mild traumatic brain injury (MTBI). A meta-analysis of the relevant literature was conducted to determine the impact of MTBI across nine cognitive domains. The analysis was based on 39 studies involving 1463 cases of MTBI and 1191 control cases. The overall effect of MTBI on neuropsychological functioning was moderate. Acute effects (less than 3 months post injury) of MTBI were greatest for delayed memory and fluency. [17]

The problems of people who had sustained moderate injury were highlighted by Rimel 1982, who found that at 3 months post-injury, many patients classified as having made a good recovery were experiencing memory problems and difficulties with activities of daily living. The results of this study led to the suggestion that 'moderate brain injury results in mortality and morbidity intermediate between those of severe and mild brain

injury'. However, in contrast one study reported no significant differences in neuropsychological impairments or global outcome at 6 months between groups of patients with moderate or severe head injury.[18]. In a study conducted by Hellawell, Taylor and Pentland [19] found that severe TBI group show signs of impaired memory, concentration and information processing abilities, whilst the moderate TBI groups appear affected to a lesser degree and reported that poorer Glasgow outcome scale scores and severe cognitive impairment were typically associated with greater severity of initial injury. A wide range of cognitive impairments is apparent following severe TBI. These cognitive deficits can have a greater impact on a person's overall level of psychosocial functioning than physical impairments [20]. One of the most commonly cited consequences of severe TBI reported by both the TBI patient and their family is memory impairment. [21]. In contrast one study reported that TBI patients exhibit significant improvements in their social, cognitive, physical and emotional functioning after 2 years post-injury regardless of the severity of their initial brain trauma. These data suggest that patients who sustain severe TBI continue to make gradual improvements in their functioning for at least 10 years post-injury. This finding contradicts the widely held assumption that the recovery process ends after 1 or 2 years post-injury [22].

CONCLUSION

Studies conducted on cognitive functioning with respect to TBI suggest that there is a decline in the cognitive functioning of TBI patients

The literature indicates that different aspects of cognitive functioning are more susceptible to injury and that recovery takes place at a differential rate across functions. However, there is no clear consensus regarding which functions are the most susceptible or the precise nature of the recovery for different functions.

Thus on reviewing the available literature pertaining to cognitive functioning in mild, moderate and severe TBI patient, It was found that it lacks consensus and further research is needed to resolve the contradiction.

REFERENCES

1. Thurman, D.J., J.E. Snizek, D. Johnson, A. Greenspan and S.M. Smith, 1994. Guidelines for Surveillance of Central Nervous System Injury, Centers for Disease Control and Prevention.

2. Bunch, J. and H. Jennifer, 2000. Information and Resources column. TBI Challenge 4, No. 2 (2000). BIA: Alexandria, Virginia.
3. Gururaj, G., 2002. Epidemiology of TBI injuries: Indian scenario. Neurological Res., 24: 24-28.
4. Bergsneider, M., D.A. Hovda and D. McArthur *et al.*, 2001. Metabolic recovery following traumatic brain injury based on FDG-PET: time course and relationship to neurological disability. J. Head Trauma Rehabil, 16(2): 135-148.
5. Vogenthaler, D.R., 1987. An overview of head injury: Its consequences and rehabilitation. Brain Injury, 1: 113-127, 1987.
6. Arciniegas, D.B., K. Held and P. Wagner, 2002. Cognitive impairment following traumatic brain injury. Curr. Treat Options Neurol., 4(1): 43-57.
7. De Guise, E., M. Feyz, J. LeBlanc, S.L. Richard and J. Lamoureux, 2005. Overview of TBI patients at a tertiary trauma centre. Canadian J. Neurological Sci., 32: 186-193.
8. Ciaramelli, E., A. Serino, A. Di Santantonio and E. Ladavas, 2006. Central executive system impairment in TBI. Brain and Cognition, 60: 198-199.
9. Johnstone, B., C.L. Hexum, G. Ashkanazi, 1995. Extent of cognitive decline in traumatic brain injury based on estimates of premorbid intelligence. Brain Inj., 9(4): 377-384.
10. Curtiss, G., R.D. Vanderploeg, J. Spencer and A.M. Salazar, 2001. Patterns of verbal learning and memory in traumatic brain injury. J. Int. Neuropsychol. Soc., 7(5): 574-585.
11. Blankenship, M., 1988. The role of the vocational rehabilitation specialist in assisting the person with a minor head injury Cognitive Rehabilitation, 6 (2): 40-41.
12. Binder, L.M., 1986. Persisting symptoms after mild head injury: A review of the postconcussive syndrome J. Clin. Neuropsychological Neuropsychol., 8: 323-346.
13. Gronwall, D., 1989. Cumulative and Persisting Effects of Concussion on Attention and Cognition. In: Mild head injury, H.S. Levin, H.M. Eisenberg and A.L. Benton (Eds.). New York: Oxford University Press, pp: 153-162.
14. Rimel, R.W., B. Giordani and J.T. Barth, 1982. Moderate head injury: Completing the clinical spectrum of brain trauma. Neurosurgery, 11: 344- 351.
15. Ponsford, J., C. Willmot, A. Rothwell, P. Cameron, A.M. Kelly, R. Nelms and C. Curran, 2000. Factors influencing outcome following mild TBI in adults. J. Neuropsychological Soci., 6: 568-579.

16. Kemp, S., P. Goulding, J. Spencer and A.J. Mitchell, 2005. Unusually rapid and severe cognitive deterioration after mild TBI. *Brain Injury*, 19: 1269-1276.
17. Belanger, H.G., G. Curtiss, J.A. Demery, B.K. Lebowitz and R.D. Vanderploeg, 2005. Factors moderating neuropsychological outcome following mild TBI: A meta analysis. *J. Intl. Neuropsychol. Soc.*, 11: 215-227.
18. Anderson, S.I., R. Taylor and P.A. Jones, 1994. A comparison of neuropsychological and functional outcome and uptake of rehabilitation services, following severe and moderate head injury. *Clinical Rehabilitation*, 8: 301-306.
19. Hellawell, D.J., R.T. Taylor and B. Pentland, 1999. Cognitive and psychosocial outcome following moderate or severe TBI *Brain Injury*, 13: 489-504.
20. Brooks, D.N., 1990. Cognitive Deficits. In: *Rehabilitation of the adult and child with traumatic brain injury*, Rosenthal, M., E.R. Griffith, M.R. Bond *et al.* (Eds.) 2nd Edn. (Philadelphia: Davis), pp: 163- 178.
21. Kersel, D.A., N.V. Marsh, J.H. Havill and J.W. Sleight, 2001. Neuropsychological functioning during the year following TBI. *Brain Injury*, 15: 283-296.
22. Sbordone, R.J., L.C. Liter and P. Pettler-Jennings, 1995. Recovery of function following severe traumatic brain injury: A retrospective 10-year follow-up. *Brain Inj.*, 9(3): 285-299.