A PROSPECTIVE STUDY OF NEUROPSYCHOLOGICAL DEFICIT AND EFFECT OF COMPUTERISED COGNITIVE RETRAINING IN TRAUMATIC BRAIN INJURY

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ABSTRACT

BACKGROUND

Traumatic Brain Injury (TBI) is a major public health issue across the globe. A range of cognitive and behavioural sequelae is exhibited by TBI. Patients of Traumatic Brain Injury (TBI) do benefit from cognitive retraining.

The aim of the present study is to observe the effects of cognitive retraining on neuropsychological deficits. Sample for the study comprised of 36 patients of head injury reporting to a tertiary care hospital.

MATERIALS AND METHODS

The cases were evaluated on Glasgow Coma Scale (GCS), Wisconsin Card Sorting Test (WCST) and Wechsler's Memory Scale (WMS) III to assess the prevalence of neuropsychological deficit. The cases were given four sessions of Brain Function Therapy (BFT) per week. A total of eight sessions were finally given to each one of the cases. The neuropsychological deficit were assessed before and after giving Brain Function Therapy (BFT) or cognitive retraining and compared.

RESULTS

The mean age of the sample was 32.13±6.14 years and majority of the cases were educated till higher secondary school. Significant differences were noted when the neuropsychological deficit assessed pre-BFT and post-BFT were compared ($p < 0.001$).

CONCLUSION

Cases of TBI do benefit with BFT, and hence, it is recommended to institute computerised cognitive rehabilitation/retraining in such cases in psychiatry setup.

KEYWORDS

Neuropsychological Deficit, Traumatic Brain Injury, Computerised Cognitive Retraining, Brain Function Therapy.

HOW TO CITE THIS ARTICLE: Nath S, Yadav KK, Srivastav K, et al. A prospective study of neuropsychological deficit and effect of computerised cognitive retraining in traumatic brain injury. J. Evid. Based Med. Healthc. 2017; 4(91), 5502-5506. DOI: 10.18410/jebmh/2017/1100.

BACKGROUND

Traumatic Brain Injury (TBI) is a major cause of death and disability in adolescents and young adults across the globe.[1-3] Over the past 3 decades, there has been a significant growth of interest in the study of TBI. Focal neurological deficits arising out of TBI may or may not be transient.[4] However, cases of TBI revealed persistent neuropsychological deficit and disability with most survivors being young and having near-normal life expectancy.[5-9] Initial and persistent cognitive deficits are the most common complaints after TBI and they are found to be the major hindrance to normalisation in the areas of independent living, social readaptation, family life and vocational endeavors.[10] Several cognitive domains are predictably impaired including frontal executive functions in problem solving, set shifting, impulse control and self-monitoring speed of information processing. Apparently, these are not completely independent domains and there is typically a mixture of deficits of varying degrees across domains.[11-14]

Both closed and penetrating type of TBI can result in a wide range of neuropsychiatric symptoms including dementia, depression, personality changes and cognitive impairments. Hence, TBI cases are a major source of burden on public health and social care in the community in India.[15] It has been seen that TBI cases have a tendency to result in a characteristic range and pattern of cognitive impairments. They are cognitive deficits in attention, speed of information processing, learning memory and executive functions, which include the ability to think in abstract terms, ability to think flexibly and ability to plan and solve problems.[16-18] The precise nature and extent of cognitive deficits vary widely as the function of the location and severity of TBI as well as premorbid and contextual factors. Moreover, it is frequently difficult to predict how impairments evident on assessment will specifically affect these TBI individual's daily life and their role performance in community settings.

Financial or Other, Competing Interest: None.
Submission 23-10-2017, Peer Review 30-10-2017,
Acceptance 20-11-2017, Published 27-11-2017.
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DOI: 10.18410/jebmh/2017/1100

The literature now abounds with studies of epidemiology, pathophysiology and outcome of TBI.[19] In spite of the plethora of research, patients still find it difficult to manage their day-to-day functions as very few treatment or rehabilitation strategies are available in developing countries. Moreover, many people with severe TBI remain significantly handicapped, often causing great stress to their families and significant socio-occupational deterioration.

TBI can also result in the disturbance of behavioural or emotional functioning.[5,20-22] Cognitive and behavioural consequences associated with TBI have been observed since the beginning of humankind as early as 3000 BC. Multicenter outcome studies have shown that 35% of severe head injury patients will die, 1-5% will remain vegetative and 5-18% will continue to be severely disabled six months after TBI.[23,24] In India, around 30,000 persons die and 1,25,000, persons are disabled every year due to TBI[20] and the financial loss is estimated to be about 51.5 million dollars annually. TBI often occurs in the 15-25 years age group and advances in neuroimaging and improved immediate management has led to an increasing number of survivors with chronic sequelae leading to an increased demand for rehabilitative services.

TBI exhibits a range of ongoing cognitive and behavioural sequelae. These occur in various arrangements and combinations and vary widely in their nature and severity depending on the location and extent of injury as well as premorbid characteristics of the injured individual.[25] The individuals who have sustained TBI and have no other injuries have returned home within a few days with the expectation of resuming their normal activities. However, due to modern medicine and progress of techniques for the acute treatment of TBI victims, patient's survival rate is increasing. Consequently, the number of patients who survive with cognitive impairment is growing. Cognitive problems are common sequel of TBI, which can result in difficulties in attention, episodic memory, executive functions (such as higher order planning, initiating and directing, monitoring, problem solving and inhibitory control), working memory, information-processing speed, language functions and visuospatial processing. Neuropsychological studies have confirmed the presence of impaired speed of information processing, attention and memory deficits in the early days after TBI. In other aetiological groups, the time frames of recovery are more variable, but in the majority, the symptoms resolved within three months.[25]

Recent studies have provided evidence that greater the likelihood of abnormal imaging findings, the more significant will be the ongoing neuropsychological problems in individual with complicated TBI suggesting that these injuries occur on a continuum of severity. Although, modern anatomical and functional neuroimaging procedures have become increasingly helpful in localising the site of brain injury following TBI, contemporary neuropsychological assessment focuses on understanding the relationship between the patient's neurocognitive deficits and the behavioural expression of these deficits within the environment. Further, neuroimaging is not always sensitive to subtle brain dysfunction and patients who have suffered a TBI may not display any positive findings on standard neuroimaging procedures, especially when the injury is mild. Neuropsychological assessment tools have been developed nearly half a century ago and are very useful in arriving at a decision whether a TBI patient is suffering from brain pathology or a functional pathology. The information collected in the course of assessment provides a basis for goal setting, treatment planning and intervention.

The World Health Organization defines impairment as "problems in body function or structure such as significant deviation or loss."[26] Cognitive impairments are deficiencies of neuropsychological function that can be related to damage in specific areas of the brain. Neuropsychological assessments are the method most commonly used to delineate the nature and severity of cognitive impairment, area of residual cognitive abilities and strengths following TBI. Studies have also found that structural neuroimaging techniques, sometimes fail to detect abnormalities in patients with neuropsychological and cognitive deficits, especially in cases with mild TBI.[9,10,27] With recent developments in neuropsychological techniques, neuropsychological and functional assessments continue to play a vital role in describing the nature and extent of impairment and disability resulting from TBI.

The aim and objectives of this study was to ascertain and describe the neuropsychological deficit (cognitive) after acute management of TBI cases and to assess the functional impairment (disability) in patients with TBI and improvement after imparting computerised cognitive retraining.

MATERIALS AND METHODS

The study was carried out at a tertiary care hospital. All consecutive patients of TBI attending to the neurosurgical ward after acute management were administered a specifically designed and validated sociodemographic questionnaire and a semi-structured interview was also conducted. Persons with past history or genetic loading of mental illness were excluded. Sample size comprised of 36 patients. All cases were interviewed clinically to look for major psychiatric disorders. Severity of head injury was assessed based on retrograde amnesia, post-traumatic amnesia, Glasgow coma scale, presence of seizure and evidence of neuroanatomical defects on imaging studies. Neuropsychological assessment was carried out during first hospitalisation by Wisconsin Card Sorting Test (WCST)[28] and Wechsler's Memory Scale (WMS).[29] Computerised cognitive retraining program (Brain Function Therapy - BFT) was given to all subjects in four sessions per week during hospitalisation after completion of acute management. The brain function therapy used addresses, word comparison, reading speed control, spatial comparison, working memory, continuous performance, temporal sequence control, alphanumeric sequencing, response inhibition, character recognition and number recognition. Every patient admitted in the Department of Neurosurgery with head injury and for whom no further requirement of active neurosurgical intervention was recommended were transferred to Psychiatry ward. Detailed history of the event of injury was noted. Informed

consent was taken for those volunteering to participate in the study. WCST and WMS were administered a day or two prior to BFT. The Wisconsin card sorting test assesses perseveration and abstract thinking, measures executive function and frontal lobe dysfunction (e.g. strategic planning, organised searching, utilise environmental feedback to shift cognitive sets, direct behavior towards achieving goals and modulate impulsive responding). The Wechsler's memory scale measures different memory function in a person and tests auditory memory, visual memory, visual working memory, immediate memory and delayed memory. Patients were explained about the procedure before and if patients had problems or could not use keyboard due to deformity or by being a novice to computers, investigator himself helped in feeding the answers. They were exposed to increasing difficulty level of BFT on subsequent sessions. Total 8 BFT levels were administered to each patient within 2 weeks. Post-BFT, WCST and WMS were conducted after a day of last BFT of each patient. Post-BFT, WCST and WMS after 8th BFT and pre-BFT WCST and WMS scores were compared using paired t-test. SPSS version 17 was used for statistical analysis.

RESULTS

The mean age of the patients was 32.13 ± 6.14 years. Majority (88.89%) of patients were educated till higher secondary school. 13 patients had non-severe closed injuries and 23 had severe injuries, which included open injury cases. Severity of TBI as assessed using Glasgow Coma Scale (GCS), Posttraumatic Amnesia (PTA) and Loss of Consciousness (LOC) are tabulated in Table 1. The Wisconsin card sorting test results (both pre and post-test) are tabulated in Table 2. There were significant differences ($p<0.01$) across all subtests of cognitive training as tabulated in Table 3. Cognitive deficits are noted to be present at initial level and at post training follow-up reduced significantly. Mean scores of letter sequencing task and spatial span are more after training on cognitive module. Table 4 shows the mean and SD of pre and post-test of overall memory quotient that was computed based on the scores of subsets of Wechsler's Memory Scale. The pre-test memory quotient was 87.0 ± 7.1, which statistically significantly increased to 92.2 ± 8.6 at post-test ($p<0.01$).

	GCS	PTA	LOC	No. of Cases (N=36)
Mild	13-15	<1 day	0-30 minutes	5 (13.89%)
Moderate	9-12	>1 to <7 days	>30 mins. to <24 hours	8 (22.22%)
Severe	3-8	>7 days	>24 hours	23 (63.89%)

Table 1. Severity of Traumatic Brain Injury

Deficits	Pretraining	Post Training
Perseverance	20% (average)	38% (average)
Conceptual level response	40% (average)	45.8% (average)
Total errors	70% (below average)	30% (below average)

Table 2. Wisconsin Card Sorting Test

Performance	Pre-training Mean (±SD)	Post-training Mean (±SD)	p Value
Letter Sequencing	6.19±1.89	8.22±2.0	<0.001
Spatial Span (Backward)	5.75±1.52	7.08±1.83	<0.001
Spatial Span (Forward)	8.61±1.90	10.64±2.26	<0.001
Performance Total Score	14.33± 3.13	17.72±3.84	<0.001

Table 3. Wisconsin Card Sorting Test Scores Pre & Post Training

	Pre-training Mean (±SD)	Post-training Mean (±SD)	p Value
Memory Quotient	87.0±7.1	92.2±8.6	<0.001

Table 4. Wechsler Memory Test Scores Pre & Post Training

DISCUSSION

In the present study, study group comprised of people of productive age group with mean age 32.13 ± 6.14 years. Severe head injury was noted to be present in majority of the cases (Table 1). Traumatic brain injury is associated with significant morbidity, which includes cognitive deficits as revealed by the various studies.[30,31] These deficits are debilitating and an attempt to correct or ameliorate its effects on the patient is paramount. Computerised cognitive retraining is one such attempt and hence was given to patients of traumatic brain injury and deficits were compared. Cognitive functions like perception, memory, language and consciousness are based on highly parallel and distributed information processing by brain commonly called binding. Several investigators have claimed over the past decade that working memory and general intelligence are identical or nearly identical constructs from an individual - difference perspective. Choosing outcomes to measure or monitor post injury change is critically important in making decisions about rehabilitation for patients as well as determining the efficacy of the rehabilitation programmes implemented. Furthermore, prediction of outcomes is also complicated by uniqueness of each injury. While many psychometric measures of outcome are used to evaluate and report on therapeutic intervention effects, more recent rehabilitation research has focused on functional outcome measures as better global indicators of patient's coping or recovery.[32,33] In the present study, outcome measure was improvement in cognitive subtests, which showed significant improvement post intervention. These findings are in concurrence with available literature.[34] Study on home-based remediation confirmed that the direct training of cognitive processes involving repetitive stimulation of distinct components of damaged cognitive functions lead to improvement of processing.[35] The mechanism of recovery of cognitive functions after TBI is explained in terms of neural plasticity. Neuronal plasticity refers to the brain's capacity to change and alter its structure and functions, which are

particularly relevant to cognitive rehabilitation.[35] Cognitive retraining utilises this mechanism, thereby allowing the brain to restore or compensate for the impaired cognitive functions that are lost due to trauma. In the past, it has been proposed that explicit vision advances in cases of vision loss, benefit has been there in reverse hierarchical direction rehabilitation as shown in perceptual learning. Processing is along the feed forward hierarchy of areas. The degree of specificity depends on the difficulty of the training conditions. As task difficulty increases, learning becomes more specific in respect to both orientation and position matching the fine retinoscopy exhibited by lower areas. Thus, in rehabilitation, the subject enjoys the learning generalisation. The dynamics of learning show improvement with easy exercises with long processing time subsequently proceeding to difficult exercises. If considered together, the dynamics suggests that learning proceeds as a counter current along the cortical hierarchy improvement begins at higher generalising levels, which in turn direct harder conditioned learning to the subdomain of their lower level inputs. The single encounter enabling effect is called as eureka effect. Hence, it can be considered that learning has practice-induced improvement in the ability to perform specific perceptual tasks. Thus, the simple concept of learning is a top-down guided process, a simple process proved powerful in skill acquisition in cases of rehabilitation of patients of TBI. Gainful employment generally is considered the best overall measure of desirable outcome. In the present study also, it is accepted that all participants were fit for duty before their injury and the treatment program emphasised return to duty and back to normal social life. The most frequent cognitive sequel of TBI was impairment of episodic memory, slowed cognitive processing speed and impaired executive functions (i.e. the ability to search cognitive processing speed and set monitor goals). The findings are generally after a single mild TBI without complications. Whereas marked persistent deficits are common after more severe TBI, the evidence to date indicates that the long-term effects of these injuries are similar regardless of the cause, but related to severity of injury. In our study, majority of the patients (63.88%) had severe injury and others were having moderate injury. Thus, rehabilitation programmes must address the complexity of the cognitive deficit affecting functional capacity to be effective. Historically, Glasgow coma scale is a common measure. Various other scales have also been used like Disability Rating Scale (DRS), Functional Independence Measure (FIM) and Functional Assessment Measure (FAM). However, these measures are only indicators of what one individual can do at a particular time in a particular context. Both the injury and self-healing (positive compensation), process are dynamic situations. So, it is an urgent necessity that all patients of TBI ought to undergo psychiatric evaluation before being discharged from hospital to let them have an opportunity of improvement before irreparable deterioration occurs.

Present study revealed that there was significant deficit in executive functioning during the pretraining and initial assessment of TBI cases. Subsequent to cognitive retraining rehabilitation therapy, significant improvement has been observed as evident from Table 3 and 4. The main limitation of this study was that no attempt was made to assess the premorbid cognitive state of the cases. Educational status was considered as a single guide and in this study, most patients were educated till class 12th. However, it may not help in substantiating the premorbid cognitive functions. This study is an attempt to address the restoration of cognitive functions and learning how to do things differently when the cognitive functions cannot be restored to preinjury levels. Ideally, rehabilitation goals for TBI should facilitate and guide natural recovery, reinforcing positive compensation and suppressing maladaptive behaviours.

Due to limited scope of the study, only some of the cognitive functions have been taken up. A generalised assessment of injury has been done though over a short period of time and eight sessions of computerised brain function therapy has been given. The details as revealed indicate significant improvement with the limited cognitive remediation measures comprising of letter cancellation and sequencing tasks. These tasks address attention, concentration and planning in the rehabilitation process. Thus, though in limited aspect, this opens the avenue for such rehabilitative processes in all patients of TBI.

CONCLUSION

The present study highlighted the importance of cognitive remediation in TBI cases. The computer-based intervention helps in producing significant improvement in the cognitive functions. Thus, it changes the functional state of the cases of TBI and decreases the burden of such cases on the organisation and the society. Till date, no such dedicated rehabilitation measures are in practice in the country. Thus, this study may open a new chapter in the present scenario. This is a preliminary study to quantify deficits in patients of TBI and effect of computerised brain function therapy. The limitations of the study are small sample size, absence of control group and short-term follow up. Hence, it is recommended that findings of this study can be validated in larger samples with control group and long-term follow-up.

It is recommended that computer-based intervention maybe given after quantifying the deficit on defined parameters. The effort must be made to equip each psychiatry centre with computerised brain function therapy who already have an inventory of psychological testing and neurocognitive test instruments. The guidelines need to be stringently put in action to have all patients with TBI to be assessed soon after active surgical intervention to decrease the functional disability, decrease burden of poor functionality and determine actual disability.

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