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Original Research Article

Assessment of Functional and Neurological Outcomes in Young Adults with Traumatic Brain Injury

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Abstract:

Background: Traumatic brain injury (TBI) is a major cause of morbidity and long-term disability among young adults, particularly due to high-risk activities such as road traffic accidents. Understanding functional and neurological outcomes in this population is critical for improving management and rehabilitation.

Aim: To assess functional and neurological outcomes in young adults with TBI and identify predictors of recovery.

Methodology: A hospital-based, observational, cross-sectional study was conducted at the Department of Neurosurgery, Malda Medical College and Hospital, India. Eighty participants aged 18–40 years with confirmed TBI were evaluated using the Glasgow Outcome Scale (GOS) and Modified Rankin Scale (mRS). Clinical data including Glasgow Coma Scale (GCS), loss of consciousness, post-traumatic amnesia, imaging findings, and motor deficits were collected and analyzed.

Results: Most participants were males aged 18–25 years, with road traffic accidents as the predominant cause. Mild TBI showed favorable outcomes (mean GOS 4.8 ± 0.4, mRS 0.9 ± 0.5), whereas severe TBI was associated with significant disability (GOS 3.2 ± 0.7, mRS 2.8 ± 0.9). GCS at admission and duration of loss of consciousness and post-traumatic amnesia were strongly correlated with functional recovery.

Conclusion: Early neurological status and injury severity are primary determinants of outcomes. Targeted assessment, rehabilitation, and preventive strategies are essential to improve functional recovery and reduce the socioeconomic impact of TBI in young adults.

Keywords: Traumatic Brain Injury, Young Adults, Glasgow Outcome Scale, Modified Rankin Scale.

Introduction

Traumatic brain injury (TBI) is one of the most significant health issues in the world because it is the cause of major morbidity, mortality, and disability among the population in the long term [1]. It refers to a change in brain functioning or other demonstration of brain pathology, induced by external mechanical force. Young adults form one of the most vulnerable groups in all age brackets mainly because they are the most active and exposed to the risk of road traffic accidents, sporting injuries, industrial trauma and interpersonal violence. The population group aged between 18 and 40 years has a disproportionate burden of TBI, which affects not only their immediate health outcomes but also has a long-term socioeconomic and psychological cost [2]. It is estimated by the World Health Organization (WHO) that by 2030, TBI will rise to be among the leading causes of death and disability in the world, especially in the low- and middle-income countries [3]. The prognosis of TBI among young adults is thus a vital social health and clinical concern that should be thoroughly examined to enhance prevention, management and rehabilitation interventions.

TBI pathophysiology is complicated and includes multiple injury mechanisms, primary and secondary ones [4]. The main damage happens at the time of the impact and consists of the mechanical destruction of the neural tissue, blood vessels, and supporting structures [5]. Subsequent development of secondary injury occurs through biochemical, cellular, and molecular cascades that assist in worsening neuronal injury, which include; oxidative stress, excitotoxicity, inflammation, and cerebral blood flow and metabolism disruption. Higher incidences of severe TBI are observed among the young adults because of high-velocity injuries that may result in diffuse axonal injury, intracranial bleeding, brain edema and increased intracranial pressure [6]. Although new methods of neuroimaging, neurocritical care, and surgery have been developed, it is generally difficult to predict outcomes in the case of TBI, because recovery depends on a myriad of factors, including both the severity of injury, the location of lesion, the pre-existing health status, age, sex and the access to medical care.

The process of outcome measurement during post-TBI is diverse, including neurological, functional, cognitive, and psychosocial levels. Glasgow Outcome Scale (GOS) and its modified counterpart (GOSE) are still some of the most commonly used scales in the assessment of global functional outcomes, as well as classifying patients in either death or persistent vegetative state to good recovery [7]. Nevertheless, these scales, although useful, might not describe the whole range of cognitive and behavioral impairments, which remain common in young survivors. The most frequent sequelae are cognitive impairment, memory impairment, mood disorders, and problems with social reintegration especially in patients with moderate to severe injuries [8]. These consequences may interfere with the achievement of education, labor market, or even human interaction, which may significantly decrease the quality of living. Also, it is a huge burden to caregivers and healthcare system because those TBI survivors who survive frequently have to undergo long-term rehabilitation and psychosocial assistance.

TBI has taken the centre stage in causing death and disability among young adults in developing nations such as India whereby road traffic accidents are on the escalation curve. The lack of compliance with the safety precautions like the usage of helmets and seatbelts, inappropriate trauma care frameworks, and the delays in emergency medical services worsen the situation. Furthermore, these environments usually restrict outcome analysis due to poor follow-up, absence of standardized data collection, and socioeconomic inequality on access to post-acute care. Therefore, the determination of outcome in this age group is essential in developing effective prevention and health promotion strategies as well as streamlining clinical management.

The recent studies pressed the significance of prognostic factors in the form of initial Glasgow Coma Scale (GCS) score, pupillary reactivity, the results of the computed tomography (CT) and the time spent in unconsciousness in the predictions of the outcomes of the young adults with TBI [9] in the recent studies. Neurocritical monitoring (including intracranial pressure (ICP) measurement, cerebral perfusion pressure (CPP) management, and multimodal neuroimaging) has advanced greatly in terms of informing the therapeutic decision-making and forecasting the recovery outcomes. Moreover, biomarkers like S100B, neuron-specific enolase (NSE), and glial fibrillary acidic protein (GFAP) have become a possible tool in the initial prognostication. Regardless of these improvements, the inaccuracy in the outcomes are still high, which emphasizes the necessity of a personalized methodology depending on the injury mechanisms, patient traits, and context-specific medical facilities.

Socioeconomic effects of TBI among young adults are especially deep since this group of the population is the most economically productive. This reduction in productivity, the rise in medical spending, and dependency are factors that add up to a huge burden on society and the economy. In addition to the physical recovery, psychosocial rehabilitation becomes a key factor in restoring patients to the community and professional life. Outcome analysis should thus not be limited to survival and neurological recovery but include functional independence, psychological well-being and social participation.

Methodology

Study Design: This research was cross-sectional, observational, and based on a hospital setting and was designed to evaluate the functional and neurological outcome among young adults with traumatic brain injury (TBI). The researchers assessed the post-injury recovery patterns, neurocognitive condition, and functional performance in general in the participants with varying levels of TBI.

Study Area: It was done in the Department of Neurosurgery, Malda Medical College and Hospital, Malda, West Bengal, India from January 2023 to December 2023

Study Participants: The respondents were sampled among patients that reported to the Department of Neurosurgery with a verifiable case of traumatic brain injury, as indicated by the clinical examination and neuroimaging.

Inclusion Criteria:

- Patients with a clinical and radiological diagnosis of TBI (mild, moderate, or severe).
- Young adults aged between 18 and 40 years.
- Patients who were conscious, cooperative, and able to provide informed consent.
- Patients who had completed a minimum of 3 months post-injury to allow for stabilization and assessment of residual deficits.

Exclusion Criteria:

- Patients below 18 years or above 40 years of age.
- Patients with pre-existing neurological, psychiatric, or developmental disorders.
- Individuals with polytrauma involving major orthopedic, spinal, or maxillofacial injuries that could independently affect functional outcomes.
- Patients with incomplete medical records or those who declined to participate.

Sample Size: A total of 80 participants were enrolled in this study based on the inclusion and exclusion criteria. The sample size was determined considering the average TBI admissions in the department, available duration for data collection, and feasibility within the study period.

Procedure: All participants were recruited through written informed consent. Participants were selected using records of hospital admissions and outpatient follow-up registers. Medical records were used to gather clinical information, such as demographic information, mode of injury, Glasgow Coma Scale (GCS) on admission, radiological reports, and length of stay in hospital.

Standardized measures like the Glasgow Outcome Scale (GOS) and the Modified Rankin Scale (mRS) were used to assess the functional outcomes, whereas a detailed neurological examination of motor, sensory, and cognitive functions was used to assess the neurological outcomes. The initial GCS scores and radiological results were used to classify the participants as mild, moderate, and severe TBI. The researchers also evaluated the post-traumatic amnesia (PTA) time, motor impairments, cognitive and speech or behavioral alterations. The data were followed up at the outpatient visit or through the telephonic interview to complete the data.

Statistical Analysis: Statistical Package of the Social Sciences (SPSS) version 27.0 was used in the analysis of data. The Demographic and injury-related variables were calculated using descriptive statistics, such as means, standard deviations, and percentages. One-way ANOVA was used to compare mild, moderate, and severe cases of TBI that were continuous and Chi-square for categorical variables. Pearson correlation coefficient was used in correlation analysis to identify the relationship between neurological deficits and functional outcomes. Multivariate regression analysis was done to determine independent predictors of poor functional recovery. The p-value of below 0.05 was taken as significant.

Result

The demographic data of the 80 study participants are provided in Table 1, with a majority of participants aged 18–25 years (35%), and the rest aged 2635 years (27.522.5%), with the most significant group belonging to the 3640-age range (15%). Most of the respondents were male (72.5%), with women making up 27.5 percent of the sample. With regards to place of residence, 57.5% of the respondents lived in the rural setting and 42.5% in urban environments. In terms of occupational status, 46.3% occupation represented employed, 27.4% occupation represented unemployed, and 26.3 percentage represented students, which implies that the majority of participants were actively involved in professional occupation. In general, the sample interviewed consisted mostly of young, rural and male people with the most prevalent occupation being employment.

Table 1: Demographic Profile of the Study Participants (n = 80)

Variable	Category	Number (n)	Percentage (%)
Age Group (years)	18–25	28	35
	26–30	22	27.5
	31–35	18	22.5
	36–40	12	15
Gender	Male	58	72.5
	Female	22	27.5
Residence	Urban	34	42.5
	Rural	46	57.5
Occupation	Student	21	26.3
	Employed	37	46.3
	Unemployed	22	27.4

In Table 2, the participants will be distributed based on the type and severity of traumatic brain injury (TBI) type. Road traffic accidents were the leading cause of injury with 56.3 percent of the cases followed by falls off height with 22.5 percent. Assaults were also the factors that contributed 11.3% of injuries, and 5% was each the case in sports-related injury and other causes. Concerning the severity of TBI according to the Glasgow Coma Scale (GCS), mild TBI cases (scores 1315) were noted in 37.5% of the participants, moderate TBI (scores 912) in 35, and severe TBI (scores 08 and below) in 27.5% of the participants. The results show that road traffic accidents constituted the most common cause of TBI among the participants with mild and moderate injuries being marginally greater than the severe ones.

Table 2: Distribution of Participants Based on Type and Severity of Injury

Variable	Category	Number (n)	Percentage (%)
Type of Injury	Road Traffic Accident	45	56.3
	Fall from Height	18	22.5
	Assault	9	11.3
	Sports Injury	4	5
	Others	4	5
Severity of TBI (Based on GCS)	Mild (13–15)	30	37.5
	Moderate (9–12)	28	35
	Severe (≤8)	22	27.5

Table 3 gives the clinical features of the respondents, where differences are seen in the intensity and nature of traumatic brain injury. In the case of loss of consciousness (LOC), most of the patients (45% of them) had brief unconsciousness, which had a duration of less than 30 minutes, other patients (27.5% each) had LOC of between 30 minutes and 24 hours, and above 24 hours, respectively. There were different episodes of: post-traumatic amnesia (PTA) duration wherein 41.3% lasted between 1-7 days, 31.3% less than a day and 27.5% more than 7 days implying varying possibilities of cognitive effects. The results of the imaging also indicated that brain damages were heterogeneous in patterns where 25 per cent were contusive, 23.8 per cent were characterized by intracranial hemorrhage, 17.5 per cent displayed skull fractures, and 13.8 per cent were characterised by diffuse axonal injury. It is interesting to note that, 20% of the participants had normal CT/MRI scans, which shows the existence of mild or non-structural injuries.

Table 3: Clinical Characteristics of Participants

Clinical Parameter	Category / Range	Number (n)	Percentage (%)
Loss of Consciousness (LOC)	< 30 minutes	36	45
	30 min – 24 hours	22	27.5
	> 24 hours	22	27.5
Post-Traumatic Amnesia (PTA)	< 1 day	25	31.3
	1–7 days	33	41.3
	> 7 days	22	27.5
CT/MRI Findings	Contusion	20	25
	Skull Fracture	14	17.5
	Intracranial Hemorrhage	19	23.8
	Diffuse Axonal Injury	11	13.8
	Normal Imaging	16	20

The functional outcomes of patients with mild, moderate, and severe TBI are summarized in table 4 based on their Glasgow Outcome Scale (GOS) and Modified Rankin Scale (mRS) scores. Patients with mild TBI had the best functional outcomes with a mean GOS score of 4.8 ± 0.4 (good recovery) and a mean mRS score of 0.9 ± 0.5 (90% functional independence). The mean GOS score of patients with moderate TBI was 4.1 ± 0.6 (moderate disability) and the mean mRS score was 1.7 ± 0.8 (68% functional independence). Patients with severe TBI had the poorest functional outcomes with a mean GOS score of 3.2 ± 0.7 (severe disability) and a mean mRS score of 2.8 ± 0.9 (41% functional independence). Across all severity levels, the mean GOS and mRS scores were 4.1 ± 0.8 and 1.6 ± 1.0, respectively, demonstrating an average of 66.3% functional independence, and a marked deterioration of functional independence and recovery with increasing severity of TBI.

Table 4: Functional Outcome Assessment Using Glasgow Outcome Scale (GOS) and Modified Rankin Scale (mRS)

Severity Group	Mean GOS Score ± SD	Functional Status (GOS Categories)	Mean mRS Score ± SD	Functional Independence (%)
Mild TBI (n = 30)	4.8 ± 0.4	Good recovery	0.9 ± 0.5	90
Moderate TBI (n = 28)	4.1 ± 0.6	Moderate disability	1.7 ± 0.8	68
Severe TBI (n = 22)	3.2 ± 0.7	Severe disability	2.8 ± 0.9	41
Total (n = 80)	4.1 ± 0.8	—	1.7 ± 1.0	66.3

Table 5 demonstrates the relationships between distinct clinical factors and neurologic and functional outcomes of young adults with a traumatic brain injury. Age had a weak negative correlation with GOS and weak positive correlation with mRS, which was not statistically significant ($p = 0.06$). However, the GCS at admission had a strong positive correlation with GOS ($r = 0.72$) and strong negative correlation with mRS ($r = -0.68$), both highly significant ($p < 0.001$), indicating that better initial neurologic status is associated with improvement in functional outcomes. The duration of loss of consciousness (LOC) and duration of post-traumatic amnesia (PTA) also had a moderate negative correlation with GOS and moderate positive correlations with mRS ($p < 0.001$), indicating that prolonged impairment predicts poor recovery. Finally, presence of motor deficits similarly was associated with worse outcomes, negatively correlating with GOS ($r = -0.47$) and positively correlating with mRS ($r = 0.52$). The duration of hospital stay had a weak but significant correlation with GOS and mRS ($p = 0.02$), indicating longer stay is modestly associated with worse outcomes.

Table 5: Correlation Between Neurological and Functional Outcomes

Parameter	Correlation with GOS (r-value)	Correlation with mRS (r-value)	p-value
Age	-0.21	0.19	0.06
GCS at Admission	0.72	-0.68	<0.001
Duration of LOC	-0.59	0.61	<0.001
PTA Duration	-0.55	0.58	<0.001
Presence of Motor Deficits	-0.47	0.52	<0.001
Duration of Hospital Stay	-0.32	0.3	0.02

Discussion

It explored the relationship between demographic, injury, and recovery variables including the Glasgow Outcome Scale (GOS) and a modified version of the rankin scale, the Modified Rankin Scale (mRS) in the current paper by evaluating functional and neurological outcomes in young adults with traumatic brain injury (TBI). In line with our results, the previous studies have indicated a higher occurrence of TBI in young males, which is mainly caused by the increase in exposure to risk prone activities like road traffic accidents and job-related risks (McKinlay et al., 2008 [10]; Gean and Fischbein, 2010) [11]). We found that 35 per cent of our sample was aged 18-25 years old, and 72.5 per cent of them were male, as is the case with McKinlay et al. (2008) [10], 68 per cent of young adult TBI cases were males. The fact that in our cohort, most of the inhabitants are rural dwellers is also similar to the literature that suggests that the lack of access to prehospital healthcare and manual labor could make TBI more prone (Ylvisaker et al., 2007 [12]; Beauchamp & Anderson, 2013) [13].

Regarding the etiology of injuries, road traffic accidents were found to be the leading cause of TBIs in our research, with falls, assault, and sports related injuries coming second. This is in line with the results of Ponsford et al. (2000), which found vehicular trauma associated with TBI as the greatest cause of TBI among young adults, with 52-60 percent of TBI cases attributed to this cause. Although we had mild and moderate TBI in the sample (mild: 40 percent, moderate: 35 percent, severe: 25 percent), a similar pattern was also found in the article by Anderson et al. (2009) [14] where mild TBI was identified in almost 42 percent, moderate in 33 percent and severe in 25 percent of the cases. This consistency highlights the trend in the world in that though severe TBIs are associated with greater morbidity, mild-to-moderate injuries make most clinical manifestations.

In our study, the clinical results showed that brief loss of consciousness (LOC) was observed in the majority of the subjects, however, it was found that long-term loss of consciousness (LOC) and the post-traumatic amnesia (PTA) were related to the impaired functional outcomes. This fact is similar to that of Bay et al. (2009) [15] who established that extended unconsciousness and cognitive functioning had a significant probability of reducing the GOS scores and increasing reliance on mRS at 36 months after injury. On the same note, Silver et al. (2009) [16] also noted that mild TBI with cognitive complaints had an adverse impact on functional independence and quality of life, indicating that subtle cognitive impairments can have a significant effect on the recovery process.

Our cohort imaging revealed a range of injuries, such as contusions, intracranial hemorrhages, skull injuries, and diffuse axonal injury, with 20 per cent of the cases showing normal imaging despite clinical TBI. This observation resonates with Gean and Fischbein (2010) [11], who had pointed out that traditional CT and MRI could not be able to detect non-structural injuries, and that clinical tests are still important in prognosis. Our findings indicate that initial neurological condition (measured by GCS scores) is not the only determinant of functional outcomes but rather a combination of imaging and initial neurological condition. The positive correlation existing between GCS and GOS ($r = 0.72$) and negative correlation between GCS and mRS ($r = -0.68$) resembles the study of Ponsford et al. (2000) [17] who tested the same correlation as follows: 0.65 and -0.62, respectively, indicating predictive value of early neurological assessment.

There is also some evidence about the comparative studies indicating that functional outcomes can be affected by post-injury psychosocial factors. Van Veldhoven et al. (2011) [18] established that stressful life events before TBI were connected with poorer post-TBI outcomes, such as reduced functional independence and increase in depressive rates, also confirmed in our study of cognitive and motor deficits. Furthermore, literature by Anderson et al. (2009) [14] showed that functional deficit, PTA and early cognitive impairment were linked with decreased occupational reintegration and reliance, which coincides with our finding that young adult severely injured patients exhibited severe functional deficit.

Surprisingly, age and the duration of stay in a hospital were not associated with outcomes in our study, which is why both demographic and hospital related factors may have a slight impact, but the severity of initial injury and neurological impairment is a more decisive factor. This is slightly different with the results of Beauchamp and Anderson (2013) [13] who found a small age-related difference in recovery processes especially in individuals above 30 years of age, where younger adults generally recover quicker though they are still susceptible to cognitive and functional impairment based on the severity of the injury.

On the whole, our findings support earlier data regarding the severity and nature of the initial TBI, early neurological findings, and cognitive and motor disability factors being the major predictors of functional recovery. Mild injuries were normally accompanied by high functional outcomes, whereas severe injuries and a long period of LOC were related to high degrees of restrictions in terms of independence. These results highlight the importance of early and extensive evaluation, individualized rehabilitation interventions, and prevention models against high-risk groups (especially young, male, and rural adults) to reduce the individual and socioeconomic effects of TBI.

Conclusion

This paper has shown that male victims between the ages of 1825 years as the most vulnerable age group are most likely to suffer traumatic brain injury with road traffic accidents being the most prevalent. The severity of the injuries was closely correlated with functional and neurological outcomes, and mild TBI had positive recovery and severe TBI was characterized by a high level of disability and lack of independence. GCS measures of early neurological status and time of loss of consciousness and post-traumatic amnesia were excellent predictors of recovery, but demographic variables like age and length of stay in the hospital were not as significant. Cognitive and motor impairment affected greatly the functional independence and reintegration across to daily life. The results indicate that early diagnosis, specific rehabilitation, and prophylactic measures are essential to enhance the outcome and minimize the socioeconomic cost of TBI among young adults.

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