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Original Research Article

CLINICAL SPECTRUM, RADIOLOGICAL PROFILE AND OUTCOME OF TRAUMATIC BRAIN INJURY IN THE PAEDIATRIC AGE GROUP: A TERTIARY CARE HOSPITAL-BASED STUDY

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ABSTRACT

Background: Traumatic brain injury (TBI) is a leading cause of morbidity and mortality in the paediatric population. Owing to age-specific anatomical and physiological differences, children exhibit unique clinical presentations, injury patterns, and outcomes compared to adults. The objective is to study the clinical spectrum, radiological findings, and outcomes of traumatic brain injury in children.

Materials and Methods: This hospital-based observational study was conducted in the Department of Paediatrics at a tertiary care teaching hospital. Children presenting with traumatic brain injury were evaluated for demographic profile, mechanism of injury, clinical features, Glasgow Coma Scale (GCS) at admission, radiological findings on CT scan, management, and outcome. Outcome was assessed using the Glasgow Outcome Scale at discharge.

Results: A male predominance was observed. Falls were the most common mode of injury, particularly in younger children, while road traffic accidents were more common in older age groups. Vomiting, altered sensorium, and seizures were frequent presenting symptoms. On CT imaging, extradural hematoma, subdural hematoma, subarachnoid hemorrhage, cerebral edema, and skull fractures were commonly identified. Most patients were managed conservatively, while a minority required surgical intervention. Favorable outcomes were seen in the majority of cases. Poor outcomes were significantly associated with severe GCS scores and diffuse cerebral edema.

Conclusion: Paediatric TBI demonstrates a wide clinical and radiological spectrum. Early diagnosis, prompt neuroimaging, and appropriate management result in good outcomes in most children. Preventive strategies focusing on fall prevention and road safety are essential to reduce the burden of paediatric TBI.

Keywords: Traumatic brain injury, Paediatric head injury, Computed tomography, Glasgow Coma Scale, Outcome.

INTRODUCTION

Traumatic brain injury (TBI) remains a significant public health concern and is one of the leading causes of death and disability among children worldwide. The paediatric brain differs structurally and functionally from the adult brain, rendering children more vulnerable to head injuries. A larger head-to-body ratio, weak cervical musculature, incomplete myelination, and increased brain water content contribute to distinctive injury mechanisms and clinical outcomes in children.[1,2]

The epidemiology and mechanism of TBI vary across age groups. Falls are the most common cause of head injury in infants and young children, while road traffic accidents, sports-related injuries, and interpersonal trauma become more prevalent with increasing age. The clinical presentation of paediatric

TBI ranges from mild symptoms such as vomiting and headache to severe manifestations including seizures, altered consciousness, and focal neurological deficits.[2]

Neuroimaging, particularly computed tomography (CT), plays a pivotal role in the evaluation of paediatric TBI. CT scan enables rapid identification of life-threatening intracranial lesions such as extradural and subdural hematomas, cerebral edema, and skull fractures, guiding timely intervention. Despite advances in neurocritical care, secondary brain injury due to hypoxia, hypotension, and raised intracranial pressure remains a major determinant of outcome.

Outcomes following paediatric TBI depend on multiple factors including severity of injury, age, mechanism, radiological findings, and timeliness of management. Early recognition and appropriate intervention can significantly improve survival and neurological recovery.[3]

This study was undertaken to analyse the clinical presentation, radiological profile, and outcomes of traumatic brain injury in children presenting to a tertiary care centre, with the aim of identifying key factors influencing prognosis and highlighting the importance of preventive strategies.

MATERIALS AND METHODS

This hospital-based observational study was conducted in the Department of Paediatrics at a tertiary care teaching hospital in Navi Mumbai over a defined study period. Children aged up to 18 years presenting with a history of traumatic brain injury were included in the study. Children with congenital neurological disorders or non-traumatic intracranial pathology were excluded.

After obtaining informed consent from parents or guardians, detailed demographic data and data related history of injury were recorded, including age, gender, mode of injury, time interval between injury and hospital presentation, and pre-hospital care received was obtained.

All patients underwent thorough clinical evaluation. Neurological assessment included

Glasgow Coma Scale (GCS) scoring at admission. Patients were categorized as having mild (GCS 13–15), moderate (GCS 9–12), or severe (GCS ≤8) TBI. Vital signs, pupillary reactions, and signs of raised intracranial pressure were documented.

Radiological evaluation was performed using non-contrast CT scan of the brain. CT findings such as extradural hematoma, subdural hematoma, subarachnoid hemorrhage, intracerebral hemorrhage, cerebral edema, pneumocephalus, and skull fractures were noted.

Management was individualized based on clinical and radiological findings. Patients were managed conservatively or surgically in consultation with neurosurgeons. Supportive care including airway management, seizure control, intracranial pressure management, and intensive care monitoring was provided as required.

Outcome was assessed at discharge using the Glasgow Outcome Scale (GOS) and categorized as good recovery, moderate disability, severe disability, vegetative state, or death.

Data were compiled and analysed using descriptive statistics. Results were expressed as frequencies and percentages.

RESULTS

Age and Gender Distribution: In our study it was noted that, majority of patients belonged to the Pre-schooler age group (26 years) which comprises 35.95% of the total population, followed by the adolescents (23.59%). School aged children were 19.10%. Toddlers were 14.6%. Children in age group-1 month to 1 year were 5.61% of the total population. Male predominance was noted in all age categories (58.42%).

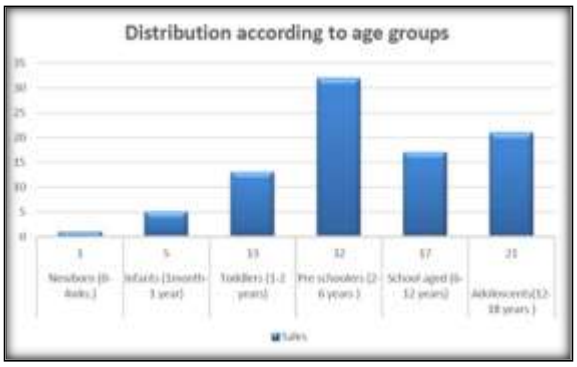

Figure 1: Age-wise distribution of paediatric traumatic brain injury cases

Mode of Injury

The most common mode of injury that was noted was Fall from height (n=43,48.31%) followed by the RTA (n=33,37.07%), fall while walking (n=6,6.74%) and fall of heavy objects on head (n=5,5.61%) were other common modes that were noted. One newborn with traumatic brain injury as a result was instrumental delivery (n=1,1.12%) and one patient of Assault (n=1,1.12%) causing head injury was observed in our study population.

Mode of injury according to age-groups in a patients with traumatic brain injury shows that the most common mode of injury in toddlers was fall from height (n=9), followed by fall while walking (n=3) and fall of heavy objects on head (n=1). The most common mode of injury in Pre schooler age group was fall from height(n=21), followed by Road traffic accidents (n=8). Two common modes of injury noted in the School aged children were Road traffic accidents (n=09) and fall from height (n=08). Amongst the adolescents, RTA (n=15) was noted to be the most common mode injury, followed by fall from height (n=3) and fall of heavy object on head (n=2). One patient (n=1) of Assault was observed in the adolescent age group.

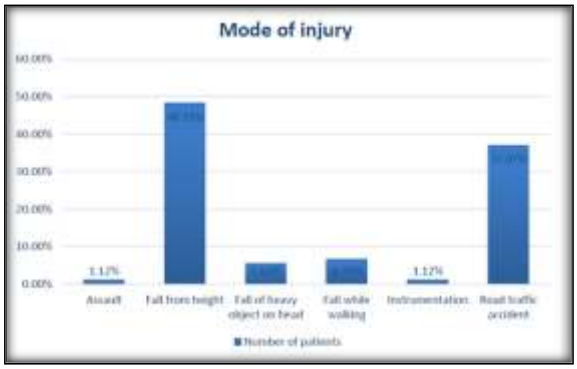

Figure 2: Distribution of mode of injury among children with traumatic brain injury

Clinical Presentation

Vomiting was the most common presenting symptom (46%), followed by altered sensorium (30.33%) and seizures (21.34%).

Table 1: Presenting symptoms in children with traumatic brain injury

Symptoms	Vomiting	Convulsion	Loss of consciousness
	n = 89 (%)	n = 89 (%)	n = 89 (%)
Present	41 (46.06%)	19 (21.34%)	27 (30.33%)
Absent	48 (53.93%)	70 (78.65%)	62 (69.66%)
Total	89 (100%)	89 (100%)	89 (100%)

Clinical signs such as Battle's sign or ear bleed was seen in only 7 patients, constituting 7.86% of the total population. Nasal bleed or fracture of nasal bone was seen in 11.23% of the total population.

Severity of Injury (GCS at Admission)

Most children presented with mild traumatic brain injury (77.52) following Traumatic Brain injury had a GCS of 13-15 which suggested Minor Brain Injury n=11, 12.35% presented to the ER with GCS of 3-8, they had severe brain injury.n=09, 10.11% had moderate brain injury (GCS-9-12) on arrival.

Table 2: Glasgow Coma Scale (GCS) on admission

GCS on admission	n = 89	(%)
13-15 (Minor)	69	77.52%
9-12 (Moderate)	09	10.11%
3-8 (Severe)	11	12.35%
Total numbers of patients	89	100%

Radiological Findings

Amongst the 89 patients, 40 patients (44.94%) had no CT finding. Subdural haemorrhage was the most common intracerebral bleed seen in n=16, 17.97% patients, followed by extra dural haemorrhage which was seen in n=14, 15.73% of the total patients. Subgaleal hematoma was the next most common bleed, n=9, seen in 10.11% of all patients. Sub Arachnoid Haemorrhage was seen in four patients, n=4, 4.49%. Subdural Haemorrhage with intraventricular Haemorrhage was seen in 2 patients. IVH alone was seen in 2 patients (2.24%). One patient with Pontine bleed (1.12%) and one patient with cerebellar bleed (1.12%) were also recorded.

Table 3: CT brain findings in paediatric traumatic brain injury

CT brain finding	n = 89	n (%)
Cerebellar bleed	01	1.12%
Extra-dural hemorrhage	14	15.73%
Intraventricular hemorrhage	02	2.24%
Pontine bleed	01	1.12%
Subarachnoid hemorrhage	04	4.49%
Subdural hemorrhage	16	17.97%
Subdural hemorrhage with IVH	02	2.24%
Subgaleal hematoma	09	10.11%
No abnormality detected	40	44.94%
Total numbers of patients	89	100%

Management

The majority of patients were managed conservatively (95.5%). Surgical intervention was required in patients with significant mass effect or neurological deterioration (4.49%).

Table 4: Management approach in paediatric traumatic brain injury

Surgical management	n = 89	(%)
Done	04	4.49%
Not done	85	95.50%
Total numbers of patients	89	100%

ICU Stay

In our study it was seen that majority of the patients (48.31%) had an average ICU stay of upto 3 days, 40.44% patients had a stay of 3-7 days. Only 11.23% of the patients had an ICU stay of more than 7 days.

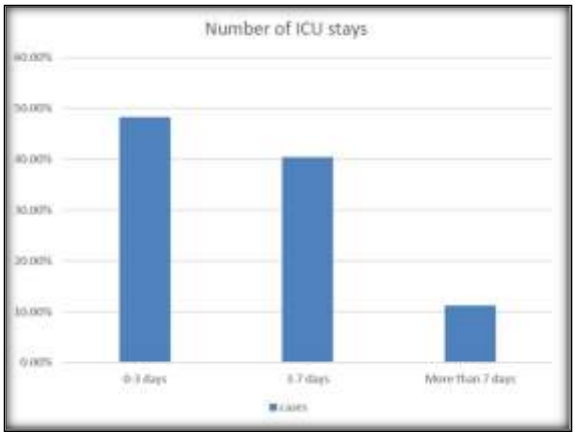

Figure 3: Duration of ICU stay among children with traumatic brain injury

Outcome

In our study, out of the 37 females,death of 5 patients was observed. Mortality was highest in the pre schooler age group (n=2,40%) and adolescent (n=2,40%). 20% mortality (n=1) was seen in female

children of the Toddler age group. 32 female children were discharged back home.

Table 5: Clinical outcome based on Glasgow Outcome Scale

Score	Functional status	Description	Total numbers of patients.(%)
5	Good recovery	Returned to the original functional level and employment with no deficit	78 (87.64%)
4	Moderate disability	Minor neurological deficit that does not interfere with daily functioning or work	03 (3.37%)
3	Severe disability	Significant neurological deficit that interferes with daily activities or prevents return to employment	00
2	Persistent vegetative state	Coma or severe deficit rendering the patient totally dependent	00
1	Death	Death	08 (8.98%)
	Total		89

DISCUSSION

Traumatic brain injury (TBI) in the paediatric population remains a major cause of morbidity and mortality. The present study analysed 89 paediatric patients with TBI and evaluated epidemiological factors, clinical presentation, radiological findings, management strategies, and outcomes, and compared these observations with available literature.

Demographic profile

In the present study, males constituted 58.42% of the study population, while females accounted for 41.57%, demonstrating a clear male predominance. Similar male preponderance has been reported by Krishna Chaitanya et al., who observed male involvement in nearly twothirds of paediatric TBI cases, attributing this to increased outdoor activity and risk-taking behaviour among boys. Dewan et al. also reported higher incidence rates among male children globally.[4-6]

Age-wise distribution revealed that the pre-school age group (2–6 years) was most affected, comprising 35.95% of cases, followed by adolescents (23.59%) and school-aged children (19.10%). Comparable age distributions have been reported by Ryan et al., who demonstrated the highest incidence of TBI among pre-school children due to falls, with adolescents showing increased incidence due to road traffic accidents.[7]

Mode of injury

Falls from height were the most common mechanism of injury in the present study, accounting for 48.31%, followed by road traffic accidents (RTAs) in 37.07% of cases. This pattern closely mirrors Indian studies by Gururaj and Krishna Chaitanya et al., where falls constituted nearly half of paediatric TBIs.[4,8-10] Dewan et al. similarly reported falls as the leading cause of TBI in children below 10 years of age.[6]

Age-specific analysis showed that falls predominated in toddlers and pre-school children, whereas RTAs were the most common cause among adolescents (71.4% of adolescent injuries).

Araki et al. observed similar trends, with RTAs becoming the dominant mechanism in older children and adolescents.[11]

Clinical presentation and severity

Vomiting was the most frequent presenting symptom, occurring in 46.06% of patients, followed by loss of consciousness (30.33%) and seizures (21.34%). These findings are consistent with Greenes and Schutzman, who identified vomiting and altered consciousness as key indicators of intracranial injury in children.[12] Ong et al. also reported a higher incidence of early posttraumatic seizures in children compared to adults.[13,14]

The majority of children in the present study presented with mild TBI (GCS 13–15) in 77.52%, while 12.35% had severe TBI (GCS ≤8). Similar distributions have been reported in tertiarycare-based studies where improved referral systems have increased detection of mild injuries.[15] Severe TBI was associated with poorer outcomes, consistent with observations by Kochanek et al.[15]

Radiological findings

CT imaging showed no abnormality in 44.94% of patients, highlighting that significant clinical symptoms can occur even in the absence of radiological findings. Among abnormal scans, subdural hemorrhage (17.97%) was the most common intracranial bleed, followed by extradural hemorrhage (15.73%) and subgaleal hematoma (10.11%). Krishna Chaitanya et al. and Schutzman et al. reported similar predominance of subdural and extradural hemorrhages in paediatric TBI4.[17]

Skull fractures were noted in 44.94% of patients, comparable to rates reported by Lang et al., who emphasized the association between skull fractures and intracranial injury in children.[18]

Pneumocephalus was observed in 20.22%, indicating significant cranial base involvement.

Cerebral edema was present in 31.46% of patients, predominantly among those with severe TBI. This finding aligns with studies by Lang et al. and Tasker, who reported that diffuse cerebral edema is more common in children due to immature cerebral autoregulation.[16,18]

Management and ICU stay

Only 4.49% of patients required surgical intervention, while 95.50% were managed conservatively. This low surgical rate is comparable with institutional studies where most paediatric TBIs are mild and respond well to medical management.[19]

Regarding ICU stay, 48.31% of patients required ICU care for 0–3 days, 40.44% for 3–7 days, and only 11.23% required prolonged ICU stay (>7 days). Hochstadter et al. reported similar associations between prolonged ICU stay, injury severity, and radiological abnormalities.[20]

Outcome

Overall mortality in the present study was 8.98%, while 91.01% of patients were discharged. Good recovery (GOS-5) was observed in 87.64% of patients, reflecting favourable outcomes in children with mild to moderate TBI. These findings are consistent with Ong et al., who reported good recovery in over 80% of paediatric TBI cases.[14]

Poor outcomes and mortality were primarily associated with severe TBI, low admission GCS, cerebral edema, and prolonged ICU stay, which have been repeatedly identified as poor prognostic factors in paediatric neurotrauma literature.[15,20,21]

CONCLUSION

Paediatric traumatic brain injury presents with a wide range of clinical manifestations and radiological findings. Early assessment, prompt neuroimaging, and appropriate management lead to favorable outcomes in most children. Severity of injury and radiological evidence of diffuse cerebral edema are key determinants of prognosis. Strengthening preventive strategies such as fall prevention, road safety education, and early referral systems is essential to reduce the burden of paediatric TBI.

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