Section: Neurosurgery

Original Research Article

PREDICTIVE FACTORS FOR OUTCOME IN PAEDIATRIC HEAD INJURY

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ABSTRACT

Background: In children, traumatic injuries to head constitute the primary cause of mortality and a significant contributor to disability. Pediatric head injuries predominantly result from falls from height and high velocity road traffic accidents, showcasing distinct prognostic outcomes compared to adults. This distinction is attributed to variations in the mechanisms of head injury and the structural differences in the skull. This study aimed to pinpoint crucial clinical parameters that could predict outcomes in pediatric patients with traumatic brain injury (TBI) who underwent Neuro-surgical intervention (Conservative, ICU care, Surgical exploration).

Material and Methods: After obtaining clearance from Institutional Ethical Committee and written assent this prospective observational study was conducted which included 152 pediatric head injury patients in a tertiary care Trauma Centre (GGH, Kakinada). Various factors, such as age, gender, mode of injury, Glasgow Coma Score (GCS) at admission, any coagulopathy at admission and radiological findings, along with their correlation to outcomes, were evaluated. Statistical analysis was conducted using SPSS version 21.0.

Results: The mean age of the study participants was 9.6 + 4.9 years. Head injury was seen in 89% of cases and in 11% of cases, head injury associated with spinal injury was seen. 99 (65.1 %) had high velocity injury (fall from greater than 10 feet height and high speed road traffic accidents). Severe head injury was seen in 71 (46.5%). Majority 60 (39.5 %) of CT findings revealed cerebral concussion followed by Intracranial hypertension 39 (25.6%). Fall from height (from buildings which are in construction and balconies greater than 10 feet height) was the most common cause of injury in our study. GCS at presentation, Hypotension along with coagulopathy (deranged BT/CT, PT, APTT, INR) were significant predictors of outcome.

Conclusion: Fall from height represent the predominant mode of injury, and early anticipation of outcomes can be achieved through straightforward clinical data. Factors such as low GCS, initial hypotension, hypoxia, coagulopathy, and age play pivotal roles in determining the ultimate outcome in the early phases (measured within 1 hour of presentation).

Keywords: Head injury, pediatric population, outcome.

INTRODUCTION

Traumatic brain injury (TBI) is acknowledged as a significant public health issue in numerous countries globally. Severe brain injury stands as the primary cause of death in children beyond the age of 1 in developed nations. Approximately 4.1% of children in India sustain traumatic brain injuries every year. (The LANCET-Global Health- Indian statistics)

Approximately 70–80% of accidental fatalities directly stem from lesions in the central nervous system. The epidemiological patterns of morbidity and mortality associated with traumatic brain injury (TBI) reveal two primary peaks during the second decade and in later life. Additionally, a smaller third peak is observed in early childhood when analyzing the mortality rate5. Within the pediatric population, the incidence of traumatic brain injury (TBI) in infants under the age of 1 year represents a significant proportion and poses a potential source of considerable lifelong disability.

While the majority of children typically fully recover from injuries, approximately 15% of affected children may encounter temporary and/or permanent impairments. Those who endure moderate-to-severe traumatic brain injuries (TBIs) face the potential for enduring physical, cognitive, and emotional-behavioural challenges. These difficulties can lead to compromised adaptive functioning, a slower learning pace, and diminished academic performance.

Severe traumatic brain injuries (GCS <8 at presentation) are uncommon, accounting for just 10% of head trauma cases. A study by Sharples et al. in the 1990s revealed that 30% of fatalities could be prevented with timely and appropriate management. On the flip side, the timely and precise evaluation of injury severity, coupled with the prompt initiation of critical care, plays a pivotal role in averting such fatalities. Early development of secondary brain injuries from systemic factors exacerbates the primary brain injury and contributes to neuronal loss caused by initial impact forces. Notably, hypoxia and hypotension emerge as significant contributors to these secondary brain lesions, further worsening overall outcomes.

The pathophysiology and outcomes of traumatic brain injury (TBI) differ between adults and pediatric patients. Infants exhibit distinct characteristics contributing to this divergence. The infant skull, being less rigid and more plastic, allows greater movement in response to mechanical stress. Additionally, neonates have less myelin in their cerebral white matter, influencing the absorption of forces differently than in adults. Moreover, the larger head-to-body ratio in neonates makes them more susceptible to head injuries, a factor supported by numerous studies reporting poorer outcomes following TBI in infants.

This study aimed to pinpoint crucial epidemiological and clinical parameters that could predict outcomes in pediatric population with traumatic brain injury (TBI) who underwent Neuro-surgical intervention.

MATERIAL AND METHODS

Study design, sample size and source of data

This was a prospective observational study conducted in the Government General Hospital, Kakinada which is a Tertiary Care Trauma centre attached to Rangaraya Medical College. The study was conducted from 1st August 2022 to 31st October 2023 with 152 patients participating in the study who were selected based on universal sampling.

Inclusion criteria

- Children aged between 0 – 18 years.
- Severity of head trauma (Mild, Moderate and Severe) which was recognized using criteria, such as the Glasgow Coma Scale (GCS) score.
- Head trauma occurring within 48hrs
- Those guardians/parents who were willing to give informed consent

Exclusion Criteria

- Age above 18 years
- Patients with pre-existing neurological conditions.
- Cases where head trauma is not the primary cause of symptoms (e.g., cases of infection or metabolic disorders).
- Patients who received specific treatments (e.g., surgery, medications) prior to study enrolment.
- Cases where informed consent couldn't be obtained due to legal or ethical reasons.

Method of data collection

Following the acquisition of ethical approval from the Institutional Ethical Committee and obtaining written informed consent from patients admitted to the tertiary care hospital, GGH, Kakinada, this study enrolled children who sustained Traumatic Brain Injury (TBI) and were subsequently referred to the neurosurgical unit for Conservative care, ICU care and various neurosurgical procedures, such as decompressive craniectomy, craniotomy, and external ventricular drain insertion.

Demographic data, including age, gender, were collected for children undergoing neurosurgical interventions due to Traumatic Brain Injury (TBI) at GGH, Kakinada. Patients were categorized into three age groups: 0–6 years, 7–12 years, and 13–18 years. Predictor variables for analysis comprised the Glasgow Coma Scale (GCS) score, mechanism of injury, presence of loss of consciousness, vomiting, palpable skull fracture, signs of basilar skull fracture, non-frontal scalp hematoma, pupil size and reactivity, CT findings of haemorrhage type, presence of age-adjusted(less than 5th centile for age) hypotension, intracranial pressure (ICP), need for blood transfusion, presence of coagulopathy and use of inotropes prior to or during surgery. Hypotension was defined based on age-specific systolic blood pressure thresholds. Mass effect was characterized by effacement or compression of basal cisterns with midline shift >0.5 cm, and midline shift was defined as a perpendicular distance >5 mm between the septum pellucidum and the midline (after acquiring CT scan findings).

All predictor variables, and adjustments were made to the verbal and motor components of the GCS scale for pediatric patients below the age of 2, following local institutional guidelines. Severity of

TBI was classified as mild (GCS 13–15), moderate (GCS 9–12), and severe (GCS ≤8). Raised ICP was defined as ICP >20 mmHg, the relevance of which is the necessity of Neuro surgical intervention.

Statistical Analysis

The data collected was analysed using JAMOVI version 2.3.10. Clinico-demographic variables were analysed in terms of mean, standard deviation (SD), frequency (n) and percentage (%). Data results were represented in the form of tables and figures. Univariate analysis employed chi-square, Fisher's exact, and paired t-test for statistical examination. The study conducted univariate followed by multivariate logistic regression analyses to identify factors associated with in-hospital mortality. Specifically, patients with cranial injuries were subjected to analysis to identify predictors of mortality. The findings are presented as odds ratios with corresponding 95% confidence intervals. A significance level of p <0.05 was employed to determine statistical significance.

Demographic Variables	Clinical Variables	CT Scan Findings	Mechanism of Injury
Age and Sex	Pulse rate, Blood Pressure, SpO2, Pupils, Loss Of Consciousness, ENT Bleed, GCS at presentation, Seizures, Focal Neurological Deficits and Coagulopathy	Epidural Hematoma , Subdural Hematoma, Intracerebral Hematoma, Skull Fractures , Traumatic Hydrocephalus, Presence of midline shift, Compression of basal Cisterns	Fall from height, Road traffic accidents, Trivial fall while playing

RESULTS

CT scan

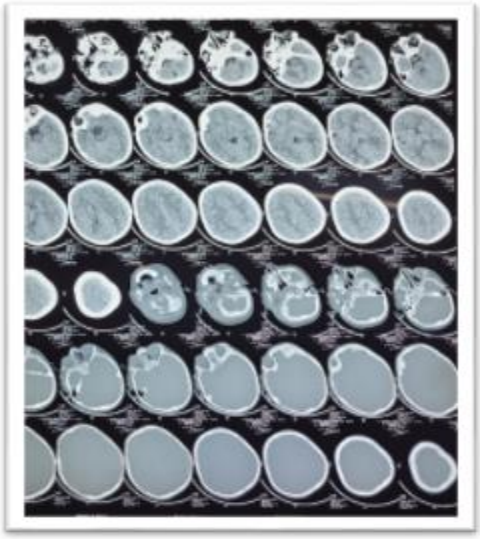

Figure 1:

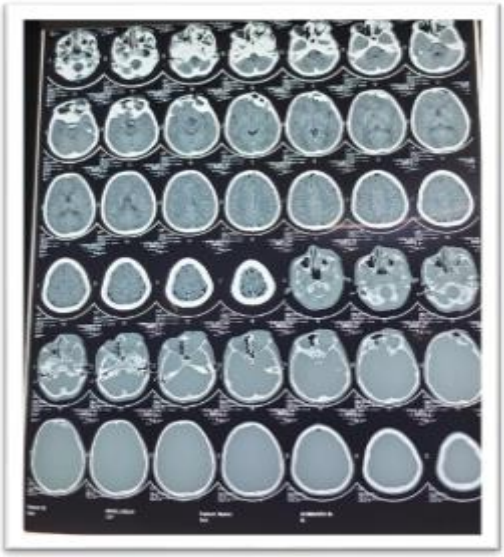

Figure 2:

Figure 3:

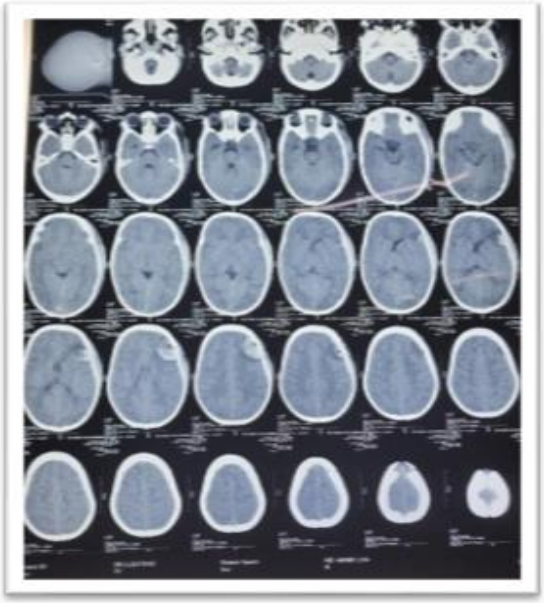

Figure 4:

The study included 152 patients in the analysis. The mean age of the study participants is 9.6 ± 4.9 years (range 4 months to 18 years). Majority of the participants belong to 7-12 years age group. Out of all participants boys were 105 (69.1%) and 47 (30.9%) were girls (table-1). Head injury was seen in 89% of cases and in 11% of cases, head injury was associated with spinal injury. 99 (65.1 %) had high velocity injury (Fall from height greater than 10 feet and high speed road traffic accidents). Severe head injury was seen in 71 (46.5%). Majority 60 (39.5 %) of CT findings revealed cerebral concussion followed by Intraabdominal hypertension 39 (25.6%). Fall from height is the most common cause of injury in our study. GCS and Hypotension were significant predictor of outcome.

High velocity injuries were seen in 99 (65.1%) of the participants. The severity of head injury was divided into mild, moderate, and severe. Severe head injury was seen in 71 (46.5%) of individuals. [Table 2]

The vitals were recorded of all study participants. The pulse rate was divided as high and low (High > 120 beats per minute, Low <80 beats per minute). High pulse rate was seen in 21 (14%) of individuals. Other vital parameters like Blood pressure (BP) where 18 (11.6%) of individuals were hypotensive (<5th centile for age). Coagulopathy (deranged BT/CT, PT, APTT, INR) is seen in 32 (20.9%) of the cases. The oxygen saturation dropped (hypoxia) in 11 (7%) of individuals. [Table 3] The signs and symptoms distribution showed that 50 (32.6%) presented with seizures. Initial focal neurological deficit was seen in 21 (14%) of individuals. 88 (58.1%) had loss of consciousness.

Table 1: Baseline characteristics of the study population (n=152)

Variables	Values
Mean age (in years)	9.6 ±4.9
Age group distribution (in years)	
0 – 6	33 (21.7%)
7 – 12	67 (44.1%)
13 – 18	52 (34.2%)
Gender	
Boys	105 (69.1%)
Girls	47 (30.9%)

Table 2: Mechanism and severity of head injury (n=152)

Parameter	n (%)
Mechanism of injury	
a. High velocity	99 (65.1%)
b. Low velocity	53 (34.9%)
Severity of head injury	
a. GCS 13-15 (Mild)	60 (39.5%)
b. GCS 9-12 (Moderate)	21 (14.0%)
c. GCS 3-8 (Severe)	71 (46.5%)

Table 3: Description of vital parameters (n=152)

Vital parameters	n (%)
Pulse rate	
a. High	21 (14%)
b. Low	131 (86%)
Blood pressure	
a. Hypotension	18 (11.6%)
b. Normal	134 (88.4%)
SPO2	
a. Hypoxia	11 (7%)
b. Normal	141 (93%)

Table 4: Distribution of signs and symptoms (n=152)

Vital parameters	n (%)
Seizures	
a. Absent	102 (67.4%)
b. Present	50 (32.6%)
Focal neurological deficits	
a. Initial	21 (14.0%)
b. Late	11 (7.0%)
c. No	120 (79.1%)
Coagulopathy	
a. Absent	120 (79.1%)
b. Present	32 (20.9%)
Pupils	
a. Anisocoria	11 (7.0%)
b. NSRL	131 (86.0%)
c. MID	7 (4.7%)

d. Pinpoint	3 (2.3%)
Loss of consciousness	
a. Absent	64 (41.9%)
b. Present	88 (58.1%)
ENT bleed	
a. Absent	99 (65.0%)
b. Present	53 (35.0%)

Table 5: Radiological Findings

Cerebral concussion	**60 (39.5%)**
Skull fractures	39(25.6%)
Extra axial Haemorrhage & Skull fracture	11(7%)
Intra axial Haemorrhage & Skull fracture	3(2.3%)
Intra axial Haemorrhage	39(25.6%)

Table 6: Distribution of outcome of the study participants

Outcome	**n (%)**
Deaths	14(9.21%)
Discharged with FND	41(26.97%)
Discharged without FND	97(63.81%)

Table 7: Predictors of long-term functional outcome

Predictive factors	**Positive outcome**	**Negative outcome**	**p-value**
GCS 3-8	17 (23.9%)	54 (76.1%)	**< 0.05**
Duration of unconsciousness	38 (53.5%)	33 (46.5%)	> 0.05
Hypotension	5 (27.8%)	13 (72.2%)	**< 0.05**
Duration of rehabilitation	31 (43.7%)	41 (57.7%)	> 0.05

***p < 0.05 is considered as statistically significant**

DISCUSSION

Pediatric traumatic brain injury (TBI) is a significant global public health issue. While developed countries have seen improved outcomes due to advanced Intensive Care Units and multidisciplinary approaches, it remains a major challenge in some regions. Strict prevention strategies are crucial.

In this current study, we examined a sizable and uniform group of children with severe traumatic brain injury (TBI). Through this analysis, we pinpointed distinct factors independently associated with morbidity and mortality. These findings could potentially serve as the basis for developing a predictive mortality grading scale in subsequent research. The epidemiological data observed in our study population closely resembled those previously documented in the pediatric trauma literature.

In our current study, mean age of 9.6 ± 4.9 years, predominantly falling within the 7-12 years age group. Of the total participants, 69.1% were boys, and 30.9% were girls. Head injury was prevalent in 89% of cases, with 11% showing an association with spinal injury. High-velocity injuries were observed in 65.1% of cases, and severe head injury was present in 46.5%. CT findings revealed that cerebral concussion (39.5%) and intra abdominal hypertension (25.6%) were the most common. Falls from height constituted the primary cause of injury. Glasgow Coma Scale (GCS) and hypotension emerged as significant predictors of outcome. Severe head injuries were noted in 46.5% of individuals. Vital parameters, including pulse rate, blood pressure, and oxygen saturation, were recorded, with 14% exhibiting high-velocity pulse rates, 11.6% being hypotensive, and 7% experiencing hypoxia. Signs and symptoms distribution indicated that 32.6% presented with seizures, 14% had initial focal neurological deficits, and 58.1% experienced a loss of consciousness. GCS and hypotension remained significant predictors of outcomes.

Traumatic brain injury is an important cause of acquired brain injury. The current study brings to light the clinicoepidemiologic profile of pediatric traumatic brain injury in India. Retrospective record analysis of children (aged ≤ 16 years) with traumatic brain injury presenting to an apex-trauma-center in North India over 4 years was done. Of more than 15 000 patients with a suspected head injury, 4833 were children ≤16 years old. Of these, 1074 were admitted to the inpatient department; 65% were boys with a mean age at presentation being 6.6 years. Most patients (85%) had a Glasgow Coma Scale score of 13 to 15 at presentation while Glasgow Coma Scale scores of ≤8 was seen in 10% of patients. Neuroimaging (computed tomography [CT]) abnormalities were seen in 12% of patients, with the commonest abnormality being skull fracture, followed by contusions, and extradural hemorrhage. Around 2% of patients required decompressive craniotomy whereas 3% of patients succumbed to their illness. Among the inpatients with pediatric traumatic brain injury, two-thirds were boys with a mean age at presentation of 7.6 years. Severity of traumatic brain injury varied as mild (64%), moderate (11%), and severe (25%). The most common mode of injury was accidental falls (59%) followed by road traffic and rail accidents (34%). Neuroimaging abnormalities were seen in

half of inpatients with pediatric traumatic brain injury, with the commonest abnormality being skull fracture. Pediatric head injuries are an important public health problem and constitute a third of all head injuries. They are more common in boys, and the most common modes of injury are accidental falls, followed by road traffic accidents.- Madaan P et al.[1]

The further developments in field of brain plasticity, stem cell, rehabilitation, evolution of new drugs, preventive community measures, and global policies to deal with head trauma are expected to play a major role in days to come. The development of future pediatric trauma centers based on current evolutions (in order to achieve a good outcome), global and emphatic preventions of trauma will be required to establish equilibrium between developed and developing countries.- Kumar R et al.[6]

In this large series of craniospinal trauma children treated in a single apex trauma center, we demonstrated that head injury is much more common than spinal injury and fall from height being the most common mode of injury. Outcome can be anticipated in the early phase with simple clinical data. Low GCS, initial hypotension, presence of coagulopathy, and young age determine outcome. – Garg k et al.[3]

In the existing literature, there is a lack of consensus regarding the outcomes in the pediatric age group. In a study by Parashar V et al,[2] 44.1% of participants were less than 5 years old. Some reports suggest that outcomes are generally more favorable in children under 10 years of age, while others indicate a higher mortality rate in those under five. However, in our series, we did not observe a distinction in poor outcomes between children below 5 years and those above 5 years, aligning with the findings reported by Suresh et al.[7]

Numerous studies suggest that the initial Glasgow Coma Scale (GCS) is a reliable indicator of mortality. However, in our observations also categorizing head injury into mild, moderate, and severe based on the initial GCS emerged as a robust prognostic factor for predicting mortality chances. Suresh et al. noted varying poor outcomes, with GCS 3–5 at 58.5%, GCS 6–8 at 35.2%, GCS 9–12 at 11.4%, and GCS 13–15 at 1.3%. Beca et al. 5 also identified the initial GCS score as the single most crucial factor influencing outcomes. Contrary to these findings, in our study, we identified hypotension and GCS as the strongest predictors of outcome. Astrand et al,[4] similarly reported a 100% poor outcome in cases of dilated pupils unresponsive to light. In our study also there was 100% mortality in bilateral dilated pupils non-reactive to light.

Based on the findings of this research, we recommend “the following guidelines for the treatment and diagnosis of pediatric patients with severe and moderate traumatic brain injury (TBI): Adherence to the Advanced Trauma Life Support (ATLS) protocol is crucial for both the diagnosis and treatment of pediatric TBI. The primary objective should be the reduction or prevention of secondary brain insults, as these significantly contribute to worsened outcomes. Management of hypotension and hypoxia, identified as primary contributors to secondary brain injury, is imperative. These factors are considered poor prognostic risk indicators, underscoring the need for effective and prompt intervention. Early consideration of emergency surgery post-head injury is recommended, guided by neurological findings and head CT results. Factors such as substantial hematoma volume or evidence of mass impact, including midline shift, should be taken into account. Addressing the delay in proper triaging and patient transfer is essential. Referral systems should undergo counselling and revision, involving administrative health authorities to enhance these processes, leading to improved patient outcomes. Direct transfer of TBI patients to tertiary hospitals equipped to handle head trauma cases is advised. This measure ensures access to facilities capable of providing specialized care, contributing to better overall patient outcomes”

CONCLUSION

Falls from height are the primary cause of injury, and early prediction of outcomes can be attained through basic clinical data. Key factors, including low Glasgow Coma Scale (GCS), initial hypotension, hypoxia, coagulopathy, and age significantly influence the ultimate outcome in the initial phases.

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