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Head trauma in pediatric patients: study of epidemiology, clinical profile and CT findings

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Abstract

This study titled "head trauma in pediatric patients: study of epidemiology, clinical profile and ct findings", was carried out in SMIMER Hospital, Surat, Gujarat.

Objective were to study epidemiology, clinical profile, morbidity and mortality with predictors of poor outcome in pediatric head injury patients.

It was a Prospective observational study carried out in Surat Municipal Institute of Medical Education and Research (SMIMER), Surat, Gujarat. All pediatric patients between age of 1 month to 18 years were included in the study.Total 57 patients with head injury were enrolled in the study. All patients were analyzed and classified according to their age, gender, mode of injury, symptoms and examination findings at the time of presentation, CT brain findings, Glasgow Coma Scale. Patients were managed in pediatric ward or Pediatric Intensive Care Unit depending on their severity and short-term outcome were analyzed at the time of discharge.

Keywords: TBI (Traumatic Brain Injury), GCS (Glasgow Coma Scale), Primary Brain Injury, Secondary Brain Injury, Skull Fractures.

Introduction

As infants and children are in the phase of motor growth and been taken care by care givers and their balancing reflexes are not mature. It is common for children to bang or bump their head. It can sometimes be difficult to tell whether an injury is significant or not. Many head injuries are not serious and simply result in bump and bruise without any serious symptoms like seizures or loss of consciousness. Occasionally these head injuries can result in serious brain damage with its sequelae (epilepsy). Any knock to the head that causes lumps, bruises, cuts (external injuries) or intracranial injury like hemorrhages, diffuse axonal loss (internal injuries).

Trauma is the third leading cause in India accounting for 9.6% of all deaths, whereas in children it is the third leading cause of death as per Government of India publication 2001-2003(1). Traumatic brain injury in children accounts for a large number of emergency department visits and hospital admissions and is reported to be the leading cause of death and disability in children around the world as per 2007 WHO report(2). The Center for Disease Control (CDC) and Prevention and the National Centre for Injury Prevention and Control label traumatic brain injury as "silent epidemic" in year 2013(3)perhaps due to rapid urbanization and increased use of motorised vehicles with inadequate safety precautions and regulation. The reported mortality in developed countries with excellent emergency medical services is 9-35%.(4)

Traumatic brain injuries have a standard definition established by the CDC and endorsed by the World Health Organisation (WHO):

Traumatic brain injury is either

- An occurrence of injury to the head with at least one of the following

1. Observed or self-reported alteration of consciousness or amnesia due to head trauma.
2. Neurological or neuropsychological changes or diagnosis of skull fracture or intracranial lesions that can be attributed to the head trauma.

- Or an occurrence of death resulting from trauma with head injury or traumatic brain injury listed in the sequence of conditions that resulted in death(5).

Injury to the brain can be divided into two i.e., Primary and secondary injury. Primary brain injury occurs at the time of impact due to diffuse neuronal lesion. Secondary brain injury occurs due to cerebral oedema or intracranial haemorrhage.(6)

Several factors influence childhood injuries, including age, sex, behaviour and environment. Among all these, age and sex are the most important factors affecting the pattern of injury. Children of age up to 4 years and adolescents of age 15-18 years are most likely to sustain traumatic brain injury. In every age group, traumatic brain injury rates are higher for males than females. Males aged up to 4 years have highest rates of TBI related emergency department visits(7).

Most of the studies carried out are done in developed nations with good quality of emergency care and facilities. Data are lacking in developing countries for epidemiology, mechanism of injury, correlation between degree of injury and CT findings and different management modalities. So, we would like to carry out this study in our setup to obtain data for the following lag backs.A head injury is divided into closed and open head injury depending on intactness of dura matter. In closed head injury dura remains intact irrespective of whether the skull is fractured or not whereas in open head injury dura is lacerated or torn and it is open to possible infection. (8)

Trauma imparted to head can be in the form of translational acceleration or deceleration forces, rotational forces or direct, focal, sharp penetrating or blunt forces. These can involve scalp, skull and brain independently or in any combination. For both treatment and medicolegal purposes, it is important to have understanding of mechanisms as to how the injury occurred. Abrupt deceleration of moving head is characterized by a relatively minor injury at the site of impact (coup injury) and an extensive contusion to the brain, remote and usually opposite to the point of impact (countercoup injury).

Abrupt acceleration of an unsupported head occurs when it is struck by a moving object. The skull accelerates against the brain causing an extensive coup injury. When a moving object strikes a well-supported head, there is little movement of the skull and brain. Most of the forces are absorbed by the skull, which will fracture. Damage to the underlying brain results from direct perforation or laceration by skull fragments. It is thus easy to understand why most cerebral contusions occur without skull fracture and why patients with spectacular fractures are often awake with only minor neurological disturbances.

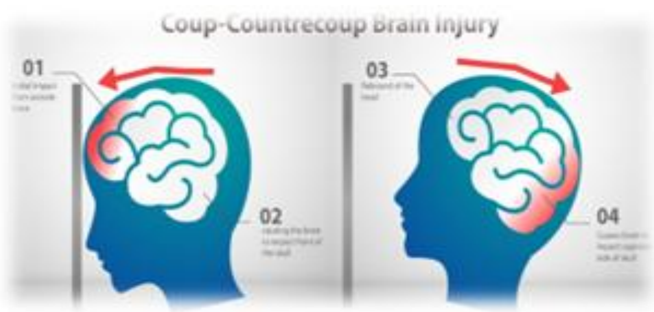


Fig 1: Showing Coup and Countercoup Injury

An injury of the head may involve the scalp, the skull, the meninges or the brain itself. These structures may be involved singly or in any combination. [9]

Scalp lacerations are common and may give rise to exsanguinating hemorrhage if not controlled. This is due to the blood vessel in the dense fibrous layer, superficial to aponeurosis. It is also important to exclude underlying depressed skull fracture. Extensive skull lacerations can cause hypovolemic shock in small infants. [10]

Different type of skull fracture may follow trauma like;

- Simple linear fracture
- Depressed skull fracture
- Base of skull fracture
- Pond fracture

Skull fractures are medically significant only if they have one of the following characteristics:

- Depressed
- Go through anterior cranial fossa and cribriform plate, allowing CSF rhinorrhea and a risk of meningitis.
- Go through petrous temporal bone into the ear, allowing CSF otorrhea and a risk of meningitis.
- Enter the sinuses.
- Involve skull base with brainstem injury. [11]

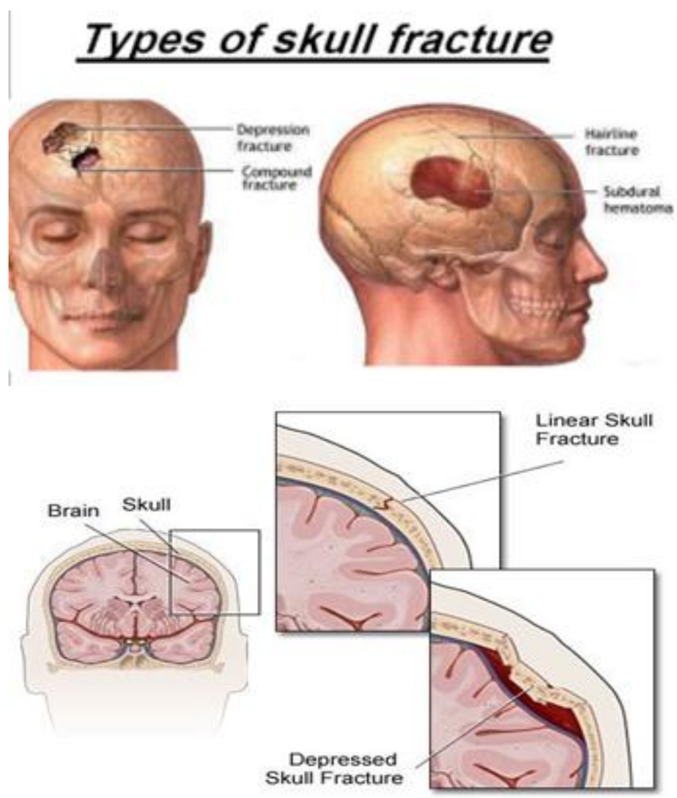


Fig 2: Types of Skull Fracture.

Primary brain injury [12]	Secondary brain injury
• Concussion • Cortical contusions/lacerations • Diffuse axonal injury • Brainstem contusions	• Intracranial hematomas • Cerebral edema • Hypoxemia • Ischemia • Infection • Epilepsy • Metabolic/endocrine disturbances

Primary brain injury is the injury caused at the time of impact (e.g., Contusion and laceration) and is irreversible. Secondary brain injury is subsequent or progressive brain damage arising from events developing as a result of the primary brain injury. The management of head injuries is aimed at preventing secondary injury.

Diffuse axonal injury is a type of brain injury occurs as a result of mechanical shearing at the grey-white matter interface following severe acceleration-deceleration type of forces due to differential brain movements. This causes disruption and rearing of axons, myelin sheaths and blood capillaries. Severity can range from mild damage with confusion to coma and even death. [13]

Cerebral concussions manifested by temporary cerebral dysfunction associated with amnesia and temporary loss of consciousness, which is most severe immediately after injury and resolves after a variable period of time. [14]

Cerebral contusions and lacerations can be demonstrated on CT scans as a small area of hemorrhage in the cerebral parenchyma. They may produce neurological deficit. Contusions may resolve with accompanying deficit or they may persist.

Epidural hematoma is a collection of blood between inner table of skull and the dura mater. The hemorrhage usually originates from the middle meningeal artery, the venous cranial sinuses or from the vessels that supply the skull. In majority of the cases there is usually a fracture, and the blood vessel in the vicinity are usually responsible for hemorrhage. The majority of epidural hematomas are located in the temporo-parietal region. The potential space between the dura and the bone is developed by expanding hematoma, allowing it to take a configuration of convex lens configuration, there is classically a lucid interval following trauma. They are more likely to occur in younger age group as dura is able to strip more readily off the underlying bone. Early identification of an intracranial lesion can reduce the risk of brain damage and death. [15]

Subdural hematoma occurs due to collection of blood between dura and arachnoid matter. Brain damage is more severe than epidural hematoma. These are usually classified as acute, subacute and chronic, depending on how long they take to present clinically following the injury.

- Acute subdural hemorrhage: less than 3 days
- Subacute subdural hemorrhage: 4-21 days
- Chronic subdural hemorrhage: more than 21 days

Intracerebral hematomas are unusual in children and may be the result of focal brain injury or penetrating trauma. Most often they involve frontal and temporal bones. Many intracerebral hematomas can be treated conservatively. Those with significant mass effect or shift may require evacuation if clinically indicated.

Penetrating head injury constitutes only a small part of the total number of traumatic head injuries but belong to the class of most severe traumatic brain injuries. In these cases, communication arises between the intracranial cavity and surrounding environment. Gunshot head wounds are most frequent.

Less frequent are injuries from knife, pencils, chopsticks and scissors.

Cerebral swelling occurs following trauma, either in focal pattern around an intracerebral hematoma following a contusion or diffusely throughout the cerebrum or cerebellum.

The pathological process is poorly understood but involves a disturbance of vasomotor tone, causing vasodilatation, loss of auto regulation and cerebral edema with an increase in both intra and extracellular fluid. In addition, cerebral contusion and petechial hemorrhages contribute to brain swelling.

It results in raised intracranial pressure and a diminished level of consciousness and is more common and more malignant in children.

Infection may occur as penetrating skull trauma and depressed skull fractures provide portals for central nervous system infection. This may lead to meningitis, brain abscesses or subdural empyema.

Hydrocephalus can develop acutely as a result of obstruction to CSF outflow due to intraventricular blood or as a delayed post-traumatic communication hydrocephalus due to impaired CSF reabsorption following traumatic subarachnoid hemorrhage.

Cerebral ischemia is common after severe head trauma and is caused by hypoxia, impaired cerebral perfusion or a combination. [21]

Cerebral herniationcan occur at several different anatomic locations [22];

- Cingulate or subfalcine herniation
- Central herniation
- Uncal herniation
- Tonsillar herniation

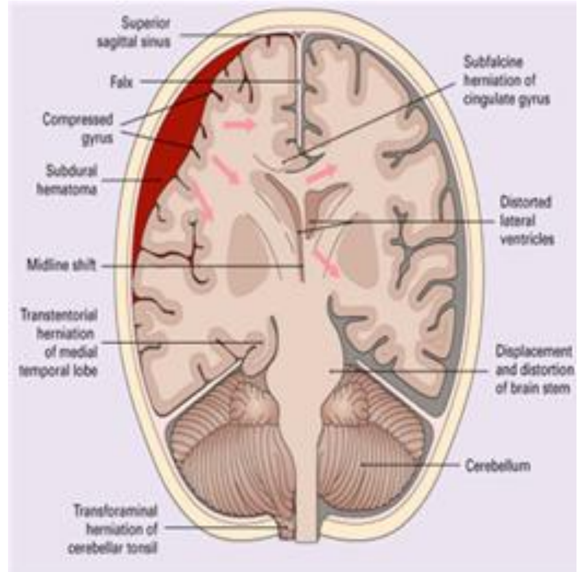


Fig 3: Types of Herniation

Head injury is classified based on Glasgow coma scale score at the time of presentation in three classes as follows [4];

Class of head injury	GCS score
Mild	13-15
Moderate	9-12
Severe	Less than 8

Aim and objectives

1. To study the clinical profile, mortality and morbidity of pediatric patients with head injury.

2.To identify the signs at presentation predictive of outcome at discharge, and determine CT findings in relation to severity of head injury.

3. Follow-up 30 days following Traumatic Brain Injury, for disability or sequelae.

4. A descriptive analysis of how did children sustain the TBI.

Material and methods

Setting

Prospective observational study was carried out at SMIMER hospital with a well-equipped pediatric ward and tertiary care teaching referral center for pediatric critical care. This hospital has facilities such as portable X-ray, CT scan, MRI imaging, EEG, Color Doppler, 2D ECHO, hematology, biochemistry, endocrine and microbiology laboratories and blood bank available round the clock along with neurosurgical and pediatric surgical support.For this study we enrolled 57 cases of Traumatic Brain Injury (TBI) admitted between periods of October 2020 to February 2022 in the above ward after Institutional Ethics Committee approval.Cases admitted between periods of October 2020 to February 2022.

Inclusion criteria

- All pediatric patients between one month to 18 years, with a history of head injury.
- Parents who are willing to give consent for participation of their children in study.

Exclusion criteria

- Children with underlying seizure disorder.
- Children with bleeding disorder
- Non consented
- Relatives not willing for CT scan

Statistical methods used

- The chi-square (χ) test of independence was used to test for a statistically significant relationship between two categorical variables. An observed relationship was called statistically significant when the *p*- value for chi-square test was less than alpha (typically alpha=0.05) In this case, if we reject null hypothesis, then we generalize that there is a relationship in the population.
- T test and ANOVA was used to test the difference between two or more continuous variables.
- Regression analysis was widely used for prediction. Regression analysis was also used to understand which among the independent variables were related to the dependent variable, and to explore the forms of these relationships.
- A p-value less than 0.05 was considered statistically significant.
- The entire data analysis was done using Statistical Package for Social Sciences (SSPS) version 20.0

Observations and results

Table 1: Gender wise distribution of patients.

Characteristics	Fall: No % 35 (61.5)	Accident 19 (33.3)	Strike 3 (5.3)	Total 57 (100)
Gender Male-n (%) Female-n(%)	20 (57.1) 15(42.)	12(63.2) 07(36.8)	1(33.3) 2(66.7)	33(57.9) 24 (42.1)

In our study incidence of head injury was more common in males as compared to females.

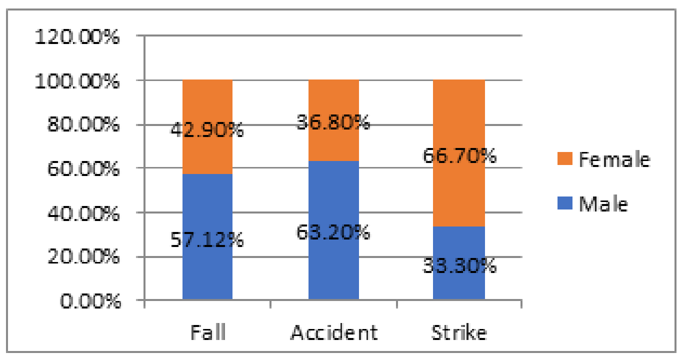


Table 2: Distribution of patients in respect to urban-rural area

Area	No. of patients	Percentage
Urban	40	70%
Rural	17	29.82%

In our study incidence of injury was more common in children living in urban area as compared to that in rural.

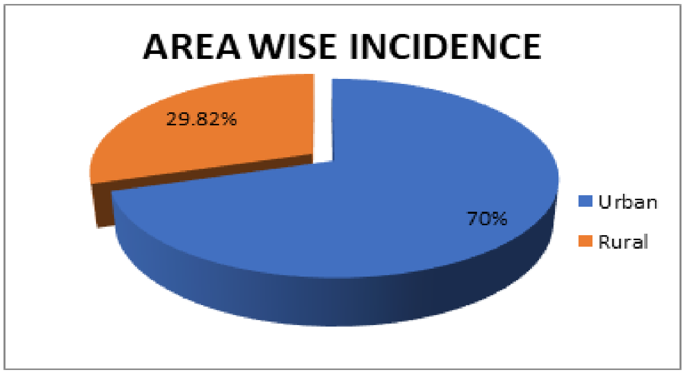


Table3: Age wise distribution of patients.

Age (years)	No. of patients	Percentage
≤5.0	37	64.9%
5.1-10.0	17	29.8%
>10.0	3	5.26%
Total	57	100%

In our study incidence of head injury was more common in ≤ 5 years old children.

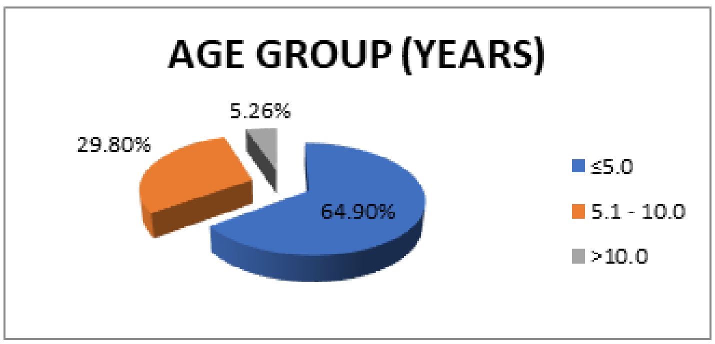
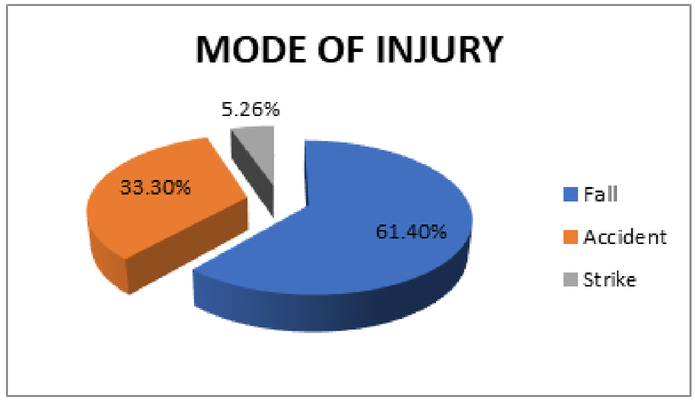


Table4: Distribution of patients with respect to mode of injury.

Mode of injury	Frequency	Percentage
Fall	35	61.40%
Road Traffic Accident	19	33.3%
Strike	3	5.26%
Total	57	100%

Fall from height/stairs was the most common cause (61.40%) of head injury in children followed by Accidents (33.3%), Strike against/by any object (5.26%).



Mechanism of TBI and its association with presenting symptoms

- Fall from height/stairs/bed was the most common cause (61.40%) of head injury in children followed by Accidents (33.3%), Strike against/by any object (5.26%).
- Subgroup analysis with Fall and Accidents showed that Accident cases had significantly more external bleeding than fall cases (42% vs. 17%, p =.04)
- Vomiting was the most common symptom following head injury. Vomiting and headache were not statistically significant as far as morbidity is concerned.
- Shock (8.6%), hypotension (8.6%), abnormal respiration (8.77%) was presented by patients who sustained head injury by fall at their initial presentation and of 8 patients Intubated, 5 (14.5%) patients were due to fall from height.
- Due to small sample size in subgroups, it is not possible to look at significant differences.

Patient Outcome by patient characteristics

- Altered sensorium was associated with poor outcome. Of 20 patients with altered sensorium 3 patients were disabled and 2 patients expired.
- Poly trauma was associated with significant mortality. Of 3 patients 2 died.
- The patients who were in shock (low blood pressure, feeble pulses) and with abnormal respiratory

pattern requiring intubation were associated with significant mortality. Of 6 patients 2 patients expired.

- Due to small sample size in subgroups, it is not possible to look at significant differences.

Table5: Distribution of patients with respect to Glasgow coma score and outcome.

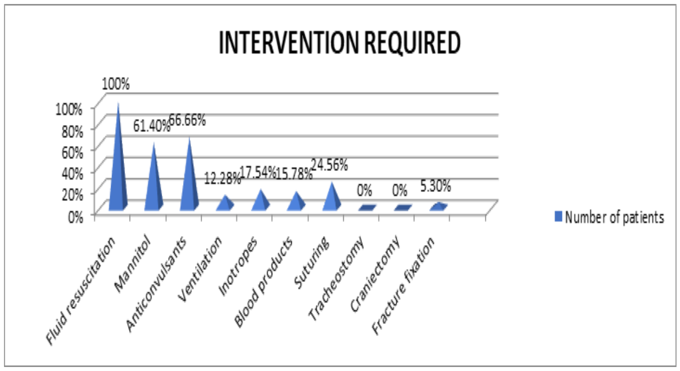
Glasgow coma scale	Outcome			Total
	Good	Disabled	Expired	
=<8 (severe)	1	4	2	07(12.3%)
9-12 (moderate)	1	1	0	02(03%)
>12 (mild)	48	0	0	48 (84%)
Total	50	5	2	57(100%)

In the present study, Glasgow coma scale ≤ 8 was associated with poor outcome. Out of 7 children who has severe head injury (GCS≤8) 2 expired and 4 were disabled.

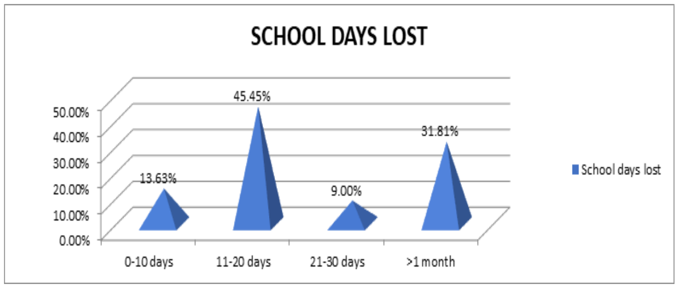
Glasgow Coma Score of > 12 was associated with good outcome.

Patient Outcome by CT scan and MRI findings

- In our study, Skull fracture (58%) was the most common finding on CT scan followed by cerebral edema, subdural hemorrhage, extradural hemorrhage, contusion is and herniation.
- But skull fracture was not statistically significant as far as morbidity or mortality was considered.
- Extradural hemorrhage, herniation and diffuse axonal injury were associated with poor outcome.
- Herniation and diffuse axonal injury were associated with high mortality.



The above table shows that minor surgical management such as suturing required in 23.72% patients while major surgery fracture fixation only 5%. all the rest were managed with medical treatment.



In respect to school days loosing max number of kids 45.45% were unable to attend school for 10-20 days and 31.8% kids for more than a month leaving a great impact on their studies.

Table 6: Showing Mechanism of Injury

Railing Short railing railing with a big gap No Railing Good railing but stool to climb	11 (19.2%)
Object falling Unprotected heavy wooden plank under construction Door hitting a small child	3 (5.2%)
Bad road condition Steep invisible at night speed breaker Uneven road loosing balance	2 (3.5%)

Ladder / staircase Small kid unsupervised on staircase Wet floor of staircase	11 (19.2%)
Under construction Incomplete work and kids playing	1 (1.7%)
Unsafe playing / walking by road side Unsupervised crossing road Inadvertent running on a busy road while playing	8 (14.0%)
Domestic accidents Fall from bed Wet floor	9 (15.8%)
Jhula made of old Saree (similar to a trampoline) Slipped knot	2 (3.5%)
RTA (two-wheeler bike) Hit by another vehicle due to lack of regulated traffic No helmet by pillion rider High speed in busy unregulated traffic	7 (12.3%)
RTA (Car) no seat belt	1 (1.7%)
Unsupervised play Unsafe material in play areas	2 (3.5%)
TOTAL	57

The above shows different type of injury mechanisms. Most common found to be was improper railing at the balcony or staircases, followed by unsupervised play on saircase.

One of the other major finding was, domestic minor head injury due towet floor or fall brom bed/sofa while playing unattended, which are the preventable causes of head injury just my increasing attention to care-giving.

Unsafe playing or walking bye the road side is also a major cause of TBI which can be prevented by educating children about the traffic rules and building playgrounds away from the roadside.

Discussion

The incidence of pediatric head injury in the Indian subcontinent is unknown because of non-availability of data. Ours was prospective observational study which was conducted in tertiary care hospital to study the clinical profile and CT findings of children admitted with head injury. The study included a total of 57 children with head injury, out of which 18 children were admitted in PICU and 11 of which required significantly higher critical care supports in the form of vasoactive agents, mechanical ventilation, blood products, careful fluid balance and 37 were admitted in ward of which 15 required only observation. A total of 50 children were normal at discharge, 19 required closer follow up due to CLW or sequelae such as black eye, on anti-convulsant. Five children had some form of disability even at the end of 30 days of follow up and 2 expired during hospitalization because of head injury.

In our study, boys (57.90%) outnumbered girls (42.10%) for head injury.Hassen et al(16), Verma et al(17), Chabok et al(18) and Shao et al(19) also reported similar findings in their study.

The incidence of head injury was more in preschool (≤5) age group (64.9%), Hawley CA et al(20) reported similar findings whereas Udoh et al found incidence more in 7 to 10 years of children. Though there was no statistically significant difference in the age and sex distribution, as far as mortality and morbidity is concerned.

In our study fall from (height/stairs/bed) constituted the commonest cause of head injury (61.40%) followed by road traffic accidents (33.33%) and other causes (5.26%). Verma et al(22), Bhargava et al(21), Shao et al(19), Zhu et al, Siraj et al(22), Lee et al(23) reported similar findings in their studies, whereas Chabok et al[18] found accidents as the commonest cause.

We found vomiting (78.9%) as the commonest symptom at presentation, followed by headache, laceration, altered sensorium, external bleed, hematoma and seizures in the same order. Altered sensorium and presence of associated injuries at the time of admission were found to be associated with poor outcome.

Presence of shock and hypotension at the time of presentation were observed to be predictors of poor outcome. In our study 6 children presented with hypotensive shock, out of which 2 expired. Abnormal respiratory pattern and abnormal pupils were independently found to be predictors of poor outcome.

In our study out of 57 children, mild head injury was seen in 48 (84%), moderate head injury was seen in 2 (3%) and 7(12.3%) had severe head injury. This shows that mild head injury constitutes a major part of total spectrum of head injury, which is also reported by Siraj MU et al[33].

We found Glasgow Coma Score (GCS) 0f ≤ 8 as poor predictor of outcome. Grinkeviciute DE et al[24] reported that a threshold of 5 for GCS was associated with potential mortality in children with severe head injury. Kamal HM et al[25] reported GCS <12 as an important predictor of death or neurological deficit. Suresh et al and Udoh et al[26] found GCS score of ≤ 8 as a poor predictor of outcome. Ghaffarpasand et al[27] suggested in pediatric age group the cut-off value for severe traumatic brain injury should be set at 5 instead of 8 in order to predict the outcome more precisely.

Skull fracture (58%) was the most common finding on CT scan followed by cerebral edema, subdural hemorrhage, extradural hemorrhage, contusion and herniation. Ciurea et al reported similar findings in their study, whereas Suresh et al found contusions and Bhargava et al found extradural hematoma as most common lesion on CT brain in pediatric patients of traumatic head injury. Extradural hematoma, cerebral herniation and diffuse axonal injury were found to be associated with poor outcome.

Of 57 patients admitted most of them were managed medically, 10 (17.5%) patients required inotropic support, 9 (15.7%) patients required blood products and 7 (12.28%) patients required ventilation of which 2 patients expired. Only few required surgical interventions. Suturing of CLW was required to be done in 14 (24.5%) patients, 3 (5.0%) required long bone fracture fixation.

One of the findings noted was loss of school days 10 (45.45%) patients lost their school for 10-20 days and 7 (31.8%) patients lost their school for > 1 month leaving a major impact on their studies and even Parents' Day to day life and economic burden.

Most of the head injuries were due to minor negligence in the part of care-givers or unsafe infrastructure at the house- falls due to improper railing at the stairs (19.2%), children playing unsupervised on stairs (19.2%), domestic accidents (15.8%), unsafe playing or walking by the road side (14%) which all were found to be preventable causes of head injury just by parent education an improving their part of care giving and looking after the children.

Conclusions

- Children in preschool age group (≤5) are more prone to head injury with predominance of males.
- Presence of altered sensorium, associated injuries (multiple fractures), hypotension, abnormal respiration at the time of presentation are predictors of poor outcome.

- Only 21% of patients with minor head trauma had normal CT scan, rest all 79% had significant finding even though some had only minor symptoms. So even when patient presents with minor symptoms it does not rule out need for CT scan.
- Glasgow Coma Score ≤ 8 at the time of presentation are associated with poor outcome.
- Mild type of injury is the most common. Fall from height/stairs/bed is the most common mode of injury. And little improvement and education on parents' part for care giving and looking after children can prevent maximum number of head injuries.
- Most of the patients with head injury can be managed with only medical treatment, very few require surgical intervention in form of fracture fixation and stabilization.

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