Spectrum of Pediatric Head Injury with Management and Outcome: A Single Tertiary Care Center Study

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Abstract

Objective This study aims to conduct a survey on the pediatric head injury cases admitted to our hospital to identify the incidence, age, sex, mechanism and type of injury, other associated injuries, initial presentations, computed tomography finding, management, length of hospital stay, outcome in the form of condition at discharge, and outcome analysis using Glasgow outcome score (GOS).

Methods This is a retrospective study of all children $\leq$ 18 years admitted for head injury to our hospital during the period August 2013 to June 2014. A total of 247 pediatrics head injury patients in between the age of 0 and 18 years were admitted and treated. In all cases age, sex, presenting symptoms, mechanism, type, severity, other associated injuries, management, duration of hospital stay, GOS, and so on, are analyzed from the stored pediatrics master register, computerized discharge tickets, patients profiles, admission register, death register, and bed head tickets.

Results Of all the patients, there was a male preponderance ($p < 0.001$). The most common presenting feature was altered sensorium. The mean duration of hospitalization in our study is 4.0615 with 89.06% of patients staying < 7 days (p-value ≤ 0.001). Most common mechanism of head injury in children was found as road traffic accident ($p < 0.001$). Most common type of injury was extradural hematoma and about 62% intracranial pathology shows no skull fracture. Mortality rate is low as compared to all head trauma victims.

Conclusion Outcome of pediatric head injury depends on initial presentation. Early recognition and prompt management contributes to decrease mortality and disability. Younger males are at a greater risk. Most injuries are mild-to-moderate in nature with high rate of good recovery.

Keywords
- pediatric
- head injury
- Glasgow coma scale
- GCS
- Glasgow outcome scale
- GOS
- computed tomography
- CT

Introduction

Out of all head injury encountered in clinical practice of neurosurgeons, pediatric traumatic brain injury (TBI) is one, which needs skilled and prompt management to overcome high morbidity and mortality.[1,2] Due to increase in the number of motor vehicle, household articles, and concrete road and houses, the incidence of pediatric head injury is quite significant among all head injury. Neurosurgeons face difficulties in proper assessment of severity of injury and management accordingly. This retrospective study is designed to analyze different demographic profile, epidemiology, management of pediatric TBI with outcome in the form of mortality and morbidity.

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Aim

This study was conducted to have a retrospective analysis on incidence, age, sex, mode of injury, type of injury, associated other injuries, initial presentation, computed tomography (CT) finding, management, indication for operative intervention, length of hospital stay, outcome, condition at discharge, and GOS.

Materials and Methods

This is a retrospective study of children ≤ 18 years admitted for head injury to our hospital during the period August 2013 to June 2014 (11 months). It does not include the following: (1) the patients who presented with minor injuries and discharged from casualty; (2) the patients who presented with low condition and died at casualty before admission; (3) the patients who had minor TBI with significant orthopedic, BTA, or chest injuries admitted to the respective department; and (4) the patients who died at the scene of injury and pre hospital duration.

A total of 254 pediatrics head injury patients in between the age of 0 and 18 years were admitted and treated out of which complete data of 247 patients were available and taken in our study. In all cases age wise distribution, sex, initial presenting clinical symptoms and signs at casualty, mechanism of injury, type of injury, radiological diagnosis, severity of injury, other associated injuries, management, duration of hospital stay, condition at discharge, and GOS, etc, are analyzed from the stored pediatrics master register, computerized discharge tickets, patients profiles, admission register, death register, and bed head tickets. The patients were treated both conservatively and surgically as per the standard protocol for pediatrics head injuries and as per decision of our treating neurosurgeon groups. We used Microsoft Excel for data compilation and statistical analysis. Chi-square analysis was utilized to test the significance of results and results were considered significant when p value < 0.05.

Results

Demographic Profile

A total of 1,895 patients of head injury were admitted to our hospital during the period August 2013 to June 2014 (11 months) and out of them 254 (13.456%) were pediatric patients aged between 0 and 18 years. From 254 patients males and females were 186 (73.333%) and 68 (26.666%), respectively. Of the 254 patients the complete data of seven patients are not available so a total of 247 patients were taken in our study.

In our study, the children from 0 to 18 years are divided into four groups such as 0 to 2, 3 to 5, 6 to 12, and 13 to 18 years for more specific age wise analysis for better understanding of clinicopathology among the pediatric head trauma population. The age wise distribution of pediatric head injury is given in ►**Fig. 1**; the commonest group of children suffering from head injury was children aged 13 to 18 year which is about 116 patients (p value < 0.001).

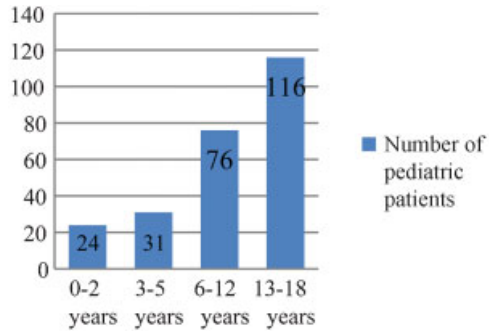

Fig. 1 Age wise distribution of numbers of pediatric patients.

Sex wise distribution (►**Fig. 2**) ratio shown that the ratio of male-to-female in 0 to 2, 3 to 5, 6 to 12, and 13 to 18 years were 1:1.4, 1.06:1, 2.15:1, 4.8:1, respectively, and in all category, there is male preponderance (p-value < 0.001) but the numbers of female in the age group of 6—12 yrs are relatively higher than the other groups. The total no. of male children in our study is 174 and females are 73.

Duration of Hospitalization

The mean duration of hospitalization (►**Fig. 3** and ►**Table 1**) in our study is 4.0615 (0—2 yrs: 4.125 days, 3—5 yrs: 3.548 days, 6—12 yrs: 4.289 days, 13—18 yrs: 4.284 days) days but most of the patients (57.894%: n = 143) are spending 3—7 days in the hospital with 89.06% of patients staying < 7 days (p-value = < 0.001): ►**Table 1**. The children between the age of 13 and 18 years are spending more days than any other group. But it is of importance that the high school and intermediate college going children loses significant number of days due to head injury. Only 18 patients stayed up to 2 weeks while 9 patients stayed more than 2 weeks. The duration of hospital stay in our study ranges from 1 to 22 days.

Course in the Hospital

Total numbers of cases operated were 62 and 185 patients got conservative medical management (p-value < 0 0.001) (►**Table 2**). Out of the conservatively managed patients two

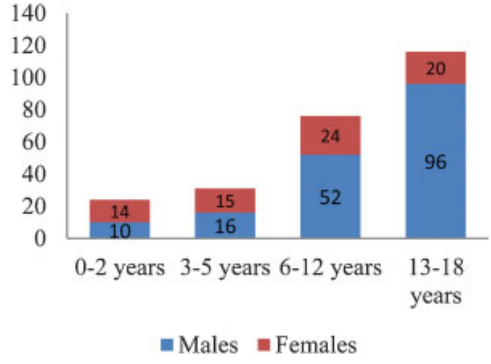

Fig. 2 Sex distribution.

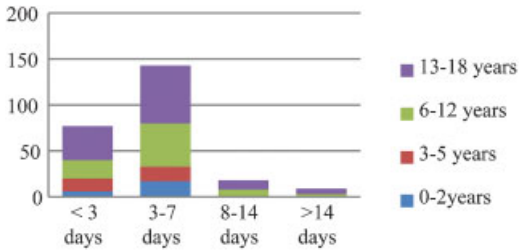

Fig. 3 Duration of hospital stay.

Table 1 Duration of hospital stay

Duration of hospital stay (d)	Number of patient	*p*-Value
< 7	220	< 0.001
> 7	27	
	247	

patients with penetrating orbital injury extending up to cavernous sinus were referred to higher neurosurgical centre for further management. The three patients left hospital against medical advice. The brief details operation under taken is described in ►**Fig. 4**.

We managed all patients of head injury in emergency department, intensive care unit (ICU) and ward as per our maintained protocol. (1) A B C management includes endotracheal intubation, tracheostomy, O_2 inhalation, circulation by normal saline, Ringer lactate for children > 5 years and Ivolyte-P for children < 5 years. (2) Head raising position 30 to 45 degrees, catheterization of bladder, neutral position of head, and avoidance of neck compression, exclusion of other injury, if needed whole blood transfusion preoperatively or during and after operation. (3) GCS and pediatric Glasgow coma scoring system (PGCS) assessment. (4) If ICU needed sent to ICU for management. (5) Common blood investigation (HIV, HCV, HBS Ag, DC, TLC, HB%, and PCV, Na+, K+, urea, creatinine) and if needed immediate intervention. (6) If planned for conservative management, aim was to evaluate thrice daily in general ward and 4 hourly in ICU by neurosurgeon to see any features of deterioration/raised intracranial pressure (ICP). (7) If required repeat CT as per indication. (8) If pathology is significant found to be operated, then surgery as per pathology including decompressive procedures. (9) Continuous observation was done to control ICP by

Table 2 Course in the hospital

	0–2 y	3–5 y	6–12 y	13–18 y	Total	*p*-value
Operative	5	5	19	33	62	< 0.001
Conservative	19	26	57	83	185	

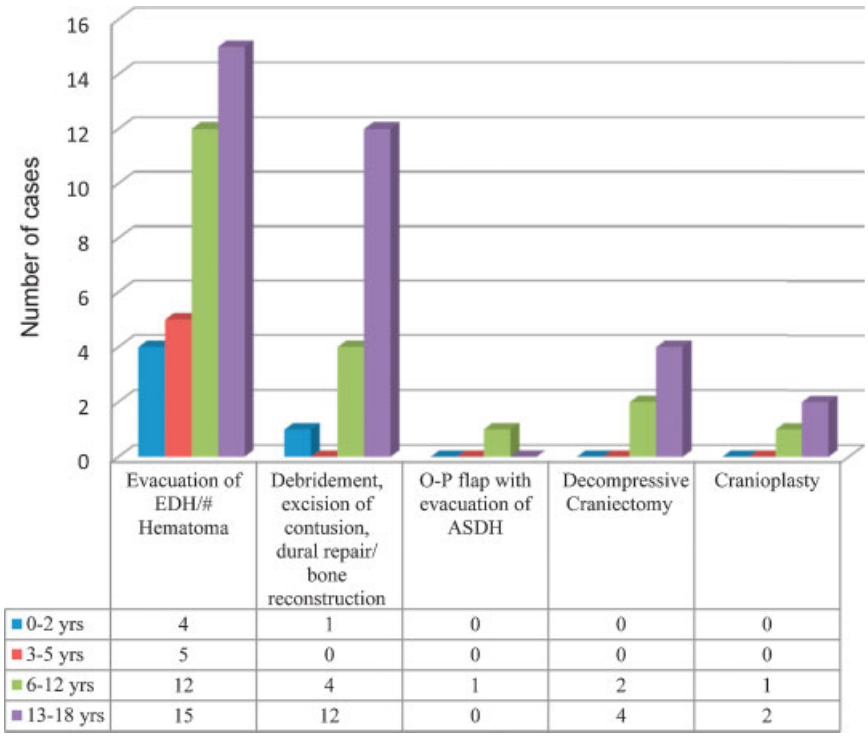

Fig. 4 Types of operation done.

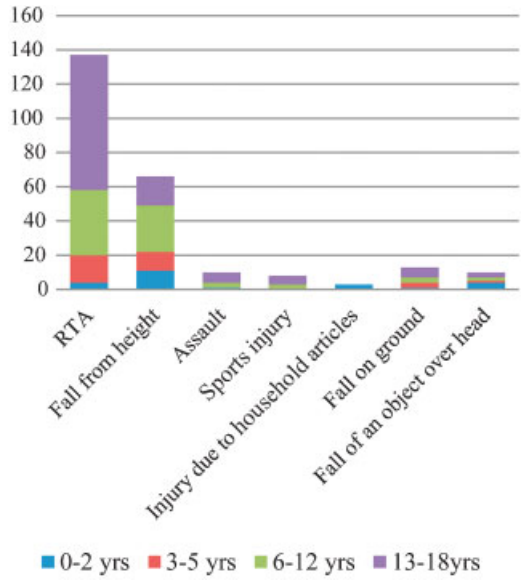

Fig. 5 Mechanism of injury. RTA, road traffic accident.

targeting $SpO_2 > 90$ mm Hg, $SPO_2 > 95\%$, and serum Na^+ between 145 and 155 Meq/L. (10) In our cases, we have used only 20% mannitol, 3% sodium chloride, furosemide, and sedation with lorazepam to control ICP. In no case, we have used hyperventilation or other sedative such as propofol or higher strength of sodium chloride solution to control ICP. In no case, we have monitored ICP. (11) Clinicoradiological features are taken as guide for determination of ICP.

A total of 24 patients needed ICU care with ventilator support, and death in ICU was 5 cases. The ICU care with ventilator is provided to conservatively managed 11 cases, preoperatively in 5 cases and postoperatively in 8 cases. The ventilator was not used for controlling ICP but is used for patients with respiratory complication, chest injury, postoperative anesthetic unexpected recovery, etc. Out of five ICU deaths, three cases were postoperative and expired due to initial presentation with low GCS of 3 to 6, dilated pupil having prehospital aspiration. Other two were conservatively managed multiple injury patient on ventilator due to septicemia and aspiration pneumonia.

Though the management of diffuse axonal injury (DAI) cases is difficult in pediatrics, our protocol in management was in a target, not to allow for further damage to brain by any secondary insults. We have managed accordingly as stated above to control raised ICP and hypoxia. In cases of DAI with diffuse cerebral edema showing refractory to medical management by clinical assessment, we have done repeat CT to know the status of basal cisterns and mass effect. As per the need, decompressive craniectomy was done as procedure of last resort to control ICP. Two cases of DAI showing diffuse cerebral edema and mass effect during hospitalization undergone decompressive craniectomy one of them was bilateral frontotemporoparietal decompression. Other four decompressive craniectomy were for multiple contusion with diffuse cerebral edema in one, compound depressed # with contusion and cerebral edema in two, and for acute subdural hematoma with mass effect and cerebral edema in one case.

Mechanism of Injury

Most common mechanism of injury was road traffic accident (RTA) (55.46%; $n = 137$), next to it was fall from height (26.72%; $n = 66$) (p-value < 0.001) Interestingly all three head injury due to household articles were in children of the age group 0 to 2 years and all are due to fall of television over head from the stand. Out of 10 cases of fall of an objects over head, coconut injury are 2, cement slab 3, branch of tree in 1 case, fall of muddy wall due to heavy rain in 4 cases. RTA is the most common cause of head injury in the age group of 13 to 18 years ($n = 79$) and it is also found that fall from a certain height is the commonest cause of head injury in the children bellow 2 years (►**Fig. 5** and ►**Table 3**).

Type of Injury

It is also seen that extradural hematoma (EDH) and # hematoma was the most common CT finding in the patients of pediatric head injury found in 63 (25.5%) cases (►**Table 4**). Second to EDH, parenchymal contusion or hematoma is the leading CT finding (►**Fig. 6**).

Table 3 Mechanism of injury

Mechanism of injury						
Category	**0–2 y**	**3–5 y**	**6–12 y**	**13–18 y**	**Total**	***p*-value**
Road traffic accident	4	16	38	79	137	0.01586
Fall from height	11	11	27	17	66	0.00531
Assault	1	0	3	6	10	0.65521
Sports injury	0	0	3	5	8	0.51152
Injury due to household articles	3	0	0	0	3	<0.001
Fall on ground	1	3	3	6	13	0.69228
Fall of an object over head	4	1	2	3	10	0.01679
Total	24	31	76	116	247	

Table 4 Age wise type of injury

Type	0–2 y	3–5 y	Type of injury		Total	*p*-value
			6–12 y	13–18 y		
EDH	6	7	16	34	63	0.99631
CD# NO DURA	2	1	2	4	9	
CD# P	2	2	4	6	14	
CD# C	3	4	5	12	24	
CONT	4	4	14	20	42	
ASDH	2	3	9	9	23	
DAI	2	4	14	17	37	
DCE	2	3	5	8	18	
MISC	1	3	7	6	17	
Total	24	31	76	116	247	

Abbreviations: ASDH, acute subdural hematoma; CD# P, compound depressed fracture with pneumocephalus; CD# NO DURA, compound depressed fracture without dural breach; CD#C, compound depressed fracture with underlying contusion; CONT, parenchymal contusion; DAI, diffuse axonal injury; DCE, diffuse cerebral edema; EDH, extradural hematoma; MISC, miscellaneous.

Associated Injury

It is found that after necessary screening at casualty during admission, patients requiring active neurosurgical intervention despite of having other associated injury were admitted to neurotrauma department after primary care given by the respective department (►**Table 5**). As a result, there were 44 patients admitted with associated injury out of which 22 (50%) cases are in the age group of 13 to 18 years. Most common injury associated is orthopedic injury. One case of blunt trauma abdomen (splenic contusion) with minimal peritoneal collection on ultrasonography admitted was in the age group of 3 to 5 years.

Presenting Features

In our study, it is found that the most common presenting features (p-value < 0.001) is altered sensorium seen in 182 (73.684%) cases, the second common presenting features is vomiting that accounts for 145 (58.704%) cases (►**Table 5**).

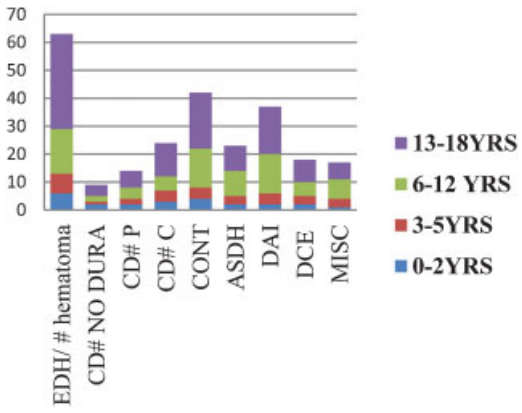

Fig. 6 Type of head injury as per CT finding and operative finding.

Headache is found in 46 cases (18.623%) which is more found in the age group of 13 to 18 years.

Early posttraumatic convulsion is found more in young children of the age group 3 to 5 and 6 to 12 years. A total of only 16 (6.477%) patient present features of early posttraumatic epilepsy, of which 13 cases belongs to ages between 3 and 12 years. Paresis unilateral, bilateral or monoparesis is found as presenting features in 10 cases. It is found more in the age group of 13 to 18 years that is 5 cases. Decreased vision is found in 15 cases, out of which 2 cases are due to direct penetrating injury to their one eye ball causing complete blindness in one eye, all others had decreased vision due to raised ICP, frontal or occipital lobe injury.

We adopted the standard GCS for children more than 2 years and PGCS for pediatric patients below 2 years to evaluate the severity of injury (►**Table 6**).[3,4] In our study, 109 (44.129%) patients presented to casualty with GCS of 14 to 15 suggesting mild head injury in pediatric population. Moderate head injury patients with GCS of 9 to 13 were 89 (36.032%). Severe head injury with GCS 3 to 8 presented to casualty was 51 (20.647%).

Outcomes

A total of 178 cases out of 227 cases are discharged with GOS of 5 and 7, the number of cases remain persistent vegetative (GOS-2) (►**Table 5**). It is also found that no vegetative were seen in the age group of 0 to 2 and 3 to 5 years though the death were 2 and 5, respectively. It is also seen that moderate disability persons with GOS-4 were relatively more in the age group of 6 to 12 years.

Mortality

The total numbers of deaths during the period of hospitalization were 15 (6.07%) out of 247 cases, with

Table 5 Age wise analysis of multiple parameters with their statistical significance

Parameters	0–2 y	3–5 y	6–12 y	13–18 y	Total	Percentage	*p*-value
Associated injury							
Fracture upper limb	0	3	4	6	13		0.933035
Fracture lower limb	0	2	5	8	15		0.815042
Chest	1	3	2	5	11		0.410694
BTA	0	1 splenic injury	0	0	01		0.022727
Spinal injury	0	0	1	3	04		
Admission Glasgow coma score							
Severe (3–8)	5	8	11	27	51	20.647%	0.440917
Moderate (9–13)	9	10	35	35	89	36.032%	
Mild (14–15)	10	13	32	54	109	44.129	
Other clinical features							
Altered sensorium	15	18	59	90	182	73.684%	0.000841
Vomiting	15	17	47	66	145	58.704%	
Headache	0	8	10	28	46	18.623%	
Convulsion	2	5	8	1	10	4.048%	
Paralysis	2	1	2	5	10	4.048%	
Visual disturbance	0	3	7	5	15	6.072%	
Glasgow outcome score							
Good recovery (5)	18	22	51	87	178		0.562862
Moderate disability (4)	3	4	16	12	35		
Severity disability (3)	1	1	4	6	12		
Vegetative state (2)		0	3	4	7		
Dead (1)	2	4	2	7	15		

M:F = 2:1, total of 227 patients were successfully treated and discharged (►**Table 7**). Total numbers of death during this period in the hospital due to head trauma irrespective of age was 270 (14.24%) out of 1,895 patients. It shows that the mortality rate among the pediatric head injury patients is quite less (p-value = 0.011928) than that of general head trauma victims. The most of the fatal outcome were in patients presented in GCS 3 to 6 with pupillary abnormality. The cause of death among them is mostly aspiration pneumonia and septicemia in 11 patients out of 15 deaths.

Discussion

Pediatric head injury is one of the most common causes of mortality and morbidity in pediatric population.[2] In this series, out of all head injury admitted to our institution, 254 (13.456%) are pediatric patients. In our series, the number of pediatric head injury increases with increase in age[5] (p-value < 0.001). As the age increases, mobility and outdoor activities increases, such as, increased vehicular usage, playing outdoor games, and increase in child labor, etc., which increases the likelihood of sustaining a head injury. Male preponderance (p-value < 0.001) in our series is also comparable with other series,[6,7] such as Schutzman and Greenes described that boys are twice as likely to be injured as compared with girls.

The mean duration of hospitalization in our study is 4.0615 days but most of the patients (57.894%) are spending 3 to 7 days in the hospital with 89.06% of patients staying <7 days (p-value < 0.001). The children of the age group 13 to 18 years are spending more days than any other group. But it is of importance that the high school and intermediate college going children loses significant number of days due to head injury.

Total numbers of cases operated were 62 and 185 (p-value < 0.001) patients got conservative medical management. In our study, it shows that operative intervention is relatively low as compared with conservative treatment which is also comparable with other series study.[8,9]

Due to scarcity of resources, we have not used ICP monitor in any case to measure the ICP. Although some recent studies support the use of ICP monitor in traumatic brain injury and consider it as beneficial, many studies describe that the use of ICP monitor does not have any impact on the outcome. Haddad and Arabi described that although there is no randomized controlled trial that has been performed demonstrating that ICP monitoring

Table 6 Glasgow coma scoring (GCS) system adopted for pediatric patients showing both pediatric GCS and standard GCS system

Standard GCS for children > 2 y		Pediatric GCS for children < 2 y	
Eye opening			
Spontaneous	4	Spontaneous	4
To speech	3	To speech/sound	3
To pain	2	To pain	2
None	1	None	1
Verbal response			
Oriented	5	Coos, Babbles	5
Confused	4	Irritable cries	4
In appropriate	3	Cries to pain	3
Incomprehensible	2	Moans to pain	2
None	1	None	1
Motor response			
Obeys command	6	Normal spontaneous movement	6
Localizes pain	5	Withdraws to sound	5
Flexion withdrawal	4	Withdraws to pain	4
Flexor posturing	3	Flexor posturing	3
Extensor posturing	2	Extensor posturing	2
None	1	None	1

improves outcome or supporting its use as standard; ICP monitoring has become an integral part in the management of patients with severe TBI in most trauma centers. However, there is contradicting evidence about whether ICP monitoring improves the outcome or not.[10] Several studies have demonstrated that ICP monitoring reduced the overall mortality rate of severe TBI.[11–15] Other studies have not shown any benefits from ICP monitoring.[15–18] Moreover, a few studies have demonstrated that ICP monitoring was associated with worsening of survival.[19,20] Potential complications of ICP monitoring include infection, hemorrhage, malfunction, obstruction, or malposition. In the Cochrane database, a recent systematic review found no randomized control trials that can clarify the role of ICP monitoring in acute coma whether traumatic or nontraumatic.[20] Nevertheless, there is evidence, and most clinicians agree, to support the use of ICP monitoring in severe TBI patients at risk for intracranial hypertension. In a recent larger study done by Alkhoury and Kyriakides described that despite current Brain Trauma Foundation guidelines, ICP monitoring is used infrequently in the pediatric population. The data suggest that there is a small, yet statistically significant, survival advantage in patients who have ICP monitors and a GCS score of 3. However, all patients with ICP monitors experienced longer hospital length of stay, longer ICU stay, and more ventilator days compared with those without ICP monitors.[21]

Table 7 Number of death in comparison to general head injury patients

Category	General	Pediatric	Total	*p*-value
No. of head injury patient	1895	247	2142	0.01192
No. of death	227	15	242	

The total number of deaths during the period of hospitalization were 15 (6.07%) out of 247 cases, with M:F = 2:1, total of 227 patients were successfully treated and discharged. Total numbers of death during this period in the hospital due to head trauma irrespective of age was 270 (14.24%) out of 1,895 patients. It shows that the mortality rate among the pediatric head injury patients is quite less (p-value = 0.011928) than that of general head trauma victims which is also comparable with other study was done by Mitra et al.[22]

In our study, most common mechanism of injury was road traffic accident (RTA)(55.46%), next to it was fall from height (26.72%) (p-value < 0.001). RTA being common cause of head injury in pediatric is also similar to other series of studies like ShahrokhYousefzadeh et al[23] and Parslow et al[5] but fall from height is described in many articles as the most common mechanism of head trauma. Taking pediatric age group as 0 to 18 years may be one of the possible cause to explain the significance in our favor. In our study, fall from height is the most common mode of injury in children of the age group 0 to 2 years which is comparable with other studies.[22–25]

It is also seen that EDH and # hematoma was the most common CT finding in the patients of pediatric head injury

found in 63 (25.5%) cases. Second to EDH, parenchymal contusion or hematoma is the leading cause. But if the patients with compound fracture with under lying contusion (24 cases) taken together with the isolated contusion of 42 (17.0%) cases it accounts to 66 (26.7%) cases becoming the most common intracranial pathology. A total of 92 (37.2%) cases shows fracture of skull with 71.4% cases of EDH shows at least a single linear skull fracture. Diffuse axonal injury was found in 37 (14.9%) cases with diffuse cerebral edema in 18 (7.28%) patients. In our study, it is seen that 62.8% of head injury can occur without a skull fracture.

It is also found that the most common presenting features is altered sensorium seen in 182 (73.684%) cases, the second common presenting features is vomiting that accounts for 145 (58.704%) cases. Headache is found in 46 cases (18.623%) which is found more in the age group of 13 to 18 years (p-value < 0.001). Only 16 (6.477%) patients present features of early posttraumatic epilepsy, of which 13 cases belongs to ages between 3 and 12 yrs. Paresis is found as presenting features in 10 cases. Found more in age group of 13–18 years that is 5 cases. Decreased vision is found in 15 cases, out of which 2 cases are due to direct penetrating injury to their one eye ball causing complete blindness in one eye, all others had decreased vision due to raised ICP, frontal or occipital lobe injury.

In our study, there were 44 patients admitted with associated injury out of which 22 (50%) cases are in the the age group of 13 to 18 years. Most common injury associated is limb injury in 28 cases and next to it is chest injury in 11 cases, spinal injury in 4 cases, and finally blunt trauma abdomen in 1 case. This pattern of injury is comparable with other study such as Parslow et al.[5]

A total of 178 cases out of 227 cases are discharged with GOS of 5 and 7 number of cases remain persistent vegetative (GOS-2). This high number of good recovery suggest that majority of head trauma are mild-to-moderate in severity. The better survival outcome may be due to the anatomic characteristics of a pediatric head (open fontanelle and skull stability is dependent upon ligamentous structures than bony structures) allow it to tolerate raised ICP better than adults. On the contrary the brain of a child is more vulnerable to these insults, which could explain the fact that the functional outcome is often unpredictable and depends on age at injury, injury severity, and time since injury, premorbid child characteristics, family factors, and the families' socioeconomic status, Lack of comorbid factors such as alcoholism hypertension, diabetes mellitus, and other age-related risk factors are also responsible for good outcome in pediatrics. Also, early recognition and timely intervention yields good results.

Conclusion

Pediatric head injury accounts a significant number in total head injury patients. The number of patient increases with age suggesting risk of head injury is more in young male children aged between 13 and 18 years. RTA is the commonest mechanism of head injury as seen in adults. Fall from height is the second most common. EDH is the most common type of head injury encountered. Most of the pediatric patients presented with high GCS, in the category of mild and moderate injury resulting in high rate of good outcomes. Also, death rate is almost 50% of adult death percentage. Though this is a retrospective study, it provides much information with definite significance.

Conflicts of Interest
The authors have nothing to declare.

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