INJ INTERNATIONAL NEUROUROLOGY JOURNAL

Clinical Spectrum of Paediatric Traumatic Brain Injury – A Prospective Observational Study

[1]Dr. Shiji Chalipat, [2]Dr. Sandeep Kumar, [3]Dr. Vishwanath Kulkarni, [4]Dr. Sudhir Malwade
Pediatric Neurologist and Professor, Department of Pediatrics, Dr D Y Patil Medical College, Hospital and Research Centre, Pune, Maharashtra, India
Resident, Department of Pediatrics, Dr D Y Patil Medical College, Hospital and Research Centre, Pune, Maharashtra, India
Pediatric Neurologist, Department of Pediatrics, Dr D Y Patil Medical College, Hospital and Research Centre, Pune, Maharashtra, India
Professor, Department of Pediatrics, Dr D Y Patil Medical College, Hospital and Research Centre, Pune, Maharashtra, India

Abstract

Background and aim: Traumatic brain injury (TBI) is a significant global health concern and an important cause of mortality and morbidity in children. Understanding injury patterns and outcome variables would indeed help in better management and neurodevelopmental outcomes. Methods: An observational prospective study was done over a period of 2 years and the study population included children aged 3 months - 12 years within 72 hours of head injury. Clinical profile, neuroimaging patterns, management, and outcome on discharge were analyzed. Results: Out of 95 children, the mean age was 4.66 ±3.61 years and M: F 1.76:1. Mild TBI was seen in 70.5%, moderate TBI in 19%, and severe TBI in 10.5% of children. Fall from height was the most common mode of injury and abnormal neuroimaging was noted in 69.4% of children. Fracture skull was the most common neuroimaging abnormality found. Conservative management was the main mode of treatment, 30 children (31.6%) required intensive care, and surgical intervention was required in 8 (8.4%) children. The mean duration of hospital stay was 5.29±6.6 days. Overall mortality rate was 2%, good outcome was noted in 88(92.6%) and poor outcome in 7 (7.3 %) children. The factors associated with poor outcomes were severe TBI, signs of raised ICP, abnormal neurological examination, and mode of injury by RTA. Conclusions: TBI is more commonly seen in school-aged children, accidental falls being the most common mode of injury. The majority of children had mild TBI and the overall outcome was really good. The most effective predictor of poor outcome was GCS-based TBI severity grading.

Key Words: traumatic brain injury, children, mode of injury, neuroimaging, outcome Running Title: Pediatric Traumatic Brain Injury

Introduction

Traumatic brain injury (TBI) is one of the most common causes of acquired disability during childhood and has become a global health problem with high number of cases reported from both developed and developing countries(1).

The worldwide incidence of pediatric traumatic brain injury (TBI) is 691 per 1,00,000 population treated in the emergency department, 74 per 1,00,000 treated in hospital, and 9 per 1,00,000 resulting in death(2). The unprecedented motorization, urbanization, rapid industrialization, and changing lifestyles along with the absence of safety policies and program has added further to this burden.

The burden of pTBI in India is unknown. In India, children <15 years constitute 35% of the total population and available literature on pTBI suggests that it constitutes 20-30% of all TBIs(3-6). Trauma is secondary to falls and Road Traffic Accidents (RTA) have been reported as the leading cause of pTBI with a mortality rate of 2-10%(7,8). There are no national guidelines for the management of TBI. Early resuscitation and immediate transport to a medical facility would have a definite impact on the outcome. Various factors affecting the outcome are the severity of the injury, children injured in RTA, significant secondary injuries, cerebral contusions, and diffuse axonal injury on neuroimaging(7-9). Various studies proves that compared to adults, children with TBI are more vulnerable to long-term cognitive deficits and they need a long-term neurodevelopmental follow-up (10).

We lack enough data on children on epidemiology and outcome(3,11,12) and there is no national registry for pTBI in India. Hence, analyzing and understanding the epidemiology, injury patterns, and economic burden is

ISSN:2093-4777 | E-ISSN:2093-6931
DOI: 10.5123/inj.2023.4.in72
Vol. 27 Iss. 4 (2023)

essential to guide future prevention efforts and policies. It will also help to improve clinical management and establish public campaigns. Therefore, this study was undertaken to describe the clinico-demographic profile, neuroimaging patterns, outcome, and factors influencing outcomes in children with TBI of varying severity.

Methodology

This was a prospective, observational, cross-sectional study conducted at the Department of Paediatrics, Dr D Y Patil Medical College, Hospital and Research Centre, Pune, India over 2 years duration (August 2019 – July 2021). The study population included children aged 3 months - 12 years admitted to the pediatric ward or ICU with a history of traumatic brain injury (TBI) of both genders presenting within 72 hours of head injury. Children presenting after 72 hours of TBI, children with polytrauma, and children who have known cases of epilepsy, pre-existing significant neurological disorders, bleeding disorders, and previous history of TBI were excluded from the study. Institutional ethics committee clearance was obtained before the commencement of the study. Written informed consent from parents was taken before enrolment in the study.

The study sample size included 95 subjects calculated based on an average global incidence of 6.9 cases in 1000 population and our hospital incidence rate of 4.5 cases of pediatric TBI per 1000 admissions in the pediatric ward (which makes 5.7 per 1000 cases), taking an acceptable difference of 1.5 per 1000 at a confidence level of 95 %. The calculations were done by the WinPepi application.

Clinical details were documented on a structured clinical proforma. It included socio-demographic characteristics, details of injury like type and mechanism of injury, previous medical history, symptomology and assessment of sensorium based on Glasgow coma scale (GCS), vitals, general examination, neurological examination, neuro-imaging findings, details of management and duration of stay and outcome on discharge. Based on the GCS score at the time of presentation, the severity of TBI was graded as mild (GCS 13-15), moderate (GCS 9-12) and severe (GCS 3-8). Hemodynamic instability included hypoxia (PaO_2 <60 mmHg and/or SaO_2 <90% or suspected by clinical signs such as cyanosis), hypotension (systolic blood pressure <90 mmHg, patients reported to be in shock and/or absent brachial pulse not related to extremity injury) and hypothermia (documented core temperature <35°C).

All cases were primarily resuscitated and evaluated in the emergency room and were later shifted to the pediatric ward / ICU. CT Bain was done as per PERCAN guidelines(13) which included a) All children with GCS <12 or GCS between 13-15 with any focal neurological deficit b) History of post-traumatic seizure c) Post-traumatic amnesia or behaving not normal as per parent d)Progressive headache e) Loss of consciousness lasting for more than 5 minutes f) Physical signs of basilar skull fracture g) Repeated vomiting (>3 episodes) or vomiting more than 8 hours after trauma h) Severe mechanism of injury i)Scalp-hematoma over parietal, temporal or occipital area j) Palpable skull fracture.

Treatment was individualized as per clinical severity, hemodynamic stability, neurological status, and neuroimaging findings. Management protocols were followed as per standard institute PICU guidelines. Neurosurgery consultations were taken in indicated cases and surgical management was done accordingly. The outcome on discharge was assessed based on the Glasgow Outcome Score (GOS). It is a 5-scaled tool, GOS-5 is classified as good recovery, GOS-4 as moderate disability, GOS-3 as severe disability, GOS-2 as persistent vegetative state, and GOS-1 as death. Good outcomes included 4 and 5 scores of GOS and poor outcomes included 1,2 and 3 scores of GOS.

Data Analysis

Data was entered into Excel spreadsheets and variables for this study were analyzed using IBM SPSS Statistics 28.0.0.0, and the conclusions were at a 5% significant level. To present the data, the mean and standard deviations were employed. Continuous Variables were calculated as frequency and percentages, t-tests, and ANOVA. Bivariate binomial logistic regression and multivariate binomial logistic regression were used to assess the variables influencing the outcome. The selected model results were expressed as an odds ratio, OR (95% Confidence Interval (CI).

Results

There were 123 patients admitted with traumatic brain injury during the period of 2 years. Out of 123 children, 95 children were enrolled in the study fulfilling inclusion criteria after getting informed consent from parents/guardians. 28 children were excluded because of various reasons (16 cases were admitted after 72 hours of TBI, 6 cases had polytrauma, 3 cases had pre-existing epilepsy, and 3 cases were left against medical advice).

Table No. 1 depicts the demographic features, severity grading of TBI, mode of injury, symptomatology, and examination findings. The mean age of the study population was 4.66 ± 3.61 years and the majority of children belonged to the 6-12 years age group (39%). A male gender preponderance was noted (M: F - 1.76:1). Majority of children belonged to the upper lower class (47.4%) followed by the lower middle class (41%) socioeconomic group. Based on the GCS score on admission, 67 children (70.5%) had mild TBI, 18 children (18.9%) had moderate TBI and 10 children (10.5%) had severe TBI.

Table No 1 – Sociodemographic and clinical profile of children with TBI

	Variable	Number of cases	Percentage
1.	**Age group**		
i.	3 months – 1 year	8	8.4%
ii.	1-3 years	22	23%
iii.	4-6 years	28	29%
iv.	7-12 years	37	39%
	Mean age 4.66 years ± SD 3.6		
2.	**Gender**		
i.	Males	60	63.16%
ii.	Females	35	36.84%
	M: F – 1.76: 1		
3.	**Socioeconomic status**		
i.	Upper middle	4	4.2 %
ii.	Lower middle	39	41.1%
iii.	Upper lower	45	47.4%
iv.	Lower	7	7.4%
4.	**Severity of TBI**		
i.	Mild	67	70.5 %
ii.	Moderate	18	18.9%
iii.	Severe	10	10.5%
5	**Mode of injury**		
i.	Fall from height	53	55.7 %
ii.	RTA	14	14.7%
iii.	Struck against objects	8	8.4%
iv.	Sports injury	14	14.7%
6	**Symptoms on presentation**		
i.	Loss of consciousness	27	28.4%
ii.	Vomiting	57	60%
iii.	Headache	29	31%
iv.	Ecchymosis	11	11.5%
v.	Scalp swelling	17	17.8%
vi.	Seizures	11	11.5%
vii.	ENT bleed	15	15.7%
7.	**Abnormal Examination findings**		
i.	Signs of raised ICP	21	22%
ii.	Hemodynamically unstable	16	16.8%
iii.	Abnormal Neurological examination	17	17.8%

RTA – Road traffic accidents, ICP- Intra cranial pressure

Mode of injury

Fall from height was the most common cause of TBI (53.7%) followed by Road Traffic Accidents (RTA - 14.8%) and sports injuries (14.8%). No cases of child abuse were reported in our cohort.

Symptomatology

The most common presenting symptom was vomiting (60%), followed by headache (29/30.5%) and then loss of consciousness (28.4%). Scalp swelling was seen in 17 children (17.8%), ENT bleeding in 15 children (15.8%), periorbital ecchymosis and seizures in 11 children (11.6%), and 4 cases (5.3 %) presented with hemiparesis.

ISSN:2093-4777 | E-ISSN:2093-6931
DOI: 10.5123/inj.2023.4.in72
Vol. 27 Iss. 4 (2023)

Clinical examination findings

On admission, 16 children (16.8%) were hemodynamically unstable. Signs of raised Intracranial Pressure (ICP) were noted in 21 (22%) children and 12 (12.6%) had papilledema. Abnormal neurological examination was noted in 17 children (17.8%) which included, cranial nerve palsies in 11 children (abducent nerve - 6, oculomotor nerve - 4, glossopharyngeal and vagus nerve – 1) hypotonia in 10 children, hemiplegia in 4 and quadriplegia in one child. It was found that the presence of signs of raised ICP, hemodynamic instability, and abnormal neurological examination were associated with moderate and severe TBI.

Neuroimaging patterns

Neuroimaging was done in all children, CT Brain being the main modality used and MRI brain was done in indicated cases of moderate and severe TBI. Normal neuroimaging was noted in 29 (30.5%) of children and 66 (69.4%) had abnormal findings. Table 2 depicts the various neuroimaging patterns.

The commonest finding was skull bone fracture (70.5%), followed by intracranial haemorrhage-ICH (38%). Various ICH included – Subdural haemorrhage-SDH (15.7%), subarachnoid haemorrhage-SAH (10.5%), and extradural haemorrhage-EDH (10.5%). Cerebral edema was noted in 18 children (18.9%), parenchymal contusion in 8 (8.4%), diffuse axonal injury in 3 (3.1%), pneumocephalus in 5 (5.2%), and secondary infarcts in 5 children (6.3%).

The commonest skull fracture was seen over the parietal bone (22.1%) followed by frontal bone (18.9%), temporal bone (13.7%), occipital bone (8.4%), and base of skull (7.4%) in decreasing order. Concurrent injuries included facial (19%) and spine injuries (1%).

Table No 2 – Neuroimaging patterns of children with TBI

S No	Neuroimaging findings	Number of cases	Percentage
1	Normal	29	29
2	Skull bone fractures	54	56.8%
3	EDH	10	10.5%
4	SDH	15	15.7%
5	SAH	10	10.5%
6	Cerebral Oedema	18	18.9%
7	Parenchymal hemorrhage and contusion	8	8.4%
8	Diffuse Axonal Injury	3	3.1%
9	Pneumocephalus	5	5.2%
10	Secondary infarct	6	6.3%

SDH – Subdural hemorrhage, EDH – Extra dural hemorrhage, SAH – Subarachnoid hemorrhage

Management

Out of 95 children, 30 (31.6%) required intensive care which mainly belonged to moderate (100%) and severe grade TBI (100%). Two children with mild TBI (3%) were admitted to the ICU for observation as they were infants with severe mechanisms of injury. Ventilatory support was required in 9 children (9.4%) (severe TBI – 8 cases and moderate TBI – 1 case). Conservative management was done for 87 cases (91.5%) which included all mild TBI cases (67), 14 cases of moderate TBI, and 6 cases of severe TBI. Neurosurgical interventions were required in 8 children belonging to moderate (22.2%) and severe (40%) TBI.

Conservative management included anti-cerebral edema measures (34.7%), antiseizure medications (ASMs) (46.5%), and other supportive measures. Commonly used anti-cerebral edema medications were 3% sodium chloride and mannitol. Steroids were not given to any of the children. 11 children (11.5%) with post-traumatic seizures received therapeutic ASMs and 33 children(34.7%) received prophylactic ASMs. Commonly used ASM was levetiracetam (77.5%) followed by fosphenytoin (16.3%) and 4 children had status epilepticus requiring multiple ASMs. Various neurosurgical interventions done were decompressive craniotomy (6.3% – SDH, EDH), the elevation of depressed fracture (1% - compound fracture skull), craniectomy (1% - cerebral contusion with infarct and severe cerebral edema) and atlantoaxial fixation (1% – cervical spine injury).

Duration of stay

The mean duration of hospital stay was 5.29 +/- 6.6 days. All the children with mild TBI had a duration of stay of less than 5 days, 18 children (18.9%) had a stay of 6-10 days who belonged to moderate and severe TBI, while 10 children (10.5%) had a stay >10 days who belonged to severe grade TBI.

Outcome

It was found that out of 95 cases, 88 (92.6%) had complete recovery, while 5 (5.2%) had partial recovery (hemiplegia- 4/4.2%), quadriplegia (1/1%)) and 2 children died (2%) who had severe TBI.

The outcome was assessed on discharge based on the Glasgow coma outcome score (GOS). Good recovery with (a score of 5) was noted in 88 children (93%), severe disability (score of 3) in 4 children (4.2%) who had hemiplegia, persistent vegetative state (score of 2) in 1 child (1%) who had a cervical spine injury and quadriplegia, and death (score1) happened in 2 children (2%). It was concluded that 92.6 % had good outcomes and 6.4 % had poor outcomes.

Factors influencing outcome

Table No 3 demonstrates details of factors associated with poor outcomes. In a univariate analysis, severe TBI (OR=126, R=0.691, P<0.001), signs of raised ICP (OR-258, R=0.785, P<0.001) and abnormal neurological examination (OR=126, R=0.691, P<0.001) were found to be highly correlated with poor outcome and thus were eliminated in step 2 of multivariate analysis. In the final equation, injury by RTA (OR=11.64, P=0.007) and duration of stay >5 days (OR=7.91, P=0.028) were found to have a significant association in children with poor outcomes. Age < 5 years (OR=0.8), injury by fall from height (OR=0.45), and abnormal neuroimaging (OR=0.12) were found to have lower risk and hence were eliminated in multivariate analysis.

Table No - 3 – Univariate and multivariate analysis of factors associated with poor outcome

Parameters	**Univariate Analysis**				**Multivariate Analysis**		
	Odds Ratio	**95% CI**	**R value**	**p value**	**Odds Ratio**	**95% CI**	**p value**
Severe TBI	126.00	(2.494, 7.179)	0.691	**<0.001**			
Duration of stay >5 days	7.065	(1.2812,38.9610)	0.260	**0.025**	7.912	(0.0419,43.7493)	**0.028**
Injury by RTA	10.400	(2.0269,53.3630)	0.337	**0.005**	11.641	(0.3067,176.3366)	**0.007**
Injury by fall from height	0.450	(0.0948,2.1370)	-0.105	0.315			
Sign of raised ICP	258.00	(20.366,3268.458)	0.785	**<0.001**			
Abnormal neurological examination	126.00	(12.1057,1311.4477)	0.691	**<0.001**			
Age < 5 years	0.800	(0.1685,3.7991)	-0.029	0.779			
Abnormal Neuroimaging	0.121	(0.0140,1.0473)	-0.229	0.055			

Discussion

In this prospective observational study, 95 children with traumatic brain injury (TBI) were enrolled. The mean age of the study population was 4.66 ± 3.6 years which was in agreement with other studies suggesting the highest incidence of TBI is reported in school-aged children(3,8,14-16). A male gender preponderance was noted which has been shown by other studies as well(3,8,11,14-17). A higher incidence of TBI in males may be due to more physical activities and participation in sports as compared to female children.

In our cohort, the majority of children had mild TBI (70.5%), comparable to various studies (3,12,14,17). Mild TBI was induced by a variety of causes, whereas moderate and severe TBI were primarily due to RTA. In contrast, Udoh et al(15) and El-Menyar et al(18) reported maximum cases of severe-grade TBI in their study population.

The most common mode of injury was fall from height (54%) followed by road traffic accidents (14.7%) and sports injury (14.7%). Patients with severe TBI belonged to these three modes of injuries. These findings were in harmony with other studies (3,4,11,19). Contrary to this, few other authors reported RTA as the most

ISSN:2093-4777 | E-ISSN:2093-6931
DOI: 10.5123/inj.2023.4.in72
Vol. 27 Iss. 4 (2023)

common mode of injury(7,9,18). Therefore, we should sensitize parents to be more watchful and diligent as well as take the proper safety precautions at home and play area.

In congruent with various studies from India (14,20), the most frequent clinical manifestations were vomiting (60%), loss of consciousness (28.4%), and headache (28.4%). In contrast, few studies have reported loss of consciousness as the most common presentation (9,12) and Nitnaware et al (21) showed seizures as the most common presentation.

In the present cohort, we found that the presence of signs of raised ICP, hemodynamic instability, and abnormal neurological examination were associated with moderate and severe TBI. This is in agreement with the results of other studies (9,12,22).

Some life-threatening injuries can present initially as mild TBI adding to the challenges in diagnosis and evaluation of such injuries (23). This was the reason for doing CT brain in all children with TBI in our cohort. No intracranial abnormality was detected in 29 (30.5%) children on initial neuroimaging. The commonest findings were skull bone fracture (70.5%), followed by intracranial bleed (38%). The presence of skull fractures, SDH, SAH, parenchymal contusion, cerebral edema, and diffuse axonal injuries was seen in children with severe grade TBI. Different patterns of primary and secondary impact injuries on imaging and their association with the severity of TBI seen in our cohort were in concordance with other studies (3,7,11,14,18,20,21). On the contrary, Mahapatra et al (4) have reported EDH and contusion as the most common neuroimaging finding. All the children were managed as per standard management guidelines and agreed with other studies (3,7,11,12,14,24).

As reported in several other comparable studies, the present study noted good recovery in 88 cases (92.6%) and overall mortality was 2%. This may be due to a smaller number of patients in the severe TBI group and greater potential for recovery in children (25-28). The great potential for recovery has been explained by reasons such as greater flexibility of cranial bones in young children, a higher capacity of traumatic force absorption, and great differences in the presence of comorbidities (7).

In the current study, the most effective predictor of outcome was GCS-based severity scoring on admission. GCS is a simple bedside scoring system that will assist clinicians in timely decisions in imaging and management. This was by findings of other studies stressing the importance of initial GCS scores (16,29). In the present cohort, other independent variables significantly associated with poor outcomes were signs of raised ICP (OR-258, R=0.785, P<0.001) and abnormal neurological examination (OR=126, R=0.691, P<0.001). Similar findings related to poor outcomes have been reported by various studies (7-9,30). Even though neuroimaging findings were strongly associated with moderate and severe grade TBI, there was no statistical significance found between imaging and outcome in our study (OR=0.12).

Strengths

We used the Glasgow outcome score, which proved to be a very effective bedside clinical assessment scale to assess the outcome of children with TBI, and outcome variables were analyzed.

Limitations

Being a tertiary care referral center, the results may not be representative of the general population and might differ compared to community-based studies.

Conclusion

TBI was more commonly seen in school-aged children, accidental falls being the most common mode of injury. The majority of children had mild TBI and the overall outcome was good. GOS-based outcome analysis is a simple bedside scoring system that can be used in our routine clinical practice. Educational and information campaigns among parents and caregivers should be encouraged to increase knowledge on ways to improve home, road, and pedestrian safety. A national pediatric TBI registry is needed of the hour which would be very much helpful in policy making and management**.**

Acknowledgments: The authors would like to thank the parents of all the patients, hospital and PICU doctors and staff, the Department of Radiology, Department of Neurosurgery, and Dr D Y Patil Medical College, Hospital and Research Centre, Pune, Maharashtra, India.

Funding: None

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement, etc.) that might pose a conflict of interest in connection with the submitted article.

References

1. Dewan MC, Mummareddy N, Wellons JC 3rd, Bonfield CM. Epidemiology of Global Pediatric Traumatic Brain Injury: Qualitative Review. World Neurosurg. 2016 Jul;91:497-509.e1. doi: 10.1016/j.wneu.2016.03.045. Epub 2016 Mar 25. PMID: 27018009.
2. Thurman DJ. The Epidemiology of Traumatic Brain Injury in Children and Youths: A Review of Research Since 1990. J Child Neurol. 2016 Jan;31(1):20-7. doi: 10.1177/0883073814544363. Epub 2014 Aug 14. PMID: 25123531.
3. Madaan P, Agrawal D, Gupta D, Kumar A, Jauhari P, Chakrabarty B, Pandey RM, Paul VK, Misra MC, Gulati S. Clinicoepidemiologic Profile of Pediatric Traumatic Brain Injury: Experience of a Tertiary Care Hospital From Northern India. J Child Neurol. 2020 Dec;35(14):970-974. doi: 10.1177/0883073820944040. Epub 2020 Aug 4. PMID: 32748676.
4. Dara PK, Parakh M, Choudhary S, Jangid H, Kumari P, Khichar S. Clinico-radiologic Profile of Pediatric Traumatic Brain Injury in Western Rajasthan. J Neurosci Rural Pract. 2018 Apr-Jun;9(2):226-231. doi: 10.4103/jnrp.jnrp_269_17. PMID: 29725174; PMCID: PMC5912029.
5. Hsaio M, Malhotra A, Thakur JS, et al. Road traffic injury mortality and its mechanisms in India: nationally representative mortality survey of 1.1 million homes. BMJ Open. 2013;3:e002621. http://dx.doi.org/10.1136/bmjopen-2013-002621
6. Gomes M, Begum R, Sati P, Dikshit R, Gupta PC, Kumar R, Sheth J, Habib A, Jha P. Nationwide Mortality Studies To Quantify Causes Of Death: Relevant Lessons From India's Million Death Study. Health Aff (Millwood). 2017 Nov;36(11):1887-1895. doi: 10.1377/hlthaff.2017.0635. PMID: 29137507.
7. Riemann L, Zweckberger K, Unterberg A, El Damaty A, Younsi A; Collaborative European NeuroTrauma Effectiveness Research in Traumatic Brain Injury (CENTER-TBI) Investigators and Participants. Injury Causes and Severity in Pediatric Traumatic Brain Injury Patients Admitted to the Ward or Intensive Care Unit: A Collaborative European Neurotrauma Effectiveness Research in Traumatic Brain Injury (CENTER-TBI) Study. Front Neurol. 2020 Apr 30;11:345. doi: 10.3389/fneur.2020.00345. PMID: 32425879; PMCID: PMC7205018.
8. Wani AA, Sarmast AH, Ahangar M, Malik NK, Chhibber SS, Arif SH, Ramzan AU, Dar BA, Ali Z. Pediatric Head Injury: A Study of 403 Cases in a Tertiary Care Hospital in a Developing Country. J Pediatr Neurosci. 2017 Oct-Dec;12(4):332-337. doi: 10.4103/jpn.JPN_80_17. PMID: 29675071; PMCID: PMC5890552.
9. Bedry T, Tadele H. Pattern and Outcome of Pediatric Traumatic Brain Injury at Hawassa University Comprehensive Specialized Hospital, Southern Ethiopia: Observational Cross-Sectional Study. Emerg Med Int. 2020 Jan 29;2020:1965231. doi: 10.1155/2020/1965231. PMID: 32399303; PMCID: PMC7204112.
10. Purcell LN, Reiss R, Eaton J, Kumwenda KK, Quinsey C, Charles A. Survival and Functional Outcomes at Discharge After Traumatic Brain Injury in Children versus Adults in Resource-Poor Setting. World Neurosurg. 2020 May;137:e597-e602. doi: 10.1016/j.wneu.2020.02.062. Epub 2020 Feb 19. PMID: 32084614; PMCID: PMC7202968.
11. Bhargava P, Singh R, Prakash B, Sinha R. Pediatric head injury: An epidemiological study. J Pediatr Neurosci. 2011 Jan;6(1):97-8. doi: 10.4103/1817-1745.84428. PMID: 21977109; PMCID: PMC3173936.
12. Satapathy MC, Dash D, Mishra SS, Tripathy SR, Nath PC, Jena SP. Spectrum and outcome of traumatic brain injury in children <15 years: A tertiary level experience in India. Int J Crit Illn Inj Sci. 2016 Jan-Mar;6(1):16-20. doi: 10.4103/2229-5151.177359. PMID: 27051617; PMCID: PMC4795356.
13. 13 Ghizoni E, Fraga Ade M, Baracat EC, Joaquim AF, Fraga GP, Rizoli S, Nascimento B. Indications for head computed tomography in children with mild traumatic brain injury. Rev Col Bras Cir. 2013 Nov-Dec;40(6):515-9. English, Portuguese. doi: 10.1590/s0100-69912013000600016. PMID: 24573632.
14. Dara PK, Parakh M, Choudhary S, Jangid H, Kumari P, Khichar S. Clinico-radiologic Profile of Pediatric Traumatic Brain Injury in Western Rajasthan. J Neurosci Rural Pract. 2018 Apr-Jun;9(2):226-231. doi: 10.4103/jnrp.jnrp_269_17. PMID: 29725174; PMCID: PMC5912029.

15. Udoh DO, Adeyemo AA. Traumatic brain injuries in children: A hospital-based study in Nigeria. Afr J Paediatr Surg 2013;10:154-9. doi: 10.4103/0189-6725.115043. PMID: 23860067.
16. Sharma SP, Gopal NN. Head injury in children: a tertiary care center study. Int J Health Sci Res. 2020; 10(2):37-42.
17. Nnadi MO, Bankole OB, Fente BG. Epidemiology and treatment outcome of head injury in children: A prospective study. J Pediatr Neurosci. 2014 Sep-Dec;9(3):237-41. doi: 10.4103/1817-1745.147577. PMID: 25624926
18. El-Menyar, A., Consunji, R., Al-Thani, H. et al. Pediatric Traumatic Brain Injury: a 5-year descriptive study from the National Trauma Center in Qatar. World J Emerg Surg 12, 48 (2017). https://doi.org/10.1186/s13017-017-0159-9.
19. Tabish SA, Nabil Syed. Traumatic Brain Injury: The Neglected Epidemic of Modern Society, International Journal of Science and Research (IJSR); Volume 3 Issue 12, December 2014, 382-406.
20. Krishna Chaitanya, Archana Addanki, Rajendra Karambelkar et al. Traumatic brain injury in Indian children, Child's Nervous System,Child's Nervous System (2018) 34:1119–1123. https://doi.org/10.1007/s00381-018-3784-z2018.
21. NitnawareAS, Vagha J, Meshram R. Clinical profile of pediatric head injury. J Datta Meghe Inst Med Sci Univ 2017. 12:191-5. DOI: 10.4103/jdmimsu.jdmimsu_83_17.
22. Bahloul M, Chaari AN, Kallel H, Khabir A, Ayadi A, Charfeddine H et al. Neurogenic pulmonary edema due to traumatic brain injury: evidence of cardiac dysfunction. Am J Crit Care. 2006 Sep;15(5):462-70. PMID: 16926367.
23. van der Naalt J, Timmerman ME, de Koning ME et al. Early predictors of outcome after mild traumatic brain injury (UPFRONT): an observational cohort study. Lancet Neurol. 2017 Jul;16(7):532-540. doi: 10.1016/S1474-4422(17)30117-5.
24. Kochanek PM, Bell, MJ. Neurologic emergencies and stabilization. In: Kliegman RK, editor. Nelson Textbook of Pediatrics. 20th ed. Philadelphia; Elsevier; 2016. p. 50812.
25. Schneier AJ, Shields BJ, Hostetler SG et al. Incidence of pediatric traumatic brain injury and associated hospital resource utilization in the United States. Pediatrics. (2006) 118:483–92. doi: 10.1542/peds. 2005-2588
26. Amaranath JE, Ramanan M, Reagh J et al. Epidemiology of traumatic head injury from a major pediatric trauma center in New South Wales, Australia. ANZ J Surg. (2014) 84:424– 8. doi: 10.1111/ans.12445.
27. Greene NH, Kernic MA, Vavilala MS, Rivara FP. Variation in pediatric traumatic brain injury outcomes in the United States. Arch Phys Med Rehabil. (2014) 95:1148–55. doi:10.1016/j.apmr.2014.02.020.
28. Robertson BD, McConnel CE, Green S. Charges associated with pediatric head injuries: A five-year retrospective review of 41 pediatric hospitals in the US. J Inj Violence Res. (2013) 5:50–60. doi: 10.5249/jivr. v5i1.205.
29. Chung C-Y, Chen C-L, Cheng P-T, See L-C, Tang SF-T, Wong AM-K. Critical score of Glasgow Coma Scale for pediatric traumatic brain injury. Pediatr Neurol 2006;34: 379-387. https://doi.org/10.1016/j.pediatrneurol.2005.10.012
30. Suresh HS, Praharaj SS, Indira Devi B, Shukla D, Sastry Kolluri VR. Prognosis in children with head injury: An analysis of 340 patients. Neurol India 2003;51:16-8. PMID: 12865508.