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Original Article

Characteristics of Children Admitted with Moderate and Severe Brain Injury: A Three-Year Investigation in the Southwest of Iran

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Abstract

Background: Considering the burden of moderate and severe brain injury on families and society, and that trauma is one of the common causes of death and disability in Iran, this study aimed to investigate the frequency of death from severe to moderate brain injury in children with brain trauma.
Methods: In this cross-sectional study, records of 126 patients under 18 years of age with moderate and severe brain injuries admitted to Namazi Hospital, Shiraz, Iran during 2017-2019 were investigated. The relative frequency of mortality, parents' education level, day of trauma, types of trauma, age, gender, and length of hospitalization were studied. P values were set at 0.05; Chi-square and T-test were used for variable comparisons.
Results: The study's male-to-female ratio was almost 2:1, and the mean and standard deviation of the age of all children in the study was 6.84±4.33. The relationship between brain injury severity and hospitalization length was significant (P<0.001). 21.4% of patients with moderate and severe brain injury were Afghan. The highest frequency of trauma was related to accidents, with 69.8%, followed by falling down at 23.8%.
Conclusion: The most common cause of death in children with brain injury was trauma caused by an accident. To decrease the burden of severe and moderate brain injury in children, health policymakers may tailor interventions to two important groups, including parents with a low level of education and Afghan nationals.

Keywords: Child Injuries, Brain, Death

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1. Introduction

Traumatic brain injuries in children have become a significant public health concern, particularly in developing countries. Recent studies have shown that children under the age of six experience more difficulties in neurocognitive development following head injuries than older children (1-3). In the United States, around 475,000 people between the ages of 0-14 suffer from traumatic brain injuries. Of these, 90% are discharged with mild injuries, 37,000 are hospitalized, and over 2,500 people die. Hospitalization for traumatic brain injury is more common among adolescents, and boys require more emergency consultations and hospitalizations than girls (4). Head trauma due to abuse is also prevalent among infants and children under the age of two. Approximately 30 out of every 100,000 children below the age of one are hospitalized due to this issue (5).

Children's skulls are more malleable than those of adults, and they absorb external forces differently. The softness of a baby's skull, along with the open sutures of the skull that act as joints, allows for a small amount of movement against pressure (6). Shaking a baby can cause a small change in the shape of the skull, and the malleable state of the skull distributes this force between the skull and the vessels of the cortex and brain. Consequently, the vessels and parenchyma of the brain may be stretched (7). During myelination development, different regions of the brain exhibit varying degrees of myelination. This process follows a specific pattern, and the degree of myelination affects the absorption of traumatic forces. Areas without myelination are more vulnerable to brain damage caused by trauma (8, 9).

Given the increased vulnerability of children's brains, the risk of injuries caused by abuse, and the social burden on families, especially those

with disabled children after brain injuries caused by trauma, this study aimed to investigate the frequency of severe and moderate brain injury and death in children with brain trauma. Additionally, considering the lack of epidemiological studies conducted in Iran, the study examined the factors associated with the severity of the injury.

2. Methods

In this cross-sectional study, we reviewed the records of 126 patients below the age of 18 with severe and moderate brain injuries who were admitted for more than 6 hours to Namazi Hospital in Shiraz, Iran between 2017 and 2019. We excluded incomplete records from the study. In this study, we considered a Glasgow Coma Scale (GCS) score of 9 to 13 as moderate brain injury and a GCS score less than 9 as severe brain injury. We extracted demographic information, including age, sex, nationality, education level of parents, and other information, such as the type and cause of trauma, type of accident, day of trauma, duration of hospitalization, living status at the time of discharge, and level of consciousness based on GCS criteria at the time of hospital arrival. We analyzed the obtained data using SPSS version 18. We extracted central indicators, such as mean, frequency, and standard deviation from the data. We used Chi-square and t-test to determine the statistical relationship between the variables. P value less than 0.05 was considered statistically significant. This study was carried out after obtaining the approval of the Ethics Committee of the Shiraz University of Medical Sciences with the code IR.SUMS.MED.REC.1399.269. The written informed consent was waived by the ethics committee due to the review of the records; however, we applied all data confidentiality standards.

3. Results

In this study, we examined 126 patients under the age of 18 who suffered moderate or severe brain injuries and were admitted to Namazi Teaching Hospital, Shiraz, Iran between 2017-2019 in terms of epidemiological variables. The mean and standard deviation of the age of children with severe and moderate brain damage in the study were 6.84±4.33 years, and the mean and standard deviation of the length of hospitalization was 11.81±8.80 days. The ratio of boys to girls was almost 2:1. The highest frequency of education level was related to fathers and mothers with elementary literacy and then illiteracy. The lowest frequency was related to the level of master's education. In general, the frequency of patients decreased with increasing education levels. In this study, 21.4% of patients with moderate and severe brain injuries were of Afghan nationality.

The highest frequency of trauma was "related to the accident" with 69.8% of all traumas, followed by "falling down" with a 23.8% share. Most of the children who were injured in accidents were car passengers (56.8% of accidents). Pedestrians and motorcycle passengers accounted for 27.27% and 14.7% of the accidents, respectively. The lowest incidence of trauma was related to the middle days of the week, i.e. Monday, Tuesday, and Wednesday. The most traumas occurred on the weekend (Thursday and Friday) with 21.4% and 18.3%, respectively (Table 1).

Out of the 126 patients included in the study, 36 (28.6%) had a moderate brain injury and 90 (71.4%) had a severe brain injury. The average age of children with moderate brain injury was 6.17±4.53 and the average age of children with severe brain injury was 7.11±4.24. This difference was not statistically significant (P=0.27). The length of hospital stay for children with moderate brain injury was 6.81±5.26, whereas for children with severe brain injury, it was 13.81±9.15. This significant difference was statistically significant (P<0.001) (Table 2).

Among the patients with moderate and severe brain injuries, 88 were boys and 38 were girls, and the number of boys with moderate and severe brain injuries was almost double the number of girls. 26.3% of girls and 29.5% of boys had moderate brain damage, and 70.5% of boys and 73.7% of girls had severe brain injuries. No significant difference was observed between gender and severity of brain injury (P=0.71) (Table 3).

All patients who died had severe brain injuries. Although 76 (67.9%) children with severe brain injuries were discharged from the hospital alive, 14 (11%) out of 126 patients included in the study died. The relationship between the severity of brain injury and death was statistically significant (P=0.04).

The number of hospitalized patients with

Table 1: Demographic information of the participants

Variable	Variable subset	Percentage/Avg	Frequency/Avg
Age		4.33±6.48	
Duration of hospitalization		8.80±11.81	
Sex	Boy	69.8	88
	Girl	30.2	38
Father's education level	Illiterate	19.8	25
	Primary	42.1	53
	Diploma	5.6	7
	Associate degree	7.1	9
	Bachelor's degree	4.8	6
	Master's degree	1.6	2
Mother's education level	Illiterate	25.4	32
	Primary	38.1	48
	Diploma	5.6	7
	Associate degree	9.5	12
	Bachelor's degree	1.6	2
	Master's degree	0.8	1
Nationality	Iranian	78.6	99
	Afghan	21.4	27
Day of trauma	Saturday	14.3	18
	Sunday	14.3	18
	Monday	10.3	13
	Tuesday	11.1	14
	Wednesday	10.3	13
	Thursday	21.4	27
	Friday	18.3	23
Type of trauma	Accident	69.8	88
	Falling down	23.8	30
	Conflict	2.4	3
	Other	4	5
Type of accident	Pedestrian	27.27	24
	Motorcycle passengers	14.7	13
	Car passengers	56.8	50
	Car turnover	1.1	1

Table 2: Comparison of the mean age and mean duration of hospital admission in different severity of brain injury

	Severity of brain injury		P value
	Severe	Moderate	
Age *	4.24±7.11	4.53±6.17	0.27
Duration of hospitalization*	9.15±13.81	5.26±6.81	<0.001

*Mean±Std deviation

Table 3: The severity of brain injury based on gender

		Severity of brain injury		P value
		Severe	Moderate	
Gender	Boy	62 (70.5)	26 (29.5)	0.71
	Girl	28 (73.7)	10 (26.3)	

Data are presented as N (%)

moderate and severe brain damage, according to the studied years 2017, 2018, and 2019, was 49, 48, and 29 patients, respectively. Table 4 shows the average age, duration of hospitalization, mortality, and gender distribution for patients with moderate and severe injuries, separated by the years studied. The highest average age of patients with severe brain damage was 15.7±33.4 in 2018, while the

Table 4: Trauma severity of children in different years based on their characteristics

		Severity of brain injury	2017	2018	2019	P value
Age		Moderate	6.53±4.97	5.11±34.4	6.50±4.00	0.73
		Severe	6.28±3.88	15.7±33.4	8.19±4.49	0.53
The duration of hospitalization		Moderate	6.26±4.30	6.00±7.17	9.00±4.98	0.42
		Severe	12.67±8.86	15.44±10.13	12.43±7.36	0.34
Mortality		Severe	6 (4.76%)	6 (4.76%)	2 (1.58%)	0.38
Gender	Boys	Moderate	11 (57.9%)	7 (77.8%)	8 (100%)	0.76
	Girls		8 (42.1%)	2 (22.2%)	0 (0%)	
	Boys	Severe	23 (76.7%)	22 (56.4%)	17 (81%)	0.78
	Girls		7 (23.3%)	17 (43.6%)	4 (19%)	

Data are presented by mean±Std Deviation

lowest average age was 5.11±34.4 in the same year. Also, the maximum and minimum duration of hospitalization were related to the year 2018 with values of 15.44±10.13 and 6.00±7.17, respectively. On the other hand, the death rate in 2019 decreased compared to the previous two years. In terms of gender distribution, in all the studied years, the percentage of moderate and severe brain damage was higher in boys than in girls, and in 2019, this difference reached its highest value.

4. Discussion

This study aimed to investigate the frequency of death resulting from severe and moderate brain injuries in children with brain trauma. More than ten percent of children included in the study died; the patients who died had severe brain injuries. This finding highlights the preventive and curative necessities for child trauma.

In this study, the duration of hospitalization in children with severe brain injury was almost twice of the duration of admission of children with moderate brain injury. This result was consistent with the study by Izadi Avanji and colleagues regarding the relationship between functional outcome and the average length of hospitalization (10). Naturally, the lower the Glasgow Coma Scale (GCS) score and the more severe the brain injury, the more time is needed for recovery and treatment. This finding is also in line with study of Ariaka and co-workers, which suggested that GCS can predict hospitalization rates (11). Therefore, more attention should be paid to the severity of brain damage caused by trauma for post-treatment care and also predicting the consequences and informing parents for further care after discharge should be considered.

Considering the greater ratio of boys to girls in moderate and severe cases of brain damage caused by trauma in the present study (the ratio is approximately 2 to 1), these results agree with the findings of Chaitanya and colleagues (12). The higher ratio of boys to girls in brain injuries can be an indication of boys' higher risk-taking. Even in studies conducted on adults, the ratio of men to women is also higher (4).

The possibility of long-term effects of trauma on children's behavior and cognitive abilities, as well as the progress of brain damage caused by trauma, indicated the need to pay attention to special care after physical recovery and rehabilitation programs in different areas for children who have brain damage caused by trauma (2). It is suggested to develop programs to educate parents and children to reduce the incidence of these injuries.

In the present study, the highest incidence of trauma was related to accidents, with 69.8% of the total traumas causing severe and moderate concussions in the children studied. The majority of these accidents occurred when the injured child was a passenger in a car. Considering the high rate of accidents in Iran compared to the world average, as well as in developed countries, it can be said that vehicle traffic accidents play a significant role in the occurrence of brain damage caused by trauma in Iran. In study of Sarnaik and colleagues, the most common cause of injury was a vehicle accident (13).

In this study, the average age of children with severe brain injury was more than average age of children with moderate brain injury; however, this difference was not statistically significant. The average age of children in this study was similar to the findings of Langlois and colleagues (14). The noteworthy point is that in these traumas, children were passengers of motorcycles or cars, so their age did not play a role in causing this trauma and accident. Preventive measures and tools are

important to protect these children and reduce the damage caused by vehicle traumas.

In the current study, the education level of the parents of children who suffered brain damage was mostly elementary and illiterate. Only one fifth of the parents of the children had education above the elementary level. In general, with an increase in the education level of parents, the number of children with brain damage decreased.

One fifth of patients with moderate and severe brain injury were Afghan. This is a very high number considering the relatively low frequency of the total population of Afghans compared to the population of Iran. The reason for this finding may be the lack of suitable educational platforms for Afghan nationals and their children in the country, as well as the greater exposure of their children to the dangers of accidents due to working at a young age. No similar study investigating concussions in children or adults and among Afghan nationality in Iran was found for comparison.

In our study, none of the 36 patients with moderate brain injury died. All patients who died had a severe brain injury. The most common cause of death in brain trauma patients was related to trauma, followed by surgery and related complications. In general, one tenth of the children included in the study died and there was significant relationship between the severity of brain injury and death. The association between low GCS and mortality from trauma has been previously confirmed (15). In study of Chaitanya and colleagues, the overall mortality in children with traumatic brain injury was 5.26%, which is almost half of the mortality rate in patients with brain trauma in this study (12).

The severity of brain injury has a significant relationship with the length of hospitalization and the cause of death. Age and gender were similar in the two groups of children with severe brain injury and those with moderate brain injury. The most common cause of death in patients with brain trauma is trauma-related factors. The relative frequency of brain damage in children is inversely related to the level of education of parents and their attitudes, which indicates the need for education and awareness for this group of parents. Afghan children suffer from brain damage more than Iranian children.

By comparing the three years examined, the number of patients in 2019 was almost half of the patients two years ago. Considering that 2019 was the first year of the COVID pandemic, the reduction in the occurrence of trauma can be justified.

Finally, it is suggested to conduct a study with a larger statistical population, including different age groups of children and multiple trauma centers, in order to obtain more comprehensive and valid results. It is also recommended that training be provided to both children from preschool age and onwards, as well as parents before having children, to ensure children's safety while traveling in vehicles. Also, training should also be done for the immigrant families in Iran, including Afghans.

4.1. Limitations

This study was limited by its cross-sectional nature, which requires more caution when making statements about causality. Further multicenter studies with larger samples are strongly recommended.

5. Conclusion

The most common cause of death in children with brain injuries is trauma caused by the accidents. In order to decrease the burden of severe and moderate brain injuries in children, health policymakers may consider tailoring interventions to two important groups, including parents with low levels of education and those of Afghan nationality.

Acknowledgement

We would like to thank the parents of the children for their cooperation.

Ethical Approval

This project was carried out after the approval of the Ethics Committee of the Faculty of Medicine with the code IR.SUMS.MED.REC.1399.269. Also, written informed consent was waived by the ethics committee due to the review of the records; however, we applied all data confidentiality standards.

Conflict of Interests: None declared.

References

1. Stocchetti N, Conte V, Ghisoni L, Canavesi K,

Zanaboni C. Traumatic brain injury in pediatric patients. Minerva Anestesiol. 2010;76(12):1052-9. PubMed PMID: 21178914.
2. Taylor HG, Yeates KO, Wade SL, Drotar D, Stancin T, Minich N. A prospective study of short- and long-term outcomes after traumatic brain injury in children: behavior and achievement. Neuropsychology. 2002;16(1):15-27. doi: 10.1037//0894-4105.16.1.15. PubMed PMID: 11853353.
3. Winn HR. Youmans neurological surgery. Philadelphia, PA: Elsevier/Saunders; 2011.
4. Faul M, Xu L, Wald MM, Coronado V, Dellinger AM. Traumatic brain injury in the United States: national estimates of prevalence and incidence, 2002–2006. Injury Prevention. 2010;16(Suppl 1):A268-A. doi: 10.1136/ip.2010.029215.951.
5. Eisele JA, Kegler SR, Trent RB, Coronado VG. Nonfatal Traumatic Brain Injury–Related Hospitalization in Very Young Children—15 States, 1999. J Head Trauma Rehabil. 2006;21(6):537-43. doi: 10.1097/00001199-200611000-00008. PubMed PMID: 17122684.
6. Ghajar J, Hariri RJ. Management of pediatric head injury. Pediatr Clin North Am. 1992;39(5):1093-125. doi: 10.1016/S0031-3955(16)38409-7. PubMed PMID: 1523019.
7. Ommaya A, Goldsmith W, Thibault L. Biomechanics and neuropathology of adult and paediatric head injury. Br J Neurosurg. 2002;16(3):220-42. doi: 10.1080/02688690220148824. PubMed PMID: 12201393.
8. Reeves TM, Phillips LL, Povlishock JT. Myelinated and unmyelinated axons of the corpus callosum differ in vulnerability and functional recovery following traumatic brain injury. Exp Neurol. 2005;196(1):126-37. doi: 10.1016/j.expneurol.2005.07.014. PubMed PMID: 16109409.
9. Stark MJ, Hodyl NA, Andersen CC. Intrauterine inflammation, cerebral oxygen consumption and susceptibility to early brain injury in very preterm newborns. Arch Dis Child Fetal Neonatal Ed. 2016;101(2):F137-F42. doi: 10.1136/archdischild-2014-306945. PubMed PMID: 26265677.
10. Izadi Avanji FS, Fakharian E, Masoodi Alavi N. Outcome of factors related to traumatic brain injuries among the patients hospitalized in intensive care unit. Feyz 2010;14(2):112-119. Persian.
11. Ariaka H, Kiryabwire J, Hussein S, Ogwal A, Nkonge E, Oyania F. A comparison of the predictive value of the Glasgow Coma Scale and the Kampala trauma score for mortality and length of hospital stay in head injury patients at a tertiary hospital in Uganda: a diagnostic prospective study. Surgery Research and Practice. 2020;2020. doi: 10.1155/2020/1362741.
12. Chaitanya K, Addanki A, Karambelkar R, Ranjan R. Traumatic brain injury in Indian children. Childs Nerv Syst. 2018;34(6):1119-1123. doi: 10.1007/s00381-018-3784-z. PubMed PMID: 29594463.
13. Sarnaik A, Ferguson NM, O'Meara A, Agrawal S, Deep A, Buttram S, et al. Age and mortality in pediatric severe traumatic brain injury: results from an international study. Neurocrit Care. 2018;28(3):302-313. doi: 10.1007/s12028-017-0480-x. PubMed PMID: 29476389.
14. Langlois JA, Rutland-Brown W, Thomas KE. The incidence of traumatic brain injury among children in the United States: differences by race. J Head Trauma Rehabil. 2005;20(3):229-38. doi: 10.1097/00001199-200505000-00006. PubMed PMID: 15908823.
15. Egbohou P, Mouzou T, Tchetike P, Sama HD, Assenouwe S, Akala-Yoba G, et al. Epidemiology of pediatric traumatic brain injury at Sylvanus Olympio University Hospital of Lomé in Togo. Anesthesiol Res Pract. 2019;2019:4038319. doi: 10.1155/2019/4038319. PubMed PMID: 31467523; PubMed Central PMCID: PMC6701323.