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Identification of Risk Factors for Disabilities in Children Following Clinically Important Traumatic Brain Injury: A Prospective Cohort Study

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Abstract

Background: Head injury is a common occurrence in children and is one of the leading causes of death and disability in this age group. Accurately predicting the outcome of children with head injuries is critical for appropriate treatment and management of these patients.

Purpose: The aim of this study was to determine the risk factors that can help predict the outcome of children who were admitted after a clinically important head injury.

Methods: We prospectively analysed the data of 65 patients under the age of 13 years who were admitted to our hospital after a clinically important head Traumatic Brain Injury (TBI). We statistically analysed various parameters such as age, gender, and mechanism of trauma, consciousness level, convulsion, vomiting, radiological investigation, duration of hospitalization, and the need for mechanical ventilation.

Results: Our study showed that some parameters gave significant predictive value for the final outcome, such as the mechanism of trauma, consciousness level, convulsion, radiological investigation, duration of hospitalization, and the need for mechanical ventilation. However, age, gender, and vomiting had no significant predictive value.

Conclusion: Our findings suggest that accurate prediction of the outcome of children with head injuries is possible by considering certain risk factors. This can aid in appropriate treatment and management of these patients, which is critical for their recovery and rehabilitation. Further studies with larger sample sizes are needed to confirm our findings.

Keywords: Traumatic brain injury; Childhood; Morbidity; Mortality risk factors

Abbreviations: TBI: Traumatic Brain Injury; ICB: Intracerebral Bleeding; CBF: Cerebral Blood Flow; DCS: Diffuse Cerebral Swelling

Introduction

Traumatic Brain Injury (TBI) is a significant global health concern that causes mortality and disability. Although recent reports indicate an increase in firearm accidents leading to child fatalities in the USA, TBI remains the primary cause of death and disability in children worldwide [1].

The leading causes of TBI are motor vehicle accidents, falls, assault, and recreational activities. Falls are the primary cause of injury in children under four years old, while motor vehicle accidents account for the second-highest number of head injuries.

The severity of TBI is assessed using the Glasgow scale. While most cases are mild and do not lead to long-term disability, moderate to severe injuries can cause significant disability [2]. The prognosis for TBI is worse for children under four years old, especially those under two years old.

Predicting the final outcome for these children is extremely challenging, given the numerous risk factors identified during admission or hospitalization [3]. Our study aims to investigate the statistical distribution of Traumatic Brain Injuries (TBI) in children in our region and compare it to international data. We also aim to identify risk factors that can be observed at admission or during hospitalization, which may help predict the final outcome and disability for these children [4].

Materials and Methods

This study is a prospective cohort study of 65 patients admitted at the university children's hospital in Damascus over one year from 1/1/2020 to 31/12/2020. The study excluded patients who were managed elsewhere and then transferred to the hospital, patients with minor injury and kids who were suffering from child abuse.

The inclusion criteria were patients admitted with a history of clinically severe head trauma [5]. The study variables included gender, age, cause of trauma, severity of the injury according to the Glasgow coma scale, clinical symptoms and neurological examination upon admission, radiographic findings on the CT scan upon admission, medical and surgical measures provided during the hospital admission period, the period of stay in the hospital, causes of morbidity and mortality, and results of treatment upon discharge [6-9].

A form was designed to collect data according to the study variables, and it was placed in the patients' records. All patients underwent a comprehensive, rigorous clinical assessment focusing on neurological examination on admission and periodic assessment during admission. Computed Tomography (CT) was performed for all patients.

The causes of morbidity and mortality during admission for all patients were classified into five groups: Septic, neurological, surgical, pharmacological, and other organ involvement. The hospital stay period was defined in two categories: Less than 7 days and more than 7 days. The results of the treatment were determined when patients were discharged into three groups: Recovery, disability, and death using the International Classification of Functioning (ICF) framework [10].

Ethical approval for the completion of the research was obtained from the children's university hospital in Damascus and the children's department of the faculty of medicine at Damascus university [11].

The data were analysed using statistical software, and descriptive statistics were used to summarize the data. The results were presented in tables and figures. *Chi-square* test or Fisher's exact test was used to compare categorical variables, and t-test was used to compare continuous variables. A p-value less than 0.05 were considered statistically significant [12].

The next stage involved statistical analysis, which was conducted using the SPSS 25 software. The following calculations were performed.

- For nominal and categorical variables, numerical frequencies were calculated, while for continuous variables, mean and standard deviation values were computed.
- Odds Ratios (OR) was calculated for binary nominal variables to identify the risk factors associated with the occurrence of disability.

Results

65 patients were admitted in our hospital for TBI causing severs clinical sings. 16 of them required admission to the intensive care unit. The follow up period ranged between one and two years [13]. Patients were divided into four age sub groups based on the allowed age range for hospital admission (up to 13 years of age). Children who were between 5 and 10 years (n=26/65, 40%) were found to be the most vulnerable group to traumatic head injuries (Figure 1).

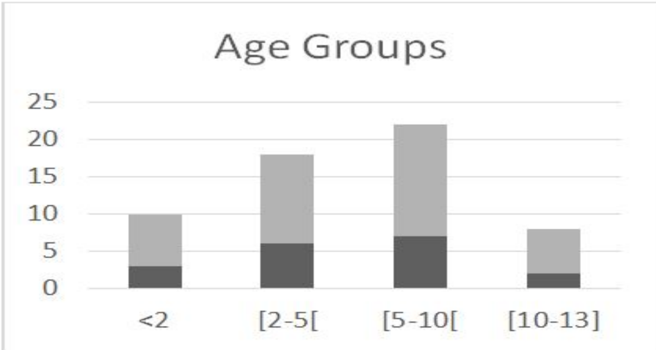

Figure 1: Age groups.

The study showed that males had a higher incidence of traumatic head injuries than females. Meanwhile the most common cause of head trauma was falls (66.2%), followed by traffic car accidents (Table 1).

Causes	Number of patients	%
Fall	43	66.20%
Traffic accident	15	23.10%
Other	7	10.70%

Table 1: Distribution of causes related to TBI.

The severity of the injury upon admission was classified according to two scales: The Glasgow coma scale for children over 2 years of age and the APVU scale for children aged 2 years and under [14]. The majority of cases had a severity rating of 13-15 on the Glasgow coma scale (n=48/55, 87.27%), while 8 cases had a rating of "alert" on the APVU scale (n=10, 80%) (Table 2).

Scales	Number of patients 65		Number of patients
GCS	55	Mild (GCS 13-15)	48 (87.27%)
		Moderate (GCS 9-12)	4 (7.27 %)
		Sever (GCS <8)	3 (5.45%)
APVU	10	A	8 (80%)
		P	2 (20%)

Table 2: Distribution of level of conciseness at admission.

We found that the most common symptom reported by patients in the sample was vomiting (n=28/65, 43.1%), followed by cerebrospinal fluid leakage (n=22/65, 33.8%) (Table 3).

Symptoms at admission	Number of patients
Headaches	4 (6.2%)
Convulsion	17 (26.2%)

Vomiting	28 (43.1%)
Orifice's bleeding	22 (33.8%)
Motor deficit	10 (15.%)
Unconsciousness	19 (29.2%)
Deterioration of consciousness	14 (21.5%)
Sphincters uncontrol	2 (3.1%)

Table 3: Distribution of symptoms at admission.

Brain computed tomography was performed for all patients, skull fractures were the most common injuries found, followed by diffused cerebral swelling and bleeding (Table 4).

Lesion	Patients number		Number of patients
Skull fracture	50 (76.9%)	Linear	29
		Depressed	13
		Skull base	11
Intracranial bleeding	16 (24.6%)	Subdural	2
		Epidural	6
		Sub arachnid	2
		Intra cerebral	6
Brain edema and swelling.	24 (37%)		

Table 4: Distribution of brain lesions seen at admission after a TBI.

The provided management was classified into two groups: Conservative management, which includes the use of sodium chloride pump in 26 patients (40%), and the intubation with mechanical ventilation applied in 13 patients, with a rate of 20% [15]. And surgical management which was performed in 17 patients. 25 patients needed a stay period of less than 7 days, and 40 patients needed a stay period equal to 7 days or more. Injuries are distributed according to the cause of trauma (fall/traffic accident/other). They were classified into three groups according to the patient's clinical condition upon discharge from the hospital (Table 5).

2	Total 65	Fall 43	Traffic accident 15	Other 7
Recovery	35	24	8	3
Disability	28	17	7	4
Death	2	2	0	0

Table 5: Relation between the cause of injury and final outcome for our admitted patients for TBI.

Using the International Classification of Functioning (ICF) framework, recovery was defined as the patient's discharge in a state of complete physical, psychological, and mental recovery without complications and without the need for any major drug treatment [16]. Disability was determined by the presence of any physical, psychological, or mental weakness that restricts a person's activity and limits his interaction with others and requires periodic follow-up and continuous treatment. Death was limited to two cases resulting from fall.

The study also investigated the causes of morbidity and mortality in five groups, with neurological causes being the most prevalent, accounting for 89.2% of the total causes.

In terms of risk factors affecting treatment outcomes (recovery/ disability), a separate analysis was conducted after excluding the two deaths. The analysis found the following factors to be significant (Table 6).

Variables		Number of patients		P-value
		Recovery	Disability	
Gender	Male	23	22	
	Female	12	8	
ICU admission	16	4	12	0.008
Stay duration	0-7	19	6	0.04
	>7	13	18	
Convulsion		4	13	0.004
Vomiting		15	13	
Skull fracture		26	24	
Intracranial bleeding		5	11	0.047
DCS		7	10	
Intubation-ventilation		3	10	0.027
Neurosurgical procedure		5	12	0.027

Table 6: Analysis of clinical factors related to outcome.

Females had higher rates of complete recovery than males, but the difference was not statistically significant. Males could be considered a risk factor as their Odds Ratio (OR) was greater than 1.

Admission to the intensive care or surgical unit: Disability rates were higher than recovery rates for patients admitted to the intensive care unit [17]. Admission to the ICU was identified as a statistically significant risk factor for disability upon discharge, with an OR greater than 1 and a p-value of 0.008.

Clinical symptoms on admission: Convulsions, vomiting, and decreased consciousness were all found to be risk factors for disability upon discharge, with OR greater than 1 for each. Convulsion and decreased consciousness were statistically significant symptoms related to disability, with p-values of 0.004 and 0.033, respectively. Therefore, patients presenting with these symptoms are more likely to develop disability upon discharge.

Radiographic findings: The presence of skull fractures, cerebral haemorrhage, and cerebral edema were identified as risk factors for disability upon discharge, with OR greater than 1. The presence of bleeding on imaging was a statistically significant risk factor with a p-value of 0.047. Therefore, the presence of bleeding on imaging is a risk factor for future disability upon discharge.

Discussion

In 2020, 65 patients with acute head trauma were admitted to the children's university hospital in Damascus. Of these, 24.6% required admission to the ICU. The study revealed that males were more frequently injured than females, possibly due to psychological and social factors that lead males to engage in riskier behavior in our country [18]. This pattern of male injury is a global phenomenon in accident cases and has been reported in previous studies.

The patients were divided into four age subgroups based on the allowed admission age range, which spanned from birth to 13 years old. The age group most commonly affected in our study was 5-10 years old, which contrasts with other reports that found the age group most exposed to accidents was 11-18 years old.

The causes of head trauma varied in our patients, with fall accidents being the most frequent cause (66.3%), followed by traffic accidents (23.1%) and 10.6% from other causes this distribution seems to be significant with p-value of approximately 0.0002. This distribution is consistent with most publications in the literature for this age group [19].

Upon admission to the emergency department, the severity of injury was assessed using two scales of awareness: The Glasgow coma scale for children over 2 years old and the AVPU Scale for children under 2 years old. Of the 65 patients, 48 had a GCS estimated between 13-15, and 8 were classified as alert based on the AVPU scale. However, it is important to note that the initial assessment alone cannot determine the severity of the trauma, as some patients may experience deterioration in consciousness within hours of admission and require intensive care or surgical treatment. Therefore, close monitoring is crucial to determine the development of the injury and potential disability [20].

The most common skull lesion encountered in children is a linear fracture. In our study, we also found that skull fractures, particularly linear fractures, were the most common injuries seen on CT scans. CT scans are the most accurate diagnostic tool for bone injuries.

While Acute Epidural Hematoma (AEDH) is relatively rare in young infants due to the strong adherence of the dura mater to the inner surface of the skull. Intracerebral Bleeding (ICB) is a rare condition after trauma compared to adult.

AEDH accounted for half of the cases of intracranial bleeding observed in our study In fact, 24.6% of the patients showed bleeding in the form of epidural or Intracerebral Bleeding (ICB).

One of the most serious consequences of Traumatic Brain Injury (TBI) is Diffuse Cerebral Swelling (DCS), which is frequently seen on CT scans. Lang et al. demonstrated that CT abnormalities of DCS tend to develop more quickly in young patients due to the relative lack of cerebrospinal fluid available for displacement. Children are particularly susceptible to cerebral hyperemia, which can cause significant intracranial hypertension, due to an immature auto-regulatory mechanism for Cerebral Blood Flow (CBF). Preclinical investigations have shown that excessive exposure of developing brain tissue to excitatory neurotransmitters can increase the inflammatory response, vascular permeability, and speed up degenerative alterations. Moreover, because new-borns have a low mean arterial pressure and limited ability to compensate for hypoxia and low blood pressure, they are more likely to experience a catastrophic fall in CBF. These processes appear to be crucial in the etiology of DCS. A hemispheric widespread low-density lesion with effacement of the cerebral sulci and cisterns, as well as the ventricular system, are common CT findings in DCS. In our group of patients, DCS was also a common finding, occurring in 26.2% of all cases.

20% (n=13) of patients required intubation and mechanical ventilation, which is lower than rates reported in a study by Kam Lun Hon, et al., for traffic accidents (44.4%) and falls (39%). However, it should be noted that their study was limited to severe brain trauma admitted to the intensive care unit, which may explain the difference in results.

Surgical intervention, particularly haemorrhage evacuation, was necessary for 26% (n=17) of our patients, mostly due to falls. This is similar to what was reported by other authors, who found a need for neurosurgical intervention in 22.7% of cases.

Early diagnosis and surgical intervention are important to avoid disability. The average length of stay for patients in the intensive care unit was 9 days, and 4 days in the recovery surgical care unit. Some authors reported shorter stays in the intensive care unit (3 days for falls and 5 days for traffic accidents). However, Ongun, et al., reported an average stay of 4 days in the intensive care unit for all causes of TBI, with an average hospital stay of 10 days.

The mortality rate in children with TBI is a serious concern, particularly in cases of severe injury. It is important to note that child abuse is a significant cause of TBI and can lead to higher mortality rates. However, this category of patients was excluded from our study.

In our study, two deaths were reported following falls, but no deaths were reported after traffic accidents. However, it is essential to consider that our study did not report mortality rates at the scene of the accident, during patient transfer, or in the emergency department.

In comparison with other studies, Kam Lun Hon, et al., reported four deaths resulting from falls (6.8%), but no deaths from traffic accidents. Mortality was reported at the rate of 12.5% in cases of severe injury according to the Glasgow Scale in all cases of death.

It is crucial to note that early diagnosis and proper management can improve outcomes and reduce mortality rates. Therefore, healthcare professionals must be vigilant in identifying TBI in children, particularly in cases of falls and traffic accidents, and provide appropriate interventions promptly.

After excluding the two deaths, the study analysed variables based on treatment outcomes (recovery/disability) using the International Classification of Functioning (ICF) framework, focusing on the domains of activities and participation. We identified certain risk factors that increase the likelihood of disability upon discharge.

While it has been suggested that the cause of an injury is a significant predictor of prognosis, based on our available data, there is no evidence to suggest that the cause of injury plays a role in the recovery, disability, and death of the patients, with a p-value of 0.109.

Although gender is not statistically significant, males had a higher rate of disability than females, with an Odds Ratio (OR) greater than 1.

Patients who were admitted to the intensive care unit had a higher risk of poor TBI outcome compared to those who were not seen in the ICU. Admission to our intensive care unit was found to be a statistically significant risk factor for a bad prognosis, with an OR greater than 1 and a p-value of 0.008.

There is a hypothesis that Post-Traumatic Seizures (PTS) may result in worse outcomes after a Traumatic Brain Injury (TBI). The deterioration of the level of consciousness is also a predictor of poor prognosis. Additionally, children who experience recurrent vomiting are more likely to have an intra-cranial injury, but no conclusive relationship has been established with the final outcome.

Our study found that convulsions, vomiting, and decreased consciousness are all considered risk factors for disability, with Odds Ratios (ORs) greater than 1 for each. Convulsions and decreased consciousness were statistically significant risk factors, with p-values of 0.004 and 0.033, respectively.

The leading cause of Intracranial Bleeding (ICB) in children, which results in high morbidity and mortality rates, is trauma. ICB significantly affects the prognosis, and the presence of skull fractures, cerebral hemorrhage, and cerebral edema are all identified as risk factors for disability, with odds ratios greater than 1. Additionally, bleeding is a statistically significant risk factor, with a p-value of 0.047.

Mechanical Ventilation (MV) is associated with other risk factors in predicting the prognosis after Traumatic Brain Injury (TBI). Both surgical management and the application of mechanical ventilation are considered risk factors for disability, with odds ratios greater than 1. Statistically significant risk factors include surgical management, and the application of mechanical ventilation, with p-values of 0.025, 0.027, and 0.008, respectively.

Conclusion

Our study demonstrated that certain parameters, such as the mechanism of trauma, consciousness level, convulsion, radiological investigation, duration of hospitalization, and the need for mechanical ventilation, were significantly predictive of the final outcome. However, age, gender, and vomiting were not found to be significant predictors.

These findings suggest that it is possible to accurately predict the outcome of children with head injuries by considering specific risk factors. This information can aid in the appropriate treatment and management of these patients, which is critical for their recovery and rehabilitation. However, further studies with larger sample sizes are necessary to confirm our findings.

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