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Original Research Article

Identification of risk factors for disabilities in children following 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. The aim of this study was to determine the risk factors that can help predict the outcome of children who have been admitted for a clinically significant head injury.
Methods: We prospectively analyzed the data of 65 patients under the age of 13 years who were admitted to our hospital after a clinically significant traumatic brain injury (TBI). We statistically analyzed various parameters, such as age, gender, mechanism of trauma, consciousness level, convulsion, vomiting, radiological investigation, duration of hospitalization and the need for mechanical ventilation.
Results: The parameters that had significant predictive value for the final outcome included the mechanism of trauma, consciousness level, convulsion, radiological results, duration of hospitalization and the need for mechanical ventilation. However, age, gender and vomiting had no significant predictive value.
Conclusions: Our findings suggest that it is possible to predict the outcome of children with head injuries accurately by considering certain risk factors. This could aid in providing 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: Childhood, Morbidity, Mortality risk factors, Traumatic brain injury

INTRODUCTION

Traumatic brain injury (TBI) is a significant global health concern that causes mortality and disability and is the primary cause of death and disability in children worldwide.[1,2] The leading causes of TBI are motor vehicle collisions, falls, assault and recreational activities. Falls are the primary cause of injury in children under four years old, while motor vehicle collisions account for the second highest number of head injuries.[3,4] The severity of TBI is assessed using the Glasgow coma scale. While most cases are mild and do not lead to long-term disability, moderate to severe injuries can cause significant disability.[5-7] The prognosis of TBI is worse for children under four years old and 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.[5]

The aim of this study was to investigate the statistical distribution of TBI in children in Damascus and compare it to international data. We also aimed to identify risk factors that can be observed at admission or during hospitalization to help predict the final outcome and disability for such children.

METHODS

This prospective cohort study examined 65 patients who were admitted at the University Children's Hospital in Damascus over one year from (January 1, 2020 to December 31, 2020). The study excluded patients who were managed elsewhere and then transferred to the hospital, had minor injury or were suffering from child abuse. The included patients had clinically severe head trauma. The study variables included sex, age, cause of trauma, severity of the injury according to the Glasgow coma scale, clinical symptoms and neurological examination upon admission, radiographic findings in computed tomography (CT) scans 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.

A form was designed to collect data according to the study variables and was applied to the patients' records. All patients underwent a comprehensive, rigorous clinical assessment focusing on neurological examination on admission and periodic assessment during admission. CT scans were performed for all patients. The causes of morbidity and mortality during admission for all patients were classified as “septic,” “neurological,” “surgical,” “pharmacological,” and “other organ involvement.” The hospital stay period was defined using two categories: less than 7 days and more than 7 days. The results of the treatment when patients were discharged were divided into three groups: recovery, disability and death, which were based on using the international classification of functioning (ICF) framework.

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. The data were analyzed using statistical software and descriptive statistics were used to summarize the data. A chi-squared test or Fisher's exact test was used to compare categorical variables and a t-test was used to compare continuous variables. A p-value less than 0.05 was considered statistically significant. The statistical analysis was conducted using the software SPSS 25. For nominal and categorical variables, numerical frequencies were calculated, while for continuous variables, mean and standard deviation values were computed. The odds ratios (ORs) were calculated for binary nominal variables to identify the risk factors associated with the occurrence of disability.

RESULTS

There were 65 patients admitted to our hospital for TBI causing severe clinical signs and 16 of them required admission to the intensive care unit (Figure 1). The follow-up period was between 1 and 2 years. Patients were divided into four age groups based on the allowed age range for hospital admission (up to 13 years of age). Children who were between 5 and 10 years old (n=26/65, 40%) were found to be the most vulnerable group to TBI (Figure 1).

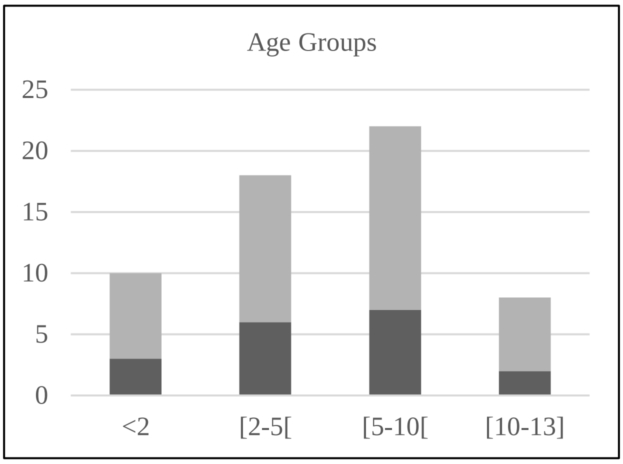

Figure 1: Distribution of age group at admission.

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

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 AVPU scale (alert, verbal, pain, unresponsive) for children aged 2 years and under. 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 AVPU scale (n=10, 80%) (Table 2).

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

The management provided was divided into two groups. Conservative management (20% of patients) included the use of sodium chloride pump (26 patients, 40%) and intubation with mechanical ventilation (13 patients). Surgical management was provided for 17 patients. There were 25 patients who needed a stay period of less than 7 days and 40 patients needed a stay period of 7 days or more. Injuries were divided according to the cause of trauma (fall, traffic collision, other). They were also classified into three groups according to the patient's clinical condition upon discharge from the hospital (Table 5).

Using the 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. Disability was determined by the presence of any physical, psychological or mental weakness that restricts a person's activity, limits interaction with others and requires periodic follow-up and continuous treatment. Death was limited to two cases and resulted from falls. The study also investigated the causes of morbidity and mortality in five groups. Neurological causes were 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. Table 6 shows the significant factors from the analysis.

Females had higher rates of complete recovery than males, but the difference was not statistically significant. Being male could be considered a risk factor as their OR was greater than 1. Disability rates were higher than recovery rates for patients admitted to the intensive care unit (ICU). 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. Regarding clinical symptoms on admission, convulsions, vomiting and decreased consciousness were all found to be risk factors for disability upon discharge with ORs 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. Regarding radiological findings, the presence of skull fractures, cerebral hemorrhage and cerebral edema were identified as risk factors for disability upon discharge with OR greater than 1. The presence of bleeding in imaging was a statistically significant risk factor with a p-value of 0.047. Therefore, the presence of bleeding in imaging is a risk factor for future disability upon discharge.

Table 1: Distribution of causes related to TBI, GCS (Glasgow coma scale) AVPU (Alert, Verbal, Pain, Unresponsive).

Causes	Number of patients	%
Fall	43	66.2
Traffic collision	15	23.1
Other	7	10.7

Table 2: Distribution of level of conciseness at admission.

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%)
AVPU	10	A	8 (80%)
		P	2 (20%)

Table 3: Distribution of symptoms at admission.

Symptoms at admission	Number of patients
Headaches	4 (6.2%)
Convulsion	17 (26.2%)
Vomiting	28 943.1%)
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 4: Distribution of brain lesions seen at admission after a TBI.

Lesion	Patient number		Number of patients
Skull fracture	50 (76.9%)	Linear	29
		Depressed	13

Continued.

Lesion	Patient number		Number of patients
		Skull base	11
Intracranial bleeding	16 (24.6%)	Subdural	2
		Epidural	6
		Subarachnoid	2
		Intracerebral	6
Brain edema and swelling	24 (37%)		

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

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

Table 6: Analysis of clinical factors related to outcome.

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

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 them to engage in riskier behavior. This pattern of male injury is a global phenomenon in collision cases and has been reported in previous studies.[3,4]

The patients were divided into four age groups based on the allowed age range at admission, which spanned from birth to 13 years old. The age group most commonly affected in our study was 5-10 years old. This contrasts with other reports, which found the age group most exposed to collisions was 11-18 years old.[4] The causes of head trauma varied in our patients, with fall collisions being the most frequent cause (66.3%), followed by traffic collisions (23.1%) and other causes (10.6%). This distribution seems to be significant with p-values of approximately 0.0002 (Table 1). This distribution is also consistent with most literature for this age group.[3,5]

Of the 65 patients, 48 had a Glasgow score of 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.[8,9]

The most common skull lesions encountered in children are linear fractures.[10] In our study, we also found that skull fractures, particularly linear fractures, were the most common injuries seen in CT scans. CT scans are the most accurate diagnostic tool for bone injuries.[2,11]

Acute epidural hematoma (AEDH) accounted for half of the intracranial bleeding cases in our study, while 24.6% of patients exhibited intracerebral bleeding (ICB). AEDH is relatively rare in young infants due to the strong adherence of the dura mater to the inner surface of the skull.[12] Additionally, ICB is less common in children following trauma compared to adults.[13,14] One of the most serious consequences of TBI is diffuse cerebral swelling

(DCS), which is frequently seen IN 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.[15] 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).[16] Preclinical investigations have shown that excessive exposure of developing brain tissue to excitatory neurotransmitters can increase the inflammatory response, vascular permeability and faster degeneration. Moreover, because newborns 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.[17] These processes appear to be crucial in the etiology of DCS. Hemispheric widespread low-density lesions with effacement of the cerebral sulci and cisterns, as well as the ventricular system, are common CT findings in DCS.[18,19] 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 by Hon et al, for traffic collisions (44.4%) and falls (39%).[20] However, it should be noted that their study was limited to severe brain trauma cases admitted to the ICU, which may explain the difference in results. Surgical intervention, particularly hemorrhage evacuation, was necessary for 26% (n=17) of our patients, which was mostly due to falls. This is similar to what was reported by other studies, which found a need for neurosurgical intervention in 22.7% of cases.[4] Early diagnosis and surgical intervention are important to avoid disability.

The average length of stay for patients in the ICU was 9 days, while the length of stay was 4 days in the surgical care recovery unit. Some studies reported shorter stays in the ICU (3 days for falls and 5 days for traffic collisions).[20] However, Ongun et al, reported an average stay of 4 days in the ICU for all causes of TBI with an average hospital stay of 10 days.[4]

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.[20] 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 collisions. However, it is essential to consider that our study did not report mortality rates at the scene of the collision, during patient transfer or in the emergency department.

Hon et al, reported four deaths resulting from falls (6.8%) but no deaths from traffic collisions.[20] A mortality rate of 12.5% was reported in cases of severe injury according to the Glasgow scale in all cases of death.[4] It is important 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 collisions and provide appropriate interventions promptly.

After excluding the two deaths, we analyzed variables based on treatment outcomes (recovery/disability) using the ICF framework while focusing on the domains of activities and participation. We identified certain risk factors that increase the likelihood of disability upon discharge (Table 5). 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 (p=0.109).[21] Although gender differences were not statistically significant, males had a higher rate of disability than females with an OR greater than 1. Patients who were admitted to the ICU had a higher risk of poor TBI outcome compared to those who were not seen in the ICU.[22] Admission to our ICU 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 (Table 6).

There is a hypothesis that post-traumatic seizures may result in worse outcomes after TBI.[23] The deterioration of the level of consciousness is also a predictor of poor prognosis.[3] 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 were all risk factors for disability, with 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 ICB in children, which results in high morbidity and mortality rates, is trauma.[13,25] ICB significantly affects the prognosis and skull fractures, cerebral hemorrhage and cerebral edema are all identified as risk factors for disability with ORs greater than 1.[26] Additionally, bleeding is a statistically significant risk factor with a p value of 0.047.

Mechanical ventilation is associated with other risk factors in predicting the prognosis after TBI.[27] Both surgical management and the application of mechanical ventilation are considered risk factors for disability with ORs greater than 1. Statistically significant risk factors include surgical management, stay in ICU and the application of mechanical ventilation, with p-values of 0.027, 0.008 and 0.027, respectively.

CONCLUSION

Our study demonstrated that certain parameters were significantly predictive of the final outcome: the mechanism of trauma, consciousness level, convulsion, radiological investigation, duration of hospitalization and the need for mechanical ventilation. 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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