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RESEARCH ARTICLE

PATTERNS, OUTCOMES, AND RISK FACTORS OF MILD HEAD INJURIES IN CHILDREN: DO WE KNOW ENOUGH?

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Abstract

Background: Mild head injuries in children are associated with morbidity and family distress. Though they are common causes of emergency department visits, they have been studied less than other more severe types of head trauma. This study aims to contribute to the reduction of this gap.

Method and Materials: The medical records of 381 children with mild head injuries were reviewed and analyzed. Identification of any associated risk factors has been attempted with regression analysis.

Results: The age group of 6-8 years was the most affected (44.6%). There was male predominance. Incidence presented seasonal variation. Concussion diagnosis was set in one tenth of patients. Half of children were under adult supervision during the traumatic incident. Cranial radiography was routinely performed in almost all patients, and computed tomography in 1.8%. Neurosurgical consultation was requested in 8.1%. Pedestrians, bicycle-riders, and car-passengers were at most risk of suffering mild head injury. Occurrence at street and playgrounds were risk factors for coexisting abdominal injuries. Absence of adult supervision was a risk factor for bicycle-riders, and occurrence at school for neurosurgical consultation.

Conclusions: Mild head injuries occur more often at the streets of urban areas. Clinical observation for 24 hours is considered satisfactory for a safe outcome. Identification of risk factors of mild head injuries may improve both prevention and outcome. Improvement of training of physicians in pediatric trauma is also required. Quality of adult supervision is important to improve prevention.

Keywords: Mild head injury, children, concussion, head trauma, risk-factors.

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INTRODUCTION

Head trauma is a common cause of child morbidity, mortality, and hospital emergency department visiting.[1] The annual incidence of head injuries in the pediatric population is estimated to be 180-300 new cases per 100,000 hospital admissions, corresponding to over 400,000 annual hospital visits in the United States of America.[2, 3] Recently, the annual number of pediatric traumatic brain injury cases has been estimated at about 475,000.[4] Most of them (80-90%) are of minor severity.[1,5] The commonest related mechanism in early childhood is falling onto the ground, while car accidents, bicycle falls and pedestrian drifts by vehicles occur more often during puberty.[6]

Severe head injuries present high morbidity and mortality and have been thoroughly investigated.[7] However, mild head injuries, although being the majority, are not equally studied, and are also occasionally under-reported, as many patients never reach healthcare facilities. [5, 8] They are also associated with morbidity and family distress, being the cause of parental anxiety and depression.[9]

The aim of the study is to evaluate mild head injuries in a cohort of school-age children, to investigate the associated parameters, to outline any possible risk factors, and to provide suggestions that might be valuable for prevention and outcome.

METHODOLOGY

Study population

The medical records of school-age children who were admitted in Patras Children's Hospital with mild head injuries, during a period of four years (January 1st, 2014 – December 31st, 2017), were reviewed. The term "mild head injury" included every head trauma with a Glasgow Coma Scale (GCS) of 13-15 on admission, occurring during the last 24 hours before examination, with symptoms such as headache, vomiting, brief loss of consciousness, amnesia, and absence of focal neurological signs.[10-13] The term "mild" is in accordance with the latest classification guidelines of the Scandinavian Neurotrauma Committee.[14] Concussion (ICD-10-CM Code S06.0), currently referred as "mild traumatic brain injury" in literature, is included in the spectrum of mild head injuries.[10, 11] The demographics, the efficacy of the healthcare infrastructure, the family parameters related to injury, the pathogenetic and risk mechanisms, the comorbidities from other organs, the diagnosis, management, and outcome, were the characteristics studied. The conduction of the study was approved by the bioethical committee of the institution where it was performed.

Statistical analysis

A chi-square goodness of fit test, or an asymptotic likelihood ratio test in the case where more than 20% of cells had expected counts less than five, was applied to determine the correlation between two random variables. To compare the proportions in two cells, a binomial test was used, and Bonferroni's confidence intervals were constructed. Binary logistic regression was used to predict a nominal dependent variable with two categories given one or more independent variables. Standard regression analysis methods were used. The threshold for statistical significance was defined as $p < 0.05$. Statistical analysis was performed using IBM SPSS version 25 software (IBM Corp., Armonk, New York).

RESULTS

A total of 381 pediatric patients, including 257 males (67.5%, age range 6-14 years, mean 9.4, standard deviation 2.6) and 124 females (32.5%, age range 6-14 years, mean 9.1, standard deviation 2.6) were admitted in the pediatric surgical department for a follow-up period of 24 hours, because of mild head injuries. This cohort corresponded to 6.4% of the 5,934 pediatric surgical admissions during this period. The demographics and clinical characteristics are presented in Tables 1 and 2.

Male patients comprised two thirds of the study population. The most affected age-group was that of 6-8 years (44.6%) (Table 1). Mild head injuries presented seasonal variability ($p < 0.001$), with increased frequency during summer (38.6%) and early autumn (29.1%). The majority occurred at street (55.3%). In half of all cases the patient was a pedestrian, while the most common mechanism of injury was falling on the ground (66.4%, $p < 0.001$).

Car accidents were involved in one third of cases. There was adult supervision in more than half of the cases (54.3%) (Table 2).

The most common clinical presentation included headache (76.4%), local swelling (38.3%), dizziness (42.5%), brief amnesia (16.3%), and history of temporary loss of consciousness (11%). Special anatomical structures involved were the face in 31%, the forehead (24%), nose (7.6%), mouth (6%), neck (4.7%), and eyes (3.7%). Clinical diagnosis of concussion was set in 11.8% of patients (Table 2).

Half of the patients were referred from other physicians. Referrals were in 71.2% from other hospitals. Most patients were transported by a private vehicle or a taxi (73.5%). Cranial radiography was performed quite in all patients (99.5%, $p< 0.001$) and computed tomography in 1.8% ($p< 0.001$). No cranial fracture was diagnosed. The time required for observation in hospital was 24 hours in 78% ($p< 0.001$%) of patients (Table 2).

Logistic regression analysis showed that certain factors presented significant risk for mild head injury when correlated with variables such as gender, age, area of origin, nationality, season, location of traumatic incident, and presence of a supervising adult. The results are summarized in different ways for the predictor variable in Tables 3-6. When the abbreviation "ref" (reference) is mentioned in the tables, it means that each category of the predictor variable (except the reference category) was compared to it. The term "repeated" means that each category of the predictor variable (except the last category) was compared to the next category (Tables 3-6).

Findings showed a significant risk of coexisting abdominal injuries (chi-square 25.34, $p= 0.031$) when accidents happened at the street ($p= 0.026$) and the playground ($p= 0.039$) (Table 3). Pedestrians presented high risk for mild head injury (chi-square 249.27, $p< 0.0005$), with those of Roma origin presenting 12.5 times higher probability compared to others ($p< 0.0005$) (Table 4). Also, there was high risk regarding children falling onto the floor at home ($p< 0.0005$) (Table 4).

Being a car passenger (chi-square 172.19) or a bicycle rider (chi-square 249.27) was also proved to be a significant risk factor for head injury ($p< 0.005$). In Table 5, it is shown that the risk of male bicycle riders was 2.5 higher compared to females ($p= 0.050$). The risk was about five times lesser in the Roma group ($p= 0.033$). Bicycle-related injury occurred most during spring ($p= 0.013$) and autumn ($p= 0.007$) compared to winter. There was higher trauma risk in summer ($p= 0.032$). The absence of a supervising adult rendered the risk of injury 17.5 times more probable for the bicycle-riders ($p< 0.0005$), while there was no difference between adult supervision in the overall patient cohort.

Neurosurgical consultation was requested more often during autumn (in 10% level of significance) with a nine-fold higher probability compared to spring ($p= 0.007$), reflecting a more compromised clinical presentation on admission (Table 6). Moreover, there is a high probability that children with mild head injury at school (four times more than those at home) required neurosurgical consultation. In opposite, consultation of other specialties, did not present variation regarding any other variables (chi-square 10.377, $p= 0.734$).

DISCUSSION

The parameters associated with the presentation and management of mild head injuries in a cohort of children were reviewed. According to an annually based analysis, the incidence of mild head injuries was not reduced during the last years, in opposite to reports from other countries.[15,16] Seasonal variation was observed, with increased frequency during summer and early autumn. The sunny and warm weather of the region and the loose attitude of both children and their supervisors during the vacation period might have contributed to the increased incidence.

The male to female ratio observed was in accordance with that known in literature and may be explained by the overactive attitude of younger males.[15-22] However, the gender and the place where the traumatic incident occurred were found unrelated to each other after logistic regression analysis ($p= 0.10$). Increased frequency of brain trauma associated with male mortality has been reported by the national center for injury prevention and control in the United States of America.[23] This finding cannot be compared to data from Greece, as domestic firearm possession is extremely uncommon, as opposed to the reality in the USA. Most patients originated from urban areas. If we combined this finding with the high frequency of trauma caused by falls occurring at street and in a great proportion due to bicycle, motorcycle, or car accident, we might presume that modern cities in Greece are quite a dangerous place for children.

A point of question was on the safety provided by adult supervisors, as more than half of incidents occurred under adult supervision. It was rather the ineffectiveness of supervision that counted than the presence of a supervisor. Overuse of mobile phones and tablets during child attendance is important to be considered as a major factor of distraction.[24] The fact that only a small portion of mild head injuries occurred at school, showed that inadequate supervision is rather a problem of the parents, than of the members of the school personnel who are more committed to surveillance.

Many patients were referred from other physicians and hospitals. Although this might be interpreted as an act of duty or even responsibility, it reveals the deficiency of training in the management of pediatric trauma. The patients with mild head injury present an optimal outcome in their majority and could be certainly treated in a primary health facility, avoiding accumulation of burden to an already compromised major hospital.[4]

The least required observation time from admission to discharge from hospital was estimated in certain studies to six hours, in the group of patients who are in better condition and without comorbidities.[14] In a recent prospective study, conservative treatment was sufficient for a good recovery in a population of which 55.3% regarded mild head injuries.[25] Furthermore, very few patients needed computed tomography scanning or consultation by a neurosurgeon, both commonly not available in primary healthcare facilities. Neurosurgical intervention is quite rare (0.1-0.2%) and performance of initial computed tomography is 4-6% in literature.[12-14, 26, 27] Although performance of computed tomography has been reported in 50% of patients with minor head injuries during the last decades, there is a dilemma between its use and the risk of malignant disease (leukemias or brain tumors) especially in the age group of 0-4 years.[28-32]

Statistical analysis showed that among all comorbidities, abdominal injury is the one that merited focus after a mild head injury in a pedestrian or at a playground. Males are exposed to greater danger as bicycle riders than females and children of Roma origin. In opposite, Roma, who spend most of their time outside, are in higher risk as pedestrians. Seasonal variation is associated with bicycle related injuries, and patients with more severe clinical presentation, which is also correlated with the need of neurosurgical consultation.

Finally, the presence of an adult supervisor proves to be an effective preventing factor only for injuries with bicycle, interpreting the loosen grade of attention in different circumstances, which are considered less dangerous, allowing thus the supervisors to let themselves loose and distracted, in ways described previously.

Limitations

There are certain limitations of the study. As trauma presents variability in medical literature in terms of terminology and management, comparison of data from countries with different cultural backgrounds is biased. A second intrinsic limitation is that the study is of retrospective nature. This implies that accuracy of information assessment depended on the physician that performed the initial examination and updated the medical record, in many instances a resident, affecting thus the consistency of the outcome. Finally, the study included children who stayed in hospital for 24 hours. However, many children with a mild head injury either do not ever visit the emergency department, or they return home after clinical and radiological examination. Therefore, more extended research is needed for the extraction of conclusions of greater validity. A community-based research on the topic might be suitable.

CONCLUSIONS

Mild head injuries in children occur more often at the streets of urban areas. The most common pathogenetic mechanism implicates falling away from home or school. Incidence is not affected by the presence of an adult supervising person except for the bicycle riders. Clinical observation by a trained physician and admission for 24 hours is considered enough for the management of most patients, while specialist consultation and computed tomography investigation are required only for the patients who present enduring or aggravating symptoms. Improvement of pediatric trauma training of the physicians employed in the peripheral healthcare network is mandatory. In any case, it is quality and not quantity of supervision needed, to improve prevention.

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DECLARATIONS AND CONFLICTS OF INTEREST

The authors declare nothing. There is no conflict of interest.

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ANNEX

TABLE 1. Demographic characteristics of the study population (N=381).

Demographic characteristics	N	%	p
Gender			< 0.001
Male	257	67.5	
Female	124	32.5	
Age group in years			< 0.001
6-8	170	44.6	
9-11	94	24.6	
12-14	116	30.4	
Nationality			< 0.001
Greek	317	83.4	
Roma ethnic group	27	7.1	
Albanian	33	8.7	
Other	3	0.8	
Area of origin			< 0.001
Urban	314	82.4	
Rural	67	17.6	
Distance from hospital in km			< 0.001
<20	182	47.8	
21-60	100	26.2	
61-100	80	21.0	
>100	19	5.0	

TABLE 2. Injury parameters regarding the traumatic incident, clinical presentation, and management (N=381).

Parameter	N	%	p
Location of injury			< 0.001
School	47	12.4	
Home	66	17.4	
Street	210	55.3	
Playground	42	11.1	
Sport activities field	16	4.19	
Adult supervision at the time of injury			0.101
Yes	207	54.3	
No	174	45.7	
Referral from another physician			0.025
Referred	205	53.9	
Without referral	175	46.1	
Referral from a healthcare facility (N=205)			<0.001
From a primary healthcare facility	59	28.8	
From a hospital	146	71.2	
Transportation to hospital			<0.001
Ambulance	101	26.5	
Private vehicle	280	73.5	
Status of the patient at the time of trauma			<0.001
Pedestrian	191	50.1	
Car passenger	72	18.9	
Bicycle rider	103	27	
Motorcycle rider	21	5.5	
Injury mechanism			<0.001
Fall on the ground	253	66.4	
Accidental collision with another child	32	8.4	
Car accident	52	13.6	
Drift by a vehicle	49	12.8	
Falling mechanism (N=246)			<0.001
From a standing position onto the ground	31	12.6	
From a height onto the ground	105	42.6	
From a bicycle or a motorcycle	110	44.7	
Trauma features			<0.001
Presence of symptoms	361	95.0	
Presence of skin laceration	89	23.3	

Concussion	45	11.8	
Trauma comorbidities			<0.001
Upper limb injury	48	12.5	
Lower limb injury	63	16.5	
Abdominal injury	93	24.4	
Thoracic injury	94	24.6	
Spinal injury without fracture	12	3.1	
Seasonal variation of injury			<0.001
Winter	42	11.0	
Spring	81	21.3	
Summer	147	38.6	
Autumn	111	29.1	
Diagnostic imaging assay			<0.001
Cranial radiography	379	99.5	
Thoracic radiography	99	25.1	
Abdominal radiography	88	23.0	
Abdominal ultrasound	43	11.3	
Brain computed tomography	7	1.8	
Treatment			<0.001
Skin laceration sutured	89	23.3	
Bruise treatment not needing surgical intervention	87	22.8	
Neurosurgical consultation	31	8.1	
Other specialties consultation (ENT, Ophthalmology)	16	4.2	
Hospital stay in hours			0.001
24	297	77.9	
48	57	15.0	
≥72	27	7.1	

Abbreviation: Ear-nose-throat medicine (ENT)

TABLE 3. Logistic regression model of predictors for coexistence of abdominal injuries.

Covariate	N	OR	95% CI for OR	p
Gender				
Male	89	0.888	(0.27, 2.91)	0.844
Female	37	(ref)	(ref)	(ref)
Age in years		1.153	(0.96, 1.38)	0.118
Area of origin				
Urban	104	1.550	(0.49, 4.91)	0.457
Rural	22	(ref)	(ref)	
Nationality				
Greek	104	-	-	1.000
Roma ethnic group	10	-	-	1.000
Albanian	11	-	-	1.000
Other	1	(ref)	(ref)	(ref)
Season				
Winter	12	0.953	(0.08, 11.62)	0.970
Spring	26	0.249	(0.05, 1.25)	0.091
Summer	57	0.289	(0.07, 1.24)	0.095
Autumn	31	(ref)	(ref)	(ref)
Location of injury				
School	6	39.165	(0.78, 1957.76)	0.066
Home	12	9.170	(0.44, 189.70)	0.152
Street	95	23.285	(1.46, 370.66)	**0.026**
Playground	10	27.485	(1.18, 640.95)	**0.039**
Other	3	(ref)	(ref)	(ref)
Adult supervision at the time of injury				
Yes	86	2.461	(0.84, 7.25)	0.102
No	40	(ref)	(ref)	(ref)

Abbreviations: Odds Ratio (OR), Confidence Interval (CI). Each category of the predictor variable is compared to the reference category (ref). Statistically significant p values are shown in bold characters.

TABLE 4. Logistic regression model of predictors of mild head injury occurrence in children on the floor.

Covariate	N	OR	95% CI for OR	p
Gender				
Male	192	(ref)	(ref)	(ref)
Female	90	2.648	(0.85, 8.24)	0.092
Age in years		1.049	(0.86, 1.28)	0.631
Area of origin				
Urban	233	(ref)	(ref)	(ref)
Rural	49	0.843	(0.19, 3.71)	0.822
Nationality				
Greek	231	(ref)	(ref)	(ref)
Roma ethnic group	20	12.527	(3.04, 51.69)	**0.000**
Albanian	29	0.346	(0.06, 1.98)	0.234
Other	2	-	-	0.999
Season				
Winter	33	(ref)	(ref)	(ref)
Spring	58	1.458	(0.18, 11.80)	0.724
Summer	109	2.975	(0.45, 19.59)	0.257
Autumn	82	0.909	(0.12, 7.12)	0.927
Location of injury				
School	47	-	-	0.998
Home	66	1105.67	(124, 9860.41)	**0.000**
Street	114	0.004	(0, 0.02)	**0.000**
Playground	40	-	-	0.999
Other	15	(repeated)	(repeated)	(repeated)
Adult supervision at the time of injury				
Yes	129	(ref)	(ref)	(ref)
No	153	0.499	(0.15, 1.66)	0.258

Abbreviations: Odds Ratio (OR), Confidence Interval (CI). Each category of the predictor variable is compared to the reference category (ref). Each category of the predictor variable is compared to the next category (repeated). Statistically significant p values are shown in bold characters.

TABLE 5. Logistic regression model of predictors of mild head injury occurrence in bicycle riders.

Covariate	N	OR	95% CI for OR	p
Gender				
Male	172	(ref)	(ref)	(ref)
Female	74	0.423	(0.18, 1.01)	**0.050**
Age in years		1.113	(0.95, 1.30)	0.176
Area of origin				
Urban	199	(ref)	(ref)	(ref)
Rural	47	1.779	(0.51, 6.21)	0.366
Nationality				
Greek	202	(ref)	(ref)	(ref)
Roma ethnic group	16	0.216	(0.05, 0.89)	**0.033**
Albanian	26	0.390	(0.12, 1.25)	0.113
Other	2	0.056	(0.00, 3.05)	0.158
Season				
Winter	26	(ref)	(ref)	(ref)
Spring	53	7.909	(1.54, 40.62)	**0.013**
Summer	107	4.689	(1.14, 19.32)	**0.032**
Autumn	60	8.355	(1.78, 39.13)	**0.007**
Location of injury				
School	13	(ref)	(ref)	(ref)
Home	40	-	-	0.999
Street	156	-	-	0.998
Playground	30	-	-	0.999
Other	7	2.191	-	1.000
Adult supervision at the time of injury				
Yes	129	(ref)	(ref)	(ref)
No	153	17.457	(3.60, 84.72)	**0.000**

Abbreviations: Odds Ratio (OR), Confidence Interval (CI). Each category of the predictor variable is compared to the reference category (ref). Statistically significant p values are shown in bold characters.

Table 6. Logistic regression model of predictors of neurosurgical consultation

Covariate	N	OR	95% CI for OR	p
Gender				
Male	149	0.742	(0.29, 1.91)	0.537
Female	70	(ref)	(ref)	(ref)
Age		0.929	(0.78, 1.11)	0.411
Area of origin				
Urban	177	1.312	(0.42, 4.14)	0.643
Rural	42	(ref)	(ref)	(ref)
Nationality				
Greek	175	0.052	(0.00, 0.81)	0.035
Roma ethnic group	15	0.016	(0.00, 0.55)	0.022
Albanian	26	0.028	(0.00, 0.66)	0.026
Other	3	(ref)	(ref)	(ref)
Season				
Winter	25	0.312	(0.08, 1.23)	0.097
Spring	43	0.110	(0.02, 0.55)	**0.007**
Summer	93	0.380	(0.14, 1.03)	0.058
Autumn	58	(ref)	(ref)	(ref)
Location of injury (ref)				
School	21	4.262	(0.35, 51.78)	0.255
Home	44	1.043	(0.09, 12.50)	0.974
Street	114	0.834	(0.08, 8.37)	0.877
Playground	31	0.726	(0.05, 10.28)	0.813
Other	3	(ref)	(ref)	(ref)
Location of injury (repeated)				
School	21	4.239	(1.05, 17.06)	**0.042**
Home	44	1.326	(0.40, 4.41)	0.645
Street	114	1.892	(0.35, 10.32)	0.461
Playground	31	0.488	(0.03, 7.85)	0.613
Other	3	(repeated)	(repeated)	(repeated)
Adult supervision at the time of injury				
Yes	119	0.627	(0.25, 1.59)	0.325
No	100	(ref)	(ref)	(ref)

Abbreviations: Odds Ratio (OR), Confidence Interval (CI). Each category of the predictor variable is compared to the reference category (ref). Each category of the predictor variable is compared to the next category (repeated). Statistically significant p values are shown in bold characters.