THE PREVALENCE OF NEUROCRANIUM INJURY IN CHILDREN IN BROD-POSAVINA COUNTY

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SUMMARY – Head injuries are very common in children and are the most frequent cause of disability and death among children. This retrospective study included 350 children hospitalized for injury of neurocranium over a 5-year period at Dr Josip Benčević General Hospital in Slavonski Brod. Boys were more commonly injured (63.4%) than girls. The most common injuries were recorded in children aged 7-14 (47.1%), followed by those aged 1-6 (33.8%) years. The injuries occurred slightly more often in urban (50.9%) than in rural (46.6%) setting. Children were more commonly injured in the street or on the road (38.6%), followed by injuries sustained at home (35.2%), at school (9.3%) and on playgrounds (5.7%). They were most commonly injured by fall (50%), followed by traffic injuries (33.5%). Statistically significant differences were found in the following age groups: all children younger than one year were injured by fall; children aged 1-14 were mostly injured by fall (less in traffic, and due to hitting), and those aged 15-18 mostly in traffic (less by fall and due to hitting). Children were mostly injured in the street or on the road (in traffic accidents), followed by injuries at home (mostly by fall), at school and around the house or in the yard (mostly by fall); on the playground (due to hitting) and on the road (in traffic accidents) (statistically significant difference). Most of them had head contusion and cerebral commotion combined (46.8%), followed by head contusion alone (12.5%) and skull fractures (10.5%). Hemorrhages and hematomas were rare (epidural, subdural, subarachnoid hemorrhage), found in 3.2% of cases. We hope that our results will prove helpful in planning preventive measures and treatment of injured children.

Key words: *Traumatic brain injury; Children; Neurosurgery*

Introduction

Head injuries are very common in children and are the most frequent cause of disability and death among children. Traumatic brain injury (TBI) has been shown to be the leading cause of mortality in patients younger than 45, as well as the cause of more than one-third of all deaths caused by trauma in the USA[1,2]. According to these data, 52,000 people die each year while 80,000 develop morbidity and suffer TBI[1-3].

In developing countries, however, the prevalence of accidents is rising along with traffic augmentation and other factors like falls, industrialization, ballistic traumas, and others. Head trauma is the cause of one-quarter to one-third of all deaths in various kinds of accidents, as well as the cause of two-thirds of deaths taking place in hospitals, which are also due to various kinds of accidents[1,4].

Analysis of injuries in children reveals TBI in children (aged 0-19) to have caused up to 7000 deaths,

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60,000 hospitalizations, and more than 500,000 emergency department visits annually in the USA[5,6]. It can be stated that TBI are the leading cause of people's death or disability in the USA, while 2% of people are estimated to live with a disability caused by TBI[7]. Injuries are noted to be the leading cause of deaths in children (aged up to 19), accounting for 62% of all deaths within this population, with up to 50% of deaths being due to TBI[8]. TBI in children contribute a fair amount to the health care system economic burden, with an estimated 1 billion dollar in annual hospital expenditures[5].

The aim of the study was to examine the prevalence of head (neurocranium) injuries in children in the Brod-Posavina County and to compare the results with those from other areas. Based on the experience of our institution, where children with injuries of the neurocranium are treated, we investigated differences within particular types of injuries according to age groups, etiologic factors of injury, and type of injury.

Patients and Methods

The study included children hospitalized for injuries of neurocranium at Division of Neurosurgery, Department of Surgery, Dr Josip Benčević General Hospital in Slavonski Brod. In this retrospective study, we analyzed the children (from one month to 18 years of age) hospitalized from January 1, 2003 to December 31, 2008. In this period, 350 injured children were hospitalized. Children with craniocerebral injuries sustained at birth as well as children with TBI treated exclusively in the Intensive Care Unit (ICU) were excluded from the study. Since this was a retrospective study, some data were not available; therefore the total number of patients varies for various parameters, while a specified number of unknown data are also noted for a particular parameter.

This retrospective study was based on medical documentation (medical history, protocols, patient lists) and all data were obtained in agreement with the parents or legal guardians. The following data were collected for each patient: age, sex, mechanism of injury, time elapsed from injury to arrival to the hospital, wider area where the injury was sustained (rural/urban), specific site where the injury was sustained, time of year of injury, type of injury, and Glasgow Coma Scale (GCS).

All children were divided according to age in the following age groups (years): 0-1, 1-6, 7-14 and 14-18. The data collected were entered into relation tables and processed using software for statistical analysis. Differences between the groups of patients were analyzed using appropriate nonparametric tests. The χ^2-test was used to analyze particular parameters in injured children. Considering the distribution of numerical data, results were analyzed with the corresponding measure of relative ratio (%). Qualitative data were shown in contingency tables. Values of $p<0.05$ were considered statistically significant (statistically significant results are shown in tables).

In this retrospective study, medical data were used in concordance with ethical and bioethical principles, so medical privacy of patients included in the study was ensured. Results were used exclusively for the purpose of scientific research and professional work.

Results

Sex and age

During the study period, there were 350 children with injuries of the neurocranium (boys 63.4% and girls 36.6%), with the following age group distribution: 0-1, 1.2%; 1-6, 33.8%; 7-14, 47.1%; and 15-18, 17.9% (Table 1).

Site of injury, time of year, mechanism and type of injury

With regard to the wider area of injury (rural/urban), a slightly higher proportion of injuries were sustained in urban setting (50.9%) *versus* rural setting (46.6%), with 2.6% of children injured on motor highways (Table 2). According to the specific site

Table 1. Number of children with neurocranium injury according to sex and age

Total	Sex		Age (yrs)			
	F	M	0-1	1-6	7-14	15-18
N=350	128 (36.6%)	222 (63.4%)	4 (1.2%)	117 (33.8%)	163 (47.1%)	62 (17.9%)

Table 2. Number of children with neurocranium injury according to wider area of injury infliction and mechanism of injury

Wider area of injury infliction			Mechanism of injury*			
Rural	Urban	HW	Fall	Traffic	Hitting	Other
162 (46.6%)	177 (50.9%)	9 (2.6%)	173 (50%)	116 (33.5%)	56 (16.2%)	1 (0.3%)
Sum	348		Sum		346	
Unknown	2		Unknown		4	
Total	350		Total		350	

*statistically significant difference between groups; HW = motor highway

of injury, they occurred most often in the street or road (38.6%), followed by injuries at home (35.2%), at school (9.3%), on playgrounds (5.7%), around the house or in the backyard (5.1%), and less often elsewhere (Table 3). Considering the time of the year (month), injuries were most commonly sustained in April (11.2%) and July (11.2%), then in June (10.6%), May (9.7%), August (9.5%) and October (8.9%) (Table 3). With regard to the mechanism of injury, half of the children were injured by fall (50%), then in traffic (33.5%), and less frequently by hitting (16.2%) (Table 2). Almost half of the injured children arrived to the hospital within one hour (49.4%), then within two hours (22%) and within three hours (12.7%) (Table 4).

Table 3. Number of children with neurocranium injury according to the site of injury and month of year

Site of injury*		Month of year*	
Street/road 128 (38.6%)		January	23 (6.6%)
Home 117 (35.2%)		February	22 (6.3%)
School 31 (9.3%)		March	26 (7.4%)
Playground 19 (5.7%)		April	39 (11.2%)
Around house/backyard 17 (5.1%)		May	34 (9.7%)
Motor highway 9 (2.1%)		June	37 (10.6%)
Ladder/staircase 6 (1.8%)		July	39 (11.2%)
Kindergarten and other 7 (2.1%)		August	33 (9.5%)
		September	28 (8%)
		October	31 (8.9%)
		November	25 (7.2%)
		December	12 (3.4%)
Sum	332	Sum	349
Unknown	18	Unknown	1
Total	350	Total	350

* statistically significant difference between groups

The majority of study children had GCS 15 (93.9%), followed by GCS 13 (2.6%), GCS 14 (1.7%) and GCS 12 (0.9%) (Table 4); other values were even more rarely recorded. According to the type of neurosurgical injury, most of the injured children had sustained concurrently blow to the head and cerebral commotion (46.8%), followed by blow to the head (neurocranium) (12.5%), skull fractures (10.5%) (Table 4), commotion or contusion with lacero-contused wound or other head injuries and injuries to other body parts (9%), commotion and/or contusion with lacero-contused wound of the head (7.8%), and distortion of the neck or distension of paravertebral muscles with contusion and/or commotion (6.1%). Hemorrhages and hematomas were rarer (epidural, subdural, subarachnoid hemorrhage) (3.2%), post-commotion syndrome (3.2%), intracerebral hematoma with fractures of the skull (0.3%), and other pathologies (0.6%) (Table 4).

In 2003 and in the period between 2005 and 2008, the children were mostly injured by fall, except for 2004, when they were mostly injured in traffic. The number of injuries by fall was approximately the same during the above mentioned years; the number of traffic injuries decreased; and the injuries due to hitting continuously increased (statistically significant difference).

Table 4. Number of children with neurocranium injury according to time elapsed from injury to hospital arrival, Glasgow Coma Scale and type of injury

Time elapsed from injury to arrival to hospital		Glasgow Coma Scale (GCS)		Type of neurosurgical injury	
Time interval	n (%)	GCS	n (%)	Type	n (%)
0.5 h	1 (0.3%)	15	326 (93.9%)	CC	161 (46.8%)
1 h	171 (49.4%)	14	6 (1.7%)	Head cont.	43 (12.5%)
2 h	76 (22%)	13	9 (2.6%)	Fracture	36 (10.5%)
3 h	44 (12.7%)	12	3 (0.9%)	CC + LCW + other	31 (9%)
4-6 h	12 (3.5%)	11	1 (0.3%)	CC + LCW	27 (7.8%)
1 day	24 (6.9%)	7	1 (0.3%)	Dist. + CC	21 (6.1%)
2 days	6 (1.7%)	5	1 (0.3%)	Hematoma	11 (3.2%)
5 or more days	11 (3.2%)			PCS	11 (3.2%)
				ICH + fracture	1 (0.3%)
				Other	2 (0.6%)
Sum	346	Sum	347	Sum	346
Unknown	4	Unknown	3	Unknown	4
Total	350	Total	350	Total	350

CC = contusion and commotion; Head cont. = head contusion; Fracture = skull fracture; CC + LCW + other = commotion and/or contusion with lacero-contused wound or other head and body traumata; Dist. + CC = neck distortion or distension of paravertebral muscles with contusion and/or commotion; Hemorrhage = epidural, subdural, subarachnoid hemorrhage; PCS = post-commotion syndrome; ICH + fracture = intracerebral hematoma with skull fracture

Statistically significant results

Study results yielded statistically significant age differences. Children aged 0-1 were most commonly injured by fall; those aged 1-6 by fall, followed by traffic accidents and injuries due to hitting, similar to children aged 7-14; and those aged 15-18 in traffic accidents, by fall and hitting. Thus, the mechanism of injury differed significantly among age groups ($p=0.022$; $\chi^2=19.344$).

Analysis of the mechanism of injury according to the site of injury revealed that children were most frequently injured in the street and road due to traffic accidents, while at home children were mostly injured by fall. At school and around the house or in the backyard, children were mostly injured by fall. On the playground, injuries were most frequently inflicted by hitting and on motor highways by traffic accidents. Statistical analysis yielded a statistically significant difference ($p<0.001$; $\chi^2=303.881$).

The mechanism of injury according to the month of the year showed seasonal variation. In winter, children were most commonly injured by fall, followed by traffic accidents and hitting. On the other hand, in summer, children were most frequently injured in traffic, followed by fall and hitting. Statistical analysis yielded a statistically significant difference ($p=0.033$;

χ^2=13.736) in the course of injury according to season.

Discussion

The prevalence of TBI, especially mild TBI, was found to be by far greater than previously considered. Although injuries of the neurocranium are frequent in childhood, only a small number of authors have studied such injuries. Yattoo and Tabish analyzed TBI and found the majority to occur in the youngest age group (25.5%), confirming the data reported by most authors who noted the highest incidence of head injuries in the age group of 2-10 years[1,9]. In our study, most of the injured children were aged 7-14 (47.1%), followed by those aged 1-6 (33.8%), etc. According to data from the Accident and Emergency Department, this maximum was marked at the age of 10 and similar data were obtained by Kennedy *et al.* who report on the majority of injured patients (90%) to be aged 0-14[1,4,10]. In Great Britain, on the other hand, monitoring of death rate and hospital admission due to head injuries showed the greatest incidence in the 15-30 age group. A recent study conducted in New Zealand showed that TBI in children, adolescents and young adults (aged 15-34) accounted for almost 70% of all TBI cases[11]. Thereby, TBI affected boys and men more often than women and girls, similar to our results (boys 63.4% and girls 36.6%)[1,11]. According to different studies, the overall male to female ratio is about 3:1.

Concerning the mechanism of injury, our study found 50% of children to have sustained injury by fall (playing, school, etc.), followed by traffic (33.5%) and hitting (16.2%). A recent study also showed that most TBI cases were due to falls (38%), mechanical forces (21%), transport accidents (20%), and assaults (17%)[11].

Very often, TBI involve children falling from lesser heights (up to 3 meters)[12-14]. These falls that happen in and around the house lead primarily to focal contact injuries such as lacerations of the scalp or contusions, although the injury cannot be found at all in the majority of children. However, 1% to 3% of these falls in younger children cause skull fractures, which are predominantly simple linear fractures not associated with intracranial bleeding or neurologic deficit. Approximately less than 1% of these fractures cause epidural bleeding and even lesser subdural bleeding. Nevertheless, these bleedings can sometimes lead to death. One could say that in childhood, more severe injuries of the neurocranium are nonetheless rare, e.g., heavier bleeding with hematomas (epidural hemorrhage, subdural hemorrhage, intracerebral hemorrhage, traumatic subarachnoid hemorrhage). Brain contusions in children are often seen along with fracture of the skull, therefore these contusions should be referred to as fracture contusions. Coup-contrecoup contusions in children younger than 4 years occur rarely or not at all, and we did not find a greater number of this type of injuries[15]. We often found benign injuries in terms of hitting to the head and cerebral commotion, especially due to fall from shorter height with minor contact injuries such as bruises (hematomas) and lacerations. We had no severely injured children with lethal outcome because such cases are admitted to the central hospital ICU. As for homicides and suicides in children, such cases are referred to department of pathology and were not included in the study.

According to the site of injury, our study children were most often injured in the street or on the road (in 38.6%), followed by injuries at home (35.2%), at school (9.3%), etc. This is also understandable since it corresponds to the places where, during the day, children mostly abide. Concerning the wider area of injury, according to Yattoo and Tabish, most patients with head injury were from rural areas[1]. Gabella *et al.* also report that severe TBI and deaths were more frequent in rural areas (71.1%) compared to urban areas (28.9%)[16]. A recent study in New Zealand showed a high incidence of moderate to severe TBI in rural population, almost 2.5-fold that recorded in urban population[11].

Yattoo and Tabish report on the greatest number of patients to be admitted in July and lowest in January[1]. In our study, injuries were most commonly sustained in April (11.2%) and July (11.2%), followed by June (10.6%), etc. The cited data refer to a greater incidence of injuries in children during warm months of the year, which is understandable considering that they stay outdoors longer than in cold season.

The analysis of risk factors for traffic injuries in children pedestrians (in Lima, Peru) has shown the risk to decrease with greater number of hours/days spent at school and greater number of years the family has been living in the same home, whereas it increases with greater vehicle dimension and speed, absence

of horizontal signalization, greater number of street salesmen, and greater number of children living in the same home[17-21].

In our study, traffic injuries (including pedestrians, passengers, bicycle and motorcycle drivers, etc.) were the second leading mechanism of injury (33.5%), immediately following the injuries at fall (50%), while other mechanisms of injury were less common. Such a high incidence of children with TBI, reported by most authors, can be explained by several factors. Children often play in the street or close to a street or road, they are less supervised by their parents and safety measures are often missing. A recent study has revealed that road users at highest risk were pedestrians, cyclists, children and young male drivers, and the highest mortality rate was associated with multiple trauma and head/vertebral column injuries[22]. Concerning motor vehicles, seating position in collisions also plays a major role in determining the pattern of injury in children[23]. While front seated children are more likely to present with head, neck or facial injuries, back seated children more often sustain long bone or pelvic fractures. As for bicycle drivers, study results confirmed that bicycle helmets significantly reduced the rates of both skull fractures and intracranial hemorrhage, encouraging their use by pediatric population[24].

According to Yattoo and Tabish, most patients had lacerations of the head (scalp) (40.4%), followed by contusion (8.8%), extradural hematoma (3.2%), subdural hematoma (4.2%) and impression fracture (3%)[1]. In our study, the greatest number of injured children had simultaneous contusion of the head and commotion (46.8%), followed by head contusion (12.5%) and fracture of the skull (10.5%). Generally, laceration of the head is the most common TBI in children, while more severe injuries that leave sequels are rarer[1,25]. Thereby, important parameters for the prognosis of injury in children is GCS, a scoring system used for quantification of the state of consciousness[10,26]. Several studies have shown fair correlation between the GCS score and neurologic outcome[27,28]. Yattoo and Tabish found normal GCS in 80.2% of patients, while 4.6% of patients had GCS <8 (a more severe stage). Similar to this, our study also showed that the majority of our TBI were mild (GCS score 13-15), which may be explained by exclusion of children with TBI who were treated exclusively at the ICU. However, patients with mild head injury have a low but important risk of intracranial injury that requires early identification and neurosurgical treatment[29]. Although mild TBI symptoms typically resolve within seven days, sometimes symptoms continue for weeks, months, or years following the injury[30]. Thus, mild TBI is one of a few disorders where a benign and misleading diagnostic classification may be stated in patients at the time of injury, which, however, can still be associated with lifelong complications.

The data obtained on overall TBI incidence and on the mechanism of injury should be considered when planning prevention and TBI care services[11]. Preventive measures and care for patients have been seriously considered and there is a current trend of less lethal outcomes and better prognosis for injured children[31-33]. As in Croatia there are not many studies including longstanding monitoring of TBI in children, our results may prove helpful in planning the prevention of such injuries, in the hospital admission process, and in the treatment of injured children.

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Sažetak

UČESTALOST OZLJEDA GLAVE U DJECE U BRODSKO-POSAVSKOJ ŽUPANIJI

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Ozljede glave su česte u djece i najčešći su uzrok nesposobnosti i smrti djece. Retrospektivnom analizom obrađeno je 350 djece hospitalizirane zbog ozljeda neurokranija u 5-godišnjem razdoblju u Općoj bolnici "Dr. Josip Benčević" u Slavonskom Brodu. Češće su bili ozlijeđeni dječaci (63,4%) od djevojčica. Najčešće su ozlijeđena djeca u dobi od 7. do 14. godine (47,1%), zatim od 1. do 6. godine (33,8%). Nešto više ozljeda bilo je u gradu (50,9%) nego na selu (n=162; 46,6%). Djeca su najčešće bila ozlijeđena na ulici ili cesti (38,6%), zatim u kući (35,2%), u školi (9,3%) te na igralištu (5,7%). Najčešće su bila ozlijeđena pri padu (50%), zatim u prometu (33,5%). Do ozljeda je najčešće dolazilo u travnju (11,2%) i srpnju (11,2%), zatim u lipnju (10,6%). Dokazana je statistički značajna dobna razlika: sva djeca do 1. godine ozlijeđena su pri padu; djeca od 1. do 14. godine najčešće su ozlijeđena pri padu (manje u prometu, te zbog udaraca), a starija djeca od 15. do 18. godine najčešće u prometu (manje pri padu, pa zatim zbog udaraca). Djeca su najčešće bila ozlijeđena na ulici i cesti (u prometnim nesrećama), zatim u kući (uglavnom pri padu), u školi i oko kuće ili u dvorištu (najčešće pri padu); na igralištu (uslijed udaraca), te na autocesti (prometne nesreće) (statistički značajna razlika). Najviše ih je imalo istodobno kontuziju i komociju (46,8%), zatim samu kontuziju glave (12,5%), te frakture kosti lubanje (10,5%). Rjeđa su bila krvarenja i hematomi (epiduralni, subduralni, subarahnoidno krvarenje) (3,2%). Nadamo se da će naši rezultati pomoći u planiranju preventivnih mjera i liječenju ozlijeđene djece.

Ključne riječi: *Traumatske ozljede mozga; Djeca; Neurokirurgija*