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Evaluation of the neurosurgical events with detailed demographic factors in pediatric traumas

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Abstract

In this study, we aimed to investigate the incidence of neurosurgical events in patients with childhood trauma to determine risk factors and to standardize the neurosurgical approach to pediatric trauma for reducing the request of unnecessary tomography imaging. According to the age distribution of children aged 17 and under who applied to the emergency department from Jan 2019 to Jan 2021 was examined in 3 separate groups; the infant-early childhood group (0-3 years old), the preschool group (4-7 years), and the pre-adolescence and adolescence group (8-17). Radiological images, type of trauma, neurosurgical damage of trauma (spinal, cranial) and treatment approaches were examined. The mean age of 1247 pediatric trauma patients admitted to the emergency department within two years was 7.71 ± 5.01. The most common reasons in terms of trauma etiology were found to be falling from height (61.2%), traffic accidents (26.5%), and then running into a hard object (10%). It was determined that 249 (19.3%) of the patients were consulted to the Neurosurgery department and 128 patients were hospitalized to the neurosurgery service due to spinal (n: 29) and cranial (n: 99) events. 11 of these patients were operated due to cranial, 2 to spinal events and a patient with spinal injury was followed up with conservative treatment due to SCIWORA (spinal cord injury without radiographic abnormalities). Although trauma is the most important cause of mortality and morbidity in the pediatric age group, most of them are preventable. Computed tomography (CT) indications for pediatric head/spinal traumas are still controversial. We think that unnecessary CT usage should be avoided as much as possible, although there is a need for imaging in order not to miss the diagnosis of severe traumatic brain injury.

Keywords: Pediatric trauma, spinal trauma, cranial trauma, falling from height, SCIWORA

Introduction

Trauma is the most important cause of death in the 1-14 age period in developed countries. In undeveloped and developing countries, trauma is the second leading cause of death after infection in the 1-4 age period, and it is the most common cause of death after the age of 4 [1-3]. Head trauma is an important public health problem in the pediatric age group. The annual incidence of head trauma cases admitted to healthcare institutions in the pediatric age group is reported to be 12% [4]. The annual incidence of inpatient pediatric head trauma cases is approximately 0.2-0.3%, and this incidence is twice as frequent in boys [5]. The mortality rate in pediatric head trauma cases has been reported to be between 2-15% [6]. Severe head trauma is the most common cause of death in patients with multitrauma. Head trauma is the third leading cause of morbidity and mortality in children (200/100.000 years) and is seen twice as often in males. It is the most common cause of death in children under the age of 15 [4,7,8].

Spinal fractures constitute 0.82% of deaths caused by trauma [9,10]. In the pediatric period, the area where injuries are most common is in the cervical region with a rate of 40-60% [11-13]. There is an inverse proportion between the age of children and the frequency of upper cervical region injury. While 33% of upper cervical region injuries result in death, 8.3% of lower cervical region injuries result in death [11]. In pediatric spinal traumas, thoracolumbar junction and lumbar region injuries are seen in 14%, and thoracic region injuries are seen in 11% [12]. Spinal cord injury without radiographic findings (spinal cord injury without radiographic abnormalities-SCIWORA) can be defined as the absence of signs of fracture and dislocation on direct radiography, tomography and myelography of the spine, although there are clinical signs of myelopathy after trauma. The cervical region is

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the most affected area in SCIWORA. Thoracic region is affected less frequently, however, studies are showing that thoracic region involvement is a sign of severe trauma and poor neurological prognosis [12,13].

Computed tomography (CT) is one of the most important diagnostic methods in determining traumatic brain and spinal injury. However, the risk of malignancies associated with ionizing radiation may increase in children due to CT [14]. The effective dose is 2-4 mSv during CT. This dose contains approximately 200 times more radiation than the chest radiograph [15]. Also, in cases requiring sedation, drug-related side effects may occur. Computed tomographic imaging indications in pediatric head/spinal traumas are still a controversial issue. Although there is a need for imaging in order not to miss the diagnosis of severe traumatic brain injury, with a careful clinical evaluation, it was found that the CT demand decreased in minor head trauma [16]. Not surprisingly, high accuracy, rapid acquisition and availability of CT have resulted in overuse all around the world. An obvious limitation of CT is ionizing radiation; in addition, there are economic implications to overuse. In recent years, efforts have been made to develop validated clinical decision rules specifically for pediatric head trauma in an attempt to decrease CT use and decrease the variation in use among hospitals and physicians, without compromising patient care. The Pediatric Emergency Care Applied Research Network (PECARN), Canadian assessment of tomography for childhood head injury (CATCH), Children's head injury algorithm for the prediction of important clinical events (CHALICE) and the National Emergency X-Radiography Utilization Study (NEXUS) criteria have been extensively tested and for identifying patients at low risk of clinically important injury who can be evaluated without a CT scan. These prediction rules have a very high, bordering on 100%, negative predictive value for clinically important traumatic brain injuries and spinal injuries, and is widely adopted [17-18].

In this study, an established algorithm of spinal trauma in the pediatric age group in emergency departments is not fully used. We wanted to remind the importance of the algorithm, that should be followed for diagnosis and treatment in this type of trauma. In order to show its importance, we planned this retrospective study.

Materials and Methods

Ethics committee approval dated 05.02.2021 and numbered 2021/96 was obtained from the Local Ethics Committee of Afyonkarahisar Health Sciences University for the study.

Children aged 17 years and younger who were admitted to the Department of Emergency Service of Afyonkarahisar Health Sciences University due to physical trauma between January 2019 and December 2020 were included in this retrospective study. Of the 1287 patients included, 478 (37.1%) were isolated head trauma, 215 (16.7%) were isolated spinal trauma and 594 (46.2%) were multitrauma. Computed tomography was requested for 767 (59.5%) patients. According to the age distribution of children aged 17 and under who applied to the emergency department was examined in 3 separate groups; the infant-early childhood group (0-3 years old), the preschool group (4-7 years), and the pre-adolescence and adolescence group (8-17 years). Radiological images, type of trauma, neurological damage of trauma and treatment approaches were examined.

Inclusion criteria; All traumatized patients 17 years of age or younger, patients with a history of cranial and spinal trauma were included.

Exclusion criteria; Any patient over 17 years of age and patients without a history of cranial and spinal trauma were not included in this study.

Statistical analysis

Categorical data were evaluated by SPSS STATISTICS 25 program. Descriptive data were presented as frequencies and percentages.

Results

1287 pediatric trauma patients who applied to the emergency department from Jan 2019 to Jan 2021, 62.8% (n=808) were male and 37.2% (n=448) were female. The mean age of the patients was calculated as 7.71 ± 5.01. It was found that the youngest patient was 3 months old. When evaluated in terms of injury etiology regardless of age groups; it was determined that pediatric traumas were mostly due to falling from a height with a rate of 61.2%, followed by traffic accidents with a rate of 26.5% and injuries due to running into a hard object with a rate of 10%. The trauma etiology of the study is given in detail in Table 1. When examined in three groups in terms of age distribution; 346 patients in group 1 (0-3 years), 345 patients in group 2 (4-7 years), and 596 patients in group 3 (8-17 years) was determined. When the etiology of trauma is examined by looking at age groups; while falling, which is the most common cause of trauma, was detected at a rate of 75.7% in group 1, it was found to be 57.9% in group 2. In Group 3, traffic accidents were the most common cause of the trauma mechanism with a rate of 48.6%.

When the radiological images taken in 1287 pediatric patients who applied for trauma were examined; 102 (8%) patients were followed up under observation without any need for imaging, 378 (29.3%) patients received only X-ray, the remaining 767 (59.5%) patients received brain and/or spinal CT, and only 7 patients (0.54%) spinal magnetic resonance imaging (MRI) was obtained. It was determined that 19.3% (n=249) of the patients who applied to the emergency department were consulted to the Neurosurgery department. It was found that 128 patients who were consulted were hospitalized to the neurosurgery service due to spinal (n: 29, 2.3% of total patients) and cranial (n: 99, 7.7% of the total patients) events. Patients who did not need hospitalization were discharged after the observation period. It was found that the most common diagnosis of calvarial linear fracture (n: 88, 6.8% of total patients, 68.7% of hospitalized patients) was found in hospitalized patients. The regions affected in terms of spinal injuries are; cervical (n: 13, 44.8% of patients hospitalized due to spinal trauma, 10.1% of patients hospitalized due to trauma, 1% of total patients), lumbar (34.4% of patients hospitalized due to spinal trauma) and the least affected region was thoracic (17.2%), (Figure 1).

Although one patient had a neurological deficit (lower extremity paraparesis), it was determined that the patient was diagnosed with SCIWORA so that no compression pathology was detected in all imaging methods. Detailed diagnostic information of the patients hospitalized is summarized in Table 2.

It was found that 11 of the hospitalized patients (8% of the patients hospitalized in the neurosurgery service, 0.8% of the total patients) were operated on due to cranial events and 2 of the hospitalized patients (1.5% hospitalized, 0.16% of the total patients) were operated on due to spinal events. The diagnoses of the operated patients are summarized in Table 3.

High dose methylprednisolone (30 mg/kg IV bolus in the first 8 hours, 5.4 mg/kg/hour infusion for the next 23 hours) was administered to one patient diagnosed with SCIWORA and this patient was followed up with physical therapy as a conservative treatment method (Figure 2).

Table 1. Demographic distribution of pediatric trauma by age group

Trauma etiology	0-3 Years (n (%))	4-7 Years (n (%))	8-17 Years (n (%))	Total (n (%))
In-vehicle traffic accident	38 (10.98%)	48 (13.91%)	118 (19.80%)	204 (15.85%)
out of vehicle traffic accident	16 (4.62%)	16 (4.64%)	76 (12.75%)	108 (8.39%)
Motorcycle accident	0	4 (1.16%)	26 (4.36%)	30 (2.33%)
Falls (less than 1 meter height)	112 (32.37%)	62 (17.97%)	30 (5.03%)	204 (15.85%)
Falls (more than 1 meter height)	44 (12.72%)	110 (31.88%)	166 (27.85%)	320 (24.86%)
Falls (from the bed/swing)	106 (30.63%)	24 (6.96%)	22 (3.69%)	152 (11.81%)
Fall from ladder	4 (1.16%)	4 (1.16%)	10 (1.68%)	18 (1.40%)
Falling off the bike	0	24 (6.96%)	70 (11.75%)	94 (7.30%)
Running into a hard object	14 (4.05%)	30 (8.69%)	44 (7.38%)	88 (6.84%)
Falling of an object/being under the object	10 (2.89%)	12 (3.48%)	4 (0.67%)	26 (2.02%)
Assault	0	2 (0.58%)	16 (2.69%)	18 (1.40%)
Animal kick	2 (0.58%)	9 (2.61%)	8 (1.34%)	19 (1.48%)
Firearm injury	0	0	1 (0.17%)	1 (0.08%)
Sports injury	0	0	5 (0.84%)	5 (0.39%)
Total	346	345	596	1287

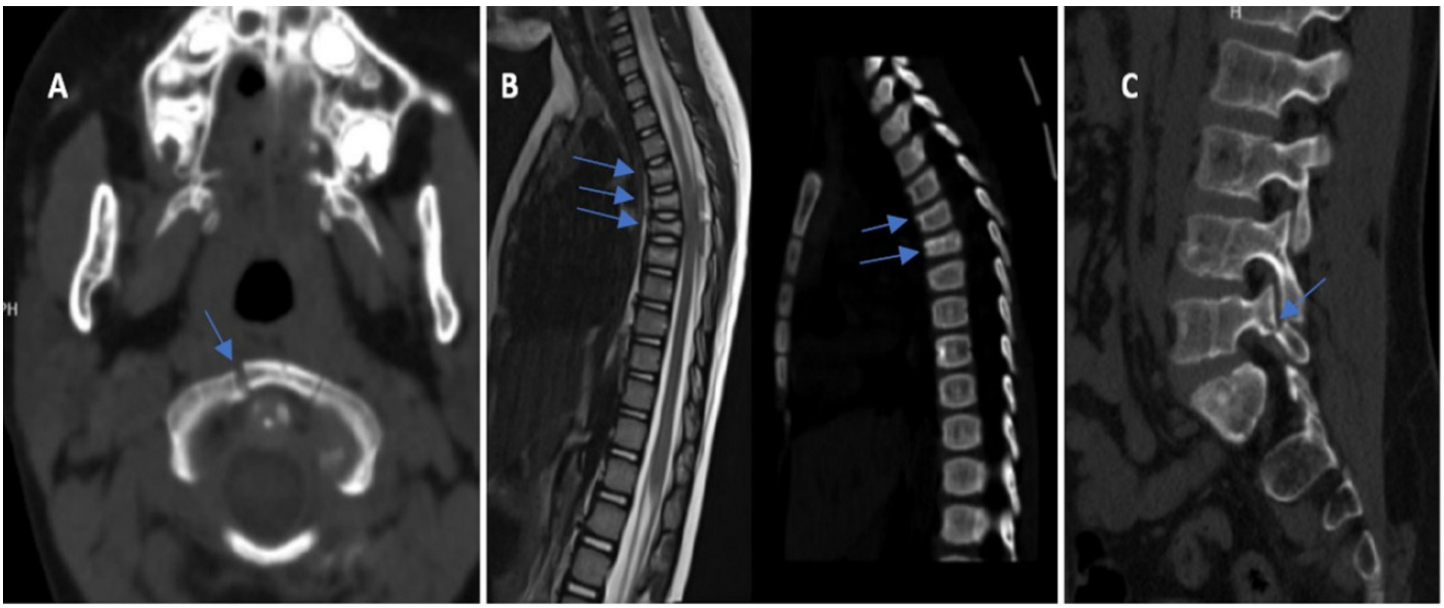

Figure 1. Spinal injuries due to trauma, (A) axial CT image reveals the cranial suture separation of C1 anterior occurs due to fall at age 4, (B) sagittal T2W MRI and sagittal CT images show T5-6 compression fracture due to fall at age 8, (C) L5-S1 Pars fracture due to in-vehicle traffic accident is seen on sagittal CT image

Table 2. Diagnostic profile of children admitted to the neurosurgery department

Cranial			Spinal		
Fracture	**Linear**	72	**Cervical**	**Upper cervical**	10
				Subaxial	3
	Non-displaced	10	**Total**		13
	Displaced	4	**Thoracic**	**Upper thoracic**	2
	Cranial suture separation	2		**Middle thoracic**	1
Total		88		**Lower thoracic**	2
			Total		5
Hematoma	**Subdural hematoma**	10	**Lumbar**		10
	Epidural hematoma	7			
	Subarachnoid hemorrhage	5			
	Intraparenchymal hemorrhage	4	**SCIWORA**		1
Brain injury	**Contusion**	11			
	Diffuse axonal damage	3			
Total		40			
Pneumocephalus		11			
Number of cranial patients		138	**Number of spinal patients**		29

A patient can have more than one diagnosis, SCIWORA: spinal cord injury without radiographic abnormalities

Table 3. Diagnostic profile of the operated patients

Cranial		Spinal	
Displaced fracture	3		
Displaced fracture + epidural hematoma	2		
Nondisplaced fracture + epidural hematoma	3	**Thoracic vertebra 12 (T12) burst fracture**	2
Subdural hematoma	2		
Intraparenchymal hemorrhage	1		
Total	11		2

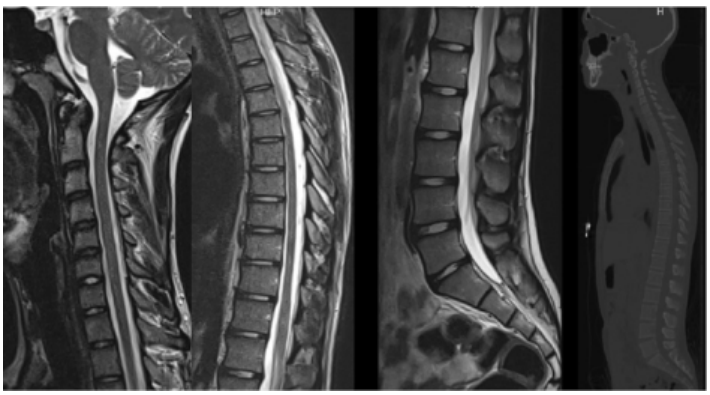

Figure 2. A 16-year-old male patient with generalized paraparesis of the lower extremity (muscle strength 2/5) after traffic accident. Sagittal T2W spinal MRI and sagittal CT images were within normal limits. The patient, who had methylprednisolone and physical therapy, can walk without support after 3 months

Discussion

Traumas are one of the most important health problems of the pediatric age group. According to the data of the World Health Organization, deaths due to trauma have been reported at a rate of 83.7 per 100.000 per year. Karasu et al. reported the vast majority of these injuries occur in underdeveloped or developing countries. This rate is 120 in 100.000 in our country. Approximately 32% of these injuries involve central nervous system injuries [19,20]. In our study, central nervous system injuries, including spinal and cranial, were found to be 13%. The male majority of the patients (62.7%) included in the study was consistent with the literature [4].

Authors such as Yildizhan and Schonfeld in their studies on head trauma examined the 0-17 age range as a whole without child age grouping [15,16]. Işık et al.'s study involving 851 patients, the

patients were divided into 3 groups according to their age as 0-2 years (infancy), 3-7 years (early childhood) and 8-14 years (school age childhood). As a result of the study, in the assessment made by considering age groups and types of falls, indoor simple falls in the first place (83%) in infancy, while outside simple falls (47%) were found at the highest rate during the school child period [7]. While the results obtained in the 1st and 2nd groups were similar to our study, they differed with the 3rd group, who was in school and adolescence. In our study, motor vehicle accidents come first with a rate of 48.6% as the trauma mechanism of the 3rd group. In a study investigating the mechanism of trauma, according to age groups, 280 patients were examined in two groups as preschool (0-6 years) and school period (7-16 years). As a result of that study, it was stated that falling from height (43.4%) and simple falling (19.6%) ranked in the first two places in the preschool period, while out of vehicle traffic accident (35%) and falling from height (24%, 8) has been reported to take the first places [4]. The result of our study coincides with the study of Şimşek et al.

In emergency situations, it is a life-saving situation to intervene in the pathological diagnosis determined by rapid and accurate examination in trauma patients without delay. Examination of childhood patients may not be as easy as adults. Sometimes it may not be very healthy to apply the Glasgow Coma Scale (GCS) assessment, which is the backbone of the neurological examination, to patients in childhood. For this reason, it can be easily seen that imaging methods are used as much as possible. Sönmez et. al.'s study involving 183 patients under 2 years of age, it was reported that neurological pathology was detected in only 27 (14.7%) of the patients in the computerized brain tomography [21]. There are many similar studies in the literature such as Zyluk and Yıldızhan [15,22]. In this study, it was determined that 767 (59.5%) of 1287 patients had undergone CT examination and the number of patients with neurological pathology was 128 (10%). The increased number of patients underwent CT examination might be due to two factors. The first factor suggests that it stems from the difficulties in examining small children and the non-standardization of CT indication. In fact, in a series of studies conducted on 1009 patients, PECARN, CHALICE and CATCH algorithm were compared and it had been shown that major brain injuries were detected more accurately with the PECARN algorithm [23]. PECARN is a commonly used method that safely evaluates pediatric patients with low-risk blunt head trauma without CT scanning [24,25]. When the retrospective anamnesis of our patients who were included in our study and CT results were examined in detail, the compliance rate for PECARN criteria was only 22%. In other words, 78% (n:598) of 767 CTs were non-indication according to PECARN critiques. The second factor suggests that it is due to the tendency of physicians to provide more medical imaging services to secure themselves due to the more necessary and unnecessary malpractice cases recently. As stated by Wong et al., increased malpractice fears increase the CT imaging demand [26]. We think that taking so many CT scans is more associated with the latter factor.

Calvarium fractures due to minor trauma are more common in children under 2 years of age than in adults. This is because covering is softer and thinner in children. Calvarium is unilaminar and it lacks bone marrow in children under 4 years of age. Therefore, in case of head trauma, the pediatric brain is less protected than adults and the risk of intracranial injury is higher [27, 28]. Sönmez et. al.'s study involving 183 patients under 2 years of age, fractures in the skull in 27 (14.7%) of the patients and subgaleal, epidural, subdural, subarachnoid hemorrhage were detected in 9 of these patients (4.9%) as a result of CT imaging [21]. Linear fracture was the most common pathology. In this study, fractures were detected in 88 (6.8%) patients' skulls. The most common cranial pathology was linear fracture detected in 72 patients. However, when evaluated in terms of cranial pathologies, it was found that cerebral contusion was seen in the second frequency with a rate of 1.1% (n=14). This was followed by pneumocephalus (0.85%), subdural hematoma (0.77%), epidural hematoma (0.5%), subarachnoid hemorrhage (0.39%) and finally intraparenchymal hemorrhage (0.31%).

Akyol and Buhs reported that spinal fractures constitute 0.82% of deaths caused by trauma and spinal fractures were observed in 5.2% of traumas in the pediatric period [29, 30]. In our study it was determined that the number of patients with spinal injuries was 29 (2% of the patients with total trauma). Mccal and Kitiş reported that the area where injuries were most common the cervical region with a rate of 40-60% in the pediatric population [9,10]. In our study, the most frequently affected areas have been cervical (and=13, 44% of patients with spinal injuries). Buhs et al. reported that there was an inverse proportion between child age and the frequency of upper cervical region injury. While upper cervical injury in children under 8 years of age constitutes 67% of all spinal injuries, this rate decreases to 39% between the ages of 9-16. Among the cervical injuries that cause serious consequences, the rate of upper cervical region injury is 80% [30]. While 33% of upper cervical region injuries result in death, 8.3% of lower cervical region injuries result in death [11]. Among the pediatric spinal injuries, thoracolumbar junction and lumbar region injuries are seen in 14%, and thoracic region injuries are seen in 11% [12]. Hamilton et al. reported that the most frequently affected thoracic region is between thoracic vertebra 4-12 (T4-12) level, followed by T12-L2 level. There is a direct proportion between thoracic and lumbar spine fractures and the age of occurrence of trauma [31]. Our results were lumbar and thoracolumbar (n=10, 34%) and thoracic regions (n=5, 17.2%), respectively. It was determined that an upper cervical injury constituted 77% of the total cervical injury and this data was found to be significantly compatible when compared with the literature.

SCIWORA can be defined as the absence of signs of fracture and dislocation on direct radiography, tomography and myelography of the spine, although there are clinical signs of myelopathy after trauma. Yücesoy and Launay reported that the incidence of SCIWORA in the pediatric population ranges from 3.3% to 32.0% [32,33]. There is currently no consensus on the definition of SCIWORA. The differences of opinion deepened after the MRI was accepted as the gold standard in spinal traumas. While pathologies such as edema, contusion, and separation in MRI are included in the definition of SCIWORA in many publications, new views are that there should be no pathology in MRI. Yücesoy et al. as a result of their research, MRI was used to diagnose SCIWORA in 313 of the cases, only 105 showed no lesions in the spinal cord. Yücesoy et al. Mentioned 'real-SCIWORA' cases that show no lesion in the spinal cord in MRI images [32].

In acute spinal cord injury, methylprednisolone treatment is frequently used in line with the recommendations [34]. These patients are recommended 30 mg/kg/15 minutes in the first 8 hours, followed by 5.4 mg/kg/hour infusion therapy for 23 hours [35]. Only one of the patients included in our study was identified as SCIWORA. Methylprednisolone was administered at the dose determined above. It was observed that the patient recovered after three months of physical therapy and rehabilitation.

Conclusions

Although trauma is the most important cause of mortality and morbidity in the child age group, most of them are preventable. Another important point that should not be forgotten is spinal cord immobilization in cases with a history of spinal trauma until clinical and radiological evaluations are completed. It should be kept in mind that spinal cord trauma may occur due to SCIWORA. Briefly, high accuracy, rapid acquisition and availability of CT have resulted in overuse for brain and spinal traumas, especially in pediatric patient population all around the world. Clinical evaluation methods like PECARN, CATCH, NEXUS criterias have the potential to reduce the burden of CT demand and aide clinicians in the decision-making process.

Conflict of interests
The authors declare that they have no competing interests.

Financial Disclosure
All authors declare no financial support.

Ethical approval
This study was approved by the Ethical Committee of Afyonkarahisar Health Sciences University, Faculty of Medicine (Date: 05/02/2021, Decision no: 2021/96).

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