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A comparison of pathological findings in head computed to-mography with clinical presentation of pediatric patients in the Emergency Department

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Abstract

Pediatric trauma is a cause for over 750.000 visits to emergency departments each year. Of all types of traumas, head injuries represent the group at most risk. Computed tomography (CT) is still the most frequently used advanced imaging method to distinguish cases of severe injuries out of thousands of mild or apparently trivial injuries. The aim of this study was to review the results of CT in terms of clinical prediagnosis and radiological findings in children categorized into four age groups, who underwent a CT scan in the Pediatric Emergency Department (ED). Among all CT studies, no findings were found in 552 (80.23%) patients, whereas CT findings were detected in 98 (14.2%) boys and 38 (5.5%) girls from all participants. The incidence of lesions in the male group is 2 times higher than in the female group. The most common abnormality was hematoma representing 26.47% of all confirmed lesions and 5.23% among all head CTs performed from the ED. Head CT is an incredibly useful tool in the evaluation of some head emergencies. However, in the majority of cases, the clinical presentation with which children present to the ED does not correlate with the severity of neuroimaging results.

Key words: injury, head CT, children TBI

Introduction

Imaging remains an important tool for evaluation of children in the Emergency Departments (EDs), which is very useful for physicians in establishing a particular diagno-sis or otherwise in excluding one [1]. The use of computed tomography (CT) became more limited in the recent years in an attempt to reduce patient exposure to ionizing radiation. Pediatric population is particularly vulnerable to the damaging effects of radiation exposure [2]. According to Food and Drug Administration (FDA) the probability of developing cancer from radiation computed tomography of the head in pediatric patients is thought to be very low, however no dose can be considered totally safe [3]. Early exposure to radiation poses a significant associated risk. Estimated life-time cancer mortality risk from CT may be an order of magnitude higher in a 1-year-old child than in an adult [4]. Also, the need for analgesia and sedation in younger children is a limitation in the use of this imaging modality [5]. Nevertheless, CT is still the most frequently used advanced imaging method, because of its increasing accessibility, lower cost compared to magnetic resonance imaging (MRI), speed and accuracy [6]. It can give results quickly, allowing potentially lifesaving decisions to be made. CT of the head is the most common CT scan performed in EDs and it can be divided into two categories: post-traumatic and non-traumatic CT head [1,7].

After obtaining a medical history and physical examination, preliminary diagnoses of patients with non-traumatic reasons that may be an indication for head CT include: headache, seizures, fewer, confusion, hematoma, infarct, optic neuritis and arrest [7]. However, there are no guidelines for performing head CT in non-traumatic patients in literature. Therefore, the proportion of imaging tests being done for non-traumatic patients is lower than those performed after an injury [8].

There are over 750.000 estimated visits to emergency departments each year for pediatric trauma [9]. In developed countries, pediatric trauma mortality still represents more than half of all childhood fatalities, which is 18 times more common than brain tumors. Of all types of traumas, head injuries represent the group at most risk in terms of consequences, because of the high probability of death and permanent disability. A fall from height, road traffic accident (RTA) especially including pedestrians, and slippage at home are the most frequently mentioned causes of head trauma. The symptoms in a child that may suggest brain damage, include: loss of consciousness, headache, vomiting, seizures and drowsiness [10]. The incidence of TBI was reported as 774 per 100.000 people per year [5]. It is a significant public health issue among the pediatric population due to the highly variable of injury severity. It is important to distinguish cases of severe TBI out of thousands of mild or apparently trivial TBI as injury to the developing brain can lead to psychosocial, cognitive, emotional and behavioral problems [11].

Materials and Methods

1. Study design

This retrospective, cross-sectional study enrolled pediatric patients who underwent a CT scan of the head in the Pediatric Emergency Department at the Prof. Antoni Gebala

Children's Hospital of Lublin in the 6 months from 1st January 2021 to 31th June 2021. All study subjects were children under the age of 18, referred for a head CT scan from the ED. The imaging was performed on Siemens Definition AS+ 128 slices without administering an intravenous contrast agent. The purpose was to compare pathological findings with the clinical presentation of each patient.

2. Data collection

The data collected are: the age at the time of examination and sex of the child, prediagnosis (data from the referral for head CT examination) and data on abnormalities obtained by the CT scan. Head CT was performed for traumatic and non-traumatic indications which were defined as preliminary diagnosis using International Classification of diseases (ICD-10). The following were considered among the indications to perform a CT scan of the head: headache (R51.9), superficial (S00) or unspecified (S09) injury of the head, nausea (R11.0) and vomiting (R11.10), unspecified convulsions (R56.9), syncope (R55.9), facial nerve disorders (G51), open wound of scalp (S01.0), dizziness and giddiness (R42), concussion (S06.0), other categories and no diagnosis on the referral. The findings in the CT scans were classified as follows: no lesions, edema of the soft tissues, pathological fluid in the ventricles, hematoma, dilatation of the ventricles, temporal bone fracture, occipital bone fracture, parietal bone, frontal bone fracture, craniofacial fracture and other categories. Each child could have one or more findings. The children categorized into four age groups: 0-1, 2-5, 6-11 and 12-18 years old, who had brain CT with post-traumatic and non-traumatic indications were reviewed in terms of clinical prediagnosis and radiological findings.

3. Analysis and statistical Method

Associations between sex, age groups, prediagnosis and CT scan findings were analyzed statistically. Statistical analysis was performed using Statsoft Statistica 13.3 and IBM SPSS software. The categorical variables are summarized using frequencies and percentages and continuous variables with mean (M) with standard deviation (SD), medians (Me) and minimum and maximum/interquartile ranges (Q25 - Q75). To determine whether there were associations between sex and CT findings or prediagnosis, between age stage and CT findings and prediagnosis, and between CT findings and prediagnosis, analyses using chi-square and Mann-Whitney were performed. The statistical significance level was set as a p-value < 0.05, while results with a p-value <0.1 were also includ-ed to determine trends in specific variables.

For statistically significant results we counted odds ratio (OR) with confidence interval of 95% (95% CI).

Results

1. Study group

The total number of 688 pediatric patients admitted to the ED, on whom a CT scan of the head was performed, were included in this study. Of these patients 386 (56.1%) were male and 302 (43.9%) were female.

The age of children varied between 0 and 18 and the mean age of patients in the study group was 9,56 ± 4,68. The largest proportion of the study group were children aged 12-18 years old – 264 patients (38.37%) with equal proportion of middle childhood (36.92%). More information about the study group is provided in Table 1 and Table 2.

Table 1. Characteristics of study group.

Sex	Age (in years)		N	%
	M±SD	Me (Min; Max)		
Female	9.76±4.60	10 (0-17)	302	43.90
Male	9.40±4.74	9 (0-17)	386	56.10
Total	9.56±4.68	10 (0-17)	688	100%

Table 2. Study group by the age groups.

Age group	N	%
Toddlers and infants (0-2 years old)	19	2.76
Early childhood (2-5 years old)	151	21.95
Middle childhood (6-11 years old)	254	36.92
Early adolescence (12-18 years old)	264	38.37
Total	688	100%

2. Indications for performing a CT scan (prediagnosis) and relationships between age groups and gender

Of all patients, 350 (50.87%) had superficial or unspecified head injury as a prediagnosis (Table 3) 141 (46.69%) of them were girls and 209 (54.15%) were boys. Depending on age category, the most common diagnosis in early childhood according to the ICD-10 classification was superficial or unspecified head injury, which accounts for 70.20%. Patients aged 2-5 years old were more likely to be prediagnozed with superficial or unspecified head injury than children in middle childhood and early adolescence, respectively 1.46 and 1.68 more times likely (Table 4). Secondly, there are other indications representing a group of 90 (13%) children with other prediagnosis according to the ICD-10 classification than those listed in the table. The other diagnoses on referral for CT scan were in descending order: 73 (10.61%) had headaches, 50 (7.27%) syncope, 38 (5.52%) open wound of scalp, 36 (5.23%) unspecified convulsions and 21 (3.05%) had nausea or vomiting. The patients from early adolescence group were 3.26 more likely to be prediagnozed with syncope than children from other age stages. There is a trend that unspecified head trauma is more likely to be seen in males and nausea and vomiting are more common indications for head CT in females. Girls (10.6%) faint almost 2 times more often than boys (4.7%).

Table 3. Prediagnosis and sex rates of the patients.

	Sex			**Pearson's chi-squared test**	
	Female	Male	Total	Test value	*p*-value
Superficial or unspecified injury of the head	141 (46.7%)	209 (54.1%)	350 (50.9%)	3.769	0,052
Other	36 (11.9%)	54 (14.0%)	90 (13.1%)	0.638	0.424
Headache	38 (12.6%)	35 (9.1%)	73 (10.6%)	2.208	0.173
Syncope	32 (10.6%)	18 (4.7%)	50 (7.3%)	8.849	0.003
Open wound of scalp	13 (4.3%)	25 (6.5%)	38 (5.5%)	1.532	0.216
Unspecified convulsions	14 (4.6%)	22 (5.7%)	36 (5.2%)	0.387	0.534
Nausea and vomiting	13 (4.3%)	8 (2.1%)	21 (3.1%)	2.853	0.091

Dizziness and giddiness	6 (2.0%)	4 (1.0%)	10 (1.5%)	1.069	0.301
Facial nerve disorders	4 (1.3%)	5 (1.3%)	9 (1.3%)	0.001	0.973
No prediagnosis	3 (1.0%)	3 (0.8%)	6 (0.9%)	0.092	0.762
Concussion	2 (0.7%)	3 (0.8%)	5 (0.7%)	0.031	0.860

Table 4. Prediagnosis and age stage (only statistically significant).

What prediagnosis?	**Age group**				**Mann–Whitney U test**	
	Toddlers and infants (0-2 years old)	Early childhood (2-5 years old)	Middle childhood (6-11 years old)	Early adolescence (12-18 years old)	Z	*p* value
Superficial or unspecified injury of the head	12 (63.16%)	106 (70.20%)	122 (48.03%)	110 (41.67%)	-5.26	<0.001
Syncope	0 (0.00%)	4 (2.65%)	12 (4.72%)	34 (12.88%)	-4.44	<0.001
Other	2 (10.53%)	9 (5.96%)	39 (15.35%)	40 (15.15%)	-2.26	0.002

3. Findings in CT

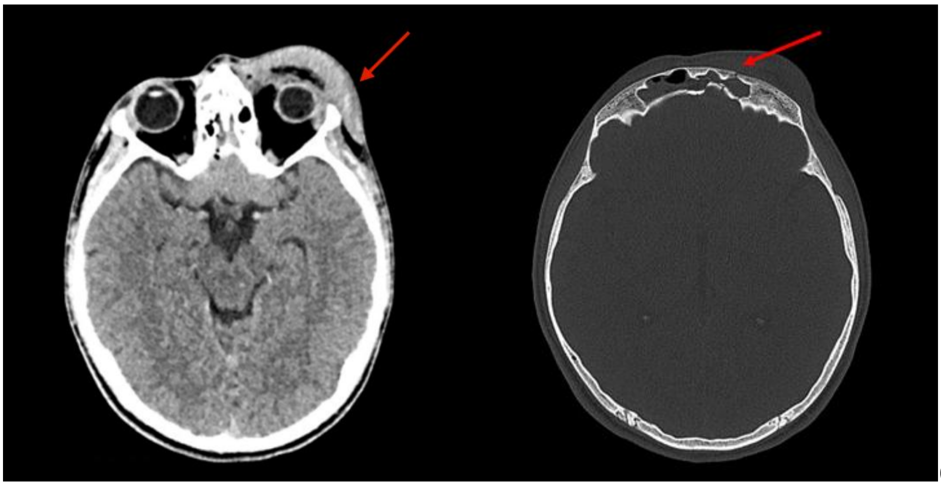
Among all CT studies, no findings were found in 552 (80.23%) patients (Table 5), whereas CT findings were detected in 98 (14.2%) boys and 38 (5.5%) girls from all participants. The incidence of lesions in the male group is 2 times higher (OR (95% CI) = 2.36 (1.56-3.56)) than in the female group. This is probably due to the fact that boys were more likely to have a head CT performed because of superficial or unspecified head injury than girls. The most common abnormality was hematoma representing 26.47% of all confirmed lesions and 5.23% among all head CTs performed from the ED. 30 (7.8%) of all males and 6 (2.0%) of all females had hematoma. Adding up all the fractures of the skull, they accounted for 22 (16.18%) of all the lesions found on CT. By age stages, neurocranial fractures are almost 2 times more common in early childhood than in middle childhood and 4 times more common than in early adolescence (Table 6). In comparison, craniofacial fractures were almost 7.8 times more likely to be seen in early adolescence than in middle childhood and almost 4.6 times more common than in early childhood. Figure 1 shows both examples of hematoma and a fracture within the head. Figure 2 and 3 show an example of a right orbital hematoma and a left frontal bone fracture caused by trauma. Pathological fluid occurred slightly more frequently than dilatation of the ventricles or other spaces of central nervous system (CNS) with 18.38% and dilatation of the ventricles with 16.91% of all lesions. Other lesions than those listed in the table were found in 33 (24.26%) patients. The chance of having other CT lesions in the male group is 2.16 times higher than in the female group (OR (95%CI) = 2.16 (0.98-4.72)).

Table 5. CT findings and sex rates of the patients.

	Sex			**Pearson's chi-squared test**	
	Female	Male	Total	Test value	*p* value
Presence of any lesion	38 (12.6%)	98 (25.4%)	136 (19.8%)	17.519	<0.001
Hematoma	6 (2.0%)	30 (7.8%)	36 (5.2%)	11.436	<0.001
Other	9 (3.0%)	24 (6.2%)	33 (4.8%)	3.889	0.049
Pathological fluid in the brain	8 (2.6%)	17 (4.4%)	25 (3.6%)	1.491	0.305
Dilatation of the ventricles	8 (2.6%)	15 (3.9%)	23 (3.3%)	0.802	0.402
Edema of the soft tissues	4 (1.3%)	14 (2.0%)	14 (2.0%)	0.10	0.922
Neurocranial fracture	4 (1.3%)	8 (2.1%)	12 (1.7%)	0.553	0.565
Craniofacial fracture	4 (1.3%)	6 (1.6%)	10 (1.5%)	0.063	1.000
Occipital bone fracture	3 (1.0%)	3 (0.8%)	6 (0.9%)	0.092	1.000
Frontal bone fracture	0 (0.0%)	4 (0.6%)	4 (0.6%)	3.148	0.135
Parietal bone fracture	1 (0.3%)	1 (0.3%)	2 (0.3%)	0.030	1.000
Temporal bone fracture	0 (0.0%)	1 (0.1%)	1 (0.1%)	0.784	1.000

Table 6. CT findings and age stage (only statistically significant).

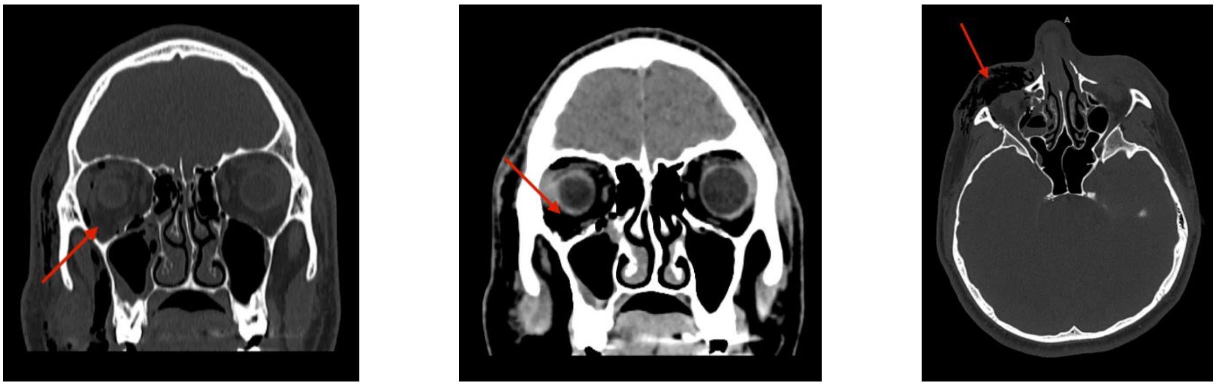
What lesion?	Age group				Mann–Whitney U test	
	Toddlers and infants (0-2 years old)	Early childhood (2-5 years old)	Middle childhood (6-11 years old)	Early adolescence (12-18 years old)	Z	*p*-value
Neurocranial fracture	0 (0.00%)	6 (3.97%)	4 (1.57%)	2 (0.76%)	1.97	0.049
Craniofacial fracture	0 (0.00%)	1 (0.66%)	1 (0.39%)	8 (3.03%)	2.39	0.017



(a)

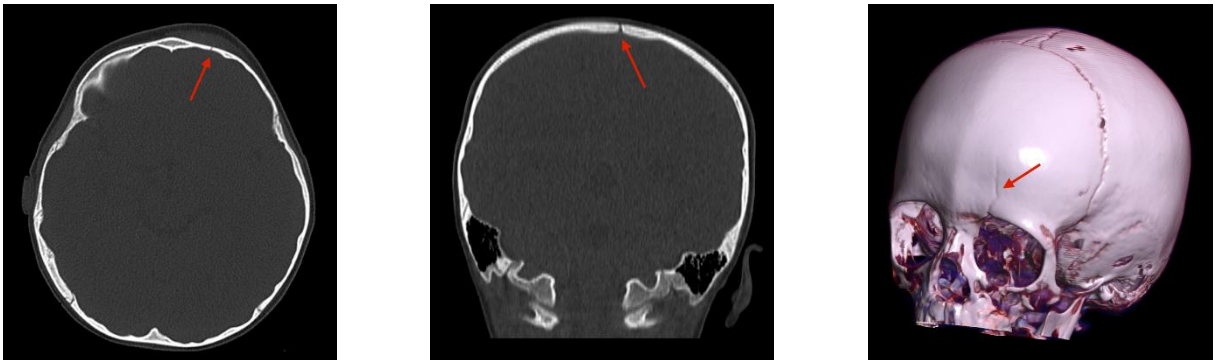
(b)

Figure 1. (a) Extracebrebral hematoma in the left frontal region; (b) Fracture of the left frontal bone, the anterior and posterior walls of the left frontal sinus and the roof of the left orbit in the medial part.



(a) (b) (c)

Figure 2. Hematoma of the right orbit (a) frontal plane, bone window; (b) frontal plane, tissue window; (c) transverse plane, bone window.



(a) (b) (c)

Figure 3. Fracture of the left frontal bone (a) transverse plane, bone window; (b) frontal plane, bone window; (c) 3D volume rendering reconstruction of left frontal bone fracture

Discussion

The pediatric Emergency Department is an important place where children of all ages are brought by self-referral, by emergency medical services or referred from either primary or secondary care. These are patients who are admitted for many reasons with both trivial problems and acute, life-threatening conditions which require immediate help [12]. The assessment of pediatric children in the emergency setting is difficult due to limited history and physical examination, which often yields findings that overlap with multiple disease entities. Therefore, diagnostic imaging has a significant role in the evaluation of pediatric patients in the EDs [1]. In acute neurologic conditions, such as traumatic brain injury (TBI), non-traumatic coma, stroke and status epilepticus, CT is prevalent because of its easy accessibility and speed, for example to rule out a hemorrhage [13]. Unenhanced head CT is the most common of all requested CTs in ED accounting for 70-80%, according to Wang et al. [14].

However, in the youngest children, less invasive imaging modalities are preferred like neonatal brain 3D ultrasonography, which offers a reproducible data set, ideal for comparing to other sectional imaging such as CT or MR [15]. In our study, toddlers and infants were the smallest group accounting for 2.76%, because in this group less invasive imaging modalities were preferred. The indications for CT fall under two categories i.e. post traumatic and non-traumatic. Dogan et al. reported that 83% CT scans of the head performed in the EDs are injury-related and the rest (17%) come from non-traumatic reasons [7]. In the study, traumatic lesions observable on CT were found in 19.8% of the examined children, while 80.2% had non-traumatic lesions.

1. Indications for performing a CT scan (prediagnosis)

The preliminary diagnoses of patients who underwent a CT for other than traumatic causes, include with decreasing incidence: headaches, seizures, fever, confusion, hematoma, infarct, optic neuritis and arrest [7]. In the study headaches are also the most common indication for non-traumatic reason. However, the results vary in other authors' work and according to Chaitanya et al. vomiting was the most common symptom [10]. In other studies it was loss of consciousness which was the most frequent one. Clinical evaluation revealed loss of consciousness (LOC) in 36 (47.3%) patients, vomiting in 42 (55%) patients and headache in 10 (13%) patients. Rosolowicz mentions headache (50%), loss of consciousness (39%) and vomiting (35%) as the most common symptoms [16]. According to Machingaidze et al. the most common indications for a head CT scan from 311 patients were seizures (54.3%), decreased level of consciousness (45.0%), headache (23.8%), and suspected abnormal venous extrusion [8].

1.1. Head injury

Head injuries in children are the common reason for presenting to ED worldwide, most often within 24 hours after an injury. In our study the patients aged 2-5 years old were most likely to be prediagnozed with superficial or unspecified injury of the head. [16,17]. However, females had longer duration of stay in the intensive care unit than males and tended to score worse when being controlled for injury severity using the Injury Severity Score [18]. According to the results we quoted, there is a tendency that the incidence of injuries of boys (54.1%) is higher than of girls (46.7%). Rosolowicz et al. reported that the incidence of head trauma is higher for boys, who accounted for 60% of the subjects, which is almost consistent with our results, where 209 (54.15%) boys had superficial or unspecified head injury as an indication for performing a CT scan [16]. This might be due to larger head circumference, more muscular build and higher physical activity rate in males compared to females. Also Araki et al. confirms that emergency consultations and hospitalizations were more common among boys who are about 2 times more likely to suffer a TBI than girls, with boys aged 0-4 years having the highest incidence rate of all pediatric patients [17].

1.2. Headaches

Headaches are considered as most common in non-traumatic preliminary diagnosis, both in our study and according to Papetti et al. They are a frequent complaint in children, especially in adolescents. According to our observations, headaches accounted for 10.6%, among girls respectively 12.6% and boys 9.1%. Generally headache is a benign condition which disappears on its own or after appropriate drug treatment [19]. Secondary benign headaches are, by far, the most common symptom in children (35–63%), followed by primary headaches (10–25%); secondary life-threatening headaches are the least common (4–15%) [20]. Those conditions that carry significant morbidity or may even be life-threatening include: brain tumors, meningitis, idiopathic intracranial hypertension, stroke, subdural empyema and brain abscess. There are some features, which are more often associated with life-threatening causes in pediatric patients referring to the ED: younger age (2-5 years), progression of signs within less than 2 months, impossibility to describe the type of pain, occipital localization and abnormal findings in neurologic examination among others: papilledema, abnormal eye movements, hemiparesis, and ataxia. Trofimova et al. indicate in their study that the recommendations for neuroimaging are acute and severe or recurrent headaches with abnormal neurologic examination such as focal findings, symptoms of increased intracranial pressure or significant alteration of consciousness, also with the coexistence of seizures. In the case of recurrent headaches without abnormalities in neurological examination, head CT should not be performed [12]. Overall, children with non-traumatic headache, without concerning features, normal fundoscopy have a low risk of life-threatening cranial disorders with incidence <0,4% [21].

1.3. Seizures

Seizures are also problem in pediatric EDs, accounting for 1% of all visits according to Veeraoandiyan et al. and around 2.9% according to Abbasi et al [22,23]. In the study unspecified convulsions accounted for 5.23% preliminary diagnoses, which was an indication to perform CT scan of the head. Martindale et al. reports that seizures are cause of about 1 of every 100 emergency visits in ED [24]. Approximately 11% of people will have a seizure during their lifetime most of which are not due to epilepsy, with the highest incidence in the first year of life [25]. However, in the study only 8.33% of children with unspecified convulsions under 2 years of age had a head CT scan because of seizures. Referring to the origin of convulsions, (in literature) the most common are febrile seizures, affecting about a third of the children in ED. Next are acute symptomatic seizures, which are secondary to underlying disease processes, such as central nervous system (CNS) infections, cerebrovascular illnesses, head trauma, metabolic disease, electrolyte imbalance, brain tumors and others [24]. Seizures present special diagnostic and treatment challenges because the etiologies of seizures range from benign to life-threatening [20]. CT of the head is often performed in case of seizures, but Cavallaro et al. reported that actionable findings occur only in as few as 1% [25]. Trauma is an important cause of seizure in children within a week of an injury, as Lee et al. reported that 47% of these may have an intracranial abnormality in CT and less than 10% should have a surgical craniotomy [26]. In the study 25% of patients with unspecified convulsions had abnormalities such as hematoma and pathological fluid in the brain. Not all causes of seizures require neuroimaging, instead they need urgent treatment because of the potential risk for the child. These conditions include: febrile convulsions, hypoxia, metabolic and electrolyte imbalance, and hypoglycemia [27].

1.4. Syncope

As well as headaches and seizures, syncope are also a common problem in pediatric ED, but most of them are benign, however the evaluation of the patient must exclude rare life-threatening disorders [39]. A transient loss of consciousness (TLOC) can affect up to 3% of all ED visits and 6% of hospital admissions [28]. Choi et al. report that TLOC episodes account for 0.41-0.90% of all pediatric emergency department visits. The most common types of TLOC are vasovagal syncope, which accounts for about 63% of the cases and seizures accounted for 10.6% of the cases. These two causes are difficult to distinguish based on clinical symptoms alone, even 25% of patients in an epilepsy clinic may not have epilepsy. Hence, syncope is often misdiagnosed as epilepsy. Sensitivity and specificity of brain CT in diagnostic of vasovagal syncope was respectively 26.3% and 85.7% and in diagnostic of epileptic seizures was 20% and 78.6% according to Choi et al. [29]. According to Viau et al. 7% to 23% of the patients will have serious underlying conditions identified either in the ED or within 30 days of their index visit. 2.3% to 4.4% will suffer from intracranial complications (subarachnoid hemorrhage, subdural hematoma, spaceoccupying lesion, or intraparenchymal infarct or hemorrhage) among patients with TLOC. For every 26 scans carried out on ED patients an estimated one CT scan will report positive findings [30]. According to our study 10% of all CT scans performed due to syncope had some abnormalities. For this reason, it is appropriate to assess potential risk associated with syncope primarily through a reliable medical history and physical examination.

The patients presenting to ED commonly complain several symptoms at once and have heterogeneous clinical status [31]. However, there are no guidelines for performing CT in children without a history of trauma. To the best of our knowledge, no studies have been published till now with the aim to identify clinical criteria for ascribing head CT in the pediatric non-trauma population [31–34].

2. CT findings

In our study 80.23% children, for whom CT scan was ordered, had no findings, which is actually in line with studies by other authors, that the most pediatric patients have no abnormalities. Machingaidze underlines that a total of 219 (70.4%) patients out of 311 had normal CT findings. The most commonly mentioned abnormality, found in 54 (58.7%) patients was hydrocephalus. It is one of the main manifestations of abnormal CT scans, which is most likely due to the number of patients (20%) with cerebral spinal fluid (CSF) shunts. Edema of the soft tissues was also found fairly often on CT imaging, ac-counting for 29 (9.3%) patients [8].

More severe symptoms such as skull fractures and hematomas can be reported as well. In the reported head CT results, the presence of lesions was confirmed in 136 out of 688 (19.77%) of all patients, compared to Wang J, who showed an individualized head CT result in 140 out of 279 (50.2%) patients. Positive findings on regular head CT in the Wang et al. study included 108 skull fracture (38.7%), 35 epidural hematoma (12.5%), 25 pneu-mocranium (9.0%), 24 cerebral contusion (8.6%), 22 subarachnoid hemorrhage (7.9%), and 14 subdural hematoma (4.7%). Of these, 7 (2.5%) patients underwent surgical procedures [14]. According to Rosolowicz et al. skull fracture was diagnosed in 48%, craniofacial frac-ture in 42%, skull base fracture in 24%, and paracerebral hematomas in 24% of the sub-jects. Cerebral injuries requiring surgical neurosurgery were reported in 7 (4%) children [16]. In our study hematomas rather than skull fractures were the most common findings, which is discussed in more detail in the paragraphs below.

2.1. Hematoma

A study by Kirschen et. involved 344 patients, of which 36 (10.5%) had a hematoma on CT examination and according to Wang et al. hematomas were seen in 17.6% patients [35,36]. In comparison to those results, in the study 36 out of 136 (26.47%) patients among children with head CT lesions were found to have hematoma, including 30 boys, for whom hematoma was also the most common traumatic lesion (7.8%). The average age at which the hematoma was most frequently observed was 9.31+/-4.80. Paul et. al. divided head injuries by cause into accidental (AHT) and non-accidental (NAT), of which hematomas were found in 35.1% of AHT patients and 66.5% of NAT patients. Among hematomas, the authors distinguished epidural hemorrhage, subdural hemorrhage, subarachnoid hemorrhage, and intraparenchymal hemorrhage. More children in the accidental injury group were diagnosed with a skull fracture (57%), while patients in the NAT group were more likely to be diagnosed with hematoma (especially subdural hematoma; 52%), likely reflecting the inertial force required to rupture the cortical vein bypass, as opposed to the direct impact required to create a skull fracture [37]. Currently, there is a lack of cross-sectional studies on the epidemiology and incidence of all combined hematomas in children, including epidural and subdural hematomas. This suggest the need for supplemental data and further investigation of this topic.

2.2. Cranial fractures

Skull fractures are one of the most significant trauma indications for head CT in the pediatric population based on Alexiou GA et. al. who report that skull fracture can occur in 2% to 20% of children with head trauma. There are four main types of skull fractures: linear, depressed, diastatic and skull base, among which linear skull fractures are the most common. Although not significant, they should be observed for an epidural hematoma, especially if they cross a major vessel. They usually require surgical treatment when a bone fragment is depressed deeper than the adjacent inner table. The deeper the depressed bone, the greater the risk of both a tear of the dura and damage to the cortex, and the worse the prognosis [38]. In many aspects, craniofacial injuries in children are similar to those in adults. The appearance of fractures and accompanying injuries are usually similar [39]. The exceptions are infants and newborns due to undescended cranial su-tures, so cranial fractures may proceed differently than in older children and adults. However, children are uniquely susceptible to craniofacial injuries due to their higher cranial-to-body weight ratio. The majority of skull fractures in children can be treated conservatively. In the results of the studied population, of the 136 patients with lesions on head CT scan, 22 (16.17%) had skull bone fractures, including facial fractures. Fractures of the skull (12 out of 136; 8.8%) and facial skull (10 out of 136; 7.4%) were the most common, with a slight prevalence in boys. According to one study, between 1% and 14.7% of all craniofacial fractures occur in the pediatric population. Most of these injuries involve boys (53.7% - 80%) [40]. Also in the Grunwaldt study, a significant majority ($p < 0.001$) of patients with facial fractures were male (68.9%); older children were significantly more likely to suffer a facial fracture ($p < 0.001$) [41]. In Irie F study, out of 224 patients with epidural hematoma, skull fracture occurred in as many as 75% of them, proving that hematomas most often are associated with fractures [42].

Conclusions

Head CT is an incredibly useful tool in the evaluation of head emergencies, including most common such as hematomas and skull bone fractures. However, in the majority of cases, the clinical presentation which children present at the ED does not correlate with the severity of neuroimaging results. We should consider the necessity of performing head CT in trivial cases, such as headaches or superficial head trauma, because children are a special group in which up to one in five children may have a positive findings in CT.

Supplementary Materials

No supplementary material published online alongside the manuscript.

Author's contribution

Conceptualization, MMW, and ŁL; methodology, JL; software, ŁL; check, ŁL, JL and MK; formal analysis, MMW; investigation, JL,MK; resources, JL,MK,IK; data curation, ŁL; writing - rough preparation, ŁL, JL, MK, IK; writing - review and editing, ŁL, JL, MK and MMW; visualization, ŁL; supervision, MMW; project administration, MMW; receiving funding, ŁL All authors have read and agreed with the published version of the manuscript.

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Institutional Review Board Statement

Not applicable. The study was conducted in accordance with the Declaration of Helsinki. In accordance with the law in force in the Republic of Poland, retrospective studies do not require the opinion or consent of the Bioethics Committee, as they are not a medical experiment in which human organisms would be interfered with. For this reason, we did not seek the consent of the Commission. What's more, the results of the study did not affect the management of patients at any stage, so the above-mentioned procedure was followed.

Informed Consent Statement

Not applicable. The study was retrospective and was conducted on the basis of collected medical documentation.

Data Availability Statement

The data that support the findings of this study are available on reasonable request from the corresponding author. The data are not public available due to privacy.

Conflict of Interest Statement

The authors declare no conflict of interest.

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