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Research Paper

A cohort retrospective study on computed tomography scan among pediatric minor head trauma patients☆

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ABSTRACT

Objectives: Computed tomography (CT) scan is commonly performed in head trauma patients to identify severity of the brain injury. However, the role of clinical signs and consciousness is critical in deciding the need of CT scan, in order to avoid unnecessary exposure to X-ray radiations. The aim of this study was to evaluate the incidence of positive CT findings in our pediatric population referred to our center with minor head trauma and its correlation with clinical signs and symptoms.

Method: In this retrospective study, children aged under 15 years presented to our center within 6 h of minor head trauma from 2019 to 2020 were included. CT findings, demographic data, Glasgow Coma Scale (GCS) and clinical sign were extracted from patient data file. Positive CT scan patients were further evaluated in terms of GCS and signs and symptoms. The data were analyzed using SPSS v25.

Result: Of 380 children included, the most common findings from CT scan were fractures (11.8%), SAH (subarachnoid hemorrhage) (6.1%), and ICH (intracerebral hemorrhage) (5.5%). 18.7% of total children had positive CT findings. Nausea and vomiting, seizure, racoon eyes, battle sign and GCS less than 15 were positively associated with positive CT finding. Mechanism of trauma and age group were not associated with positive CT.

Conclusions: Clinical signs should be observed among the patients along with level of consciousness before CT scan. Further studies are required to design a precise algorithm and guidelines regarding the use of CT scan among pediatric minor head trauma patients.

1. Introduction

Head trauma is one of the common causes of emergency department referral and admission and is the leading cause of mortality and morbidity in some regions [1]. In the United State of America, 180–300 children of 100,000 are admitted to the hospital where 74–80% children with mild GCS (Glasgow Coma Scale) have mild brain trauma [2]. Damage to the skull following trauma is divided into three categories: cranial fractures, localized brain lesions, and diffuse brain lesions [3,4].

Skull fractures can occur with or without brain damage [5]. Localized brain lesions include epidural hemorrhage, subdural hemorrhage, subarachnoid hemorrhage, intracerebral hemorrhage, cerebral tissue compression [6,7]. Diffuse brain lesions are also of two types: edema and diffuse damage to nerve axons (5). The most important tool for diagnosing the severity of injury and the patient's condition is the use of the GCS system to determine the level of consciousness of patients, which almost all experts agree on [8]. The GCS system has been developed to determine the level of consciousness of patients with acute brain dysfunction, with a minimum of 3 and a maximum of 15 [9].

In order to understand the severity and potential damage by head trauma, extensive history of mechanism of head trauma, amnesia, loss of consciousness and other clinical signs are symptoms are of great clinical significance [10]. Computed tomography (CT) scan is usually performed in moderate to severe trauma

☆ The design was approved by the Ethics Committee of Kermanshah University of Medical Sciences. (IR.KUMS.REC.1398.929) https://ethics.research.ac.ir/ProposalCertificateEn.php?id=99,601&Print=true&NoPrintHeader=true&NoPrintFooter=true&NoPrintPageBorder=true&LetterPrint=true

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patients to obtain essential information regarding the injury in order to perform required intervention and consultancy [11], nonetheless, it is also performed in the cases of minor trauma that exposes patients to unnecessary X-ray radiations, that is associated with three times increased risk of leukemia and brain tumors [12 13]. 83–97% of CT findings are allegedly negative following minor head trauma [14]. It is important to rule-out the need of CT scan in minor head trauma, particularly, in pediatric patients based on the type and mechanism of the trauma and clinical sign and symptoms presented [15].

The aim of this study is to evaluate the incidence of positive CT findings among pediatric patients presented with minor head trauma to our center and its correlation with demographic and clinical data.

2. Methods

This descriptive-analytical retrospective study was conducted at (XXX) to identify relation between brain CT scan findings, clinical history and radiation exposure in pediatric patients during January 2019–December 2019. Pediatric patients aged under 15 years, who were referred to our center within 6 h of the head trauma were included in the study. Patients with the previous history of head trauma, neurologic defects and history of prior seizures were excluded from the study.

By referring to patients' clinical records, information based on demographic characteristics, injury mechanism, Glasgow Coma Scale, type of trauma, severity of trauma, location of trauma, CT scan report, recurrent vomiting, seizure, fracture or non-fracture recorded in CT scan were obtained and documented in a questionnaire by trained research assistant. The patients' charts were filled by pediatric emergency trained attending or fellow physician. This questionnaire was approved by the first executor of the project as an expert. In case of incomplete file, the patient was removed from the study.

CT findings were primarily assessed by radiologist and patients with without any intracranial and/or extracranial injury in CT findings were considered as CT negative patients. Patients with negative CT and absence of signs and symptoms were assumed to have no brain injury.

The data was computerized and statistically analyzed using SPSS v25. In the descriptive analysis, the frequency of clinical findings and CT findings were presented as the main variables in different groups and all demographic and clinical data of patients were reported based on descriptive criteria. For analytical analysis, Chi-square test was used for qualitative data and independent *t*-test was used to compare quantitative data. If the initial assumptions were not met as normal, Mann-Whitney parametric test was used. P value < 0.05 was considered to be statistically significant.

The design was approved by the Ethics Committee of (XXX).

Registration unique identifying number (UIN): Researchregistry6458.

The work has been reported in line with the STROCSS criteria [16].

3. Results

Of 380 children included, 239 (62.9%) were boys and 141 (37.1%) were girls. The mean age of the subjects was 6.92 ± 4.02 years, Fig. 1. 18.7% of children who underwent CT scan had abnormal imaging findings and the most common findings were fractures (11.8%), SAH (subarachnoid hemorrhage) (6.1%), and ICH (intracerebral hemorrhage) (5.5%).

The type of injury was evaluated based different age groups. The age was not significantly associated with the type of injury, $P = 0.174$. Similarly, the gender of the patients was also not associated with the type of brain injury, $P = 0.205$.

The frequency of all positive CT scan findings in patients with nausea and vomiting (68.6%) was significantly higher than those without nausea and vomiting (10.9%), $P < 0.001$(Table 1).

The positive CT findings among patients with seizure were seen in 85% patients and 15% patients with positive CT positive CT did not have seizures. The difference the two groups was statistically significant, $P < 0.001$(Table 2).

Of 71 patients with positive CT, 90.9% had battle sign and 14.2% did not have battle sign. This difference was significantly different, $P < 0.001$. Patients with EPH, SDH and intraventricular hemorrhage (IVH) did not show significant difference in term of battle sign and positive CT scan, $P = 0.419$, $P = 0.419$ and $P = 0.613$, respectively (Table 3).

93.3% patients presented with racoon eye had positive CT whereas, 15.6% did not have racoon eyes and had positive CT. The difference in the two groups significantly different,

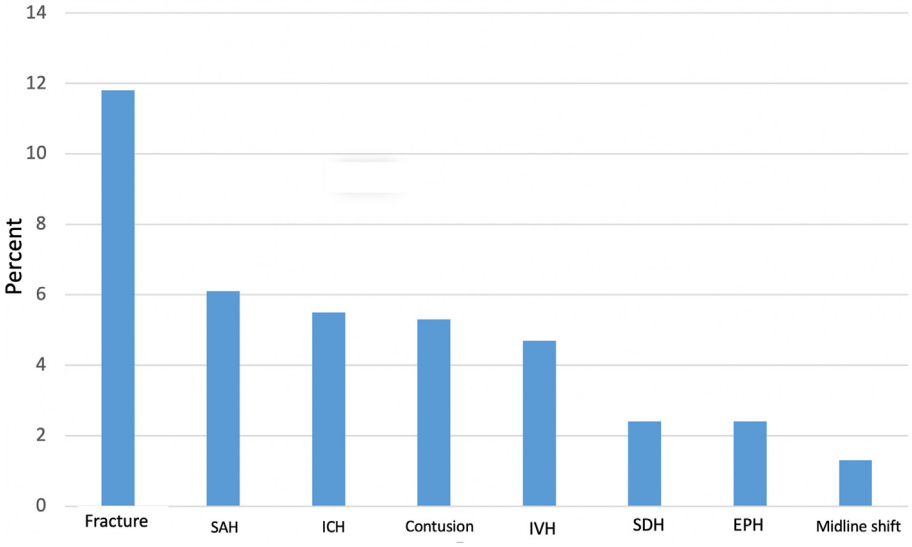

Fig. 1. Frequency of CT findings in the studied patients.

Table 1
Frequency of CT scan findings in children with head trauma based on nausea and vomiting.

nausea & vomiting		No	Yes	Total	p-value
Variables					
Fracture	Number	21	24	45	<0.001
	Percent	6.4	47.1	11.8	
SAH	Number	12	11	23	<0.001
	Percent	3.6	21.6	6.1	
ICH	Number	5	16	21	<0.001
	Percent	1.5	31.4	5.5	
Contusion	Number	9	11	20	<0.001
	Percent	2.7	21.6	5.3	
IVH	Number	10	8	18	<0.001
	Percent	3.0	15.7	4.7	
SDH	Number	5	4	9	0.022
	Percent	1.5	7.8	2.4	
EPH	Number	5	4	9	0.022
	Percent	1.5	7.8	2.4	
Midline shift	Number	1	4	5	<0.001
	Percent	0.3	7.8	1.3	
Total pathological findings	Number	36	35	71	<0.001
	Percent	10.9	68.6	18.7	

Table 2
Frequency of CT scan findings in children with head trauma based on seizures.

seizures		No	Yes	Total	p-value
Variables					
Fracture	Number	37	8	45	<0.001
	Percent	10.3	40.0	11.8	
SAH	Number	18	5	23	<0.001
	Percent	5.0	25.0	6.1	
ICH	Number	16	5	21	<0.001
	Percent	4.4	25.0	5.5	
Contusion	Number	6	14	20	<0.001
	Percent	1.7	70.0	5.3	
IVH	Number	11	7	18	<0.001
	Percent	3.1	35.0	4.7	
SDH	Number	5	4	9	0.001
	Percent	1.4	20.0	2.4	
EPH	Number	6	3	9	0.009
	Percent	1.7	15.0	2.4	
Midline shift	Number	2	3	5	0.001
	Percent	0.6	15.0	1.3	
Total pathological findings	Number	54	17	71	<0.001
	Percent	15.0	85.0	18.7	

Table 3
Frequency of CT scan findings in children with head trauma based on the presence of Battle sign.

Battle sign		No	Yes	Total	p-value
Variables					
Fracture	Number	25	20	45	<0.001
	Percent	7.0	90.9	11.8	
SAH	Number	13	10	23	<0.001
	Percent	3.6	45.5	6.1	
ICH	Number	11	10	21	<0.001
	Percent	3.1	45.5	5.5	
Contusion	Number	16	4	20	0.022
	Percent	4.5	18.2	5.3	
IVH	Number	18	0	18	0.613
	Percent	5.0	0.0	4.7	
SDH	Number	8	1	9	0.419
	Percent	2.2	4.5	2.4	
EPH	Number	8	1	9	0.419
	Percent	2.2	4.5	2.4	
Midline shift	Number	3	2	5	0.029
	Percent	0.8	9.1	1.3	
Total pathological findings	Number	51	20	71	<0.001
	Percent	14.2	90.9	18.7	

$P < 0.001$(Table 4). However, in EPH, SDH and IPH patients, the difference was not statistically significant $P > 0.05$.

The frequency of CT scan findings in children with head trauma was not statistically significant based on the mechanism of trauma, $P = 0.329$. The frequency of CT scan findings in children with head trauma was not statistically significant based on the type of trauma, $P = 0.99$. The frequency of all positive CT scan findings in patients with GCS less than 15 was significantly higher than those with GCS more than 15, $P < 0.001$(Table 5). The mean DLP and CT index was not statistically significant, $P = 0.813$ and $P = 0.288$, respectively.

4. Discussion

The findings of our study showed that brain fracture, subarachnoid hemorrhage and intracerebral hemorrhage are the most common CT findings among the pediatric patients with brain trauma referred to our center.

A review study by Enrico et al., In 2013 suggested criteria for performing CT scans of the head in children with brain injury [17]. CT scan among patients with GCS <14 and those with brain fracture should be performed. In case of loss of consciousness, severe brain trauma and subgaleal hematoma, it is recommended to perform CT, otherwise the scan can be exempted. Furthermore, among patients aged less than 3 months with any kind of trauma, it should be performed [18]. However, if there is nausea, vomiting and the severity of the trauma, according to the doctor's experience and other findings, CT scan should be performed [17]. The findings of this study are quite similar to our study. Although the severity of the trauma was not evaluated in our study, it was found that the abnormal findings of CT scan in patients with nausea and vomiting and GCS less than 15 are significantly higher, showing that history and GCS should be considered upon arrival, and unnecessary CT scans should be avoided, and patients' request a CT scan based on their clinical signs [19].

A cross-sectional study by A Kemp including 57,000 children under the age of 15 from 2009 to 2010 reported that CT scans were higher in children over 1 year of age. Only 50% of children under 1 year of age with a G.C·S index of less than 14 underwent CT scan. 77% Children over 1 year of age with a G.C·S index of less than 14 received CT [20]. Among them, 72% CT scan findings of children under 1 year and 47% of CT scan findings of children over 1 year were abnormal [21]. Also, 20% and 28% of children less than 1 year old, respectively with GCS more 15, had more CT scans. Most common abnormal CT scan findings for children were ICH, depressive fracture, simple fracture and others [22]. They also showed that children who had CT scan had a longer stay in the hospital than those who didn't undergo CT [23]. The most common CT findings were similar to our study.

In a review study conducted by Ali Reza Azizahari et al., radiation exposure as a result of CT scan in children was evaluated. Numerous studies have shown that low-dose radiation in children slightly but significantly increases the risk of fatal malignancy during their lifetime. Therefore, recently, several solutions and protocols have been proposed to reduce the amount of radiation in children, which has been done by reducing the number of CT scans and replacing it with other imaging modalities, as well as optimizing the parameters of the imaging device to reduce the amount of radiation while maintaining quality [24]. Due to the widespread and growing use of CT scan modality in children and considering the amount of harmful radiation, more familiarity and preventive measures in this area seems necessary [25].

Türedi et al. [26] reported that GCS<15 and vomiting can be considered as a high-risk criterion for performing CT in children

Table 4
Frequency of CT scan findings in children with head trauma based on the presence of Raccoon eye.

Raccoon eye		No	Yes	Total	p-value
Variables					
Fracture	Number	32	13	45	<0.001
	Percent	8.8	86.7	11.8	
SAH	Number	18	5	23	<0.001
	Percent	4.9	33.3	6.1	
ICH	Number	15	6	21	<0.001
	Percent	4.1	40.0	5.5	
Contusion	Number	15	5	20	<0.001
	Percent	4.1	33.3	5.3	
IVH	Number	17	1	18	0.524
	Percent	4.7	6.7	4.7	
SDH	Number	8	1	9	0.307
	Percent	2.2	6.7	2.4	
EPH	Number	9	0	9	1
	Percent	2.5	0.0	2.4	
Midline shift	Number	3	2	5	0.014
	Percent	0.8	13.3	1.3	
Total pathological findings	Number	57	14	71	<0.001
	Percent	15.6	93.3	18.7	

Table 5
Frequency of CT scan findings in children with head trauma based on GCS level.

GCS		15	15>	Total	p-value
Variables					
Fracture	Number	16	29	45	<0.001
	Percent	4.9	51.8	11.8	
SAH	Number	8	15	23	<0.001
	Percent	2.5	26.8	6.1	
ICH	Number	9	12	21	<0.001
	Percent	2.8	21.4	5.5	
Contusion	Number	8	12	20	<0.001
	Percent	2.5	21.4	5.3	
IVH	Number	2	16	18	<0.001
	Percent	0.6	28.6	4.7	
SDH	Number	3	6	9	0.001
	Percent	0.9	10.7	2.4	
EPH	Number	5	4	9	0.03
	Percent	1.5	7.1	2.4	
Midline shift	Number	1	4	5	0.002
	Percent	0.3	7.1	1.3	
Total pathological findings	Number	24	47	71	<0.001
	Percent	7.4	83.9	18.7	

with minor head trauma. A study by Maghsoudi et al. [27] reported that amnesia, vomiting, racoon eye, otorrhea, base of skull fracture, headache, and loss of consciousness were significant predictors of positive CT findings in minor head trauma pediatric patients. Seizure was not considered as a significant predictor of the positive CT finding. Clinical presentations at the time of trauma should be carefully observed and optimized protocols are required to rule out the need of CT scan. Similar to previous studies, based on clinical findings patients can be categorized as mild, moderate and severe-risk head injury and corresponding recommendation of CT scan should be provided [28].

This is not an interventional study and is based on limited descriptive variables due to retrospective nature of the study. Studies involving risk analysis are further required to draw absolute conclusion.

5. Conclusion

In our finding racoon eye, battle and nausea and vomiting were considered as significant clinical signs associated with positive CT scan. Careful consideration of clinical signs and symptoms along GCS is important to indicate CT scan in pediatric patients with minor head trauma. Presence or absence of racoon eye, battle sign, nausea and vomiting along with GCS<15 was significantly different among patients with positive CT signs.

Ethical approval

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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None.

Author contribution

Dr. Shahrouz Tabrizi: conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr.Elahe Zafar: Designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript.

Dr.Hooman Rafiei: Coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

Declaration of competing interest

The authors deny any conflict of interest in any terms or by any means during the study.

Guarantor

Dr. Shahrouz Tabrizi

Research Registration Number

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2. Unique Identifying number or registration ID: IR.KUMS.REC.1398.929
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Provenance and peer review

Not commissioned, externally peer-reviewed.

Human and animal rights

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

Consent for publication

Informed consent was obtained from each participant.

Availability of data and materials

All relevant data and materials are provided with in manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijso.2021.01.005.

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