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The Relationship between Risk Factors of Head Trauma with CT Scan Findings in Children with Minor Head Trauma Admitted to Hospital

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Abstract

BACKGROUND: In emergency medicine for determining the intracranial injury (ICI) in children with head trauma, usually brain CT scan is performed. Since brain CT scan, especially in children, has some disadvantages, it is better to find a procedure which could help to choose only the children with real head trauma injury for brain CT scan.

AIMS: The aim of this study is to find such procedure. This study was descriptive, analytic and non-interventional.

METHODS: We reviewed the archived files of children with head trauma injuries referred to the emergency department of Imam Hossein Hospital within two years. Patient's CT scan findings and head trauma risk factors were evaluated in this study.

RESULTS: Out of 368 patients, 326 patients had normal brain CT scan. 28 of them showed symptoms of ICI consisting intraventricular haemorrhage (IVH), contusion, subarachnoid haemorrhage (SAH), subdural haemorrhage (SDH), epidural hematoma (EDH), and pneumocephalus. Twenty-seven patients showed skull FX, which 14 of them had an Isolated fracture, and 13 of them also showed symptoms of ICI. Since patients with isolated FX usually discharge quickly from Emergency Department; their data did not include in results of the study. The patients have been divided into two groups: 1- ICI, 2- without ICI. RR (relative risk), CI (Confidence interval) and sensitivity, positive predictive value (PPV), negative predictive value (NPV) and association of these risk factors with ICI were assessed with the Chi-2 test. In the end to determine the indications of CT scan, the presence of one of these five risk factors is important including abnormal mental status, clinical symptoms of skull FX, history of vomiting, craniofacial soft tissue injury (including subgaleal hematomas or laceration) and headache.

CONCLUSIONS: For all other patients without these risk factors, observation and Follow Up can be used which has more advantages and less cost.

Introduction

Head injury is a common cause of emergency-department (ED) presentation, accounting for approximately one million doctor visits annually in the hospital. Although the majority of patients with head trauma have a minor injury that requires no specific therapy, a small number are diagnosed with clinically significant intracranial injury (ICI) [1]. Annually, in the United States, more than 1.1 million patients are investigated for acute head injury, which is also one of the most common injuries in children under 5 years. Approximately 500,000 children in the United States annually are evaluated with head trauma which 100,000 cases of them hospitalised and 7,000 cases die.

Traumatic Brain Injury (TBI) itself is the important cause of death in children, resulting in ~3000 deaths as well as 50000 admissions and 650000 emergency department (ED) visit per year in the United States [2-4]. Most of the head trauma in children is injuries related to falling from a height and during transportation. Also, child abuse is still a common cause of head injury in children. As long as the cranial sutures are not closed, the cranium in children is more vulnerable to expansion than adults. As a result, most of the children who experience head trauma might have lower TBI than adults. On the other hand, the brain tissue is more sensitive in children compared with adults. Since children's brain is less myelinated that is the basic cause for more shearing forces [5]. Head trauma in children under one year following traumatic events has more mortality compared with older children with the same intensity of trauma.

Several factors involved in this issue including limitations in verbal communication and understanding of children, difficulty in performing a detailed neurological physical examination, underestimating the severity of injuries in younger children, and unwillingness to perform invasive interventions like getting IV line and inducting sedation for Brain CT Scan [5, 6].

In the term of the severity of the injury, head trauma patients are divided into 3 categories based on GCS. In this classification, 80% of patients have minor head trauma (the GCS = 14-15 and in some other studies GCS= 15-13), 10% of patients have moderate Head trauma (GCS = 9-13 and in some references GCS =9-12) and 10% of patients have severe head trauma (GCS ≤ 8) [6]. At present, Brain CT Scan is performed routinely for evaluation of children with head trauma at the emergency department.

Several factors proposed as indications for brain CT Scan, but the presence of all of them is not required to indicate a CT Scan. There is controversy regarding CT scan indication. This disagreement is more evident in children Brain CT Scan. Besides that, this diagnostic method has several disadvantages. So, the ideal is finding a method that can select the appropriate cases of head trauma which mostly need Brain CT Scan [7-10].

Brain CT scan disadvantages in children include: moving the traumatised child from emergency medical care services, need for pharmaceutical sedation, and exposure to additional radiation, and increasing the cost of care and time of evaluation in emergency service. In contrast, delay in diagnose and treatment of ICI in children raise mortality rate and worsen the prognosis [11]. Besides, plain skull X-ray in children and an adult is not a good substitute when Brain CT Scan is indicated.

The existence of Skull FX increases the chance of intracranial pathology four times more, whereas a normal Skull X- ray, does not guarantee the absence of ICI [12]. Skull X- ray could be used as screening methods to determine the need for Brain CT Scan, especially in children under 2 years old, for whom neurologic examination and evaluation is difficult. In scalp hematoma in children under 2 years old, whether they have normal consciousness level appropriate with age, the Skull X-ray tomography can be a useful method for screening patients. If Skull X-ray is normal, performing the Brain CT Scan is unnecessary. Performing Skull X-ray in older children is rarely useful [13-15].

Exceptions include specific lesions such as Linear or Depressed Skull FX or when there is a Penetrating Foreign Object. Therefore, Skull X- ray has clinical significance as a diagnostic method in younger children. In this study, 368 children with minor head trauma were investigated. The head trauma association and predictive power of various risk factors with ICI findings in Brain CT Scan were evaluated [16].

To evaluate the relationship and predictive power of risk factors with ICI findings in Brain CT Scan, Specificity, Sensitivity, Relative Risk, NPV (Negative Predictive Value) and PPV (Positive Predictive Value) were evaluated for them. Also, we calculated the relative risk and confidence intervals for all the parameters associated with intracranial injury in our study. Univariate and multivariate analyses were used to seek associations between clinical parameters and the presence of intracranial trauma. Statistical significance was assessed using confidence intervals and the Chi-2 method where appropriate.

Sensitivity and positive and negative predictive values were also calculated when appropriated. Sensitivity is the ability of a test or factor to detect all positive cases that exist; when they are positive [17-21]. Specificity in this study means lack of probability of a risk factor in the patients who have no ICI in Brain CT Scan. In other words, risk factor is not high when the specificity of that is high in a patient with normal Brain CT Scan. Specificity in this study is the lowest value compared to other parameters. PPV is the ability to identify positive cases, when they are truly so, or the ability to avoid false positive results. NPV means the predictive value of a test or risk factor for the differentiation of true negative cases that would be considered negative.

In other words, in this study with high NPV of a risk factor, we might conclude that with this risk factor, more confidentially the existence of ICI can be rejected by Brain CT Scan. Probably in this study, NPV have the highest value to express the power of predictive risk factors.

Methods

The design of the current study was descriptive and cross-sectional. The subjects of this study consisted of children with minor head trauma who were admitted to Imam Hussain hospital of Tehran in the years 2006-2007. Inclusion criteria were all children under 18 years old with blunt head trauma (GCS: 13-15) who were a candidate for Brain CT Scan.

Exclusion criteria included children with minor HT resulted from fall to the ground or head trauma caused by walking or running into a fixed object that only had scalp laceration with a scratch. The required sample size with 95% confidence interval and a maximum error of 5% was calculated based on the equation: N = Z2 P(1-P)/d^2. According to the study of Dr Palchak et al. who reported that the ratio of children with minor head trauma undergoing Brain CT Scan was 62%, therefore sample size considered to be approximately P = 60%. After enrolling all patients, the obtained data entered to Spss-15 for further analysis [11].

Results

The results of this study indicated that among 368 children with head trauma enrolled in this study, 28 cases had ICI (7.6%). The sex ratio of the patients was 37.8% (139 patients) female to 62.2% (229 patients) male. The average age of all the patients was 9.01 ± 7.2 and in patients with ICI average age was 7.46 ± 5.8. Regarding gender ratio, findings showed that 39.3% (11patient) of girls and 60.7% (17 patients) of boys had ICI. These ratios in children without ICI were 37.6% (128 patients) and 64.2% (212 patients), respectively. However, comparison of these ratios with K-square test did not show a significant difference (P > 0.05). Table 1 shows the age ratio of studied patients. As seen in Table 1, the comparison between age ratio of the patients and outcome of ICI does not indicate a statistically significant relationship (P > 0.05).

Table 1: The age ratio of patients in terms of presence or absence of ICI

	> 3 month	3 > month > 12	1 ≥ year ≥ 2	2 > year > 18	Total
ICI −	5 (1.5)	21 (6.2)	30 (8.8)	284 (83.5)	340 (100)
ICI +	0 (0)	4 (14.3)	4 (14.3)	20 (71.4)	28 (100)
total	5 (1.4)	5 (6.8)	34 (9.2)	304 (82.6)	368 (100)

Data in the table is presented as No. (%).

The causes of head trauma between our participants were as follow 150 children (40.8%) had fallen from height, 103 children (28%) had a motor vehicle accidents (MVC), 70 children (19%) had pedestrian conflicts (crash with vehicles in walking areas), 26 children (7.1%) had sport injury (sporting events), 11 children had bicycle accident (9.3%), 4 children (1.1%) had fight and in 4 children (1.1%) other reasons caused head trauma. The relationship between mechanisms of head trauma and ICI outcome was evaluated and listed in Table 2. Comparing the data does not show the statistically significant relationship (P > 0.05).

Table 2: The frequency of head trauma Mechanism in studied children

	ICI+	ICI-	total
Falling from height	12 (8)	138 (92)	150 (100)
Motor vehicle accident	4 (3.9)	99 (96.1)	103 (100)
Pedestrian	6 (8.6)	64 (91.4)	70 (100)
Sports accident	3 (11.5)	23 (88.5)	26 (100)
Cycling accident	2 (18.5)	9 (81.8)	11 (100)
Fight	1 (25)	3 (75)	4 (100)
Other	0 (0)	4 (100)	4 (100)
Total	28 (7.6)	340 (92.4)	368 (100)

Data in the table is presented as No. (%).

To investigate the relationship between clinical symptoms in a skull fracture and ICI, we determined the clinical symptoms of skull fracture according to the ICI which is listed in Table 3. As the contents of the table show, the correlation was very high. For example, there is a statistically significant relationship between skull fractures and ICI (P < 0.001), (RR = 11.9 CI = 3.25 -25.55). If considering the clinical symptoms of skull fracture as a predictor of ICI, this diagnostic symptom would have 25% sensitivity, 96.5% specificity, positive predictive value of 36.8% and negative predictive value of 39.9%.

As the table shows skull fracture, abnormal mental status, focal neurologic deficit, systemic injury, X- ray symptoms of skull fractures and skull fracture observed at brain CT scan (P > 0.001) have a significant relationship with ICI. Whereas in evaluating the relationship between other predictive risk factors such as the history of vomiting, loss of consciousness(LOC), post-traumatic amnesia (PTA), diffuse headache, craniofacial soft tissue injury and post-traumatic seizure with ICI, the relationship was not statistically significant (P > 0.05).

Table 3: The relationships between predictor risk factors and ICI in studied children ((Negative predictive value (NPV) and positive predictive value (PPV))

Predictor risk factor	Sensitivity, %	Specificity, %	PPV, %	NPV, %	RR (95% CI)
Clinical symptoms of skull fractures	25	96.5	36.8	39.9	1.9 (3.25-25.55) *
Abnormal Mental Status	85.7	61.2	15.4	98.1	9.45 (3.2-3.65) *
History of vomiting	28.6	79.4	10.2	93.1	1.54 (0.625-3.65)
Loss of Consciousness (LOC)	60.7	54.4	9.9	94.4	1.845 (0.839-4.05)
Post traumatic Amnesia (PTA)	32.1	62.1	6.9	91.7	0.774 (0.34-1.76)
Diffuse headache	25	60.3	4.9	90.7	0.506 (0.0209-1.22)
Post Traumatic Seizure (convulsion)	10.7	95.8	17.65	92.8	2.794 (0.753-10.373)
Focal Neurological Deficit	14.3	79.9	36.7	93.3	7.93 (2.17-28.99) *
craniofacial Soft tissue(ST) injury	53.6	61.5	10.3	94.1	1.84 (0.849-3.99)
Craniofacial ST injury in patients > 2years	55	65	10	95.4	2.284 (0.0916-5.698)
Craniofacial ST injury in patients < 2years	50	67	18.2	90.5	2.111 (0.916-5.698)
Craniofacial trauma in patients < 3 month	-	-	-	-	-
Craniofacial trauma In patients 3 months to 1 year	50	71.4	25	88.4	2.5 (0.284-22.042)
Craniofacial trauma patients with 1-2years	50	70	18.2	91.3	2.333 (0.283-19.242)
Craniofacial trauma in patients 2-3 years-old	33.3	75	12.5	91.3	1.5 (0.117-19.178)
Systemic Injury	17.9	80	6.8	92.2	1.31 (0.31-2.56) *
X- ray symptoms of skull fractures	28.6	92.5	47.	84.6	4.86 (1.68-14.18) *
Skull fracture observed at CT Scan	46.4	95.9	48.1	95.6	20.18 (8.08-50.4) *

* Starred items indicate a statistically significant relationship between the variables.

To investigate the relationship between Soft craniofacial tissue (ST) injury and ICI, the study was conducted in three groups of children (Table 3). The analysis showed no significant relationship between craniofacial ST injuries in children in different age groups and ICI (P > 0.05).

Our findings indicated that among 368 patients, 73 cases had traumatic injuries to other remote regions. The frequency of remote injuries was as follows: 16 patients (22%) had cervical injuries, 12 (16%) had a thoracic injury, 9 patients (12%) had upper extremities injury, and 15 (21%) had an injury to the lower extremities (Figure 1).

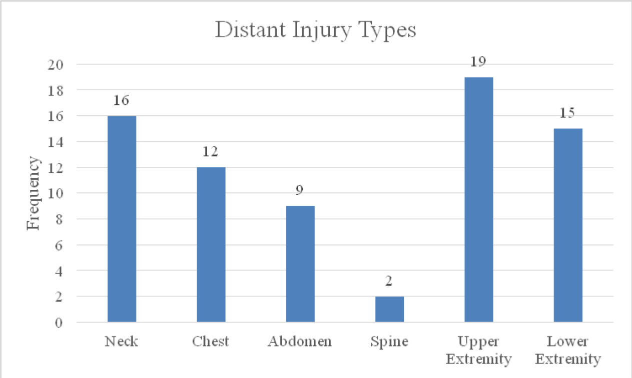

Figure 1: Diagram of frequency of systemic trauma types in patients

Brain CT Scan was performed in 28 of patients who had ICI findings, 15 cases had two risk factors, 9 cases had three risk factors, and four cases had four risk factors. None of these cases had one or more than 4 risk factors. According to calculations of minimum two risk factors and ICI, there is a significant relationship.

Discussion

The results of this study showed that between 368 children enrolled with minor head trauma, 28 children had ICI (7.6%). The gender ratio of male to female was (M/F) = 1.67. The mean age of patients was 9.01, and in patients with ICI, the mean age was 7.46. Evaluating the relationship of predictor risk factors of ICI in CT scan (Table 3) showed that abnormal mental status (85.7%), LOC (60.7%), Craniofacial ST Injury (53.6%) had the maximum sensitivity among 12 predictor risk factors of ICI in Brain CT Scan, respectively. The highest specificity belonged to the focal neurologic deficit (97.9%), clinical symptoms of skull fracture (96.5%) and post-traumatic seizure (95.8%), respectively.

Also, the highest PPV belonged to clinical symptomssymthoms of skull Fx (36.8%), focal neurologic Deficit (36.7%) and Craniofacial ST Injury under one-year-old (25%) and 1 to 2 years old (18.2%), respectively. The highest NPV belonged to abnormal mental status (89.1%), craniofacial ST injury and age> 2y (95.4%), and LOC (94.4%), respectively.

In evaluating the relationship between these risk factors with ICI in Brain CT Scan relative risk test and Chi-2, showed that only 3 risk factors of clinical symptoms including skull FX, Abnormal mental status, and focal neurologic deficit, were statistically related with ICI in Brain CT Scan. Whereas, 7 other risk factors including history of vomiting, LOC, PTA, diffuse headache, post-traumatic seizure, and systemic (distant) craniofacial ST injury in brain CT scan showed no significant relationship with ICI.

In agreement with our study Palchak et al., investigated 9 predictor variables and their relationship with ICI. His results showed that the Relative Risk (RR) of Abnormal mental status was 6.8, RR in Clinical symptoms of skull Fx was 5.5, RR of the focal neurologic deficit was 5.3 and then in descending order were Scalp hematoma and Age < 2y (2.6), seizure, PTA, LOC and vomiting. Each eight factors showed a significant relationship with ICI in Brain CT Scan, and the only headache did not show a significant relationship with ICI in [19].

Another study was carried out by Bruce Simon in the Bay State Medical Center. He investigated 4 parameters including craniofacial ST Injury, distant injury, skull fracture, and LOC. his results showed no statistically significant relationship between LOC and distant craniofacial injury with ICI at brain CT scan. Skull fracture also showed no significant association with ICI in brain CT scan. In this study, there was a statistically significant relationship between Skull Fracture in X- Ray and ICI in Brain CT Scan (RR = 4.89) [12].

Finding symptoms of skull fracture in the skull X- ray had 28.6% sensitivity, 92.5% specificity, 47% PPV and 84.6% NPV. Also, there was a significant relationship between skull FX in Brain CT scan and ICI (RR = 20.18), which based on this result, the sensitivity value was 64.4%, specificity was 95.9%, the PPV was 84.1%, and the NPV was 95.6% (Table 3).

In Simon and colleagues study the symptoms of skull fractures in skull X-ray was correlated with the presence of ICI in the Brain CT Scan, but it had low NPV (NPV = 90%), means that 45% of patients with ICI did not have a skull fracture. Finally, in Simon study, there was a significant relationship between skull fracture in brain CT scan and ICI in brain CT scan (RR = 20.18) [12].

In this study we evaluated five risk factors of brain trauma including abnormal mental status, existence of clinical evidence of skull Fx, history of vomiting, presence of craniofacial ST injury in children under 2 years old and diffused headache, as warning symptoms in children with minor head trauma warned the need for Brain CT Scan evaluation. According to this study, all the children diagnosed with ICI in Brain

CT Scan had experienced these five risk factors with 100% sensitivity and 70% specificity.

Also, with considering high-risk trauma mechanisms (variables are defined in the table3) as warning symptoms for performing Brain CT Scan, all children with ICI were diagnosed by CT scan with 98% sensitivity and specificity. Also, the study showed that all children with ICI in Brain CT Scan had at least two ICI risk factors. Finally, since the low percentage (7.6%) of patients undergone CT Scan had ICI and considering disadvantages of this diagnostic method, the advantages and disadvantages of Brain CT Scan, should be considered carefully before indicating it.

In conclusion, we confirm that observation approach is recommended in children with minor head trauma to reduce Brain CT-Scan which is risky and expensive. Performing CT -Scan based on physician clinical judgment, or based on the different indications that are listed in different guidelines and protocols, is not recommended. However, our findings suggested using risk factors for evaluating Brain CT Scan indication in children with minor head trauma. Although, more prospective studies with larger sample sizes is required to provide further evidence.

Limitations: A limitation *of the* study was the relatively small sample size.

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