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Original Article

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

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ABSTRACT

Trauma is a common presentation to hospital emergency departments in most societies. The dramatic increase in the demand for imaging following mild and moderate head trauma and the impact of radiation exposure have become a concern. This study aimed to determine the results of brain CT scans in patients referred to our center with minor head trauma and its correlation with clinical signs and symptoms. In this retrospective study, 709 patients with mild and moderate head trauma who referred to our center from 2022 to 2023 were included. The required data were extracted from the patients' medical records and analyzed using SPSS software version 26 at a confidence level of 95%. Of the 709 cases included 465 (65.6%) were male and 244 (34.4%) were female. Blunt trauma (93.2%) was the most common type. The most common mechanism of head trauma was traffic accidents (50.9%) followed by falling (35.4%).636 cases (89.7%) had normal and 73 cases (10.3%) had positive CT findings. The most common pathologic findings were linear skull fracture (3.7%) and hemorrhage (3.6%). In logistic regression analysis, injury severity and CT scan indication were significant predictors of abnormal brain CT scan results in patients with mild and moderate head trauma. A significant proportion of brain CT scans requested in patients with mild and moderate head trauma were unnecessary. Trauma patients who had more severe injuries and had indications for brain CT scanning were more likely to have abnormal CT scan results.

Keywords: Trauma, CT scan, Brain injury,X-ray, Radiation

Introduction

Traumatic brain injury (TBI) is a leading cause of death. The incidence of these injuries is estimated at 266 per 100,000 people in developed countries [1]. It is estimated that 3.7 million Americans live with disabilities resulting from TBI. It is also estimated that traumatic brain injury affects more than 54 to 60 million people annually, leading to hospitalization or death [2]. These injuries range from mild and reversible to severe and life-threatening. Mild brain injuries are without structural changes, and patients usually have a level of consciousness between 13 and 15 on the Glasgow Coma Scale (GCS) [3].

The burden of head injury is greatest in low- and middle-income countries, which account for 85% of the world's population [4]. The World Health Organization estimates that approximately 90% of deaths occur in low- and middle-income countries with increased risk factors for head injury but yet lack adequate health care capacity to deal with its associated complications. Significant disabilities resulting from head injury impose a significant burden on the healthcare system therefore understanding the epidemiology of head injury and developing preventive measures to reduce this burden is crucial [5]. Head injury is the leading cause of disability in people under 40 years of age, severely disabling 150–200 per million people annually [6,7]. Most cases are caused by road traffic injuries (60%), followed by falls (20–25%) and violence (10%) [8]. Young men are the most common group of people to suffer from head injuries [34]. In children under 15 years of age, head injuries are the leading cause of death. In older adults, the leading cause of head injuries is falls from

heights [10]. The severity of injuries from falls is greater in urban areas than in rural areas [11].

CT scanning is the fastest method for diagnosing intracranial hemorrhage and is widely and increasingly used because it reliably reports intracranial hemorrhage [12]. Figures show a 200% increase in the use of advanced traumatic brain injury imaging methods, indicating the lack of a reliable method for identifying life-threatening conditions. CT scans are also commonly used for patients who do not suffer from loss of consciousness or abnormal neurological conditions which constitute a large number of normal CT scans in hospitals [2,13]. In the United States, 400,000 requests for CT scans are reported annually for children with mild traumatic brain injury, with normal CT scan results [12,14].

Certainly, it is important to rule-out the need of CT scan in minor head trauma based on the type and mechanism of the trauma and clinical sign and symptoms. The aim of this study is to evaluate the incidence of positive CT findings among patients presented with minor head trauma to our center and its correlation with demographic and clinical data.

Materials and Methods

This descriptive-analytical retrospective study was conducted at a tertiary academic hospital in west of Iran to review of the frequency and results of brain CT scans in mild head trauma patients during January 2022- December 2023. All patients 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. The samples were selected using the total number method, and all those eligible for the study were included. Information was obtained and documented in a questionnaire by trained research assistant. The patients' charts were filled by 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 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 v26. Quantitative variables were reported as mean ± standard deviation or median, and qualitative variables were reported as number (percentage). To compare normal and abnormal CT scan results by age, Student's t-test was used, by gender, trauma severity, and trauma mechanism, Chi-square test was used, and by indication for requesting CT scan, Chi-square test and Fisher's exact test were used. In multivariate analysis, logistic regression was used to eliminate the effects of possible confounding variables. The significance level was 95% in all cases and a P value of less than 0.05 was considered significant.

Results and Discussion

The mean and standard deviation of the patients' age was 29.84±21.38 years (range 1 month to 90 years). The highest frequency was in the age group of 1 to 10 years and then 30 to 39 years (Figure 1). Of 709 patients included 465 (65.6%) were male and 244 (34.4%) were female (Fig 2).

Most patients had low severity (GCS = 14-15) (94.4%) and blunt trauma (93.2%) was the most common type table 1.

Table 1. Frequency of severity and type of head injury

variable	Number	percentage
Injury severity		
Mild (GCS>13)	669	94.4
Moderate (GCS=9-13)	40	5.6
Total	709	100
Injury Type		
Blunt	661	93.2
Penetrating	48	6.8
Total	709	100

The most common mechanism of head trauma was road accident (50.9%) followed by fall (35.4%) table 2.

Table 2. Frequency of head trauma mechanisms

Trauma mechanism	Number	Percentage
Motor vehicle collision	361	50.9
fall	251	35.4
assault	79	11.1
Blunt trauma	16	2.3
Others (hanging, Electrical injury,…)	2	0.3
Total	709	100

Of the CT scan results, 636 cases (89.7%) were normal and 73 cases (10.3%) were abnormal. Linear fractures (temporal, orbital, ethmoid, and sphenoid) were the most common finding (3.7%) following by hemorrhage and hematoma in different parts of the brain (3.6%) table 3.

Table 3. Frequency of CT scan results

CT result	number	%
normal	636	89.7
contusion	7	1
Subgaleal hematoma	3	0.4
Pneumocephalus	7	1
Linear fracture	26	3.7
Intra cerebral hemorrhage (ICH)	4	0.6
Subdural hematoma(SDH)	6	0.8
Epidural hematoma(EDH)	6	0.8
Subarachnoid hemorrhage(SAH)	8	1.1
Intraventricular hemorrhage(IVH)	2	0.3
nonspecific	4	0.6

total	709	100

The mean and standard deviation of the age of patients with normal and abnormal CT scan results were 29.97±21.49 and 28.71±20.56 years, respectively. Based on the results of the student's t-test, no significant difference was observed between normal and abnormal brain CT scan results by age (p=0.634, t=0.467).

A significant correlation was observed between abnormal brain CT scan results and male gender (P<0.001), moderate trauma severity (P=0.008), and penetrating trauma (P=0.001) table 4.

Table 4. Frequency of CT scan results by patient gender, type and severity of trauma

variable	CT result			P value*
	Normal Number(%)	Abnormal Number(%)	Total Number(%)	
Gender				
Male	407(87.5)	58(12.5)	465(100)	0.008
Female	229(93.9)	15(6.1)	244(100)	
Injury severity				
Mild	620(92.7)	49(7.3)	669(100)	< 0.001
moderate	16(40.0)	24(60.0)	40(100)	
Type				
Blunt	600(90.77)	61(9.22)	661(100)	0.001
penetrating	36(75)	12(25)	48(100)	

*Chi-square test

No significant difference was observed between the results of brain CT scans in terms of the mechanism of trauma table 5.

Table 5. Frequency of CT scan results by mechanism of trauma

variable	CT results			P value*
	Normal Number(%)	Abnormal Number(%)	Total Number(%)	
Road accidents	328(90.9)	33(9.1)	361(100)	
fall	224(89.2)	27(10.2)	251(100)	
assault	70(88.6)	9(11.4)	79(100)	0.311
Blunt trauma	12(75.0)	4(25)	16(100)	
Other	2 (100)	0	2(100)	

* Fisher's exact test

Of 709 patients, 332(46.8%) had an indication for brain CT scan and 377 (53.2%) had no indication. Headache, scalp laceration, vomiting, and age over 60 years, alone or in combination, were the most common indications for requesting a CT scan. Table 6.

Table 6. Frequency of indications for brain CT scan

Indication	number	%	Indication	number	%
headache	86	25.9	Scalp laceration+age >60	5	1.5
Age > 60	34	10.2	Vomiting+age >60	6	1.8
Scalp laceration	48	14.5	Raccoon eye+age>60	1	0.3
vomiting	50	15.1	FND + age >60	1	0.3
Raccoon eye	13	3.9	Otorrhea+age >60	1	0.3
Focal neurologic deficit(FND)	21	6.3	Scalp laceration+vomiting	1	0.3
Otorrhea-rhinorrhea	5	1.2	Laceration + FND	1	0.3
Headache + age> 60	5	1.5	Vomiting + FND	9	2.7
Headache+laceration	4	1.2	Vomiting + otorrhea	2	0.6
Headache+vomiting	9	2.7	Raccoon eye+FND	1	0.3
Headache+FND	13	3.9	>2 indications	13	3.9
Headache+rhinorrhea or otorrhea	3	0.9	total	332	100

Patients who had an indication for a head CT scan had a 2.55 times higher risk of an abnormal head CT scan table 7.

Table 7. Frequency of CT scan results according to CT scan indication

CT result	Indication		Odds ratio	P value.
	No Number(%)	Yes Number(%)		
Normal	353(93.6)	283(85.2)		
Abnormal	24(6.4)	49(14.8)	2.55	< 0.001
total	377(100)	332(100)		

A significant association was observed between the clinical symptoms of headache (p=0.010) and scalp and facial laceration (p=0.043) with abnormal head CT scan results. However, no significant association was observed with other signs and symptoms table8.

Table 8. Frequency of head CT scan results by signs and symptoms

sign		CT result			P value
		Normal Number(%)	Abnormal Number(%)	Total Number(%)	
Nausea & vomiting	no	513(89.8)	58(10.2)	571(100)	0.805*
	yes	123(89.1)	15(10.9)	138(100)	
Blurred vision	No	629(89.6)	73(10.4)	702(100)	0.622**
	yes	7(100)	0	7(100)	
vertigo	No	593(89.2)	72(10.8)	665(100)	0.074**
	yes	43(97.7)	1(2.3)	44(100)	
Head and facial hematoma	No	597(98.8)	68(10.2)	6959100)	0.797**
	yes	39(88.6)	5(11.40	44(100)	
Head and facial laceration	No	509(90.9)	5199.1)	560(100)	0.043*
	yes	127(85.2)	22(14.8)	149(1000	
headache	No	510(91.2)	49(9.1)	559(100)	0.010*
	yes	126(84.00	24(14.8)	150(100)	
rhinorrhagia	No	616(90.1)	68(9.9)	684(100)	0.164*
	yes	20(80.0)	5(20)	25(100)	

* Chi-square test ** Fisher's exact test

Among the variables that were associated with CT scan results in univariate analysis, only injury severity and the presence of CT

scan indication had a significant association with the results in multivariate analysis table9.

Variables in the Equation

95% C.I.for EXP(B)

Table 9. Variables predicting normal and abnormal CT scan results based on logistic regression

	B	S.E.	Sig.	Exp(B)	lower	upper
gender	-.597	.330	.070	.550	.288	1.051
severity	2.973	.378	.000	19.545	9.322	40.978
type	.636	.464	.171	1.888	.760	4.690
CT indication	.709	.324	.029	2.031	1.077	3.831
H&facial laceration	.344	.337	.308	1.410	.728	2.731
headache	.608	.329	.065	1.837	.964	3.499
constant	-6.093	.852	.000	.002		

In the present study, 89.7% of head scans were normal and 10.3% were abnormal. Of the abnormal cases, 4 cases (0.4%) were unrelated to trauma.

In a study by Nayebaghayee et al. (2016) in Tehran, in examining the relationship between the Glasgow Coma Scale and CT scan findings in patients with brain trauma, 54.5% of all patients had abnormal CT findings [12].

In a study conducted by Jamali et al. (2018) in Shiraz, in examining the results of CT scans in patients with mild head trauma based on its indications and final clinical outcomes, the most common indication was vomiting and the most common abnormal finding was linear skull fracture. Four signs of level of consciousness, headache, post-stroke seizures, and vomiting were variables to predict the need for CT scanning in patients with mild brain injury, the most common abnormal CT scan finding was linear skull fracture which is consistent with our finding [14]. In another study conducted in Iran, an average of 13.5% of patients with minor trauma had abnormal CT results [15].

In a descriptive-analytic study conducted by Moradi et al. in Zanjan (2023) in a study of trauma patients who underwent head CT scans, 88% of the cases had normal results, 9% had abnormal results related to their current trauma, and 3% had abnormal results unrelated to the current trauma [16].

In a study conducted by Salehi Zahabi et al. in Kermanshah (2020), CT scan findings were abnormal in 0.2% of patients. Most patients undergoing brain CT scan had scalp lesions, headache, and vomiting [17]. Our findings regarding the presence of scalp lesions and vomiting as indications for requesting brain CT scan are consistent with the results of the studies of Jamali et al. and Salehi et al. In our study, a significant portion (10.2%) of patients underwent brain CT scan only because they were over 60 years of age. This may be one of the reasons for more normal brain CT scan results of our study.

As can be seen in studies conducted in Iran, in head trauma patients, the range of abnormal head CT scan results has been reported to be between 0.2% and 54.5%, and in other countries between 29.2% and 33.9%. The heterogeneity of the results may be due to differences in the severity of head trauma. In our study, mild to moderate head trauma patients were included, but in the study by Nayebaghayee et al., severe trauma was also investigated. Another cause of the heterogeneity of the results may be the degree of compliance with CT scan request protocols.

In a study conducted by Hamrah et al. (2018) in Iran, regarding the frequency of brain CT scan findings in patients with scalp laceration following mild traumatic brain injury, the most common finding was subgaleal hematoma, followed by skull base fracture, linear skull fracture, and brain contusion [18]. The slight difference in CT scan results in different studies may be due to differences in the type of trauma (blunt or penetrating), the severity of the trauma, and its mechanism.

In a study by Nugraha et al. (2024) in Indonesia, in examining abnormal CT scan findings in patients with clinical mild traumatic brain injury, 33.9% of brain CT scans were abnormal, in logistic regression analysis, skull fracture and signs of skull base fracture were the strongest abnormal CT predictors [19]. In the present study, in univariate analysis a significant relationship was observed between abnormal brain CT scan results and male gender, moderate trauma severity, penetrating trauma, presence of indication for requesting a CT scan, presence of headache and scalp and facial laceration. However, in multivariate logistic regression analysis, only injury severity and the presence of CT scan indication were significantly associated with abnormal CT scan results.

As the results of the survey by Lagares et al. (2023) in France, Spain, Greece, and Portugal showed, there were differences and variations in the use of guidelines and their compliance among the mentioned countries in terms of indications for brain CT scanning after mild traumatic brain injury [20].

In a study by Klang et al. (2017) in Canada, which aimed to estimate the demand for brain CT scans in the emergency department of a subspecialty hospital, 89.10% of patients did not have an indication for CT according to the CCHR criteria, and the overuse of brain CT scans for minor brain injuries, especially in younger patients, was 37.3% [21]. In our study, 332 patients (8.46%) had an indication for brain CT scan, obviously the rate of non-adherence to the indications for requesting a brain CT scan in our study is higher which requires further investigation.

In a study by Kista et al. (2012) in examining predictors of positive head CT scan findings and neurosurgical procedures after minor head trauma, 29.2% of patients had positive head CT scans. Older age, male gender, ethnicity, and mechanism of injury (falling to the ground) were significant predictors of positive findings on head CT scan and the need for neurosurgical procedures [22].

Our findings regarding the association between abnormal CT scan results and headache, skull fracture and gender are consistent with findings of Jamali et al.'s, Nugraha et al. and Kista et al. studies respectively.

Conclusion

In our study head trauma was more common in men and in the third decade of life. A significant proportion of brain CT scan

requests in patients with mild and moderate head trauma were unnecessary, without indication, and with normal results. Trauma patients with more severe injuries and indications for CT were more likely to have abnormal brain CT scan results. Despite the overuse and sometimes unnecessary use of brain CT and the normality of brain CT scans in most patients with minor head trauma with emphasis on the use of guidelines for requesting brain CT scans, performing an initial CT scan in patients with head trauma in the emergency department still seems an appropriate method for ruling out potential life-threatening injuries. Following the guidelines, considering the local resources and conditions might help reduce costs and potential harm from unnecessary radiation exposure.

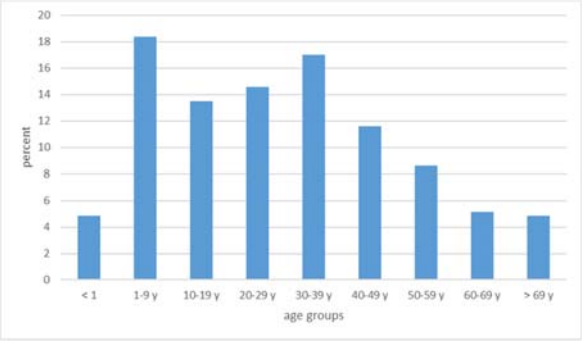

Fig 1. Frequency of age groups of patients

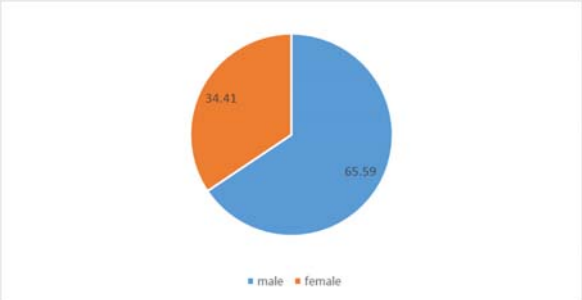

Fig 2. Gender frequency of patients

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Ethics statement: 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. The design was approved by the Ethics Committee of the University of Medical Sciences.

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